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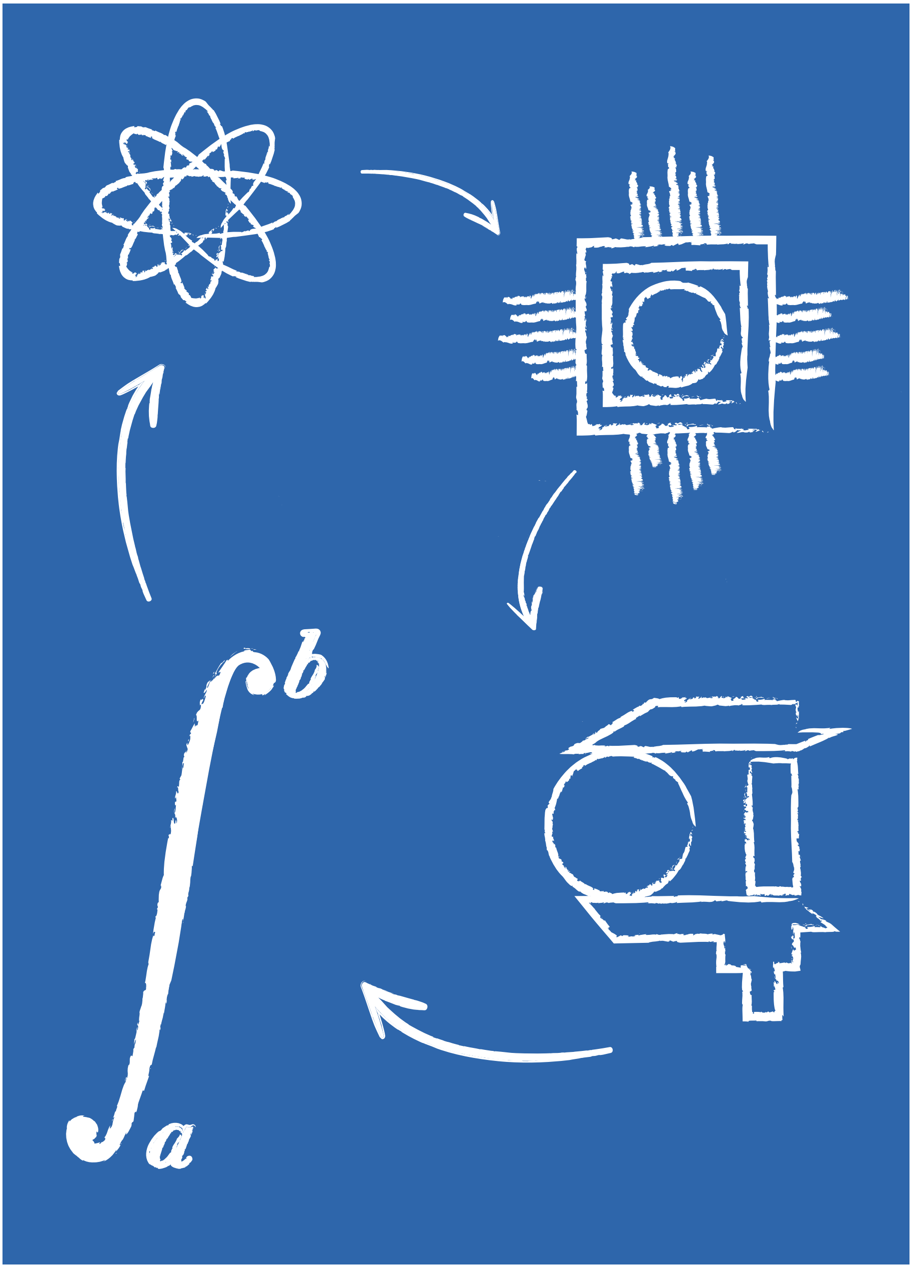

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/SUMMARY/

/1/

DEEP ARCHITECTURES FOR HUMAN ACTIVITY RECOGNITION USING SENSORS

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ABSTRACT

Human activity recognition (HAR) is a renowned research field in recent years due to its applications such as physical fitness monitoring, assisted living, elderly–care, biometric authentication and many more. The ubiquitous nature of sensors makes them a good choice to use for activity recognition. The latest smart gadgets are equipped with most of the wearable sensors i.e. accelerometer, gyroscope, GPS, compass, camera, microphone etc. These sensors measure various aspects of an object, and are easy to use with less cost. The use of sensors in the field of HAR opens new avenues for machine learning (ML) researchers to accurately recognize human activities. Deep learning (DL) is becoming popular among HAR researchers due to its outstanding performance over conventional ML techniques. In this paper, we have reviewed recent research studies on deep models for sensor–based human activity recognition. The aim of this article is to identify recent trends and challenges in HAR.

KEYWORDS

Deep Learning models, Sensors, Human activity recognition.

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1. INTRODUCTION

Recent years have shown significant progress in the use of smart gadgets and sensor–enabled devices. The reduced cost of these devices and ease of use makes them a perfect choice to use for human activity recognition (HAR). HAR is trending research field with its various applications including smart homes, sports, health monitoring, emergency services, and lifelogging (Chan, EstèVe, Fourniols, Escriba & Campo, 2012; Lara & Labrador, 2013).

Initially, activity recognition task was successfully done through video recordings but video–based systems are location specific and it somewhat interfere one's personal life. For the reason, sensor–based activity recognition is gaining widespread acceptance. In sensor based HAR systems, low cost wearable sensors are deployed which reduces interference in daily activities. Another recent development in HAR is use of smartphones as these latest cell phones are equipped with many sensors. The unobtrusive nature of smartphones makes them appropriate for HAR.

Activity recognition systems most often use classification algorithms to classify activities as class labels. Like other time–series data, the first step in sensor based HAR is to segment data into time frames and then to extract time and frequency domain feature from those data segments. In conventional machine learning algorithms feature extraction is often done by manually using heuristic methods, in contrast deep Learning provides automatic feature extraction. It also helps in mining complex knowledge from massive amount of unsupervised data. Plötz, Hammerla, and Olivier (2011) used deep learning for the first time for feature extraction and compared the results with principal component analysis. After that a number of researchers worked on deep learning approaches for automatic feature extraction in human activity recognition (Twomey, *et al.*, 2018; Ronao, Charissa & Cho, 2015; Alsheikh, *et al.*, 2016). The main contribution of this research is to review latest trends in human activity recognition using deep architectures. This paper reviews and analyses recent research articles on deep learning based HAR using sensors.

The rest of the paper is organized as follows: section 2 discusses some of the deep learning architectures and section 3 elaborates some publically available datasets used for HAR. In section 4, recent studies on deep learning based HAR are presented. Section 5 presents research challenges in activity recognition field. Finally, section 6 concludes the article.

2. DEEP LEARNING ARCHITECTURES

Deep learning (DL) is a renowned field of research and successfully implemented in image and voice recognition problems. Generally, there are three categories of deep models, which are generative, discriminative and hybrid models (Deng & Jaitly, 2016). A generative model learns the true distribution of training data and makes some variations to generate new samples which follow same probabilistic distribution. Some generative DL methods include Restricted Boltzman Machine (RBM), Deep Autoencoders, and Sparse Coding. A discriminative method directly estimates the probability of the output given an input i.e. $p(y|x)$ by approximating posterior distribution classes. Most commonly used discriminative models in activity recognition are Convolutional Neural Network (CNN) and Recurrent Neural Networks (RNN) (McDaniel & Quinn, 2018). Many research studies have combined discriminative and generative methods to extract more effective features. The combination of generative and discriminative models is known as hybrid model. In most studies CNN is used along with other generative or discriminative methods for HAR. This section explores some of the deep learning models used in sensor–based HAR.

2.1. CONVOLUTIONAL NEURAL NETWORK

The Convolutional Neural Network (CNN) learns internal representations of raw sensor data without domain expertise in feature engineering (Ronao & Cho, 2015). For the reason, it is most widely used method for data analysis and activity recognition. In CNN convolution operation is performed on sensor data through many hidden layers. The components of CNN include convolutional

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layer, pooling layer, dense (fully connected) layer and softmax layer (Ignatov, 2018). ***Convolutional layer*** detects distinct features from input by performing convolution operation on data. The first convolution layer identifies low level features whereas next convolutional layers detect higher level features (Namatēvs, 2017). The convolutional layers then introduce nonlinearities to the model through using activation functions such as tanh, sigmoid and rectified linear unit (ReLU) (Albelwi & Mahmood, 2017). ***Pooling layer*** is used to downsample the dimensionality of the feature map.It compresses features and reduces network's computational complexity (Affonso, Rossi, Vieira & Ferreira, 2017). Most frequently used pooling algorithm is max pooling which is robust to small changes (Kautz, *et al.*, 2017). The last component of CNN is ***dense layers or fully connected layers***. These layers are fused with softmax classifier to perform classification on extracted features. So far CNN is the most widely used deep model in activity recognition and feature learning.

Zeng, *et al.* (2014) proposed a CNN based approach for HAR which automatically extract discriminative patterns and captures local dependencies of a sensor signal. They used partial weight sharing method to accelerometer data for performance improvement. Yang, Nguyen, San, Li, and Krishnaswamy (2015) also presented a CNN model for multichannel time–series data for HAR. The convolution and pooling layers of the proposed model capture the salient features, which are systematically unified among multiple channels and then mapped into activity classes.

2.2. RESTRICTED BOLTZMANN MACHINE

Restricted Boltzmann Machine (RBM) is a stochastic deep model, which learns a probability distribution on its input dataset using a layer of binary hidden units. The meaningful features are automatically extracted from input labelled and unlabeled data. It is most commonly used for dimensionality reduction and complex feature learning problems. It is a type of shallow neural network that learns to reconstruct data by itself in an unsupervised manner. There are two variations in RBM, one is Deep Belief Networks (DBN) and other is Deep Boltzmann Machine (DBM).

The concept of deep belief networks was first conceived by Hinton, Osindero, and Teh (2006) as a replacement of backpropagation. In terms of network structure, a DBN is very similar to multilayer perceptron but their training process is entirely different. In fact, the difference in training method is key factor that enables DBN to outperform the shallow counterpart. A deep belief network consists of multiple hidden layers. The layers are connected with each other but the units in each layer are not connected. To make learning easier the connectivity is restricted i.e. there is no connection between hidden units. DBNs can be divided in two major parts. The first one consists of multiple layers of RBMs to pre–train the network, while the second one is a feed–forward backpropagation network that will further refine the results from the RBM stack. Alsheikh, *et al.* (2016) proposed a DBN based model which is trained on greedy layer–wise training of RBMs. The proposed model provides better recognition accuracy of human activities and avoids expensive design of handcrafted features. Bhattacharya and Lane (2016) used RBM–based pipeline for activity recognition and have shown their approach outperforms other modeling alternatives.

2.3. AUTOENCODERS

Autoencoders are deep neural networks to perform data compression using machine learning. An autoencoder learns compressed distributed representation of input data for dimensionality reduction (Nweke, Teh, Al–Garadi & Alo, 2018). It applies back propagation i.e. the output values will be set as the input. Principle Component Analysis (PCA) does the same for linear functions whereas autoencoder can perform non–linear transformations. An autoencoder also gives a representation as to the output of each layer and having multiple representations of different dimensions is always useful. So an autoencoder uses pre–trained layers from other models to apply transfer learning to prime the encoder of the decoder. There are three components of an autoencoder; encoder, code, and decoder. ***The encoder*** compresses/encodes the input data into a latent space representation. ***The code*** represents the compressed input that is fed to the decoder. ***The decoder*** reconstructs/decodes the input from the latent space representations.

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Different variations in autoencoders include Sparse Autoencoder (SAE), Denoising Autoencoder (DAE) (Nweke, *et al.*, 2018). Almaslukh, AlMuhtadi and Artoli (2017) proposed stacked autoencoder based model for better recognition accuracy along with reduced recognition time.

2.4. RECURRENT NEURAL NETWORK

Recurrent Neural Network (RNN) is a deep model with cyclic connections, which empowers it to capture correlations between time series data. RNN is successfully used in handwriting recognition and speech recognition applications (Wang, Chen, Hao, Peng & Hu, 2018). RNN is a network with a loop in it allowing information to persist. The iterative nature of RNN enables data to be passed starting with one stage of the network to the next. RNN can be considered as numerous replicas of the same network, each network passes information to the next. RNN is a very flexible and powerful network which does not require additional data labelling and works well for modelling short–term memory. This makes it a good choice to easily model sequence learning or time–related problem where the output of one layer acts as an input to the next layer. There are two variations of recurrent neural networks, one is Long Short Term Memory (LSTM) and the other is Gated Recurrent Unit (GRU). Such networks make use of different gates and memory cells to store time series sequences (Graves, 2013). Murad and Pyun (2017) used unidirectional, bidirectional and cascaded deep RNN on five public datasets. They proposed three novel LSTM–based deep RNN architectures which extract discriminative features using deep layers and provide performance improvements. M. Inoue, S. Inoue and Nishida (2018) proposed an RNN based approach to provide better recognition accuracy with reduced recognition time.

2.5. HYBRID MODELS

Hybrid models are a combination of generative and discriminative models. Many researchers have implemented hybrid models in activity recognition as well as in other fields. For instance, Murahari and Plötz (2018) used deep convolutional LSTM model to explore the temporal context in activity recognition. Lee, Grosse, Ranganath, and Ng (2009) proposed a convolutional deep belief network that used the probabilistic max–pooling technique for visual recognition tasks. In some studies, RNN and CNN are combined together where CNN captures spatial relationships and RNN uses temporal relationships. Ordóñez and Roggen (2016) presented a deep convolutional LSTM recurrent neural network for multimodal wearable sensors. The deep CNN is used for automated feature extraction and LSTM recurrent unit captures temporal dynamics of activities. Yao, Zhao, Hu, and Abdelzaher (2018) also introduced a CNN and RNN based framework which designs a self–attention module for estimating input quality by exploiting its temporal dependencies. More research in these models is expected in future.

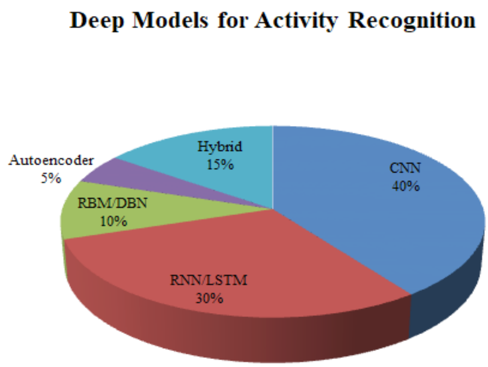

Figure 1. Deep Models for Activity Recognition.

The Figure 1 shows a pie chart showing the percentage of the deep learning methods used in activity recognition. This percentage only represents deep models used in studies presented in this research article.

The mostly used deep model here is CNN which is 40%, this is due to the success of CNN in the image processing field. CNN also gives an outstanding performance in sensor–based HAR due to its discriminative feature extraction

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capabilities. Other models also perform well in activity recognition and are gaining popularity.

3. DATASETS

Validating a new human activity recognition approach on the new or self–created dataset is a challenging task. The effectiveness of such approaches can be achieved by testing them on some standard datasets where the researchers have already tested their results. This section gives a brief description of some publically available benchmark datasets which paid a remarkable contribution in HAR research. All these datasets are sensor based and are summarized in Table 1.

Table 1. Datasets for sensor–based HAR (ADL= Activities of Daily Life, A= Accelerometer, G= Gyroscope, M= Magnetometer, HR= Heart Rate, AM= Ambient Sensors, O= Object Sensors, L= Light Sensors, S= Sound Sensor, ECG= Electrocardiogram, EEG= Electroencephalogram, EOG= Electro–Oculogram, GPS= Global Positioning System, MF= Magnetic Field Sensor).

Dataset	Sensors used	Activities	Sampling rate (Hz)	No. of Instances	No. of Subjects	Application
DaLiAc (Leutheuser, Schuldhaus & Eskofier, 2013)	A, G	Sitting, Lying, Standing, Washing, dishes, Vacuuming, Sweeping, Walking outside, Ascending stairs, Descending stairs, Treadmill running (8.3 km/h), Bicycling (50 watt), Bicycling (100 watt), Rope jumping	200	—	19	ADL
UCI HAR (Anguita, Ghio, Oneto, Parra & Reyes–Ortiz, 2013)	A, G	Walking, Walking upstairs, Walking downstairs, Sitting, Standing, Laying	50	10,299	30	ADL
PAMAP2 (Reiss & Stricker, 2012)	A, G, M, HR	Lying, Sitting, Standing, Walking, Running, Cycling, Nordic Walking, Watching Tv, Computer Work, Car Driving, Ascending Stairs, Descending Stairs, Vacuum Cleaning, Ironing, Folding Laundry, House Cleaning, Playing Soccer, Rope Jumping, Other (Transient Activities)	100	3,850,505	9	ADL
WISDM (Kwapisz, Weiss & Moore, 2010)	A	Walking, Jogging, Upstairs, Downstairs, Sitting, Standing	20	1,098,207	29	ADL

Dataset	Sensors used	Activities	Sampling rate (Hz)	No. of Instances	No. of Subjects	Application
Actitracker (Lockhart, *et al.*, 2011)	A	Walking, Jogging, Stairs, Sitting, Standing, Lying down	20	2,980,765	36	ADL
OPPORTUNITY (Roggen, *et al.*, 2010)	A,G, M, O, AM	17 activities including ADL run and Drill run	32	701366	4	ADL
STISEN (Stisen, *et al.*, 2015)	A, G	Biking, Sitting, Standing, Walking, Stair Up, Stair Down	100~200	43930257	9	ADL
GAIT (Ngo, *et al.*, 2014)	A, G	walking on a flat surface, walking up the slope, walking down the slope, descending stairs and ascending stairs	100	—	744	Gait Analysis
Sleep–EDF (Goldberger, *et al.*, 2000)	EEG, EOG, EMG	Sleep stages i.e. Awake, Stage–1, Stage 2, Stage 3, Stage 4, REM	100	—	20	Sleep Analysis
RealWorld HAR (Sztyler & Stuckenschmidt, 2016)	A, G, GPS, L, MF, S	Climbing Downstairs, ClimbingUpstairs, Jumping, Lying, Standing, Sitting, Running/Jogging, And Walking	50	944,356	15	ADL

4. DISCUSSION

Although conventional machine learning algorithms have shown remarkable performance in recognition of human activities, these algorithms require domain expertise to develop robust features for high dimensional complex real–world data. However, this is time consuming and expensive task. This captivated researchers towards the use of deep learning. In deep architectures, the layers of feature representations are stacked together to extract more complex features in data. Recent studies have shown the incredible performance improvement of deep learning in HAR. Feature extraction plays a significant role in recognition process as it extracts features from sensor data which helps in reducing computational complexity and improves classification accuracy (Abidine, Fergani, Fergani & Oussalah, 2018). Conventional approaches use hand–crafted feature engineering, whereas in deep learning features are automatically learned through the deep network. Another challenge is most ML algorithms require a good amount of labelled data for model training but the data in real–time applications is mostly unlabeled. Deep learning works well with unlabeled data too (Almaslukh, *et al.*, 2017). Table 2 provides recent research on deep learning based human activity recognition models.

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Table 2. Deep learning based recent research for HAR.

Study	Dataset	Deep Learning Method	Application	Description
(Alsheikh, *et al.*, 2016)	WISDM, Daphnet Gait, Skoda	DBN	ADL, Parkinson	DBNs are trained on greedy layer–wise training of RBMs. The proposed model provides better recognition accuracy of human activities and avoids the expensive design of handcrafted features.
Hammerla, Halloran & Plötz, 2016)	OPPORTUNITY, PAMAP2, Daphnet Gait	DNN, LSTM, CNN	ADL, smart home, Gait	They introduced a novel regularization approach. Three deep learning approaches DNN, RNN and CNN are explored across three benchmark datasets.
(Ordóñez, *et al.*, 2016)	OPPORTUNITY, Skoda	Deep Convolutional LSTM	ADL	They presented a deep convolutional LSTM recurrent neural network for multimodal wearable sensors. The deep CNN is used for automated feature extraction and LSTM recurrent unit captures temporal dynamics of activities.
(Bhattacharya, *et al.*, 2016)	OPPORTUNITY, Self–generated	RBM	ADL, Gesture, Transportation	They used RBM–based pipeline for activity recognition which outperforms for other modelling alternatives.
(Murad, *et al.*, 2017)	UCI–HAD, USC–HAD, Daphnet FoG, OPPORTUNITY, Skoda	DRNN	ADL, Gait	They used unidirectional, bidirectional and cascaded DRNN on five public datasets. They proposed three novel LSTM–based DRNN architectures which extract discriminative features using deep layers and gives performance improvement.
(Ravi, Wong, Lo & Yang, 2017)	ActiveMiles, WISDM, Skoda, Daphnet FoG	CNN	ADL	They used shallow and deep features for activity classification and it resolves the issues related to on–node computations.
(Münzner, *et al.*, 2017)	PAMAP2, Robert Bosch Hospital (RBK)	CNN	ADL	They evaluated the influence of normalization techniques and explored the change in classification accuracy by using early and late fusion techniques.
(Almaslukh, *et al.*, 2017)	UCI HAR	Stacked Autoencoder (SAE)	ADL	They proposed stacked autoencoder based model which provides better recognition accuracy with reduced recognition time.
(Yao, *et al.*, 2018)	STISEN	Deep Convolutional RNN	ADL	They introduced QualityDeepSense framework for IoT applications. It estimates input sensing quality by using temporal dependencies.
(Radu, *et al.*, 2018)	STISEN, GAIT, Sleep–Stage, Indoor–Outdoor	Multimodal–CNN, Multimodal–DNN	ADL, Gait, Sleep analysis	Four distinct multimodal CNN architectures have been proposed for activity and context recognition.
(Murahari, *et al.*, 2018)	OPPORTUNITY, PAMAP2, Skoda	DeepConvLSTM	ADL	An Attention model has been proposed in activity recognition research as a data–driven approach to explore temporal context. Attention layers have been added to DeepConvLSTM model.

Study	Dataset	Deep Learning Method	Application	Description
(Almaslukh, Artoli & Al–Muhtadi, 2018)	RealWorld HAR	CNN	ADL	Deep convolution neural network model for position–independent activity recognition.
(Khan, Roy & Misra, 2018)	Self–generated	Heterogeneous Deep CNN	ADL	A CNN–based HAR approach for transfer learning with automatic model learning across different domains while requiring minimum labelled data.
(Zhu, Chen & Yeng, 2018)	UCI HAR	Deep LSTM	ADL	A semi–supervised model using a DeepLSTM based approach with temporal ensembling for activity recognition using inertial sensors.
(Xi, *et al.*, 2018)	OPPORTUNITY, PAMAP2	CNN, RNN	ADL	They used dilated convolutional layers to automatically extract inter–sensor and intra–sensor features. They also proposed a novel dilated SRU (Simple Recurrent Unit) approach to capture the latent time dependencies among features.
(Ignatov, 2018)	WISDM, UCI HAR	CNN	ADL	A CNN based approach to provide user–independent human activity recognition with small recognition intervals (1s) and almost no preprocessing and feature engineering required.
(Inoue, *et al.*, 2018)	HASC corpus, UCI HAR	RNN	ADL	They used an RNN based approach to provide better recognition accuracy with reduced recognition time.
(McDaniel & Quinn, 2018)	UCI HAR	LTSM	ADL	They proposed LTSM based pipeline which can directly process raw data without extensive preprocessing and gives outstanding performance.

5. RESEARCH CHALLENGES

Human activity recognition is a trending research field with many challenges that need to be addressed. Although, HAR is a well–researched field still these challenges need to be further investigated for the effective realization of HAR systems. These research challenges include:

Sensor placement: The position of the sensor plays an important role in recognition accuracy. Different placement positions include right/left arm, ankle, foot, hip and chest etc. Sensor signal readings vary at different positions for the same activity.

Sensor modalities: Sensor modality can be classified into wearable sensors, ambient sensors and object sensor. In most HAR systems, wearable sensors are successfully used but in only few research studies these sensor modalities are

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combined to improve the recognition accuracy and to infer high–level activities such as having coffee with RFID tag on the cup.

Compatibility with real–world data: Real world data is often different from laboratory data with the constrained environment. Most of real–world data come in streams and are unlabeled; therefore the HAR systems should be robust enough for real–world scenarios.

Context Awareness: As HAR systems are designed to provide analysis on user's activity and behavior, so it is necessary that the system must be aware of user's behavior, age, gender and physical condition and environment. For example, running the signal of a 75 years old patient might be equivalent to the walking of a young user. In such situations context information is vital.

Overlapping activities: Most of the HAR systems recognize single activity at a time such as walking, standing, sitting or brushing teeth, but generally there can be some overlapping activities like having coffee while watching TV or walking while drinking water. Few types of research have been done in this direction but still, there are good research opportunities in this direction.

Hyper–parameter setting: accuracy of deep models heavily rely on adjustment of network parameters such as learning rate, dropout, filter size, kernel reuse, no. of units and deep layers, regularization etc. In most of the research, these parameters are set using heuristic methods (Liu, *et al.*, 2017), so there is a need to use optimization algorithms to adjust these hyper–parameters.

Sensor Fusion: In sensor based HAR systems, it is crucial to choose which sensors need to be fused together to improve the recognition process. Münzner, *et al.* (2017) presented four data fusion techniques including early fusion, sensor–based late fusion, channel–based late fusion and shared filters hybrid fusion. Chowdhury, Tjondronegoro, Chandran and Trost (2017) also presented a fusion technique namely posterior adapted class based fusion.

6. CONCLUSION

This article discussed recent developments in sensor–based human activity recognition using deep architectures. The goal of this article is to identify recent trends and challenges in HAR. Recent research studies on HAR are compared with respect to sensor type, the dataset used, deep learning models and its applications. Some basic deep models are also discussed, which are successfully implemented in HAR. The paper also presented some publically available sensor based datasets for activity recognition. In the end, various research challenges are discussed which may be addressed to make HAR systems more robust and implementable in real–world scenarios.

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ENERGY EFFICIENT AND HIGH–PERFORMANCE FIR FILTER DESIGN ON SPARTAN–6 FPGA

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ABSTRACT

In this paper, we are going to design the energy efficient Gaussian low pass FIR filter on spartan–6 FPGA. To make an energy efficient filter, we have used different methods in this paper like capacitance scaling, frequency scaling, and then we analysed the demand for power by Gaussian low pass FIR filter. The frequency range which is used in this paper is 1 GHz, 2GHz, 2.5GHz, 5 GHz, 10 GHz and the range of capacitance which we have used in this paper is 5pF, 10pF, 25pF, 40pF and 50 pF. An FIR filter always remnants in linear phase with the help of symmetric coefficient and this is the very useful feature of the FIR filter for phase sensitive application like data communications etc. At present, there are many different methods of communications and networking. So, in this paper, we have designed an energy–efficient FIR filter and that design will faster than traditional design.

KEYWORDS

FIR filter, Gaussian, FPGA, Energy efficient, Spartan–6 FPGA.

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1. INTRODUCTION

Gaussian filter is a type of filter and the impulse response of this filter is in Gaussian function. A linear phase is the important feature of any filter. Linear phase means that the filter phase response of the filter will be a linear function of frequency. A finite impulse response (FIR) is a filter and it settles to zero in finite time so then impulse response, and that features make the FIR an ideal choice for phase sensitive application i.e. data communications, seismology, crossover filters and mastering etc. Here we can say that an energy efficient design of FIR filter leads to energy efficient data communication.

Figure 1. Top Level Schematic of Gaussian Low Pass FIR Filter.

Spartan–6 FPGA is a high–performance FPGA in terms of price and performance using 45nm transistor technology. The function of the low pass filter is to pass the low–frequency signals and prohibits the signals which are higher than the cut–off frequency as shown in Figure 1. In this paper, we have operated the Gaussian low pass filter with 1GHz, 2GHz, 2.5GHz, 5GHz, and maximum of 10 GHz frequency. We have also used capacitance scaling method to analyse the power (Pandey, Kumar, Das, Yadav & Pandey, 2014).

2. LITERATURE SURVEY

In Pandey, *et al.* (2014), the author has used capacitance scaling techniques as well as frequency scaling techniques but on 28nm Kintex–7 FPGA using available 240 DSP slice. There is open scope to design different energy efficient DSP IP block like Modulation, Transforms, Tring functions, Demodulation, Error

Correction. In this paper, the dynamic power of the CMOS circuit is dependent on the capacitance of payload and switching activity of circuit. Due to the operating frequency of the device is high, the clock signal is the main factor for the generation of dynamic power. The paper of Pandey, *et al.* (2014) shows that there are no change in DSP power, signal power, logic power if there is a change in capacitance, but IO power and leakage power are increasing so the overall power is also increasing. In Pandey, Kumar, Das, Islam and Kumar (2014) the authors analyse that there is no any change in clock power due to airflow, but the airflow is affecting the logic power, signal power, DSPs power and IOs power and they are increasing. The authors have used 250 LFM and 500LFM airflow in order to design an energy efficient FIR filter. They have used custom, low profile, medium profile and high profile hit the sink. In Pandey, *et al.* (2018), FIR filter is using 5% of IO resource available in ultra–scale FPGA. So, then there is a possibility to implement bigger FIR filter in this ultra–scale FPGA. FIR filter is using 1 out of 480 clock buffer available on FPGA so then it provides 479 remaining global clock buffer to the different component of future design. The distribution of dynamic and static power is 15% and 85% as shown in Figure 2.

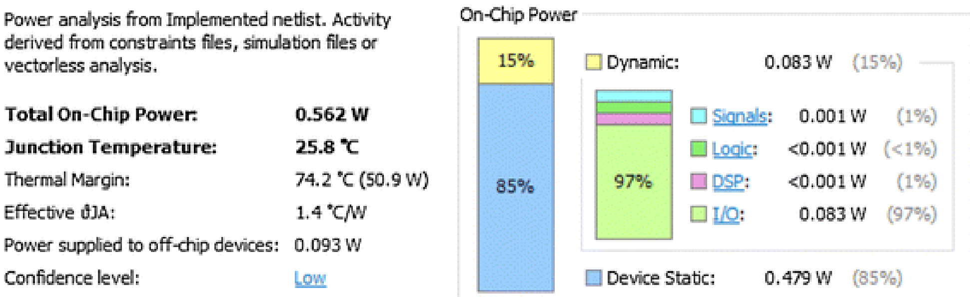

Figure 2. Power Dissipation of FIR Filter. **Source:** Pandey, *et al.*, 2018.

In Pandey, *et al.* (2017), the author has analysed the power demand by device of Artix–7, Kintex–7, Zynq and ultrascale FPGA then they conclude that all programmable SoC is a power hungry architecture but Kintex ultra–scale architecture is the very energy efficient architecture. There is significant improvement when they migrate design from 28 nm process technology based seven series architecture to 20 nm process technology based ultra–scale architecture. Reduction in latency will increase the efficiency of any communication design

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not only this FIR Filter but also many others. The requirement for accurate, high performance and indoor localization using wireless sensor networks (WSNs) is increasing day by day (Pak, Ahn, Shmaliy & Lim, 2015). Zhao, Shmaliy, Huang and Liu (2015) research work is concerned with the minimum variance unbiased (MVU) finite impulse response (FIR) filtering problem for a linear system. Digital filters are mainly used in a lot of digital signal processing areas. Filters of finite impulse response (FIR) category has stability and compliance to be adaptive, in compare to filters of infinite impulse response (IIR) category (Mirghani, 2018). Transpose form finite–impulse–response (FIR) filters are inherently pipelined and support multiple constant multiplications (MCM) technique (Mohanty & Meher, 2016).

3. RESULT AND DISCUSSION

Table 1 has shown the total power consumption of Gaussian low pass FIR filter for 5 pF capacitance at different frequencies. The total power consumption in Gaussian low pass FIR filter for 5 pF capacitance is 0.072W, 0.125W, 0.153W, 0.291W, 0.566W on 1 GHz, 2 GHz, 2.5 GHz, 5 GHz, 10 GHz respectively.

Table 1. Power of Gaussian Low Pass FIR Filter for 5 pF Capacitance.

Frequency	Dynamic Power (Watt)	IO–Power (Watt)	Leakage Power (Watt)	Total Power (Watt)
1 GHz	0.017	0.040	0.015	0.072
2 GHz	0.029	0.081	0.015	0.125
2.5 GHz	0.036	0.101	0.016	0.153
5 GHz	0.074	0.201	0.017	0.291
10 GHz	0.144	0.403	0.020	0.566

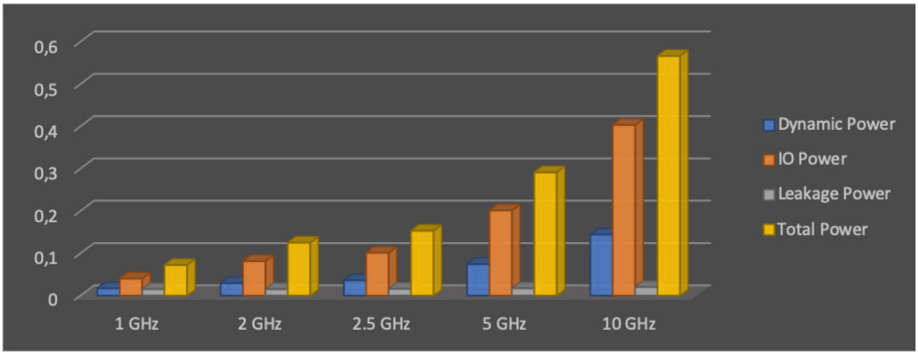

Figure 3. Power Dissipation of GLP FIR Filter on a different frequency and 5 pF capacitance.

As we can see, power dissipation is increasing with respect to frequency and capacitance. The total power is the sum of static and dynamic power, and the Dynamic Power is the sum of signal, clock, and logic power. The distribution of power analysis has shown in Figure 3.

Table 2. Power of Gaussian Low Pass FIR Filter for 10 pF Capacitance.

Frequency	Dynamic Power (Watt)	IO–Power (Watt)	Leakage Power (Watt)	Total Power (Watt)
1 GHz	0.017	0.049	0.015	0.080
2 GHz	0.029	0.097	0.016	0.142
2.5 GHz	0.036	0.121	0.016	0.174
5 GHz	0.074	0.242	0.017	0.333
10 GHz	0.144	0.485	0.021	0.650

Table 2 has shown the total power consumption of Gaussian low pass FIR filter for 10 pF capacitance at different frequencies. The total power consumption in Gaussian low pass FIR filter for 10 pF capacitance is 0.080W, 0.142W, 0.174W, 0.333W, 0.650W on 1 GHz, 2 GHz, 2.5 GHz, 5 GHz, 10 GHz respectively. So, we can conclude that the total power is increasing with respect to frequency and capacitance. The total power is the sum of static and dynamic power, and the Dynamic Power is the sum of signal, clock, and logic power as shown in Figure 4.

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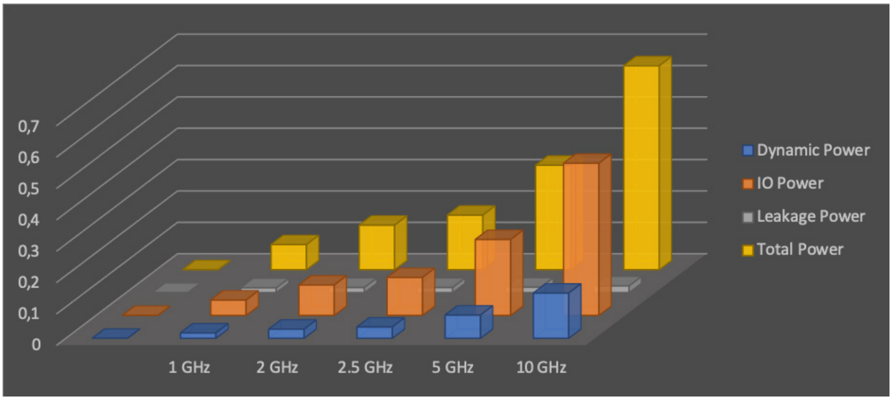

Figure 4. Power Dissipation of GLP FIR Filter on a different frequency and 10 pF capacitance.

Table 3. Power of Gaussian Low Pass FIR Filter for 25 pF Capacitance.

Frequency	Dynamic Power (Watt)	IO–Power (Watt)	Leakage Power (Watt)	Total Power (Watt)
1 GHz	0.017	0.073	0.015	0.105
2 GHz	0.029	0.146	0.016	0.192
2.5 GHz	0.036	0.183	0.016	0.236
5 GHz	0.074	0.366	0.019	0.458
10 GHz	0.144	0.731	0.025	0.900

Table 3 has shown the total power consumption of Gaussian low pass FIR filter for 25 pF capacitance at different frequencies. The total power consumption in Gaussian low pass FIR filter for 25 pF capacitance is 0.105W, 0.192W, 0.236W, 0.458W, 0.900W on 1 GHz, 2 GHz, 2.5 GHz, 5 GHz, 10 GHz respectively. IO–Power is the major contributor in total power dissipation of the FIR filter as shown in Figure 5.

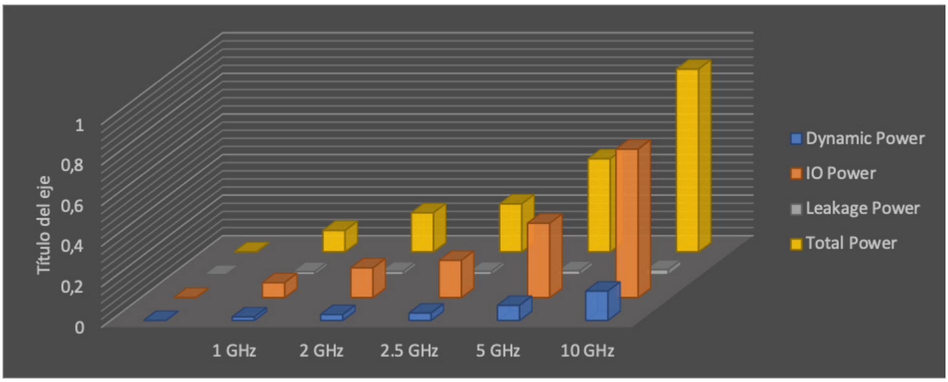

Figure 5. Power Dissipation of GLP FIR Filter on different frequencies and 25 pF capacitance.

Table 4. Power of Gaussian Low Pass FIR Filter for 40 pF Capacitance.

Frequency	Dynamic Power (Watt)	IO–Power (Watt)	Leakage Power (Watt)	Total Power (Watt)
1 GHz	0.017	0.098	0.015	0.130
2 GHz	0.029	0.196	0.017	0.241
2.5 GHz	0.036	0.244	0.017	0.298
5 GHz	0.074	0.489	0.020	0.582
10 GHz	0.144	0.978	0.030	1.151

Table 4 has shown the total power consumption of Gaussian low pass FIR filter for 40 pF capacitance at different frequencies. The total power consumption in Gaussian low pass FIR filter for 40 pF capacitance is 0.130W, 0.241W, 0.298W, 0.582W, 1.151W on 1 GHz, 2 GHz, 2.5 GHz, 5 GHz, 10 GHz respectively. So, dynamic power is approx. 13% of total power dissipation and static power is 87% of total power dissipation for 1 GHz as shown in Figure 6.

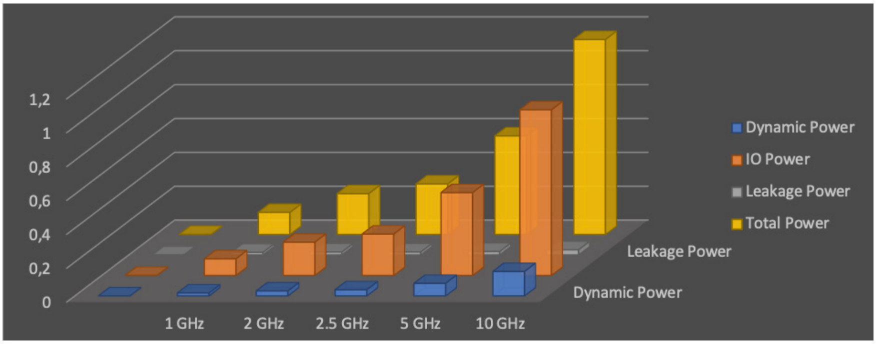

Figure 6. Power Dissipation of GLP FIR Filter on different frequencies and 40 pF capacitance.

Table 5. Power of Gaussian Low Pass FIR Filter for 50 pF Capacitance.

Frequency	Dynamic Power (Watt)	IO–Power (Watt)	Leakage Power (Watt)	Total Power (Watt)
1 GHz	0.017	0.114	0.016	0.147
2 GHz	0.029	0.228	0.017	0.275
2.5 GHz	0.036	0.286	0.018	0.340
5 GHz	0.074	0.571	0.022	0.666
10 GHz	0.144	1.142	0.034	1.320

Table 5 has shown the total power consumption of Gaussian low pass FIR filter for 50 pF capacitance at different frequencies. The total power consumption in Gaussian low pass FIR filter for 50 pF capacitance is 0.147 W, 0.275 W, 0.340 W, 0.666 W, 1.320 W on 1 GHz, 2 GHz, 2.5 GHz, 5 GHz, 10 GHz respectively. So, we can say that dynamic power is increasing with respect to frequency. The total power is the sum of static and dynamic power as shown in Figure 7.

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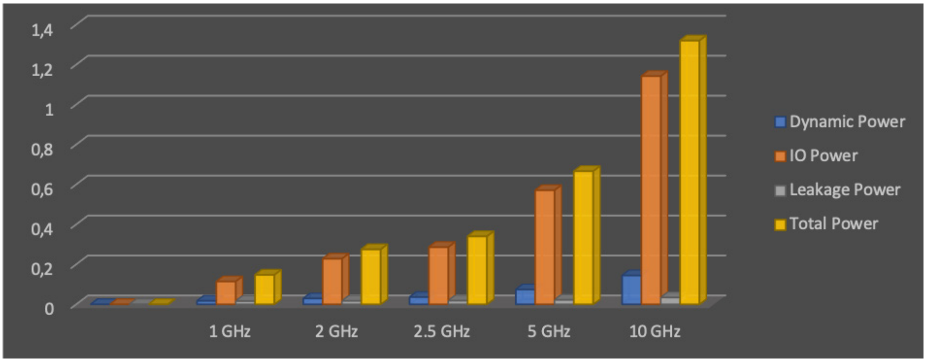

Figure 7. Power Dissipation of GLP FIR Filter on a different frequency and 40 pF capacitance.

Table 6. IO Power analysis of Gaussian Low Pass FIR Filter.

Frequency	5 pF	10 pF	25 pF	40 pF	50 pF
1 GHz	0.040	0.049	0.073	0.098	0.114
2 GHz	0.081	0.097	0.146	0.196	0.228
2.5 GHz	0.101	0.121	0.183	0.244	0.286
5 GHz	0.201	0.242	0.366	0.489	0.571
10 GHz	0.403	0.485	0.731	0.978	1.142

As we can see in Table 6, the IOs power is decreasing by decreasing the device operating frequency and by decreasing the capacitance values. It is decreasing at approx. 14%, 35%, 57%, 64% when the capacitance value is scaled down from 50 pF to 40pF, 25pF, 10pF and 5 pF for the all range of frequency, which we have used for FIR filter i.e. 1 GHz, 2 GHz, 2.5 GHz, 5 GHz, 10 GHz. In another way, the IOs power is decreasing by 50%, 75%, 80%, 90% when we decrease the FIR filter device operating frequency from 10 GHz to 5 GHz, 2.5GHz, 2 GHz and 1 GHz for all capacitance values as shown in Figure 8.

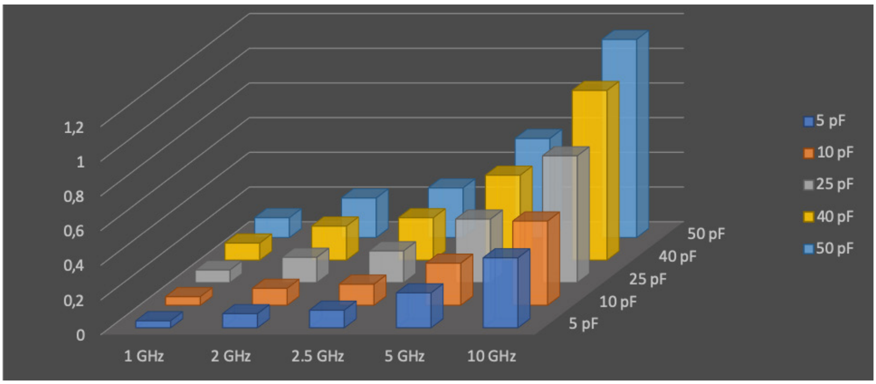

Figure 8. IO–Power Dissipation of GLP FIR Filter on the different capacitance value.

Table 7. Leakage Power analysis of Gaussian Low Pass FIR Filter.

Frequency	5 pF	10 pF	25 pF	40 pF	50 pF
1 GHz	0.015	0.015	0.015	0.015	0.016
2 GHz	0.015	0.016	0.016	0.017	0.017
2.5 GHz	0.016	0.016	0.016	0.017	0.018
5 GHz	0.017	0.017	0.019	0.020	0.022
10 GHz	0.020	0.021	0.025	0.030	0.034

As we can see in Table 7, the Leakage power is decreasing by decreasing the device operating frequency and by decreasing the capacitance values. It is decreasing at approx. 6%, 12%, 20% when the capacitance value is scaled down from 50 pF to 5 pF for 2 GHz to 10 GHz frequency. In another way, the leakage power is decreasing by 25%, 28%, 40%, 50% and 52% when we decrease the FIR filter device operating frequency from 10 GHz to 1 GHz for 5 pF, 10 pF, 25 pF, 40 pF, 50 pF capacitance value respectively. This analysis has shown in Figure 9.

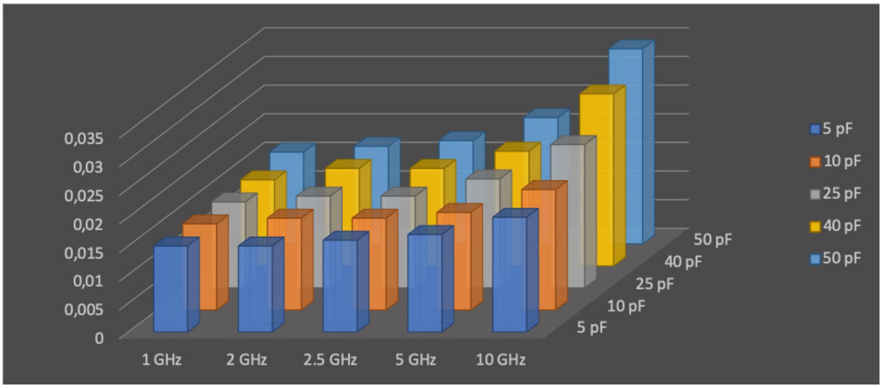

Figure 9. IO–Power Dissipation of GLP FIR Filter on the different capacitance value.

Table 8. Total Power analysis of Gaussian Low Pass FIR Filter.

Frequency	5 pF	10 pF	25 pF	40 pF	50 pF
1 GHz	0.072	0.080	0.105	0.130	0.147
2 GHz	0.125	0.142	0.192	0.241	0.275
2.5 GHz	0.153	0.174	0.236	0.298	0.340
5 GHz	0.291	0.333	0.458	0.582	0.666
10 GHz	0.566	0.650	0.900	1.151	1.320

As we can see in Table 8, the total power is decreasing by decreasing the device operating frequency and by decreasing the capacitance values. It is decreasing at approx. 12%, 30%, 48%, 57% when the capacitance value is scale down from 50 pF to 40pF, 25pF, 10pF and 5 pF respectively. In another way, the total power is approx. 88% decreasing when we decrease the FIR filter device operating

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frequency from 10 GHz to 1 GHz as shown in Figure 10.

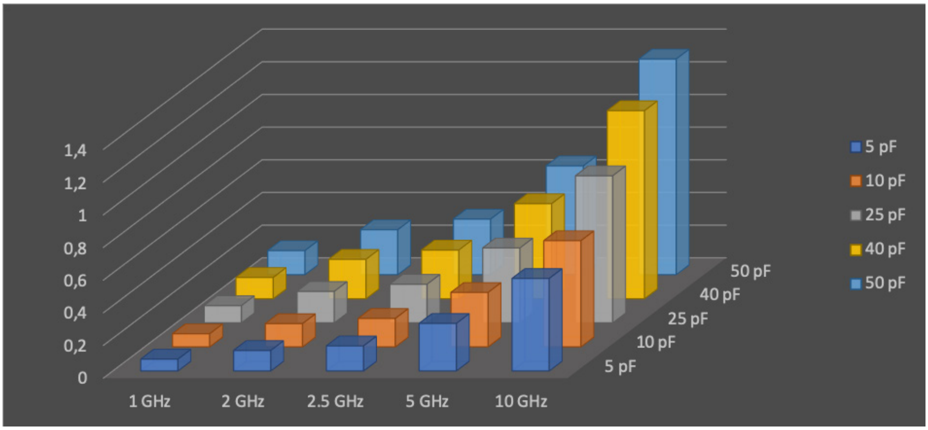

Figure 10. IO–Power Dissipation of GLP FIR Filter on the different capacitance value.

4. CONCLUSION

According to the above analysis, we have analysed dynamic power are increasing due to change in device operating frequency but for the same frequency, the dynamic power remains the same for any value of capacitance. Instead of this, the IO power, leakage power is increasing if we use capacitance scaling techniques as well as scaling of device operating frequency. The IO power is decreasing approx. 14%, 35%, 57%, 64% when the capacitance value is scaled down from 50 pF to 40pF, 25pF, 10pF and 5 pF for the all range of frequency, which we have used for FIR filter i.e. 1 GHz, 2 GHz, 2.5 GHz, 5 GHz, 10 GHz. The leakage power is decreasing approx. 6%, 12%, 20% when the capacitance value is scaled down from 50 pF to 5 pF for 2 GHz to 10 GHz frequency. But here we can say that the leakage power is increasing very slowly with increasing capacitance. The total power is decreasing approx. 12%, 30%, 48%, 57% when the capacitance value is scale down from 50 pF to 40pF, 25pF, 10pF and 5 pF respectively. In another way, the total power is 88% and 50% decreasing when we decrease the FIR filter device operating frequency from 10 GHz to 1 GHz and 5 GHz respectively.

5. FUTURE SCOPE

In this paper, we have used the Spartan–6 FPGA to design the energy efficient Gaussian low pass filter. There are many open scopes available to make the energy efficient filter design using Floating–Point, Modulation, Transforms, Demodulation, Video, Error Correction, Imaging and even more DSP IP block. The current FPGA which we have used in this paper is 45nm FPGA. There is open scope to implement the design on 28nm FPGA, 20nm or even lower 14nm ultra–scale FPGA.

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A LEXICON BASED APPROACH TOWARDS CONCEPT EXTRACTION

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ABSTRACT

The emergence of digital media has tremendously increased the amount of unstructured data. Recently 80% of data, generated over the web, is in an unstructured format. This immense amount of data is a great source for the knowledge discovery and thus, may be utilized for extracting purposeful information. This study adopted a lexicon–based approach for automatic concept extraction from online news stories and events. An application prototype has been developed to demonstrate the applicability and effectiveness of the adopted approach. The extracted knowledge about news stories, articles and blogs are essential in understanding in–depth information for news analysts. This knowledge plays a vital role in building societies since media is considered as an opinion maker for its audience.

KEYWORDS

Online news, Unstructured data, Concept extraction.

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1. INTRODUCTION

The digital age has provided an immense amount of data in terms of news articles, social media data, and web LaValle, Lesser, Shockley, Hopkins & Kruschwitz, 2014; Gharehchopogh & Khalifelu, 2011). Every day, a large amount of data is published on the news websites, micro–blogging websites and other information repositories (Lei, Rao, Li, Quan & Wenyin, 2014). The published news articles reveal the events happening around the world (Lei, *et al.*, 2014). The challenging issue, specifically, in the textual data format (i.e., news articles) is to extract purposeful information. Manually, it is a hard task to interpret a large collection of data (Lee, Park, Kim & No, 2013). Besides, the information hidden in unstructured data format inherently makes it difficult processing tasks, because it deals with natural language processing. Therefore, in the current era of information flow, media analysts and other researchers need an easily understandable and high–level summary of information. For instance, a media analyst may require searching news regarding a certain topic, events happening to a certain geo–location, and/or news events based on a timeline. These and other such queries are objectives, which requires an efficient method to answer such queries.

Text Analytics allows knowledge discovery and purposeful finding of information from such a massive amount of data for investigation. The extracted knowledge can be used for better decision–making strategies and effective resource management. Therefore, extracting purposeful knowledge from large data having natural language involvement is an open challenge, which acquires sophisticated methods and algorithms to deal with it. To this aim, this research study extracts concepts from a large number of news stories and articles. The concept extraction refers to a meaningful sequence of words that are used to represent objects, events, activities, entities (real or imaginary), topics or ideas, which are of interest to the users (Parameswaran, Garcia–Molina & Rajaraman, 2010; Szwed, 2015). The concept extraction technique is a very effective way of extracting all the possible useful and meaningful concepts from text documents. The extracted concepts, later, may be tagged as essential concepts and may be represented in an efficient mechanism (Zhang, Mukherjee & Soetarman, 2013). The concepts, especially, present the understanding of the unstructured data format. The coverage and patterns of such concepts help in understanding in–depth about the news stories, news articles and inclination of the author's mindset. This knowledge about news stories, articles and blogs are essential for news analysts and plays a vital role in building societies, because media plays the role of opinion maker for the inhabitants of society.

An application prototype has been developed in this study to demonstrate the automated concept extraction that works based on lexicon approach. On the contrary, the machine–learning approach (i.e., supervised learning) inherently possesses challenges due to unstructured data format. Whilst, the lexicon–based approach has produced comparatively better results. The developed prototype presents the applicability and effectiveness of the considered approach.

This paper is structured as follows: section 2 reports existing scientific literature about concept extraction, section 3 describes the architecture of the developed application. Results and discussion are reported in section 4, and finally, section 5 concludes.

2. RELATED WORK

The concept extraction has been remained focus of in the recent existing literature (Sˇili´c, *et al.*, 2012; Parameswaran, *et al.*, 2010; Villalon, *et al.*, 2009, Weichselbraun, *et al.*, 2013; Termehchy, *et al.*, 2014; Brin, 1998, Mahmood, *et al.*, 2018). Specially, concept extraction in the context of online news has become ta opic of interest. For instance, social emotions have been detected using a lexicon–based approach from news articles in (Lei, *et al.*, 2014). CatViz Temporally – Sliced Correspondence Analysis Visualization performs exploratory text analysis on large collection of textual data. The basis of CatViz is Correspondence Analysis (CA) and allows va isual analysis of different aspects of text data (Sˇilı´c, *et al.*, 2012).

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Extraction of concepts from query log data repository has been carried out in Parameswaran, Garcia–Molina and Rajaraman (2010), where sub–concepts and super concepts are pruned. The core concepts are taken into consideration, which is oriented on frequency, better meaning and idea. Similarly, automatic concept extraction from essays written by students in order to draw concept maps is reported in Villalon and Calvo (2009) for the concept map mining purpose. The limitations faced in machine–learning approach during training model have been addressed in Weichselbraun, Gindl and Scharl (2013). Two potentially efficient algorithms have been proposed Termehchy, Vakilian, Chodpathumwan and Winslett (2014), namely: 1) Approximate Popularity Maximization (APM) and Annotation–benefit Maximization (AAM). The patterns hidden in web documents have been explored in Brin (1998), where patterns are analyzed for concept determination.

The Dawn (newspaper) and The New York Times (newspaper) have been focused on Mahmood, Kausar and Khan (2018) for the purpose of textual analysis. `This study also focused on online news stories and events published at The Dawn (newspaper) as the data source in order to automatically extract concepts using lexicon–based approach. The dictionaries used for the understanding of concepts and meanings of the terms and/or concepts are WordNet and DBPedia.

3. LEXICON BASED CONCEPT EXTRACTION APPROACH

An application prototype has been developed for online news data in order to extract key concepts. The prototype is developed using C# (c sharp) programming language.

The application architecture of the developed prototype comprised of three layers: Layer 1: Data Source, Layer 2: Middleware and Layer 3: News Mining as shown in Figure 1. The purpose of each layer is reported in the subsequent sections.

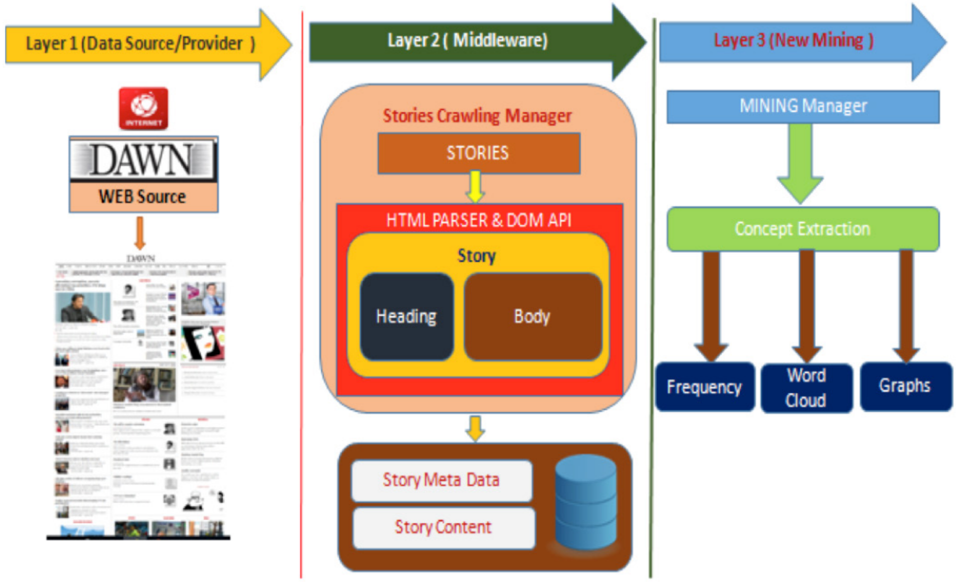

Figure 1. Prototype Application Architecture.

3.1. LAYER 1: DATA SOURCE/PROVIDER

Data source/Provider layer crawls online news events and stories published at ***The Dawn***[1] newspaper official website. The application, however, allows providing URL (Uniform Resource Locator) of a certain news website. This study has focused on the news stories and articles of The Dawn newspaper. This layer traverses the given URL to crawl its news events and stories available at its several webpages. The crawler uses the existing APIs (Application Programming Interfaces) for the traversing and retrieval of data from the source website (***The Dawn*** in this case).

3.2. LAYER 2: MIDDLEWARE

Middleware layer takes the news stories and articles and parses the given obtained news stories. In particular, HTML (Hypertext Markup Language) parser and DOM (Document Object Module) API has been used for the processing of news stories. The parsed and processed data is stored in the relational database.

1 The Dawn (www.dawn.com)

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A relational database is the collection of data into table formats, which are logically related to each other. The news stories and articles comprised of several tags as represented in Figure 2.

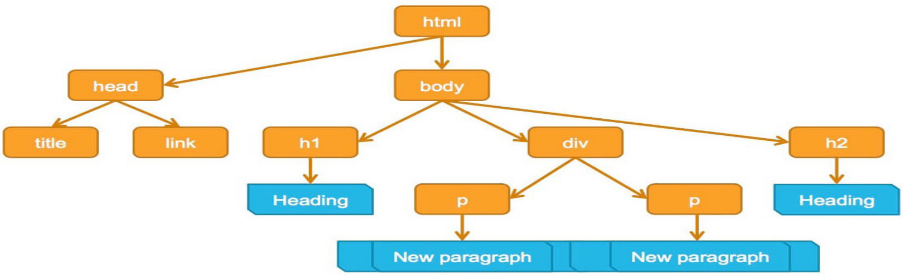

Figure 2. HTML webpage tags in a tree structure.

Middleware layer takes the news stories and articles and parses the given obtained news stories. In particular, HTML (Hypertext Markup Language) parser and DOM (Document Object Module) API has been used for the processing of news stories. The parsed and processed data is stored in the relational database. A relational database is the collection of data into table formats, which are logically related to each other. The news stories and articles comprised of several tags as represented in Figure 2.

HTML Parser is, basically, a library and it is used in parsing if text files formatted in HTML. Likewise, DOM API, written in JavaScript, is an object representation of webpage. The news stores and articles are provided as an input to the third layer of the developed prototype application.

3.3. LAYER 3: NEWS MINING

This layer is the key layer that actually automatically extracts concepts present in the collected news stories and articles. In particular, this layer comprised of Mining Manager, which performs necessary text preprocessing steps to transform the collected and stored news stories and articles into a suitable format for further processing.

Mining Manager: it performs tokenization, stemming, stopword removal operations before actual processing of automatic concept extraction.

Tokenization: this operation breaks given textual data into its tokens (i.e., terms or words). For instance, consider a sentence *'This study aims at automatic concept extraction using lexicon–based approach.'* The tokenization produces the following outcomes: ***'This', 'study', 'aims', 'at', 'automatic', 'concept', 'extraction', 'using', 'lexicon', 'based', 'approach', '.'***.

Stemming: stemming refers to an operation in which words (i.e., tokens) obtained from the previous step (i.e., tokenization) are acquired into their roots or base words. For instance, ***'Multiplying'*** becomes ***'Multipli'***, ***'Engineering'*** becomes ***'Engine'*** and many more. This step helps into a reduction of redundant terms used in textual data.

Stopword Removal: this operation prunes unnecessary words present in the text. These unnecessary words usually refer to auxiliary verbs and grammatically articles. For example, ***'the' 'is' 'am' 'are' 'was' 'and' 'a' 'an'*** and many more.

The processed tokens are further used as an input for automatic concept extraction. The application uses popular bag–of–words (BOW) as vector space representation model for the processed tokens. The words that are left after stopword removal operation are the bag–of–words, each word has its frequency in certain news story or article. The BOW is supplied to Concept Extraction module for determining concepts.

Concept Extraction: The concept extraction module determines the meaning and being concept state of terms, which have been processed at Mining Manager. The BOW is further supplied to concept extraction module as shown in Figure 3 that is connected with dictionaries: WordNet, DBpedia and Linked data to determine the meaning and concept for a given word of BOW.

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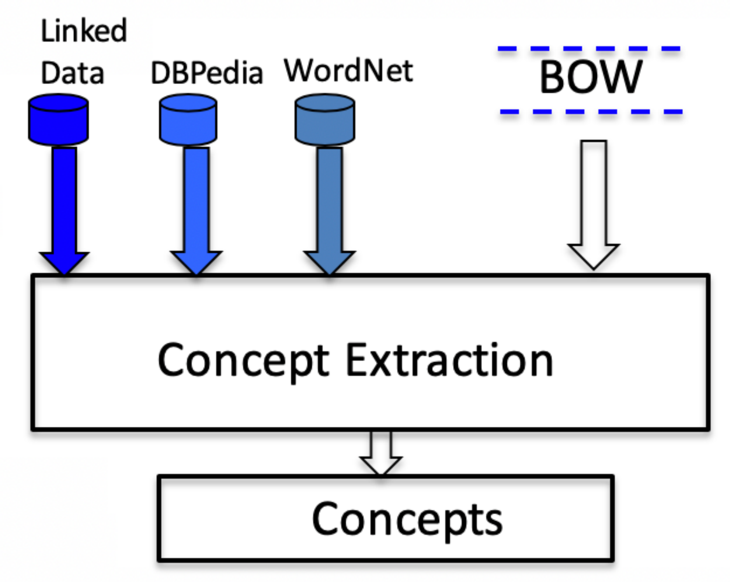

Figure 3. Lexicon based Concept Extraction Approach.

Each word in BOW undergoes for the concept extraction process. The outcomes of the concepts are later used for visualization. In particular, the frequency of the concepts is measured for a given article or news story. The word cloud is displayed for the concepts and graphs represent the trends of the concepts available in the news.

4. RESULTS AND DISCUSSION

This section discusses the outcomes of the developed application prototype. Figure 4 represents the crawled data. A certain URL of the newspaper website is provided to crawl its data and store into a database. The collected story is displayed at the user interface of the application as in Figure 4.

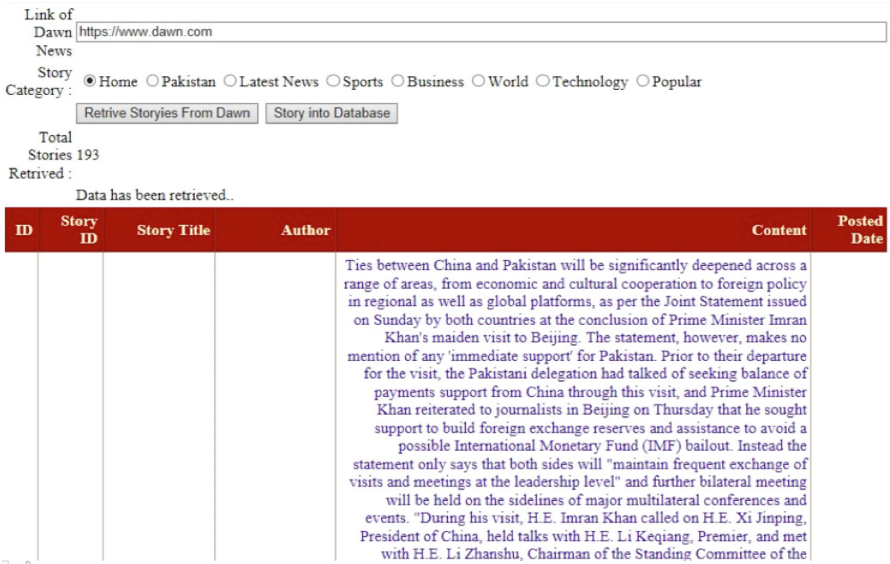

Figure 4. Developed Application Prototype.

Figure 5 represents the concepts extraction and the frequencies used for the BOW as an input for concept extraction module discussed in section 3.3. Since the BOW is large in number, the prototype allows increasing or decreasing the number terms in BOW based on their frequencies.

Figure 5. Prototype – Concepts and their Frequencies.

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The graphs and concepts in terms of word cloud are presented in the developed prototype for a better understanding of concepts present in the news stories and articles as reported in Figure 6.

Figure 6. Prototype – Concepts and their Word Cloud.

The outcomes of the approach help in understanding in–depth news stories and articles, which may be used as a baseline for the decision–making strategies. The news media has been used widely for opinion making purposes. Thus, the extracted concepts help in getting an insight into the news events, articles and mindset of the journalists.

5. RESEARCH CHALLENGES AND LIMITATIONS

To acquire data for this study, The Dawn newspaper has been targeted due to its popularity and neutrality. This could be considered as the limitation of the study since the emphasis of the study remained over concept extraction using lexicon approach. However, the developed approach may also be provided a dataset of any other newspaper.

The challenges that have been encountered during the course of the research study is PakistaniEnglish words. The injection of *Urdu* words in English has been referred to as Pakistani English. For instance, *chai–wala, ziaism, Sahab* and *Naya Pakistan* are some of the PakistaniEnglish vocabulary. The challenge is to determine the concepts from this derived vocabulary. PakistaniEnglish vocabulary has been not addressed in the study due to lack of its lexical chains and thorough grammatical aspects that help in understanding words.

6. CONCLUSION

This study reported a lexicon–based approach for concept extraction. In particular, a working prototype has been developed to demonstrate the applicability and effectiveness of the approach. The application automatically crawls news events and stories, which are stored in a relational database. The focus remained on The Dawn newspaper for the data source due to its neutrality and popularity in the region.

The collected news data has been gone through necessary text processing phases in order to transform it for further process. The concepts have been extracted with the help of WordNet, DBPedia and Linked Data. The extracted concepts, later, have been displayed with visualization techniques such as Word Cloud and charts. Generally, media has an influential role over the minds of its audience. Thus, the extracted concepts may help in understanding the core concepts available in the news events and stories that may lead to strategic decision–making. The outcomes of this study may assist and help media analysts to have an in–depth understanding of media personnel and general public opinion about news and facts on the ground.

The deviation of lexical chains in terms of PakistaniEnglish words will be considered as future work. In particular, developing PakistaniEnglish corpus to tackle the limitations of this study would be a focus in future work.

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AN ECONOMICAL AND RELATIVELY EFFICIENT IMPLEMENTATION OF THE REAL–TIME SOLAR TRACKING SYSTEM

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ABSTRACT

The bi–facial solar system which is available in the commercial markets having a variety of advantages and efficiency but they are too much costly. Therefore there is a dire need to design a low price solar system that overcomes the increasing energy demand. In this research, we have designed a system which reflects the bi–facial model with an economical prize for the developing nations. However, the efficiency of the proposed solar system was checked on a sunny day and its observation was closely related to the real–time bi–facial solar system. The prototype has been designed by combining the two equal watts solar penal having anti–parallel alignment with each other. The rear penal of the design system is supported by concentrator for strengthening the efficiency of the scattered irradiation. The scattered irradiation generates extra energy due to the design structure of the proposed system. The voltage of the system is conjoint increases slightly as the timely increasing irradiation strength. The power of the designed system increases with the increasing voltage proportional relationship with the current. The design system verifies the voltage, current and power measurement from all location of the calculation.

KEYWORDS

Renewable Energy, Solar System, Efficient Design System.

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1. INTRODUCTION

Nowadays deficiency of energy issues has been increasing which causes social and environmental problems, however, the developing countries urging the researchers to seek out alternative resources which may balance the demand for fossil fuel.

The alternative source like solar and wind are highly available to fulfill the increasing demand (Guerrero–Lemus, Vega, Kim, Kimm & Shephard, 2016). While freely available solar irradiation is a reliable source of solar power generation and solar energy will be generated easily by harnessing the facility of the radiation, this energy source is clean and environmental friendly (Jia, Gawlik, Plentz & Andrä, 2017; Luque, Torres & Escobar, 2018). The energy from the sun intercepted by the earth is roughly 1.8x1011MW which is several thousand times larger than the current consumption.

The most drawbacks with solar power are its dilute nature. Even within the hottest regions on the planet, the irradiation flux available nearly is inadequate for technological utilization. This drawback may be corrected by many techniques which ensure the greatest intensity of sun rays striking the surface of the panel from sunrise to sunset (Kim, Kim & Hwang, 2018; Duan, Zhao, He & Tang, 2018). This drawback can be overcome by the advanced design system, which is a bifacial solar system, it may generate electricity from either front or rear face, it will consider as the advanced photovoltaic system. This system is the noticeably exaggerated physical phenomenon of advance conversion system (Lamers, *et al.*, 2018). We tend to gift here such type of model which associates in the alternating deposition technique such as bi–facial solar cells (Liu, Zhao, Duana, He, Zheng & Tang, 2018). Such type of photovoltaic unit maximizes the output power by utilizing both sides of the PV cell to capture the maximum irradiation. The bi–facial solar device yields and maximizes the efficiency of available system and this strategy provides new opportunities for fabricating high performance (Lo, Lim & Rahman, 2015; Sun, Khan, Deline & Alam, 2018). Bi–facial solar system which harvests the incident light irradiation from the front face and collects scattering light irradiation with the help of concentrator to facilitate the rear surface for the maximum utilization of light irradiation, therefore, system gain the best power outputs.

The rear face uses to increase the efficiency of the solar system as well as support the name bi–facial. The traditional aluminum metal is used to collect the scattered irradiation to get advantage from the useless irradiation and provide support to the rear pedal. The rear penal adds its power to increase the efficiency of the overall solar system. The scattered irradiation plays a significant rule for the rear side of the solar penal. The rear penal gets the advantage from the scattered irradiation to extract the maximum power from the bi–facial solar system (Pan, Cardoso, & Reis, 2018). This system has a relatively little bit less photoelectrical conversion potency of the rear penal as compare to the front penal. The proposed system provides a significantly attainable application in the existing solar system. Generally, the designed system organized in well–observed alignments, thus partial sunlight is mirrored by the concentrator and throw toward the rear penal, so that requires energy might convert into thermal energy with the high efficiency by using the advanced bi–facial solar system (Zhu, Wang, Wang, Sun, He & Tang, 2017).

The concentration of scattered irradiation in rear surface increases the overall efficiency of the designed system. All solar panels are in a much–maligned arrangement in a real application of electrical phenomenon power stations. The high–efficiency solar system expected to gain the scatter irradiation with the help of concentrator (Rodriguez, *et al.*, 2018). The metallic portion encompasses a well–made reflection to the incident irradiation resulting in comparatively effective implementation of the system efficiency. A major motivation for the proposed system with a concentrator that is a program by the microcontroller known as Raspberry Pi for tracking the system to yield the additional energy. The mono facial panels are not so much reliable due to the light sensitivity as compare to the bifacial solar system. Most of the panel is using single access tracking system but we are motivated to design the bi–facial solar tracking system having two sides for the power extraction sides X at the front and Y for the

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rear penal to collect the scattered irradiation (Wang & Lu, 2013; Patil & Asokan, 2016). The potential of this improved module power output and energy yield was repeatedly commendable from all measurements through installations in numerous orientations. However, uncertainties regarding the particular output of this projected system still deter attainable investors. Even within the solar community, the important quantitative profit thanks to the bifacial system to suited technical ideas square measure still below discussion. The bi–facial solar system will dramatically improve the condition of generation compared to the existing solar system, so this type of advance model will gain a lot of attention in the future. This advanced solar model has been investigated intensively and characterized largely in the field with completely high gain. The proposed systems will provide the lump sum output power gain of the front and rear penal measurement. Such measurements were very reliable, so typically the different installation angles and backgrounds were terribly support to the effective measurement (Khalil, Asif, Anwar, Haq & Illahi, 2017). Basically, the performance of this bidirectional solar system originates from the strength and angle of each location, and the scattered irradiation from the background at the rear penal. The precise nature of the bidirectional solar system would be more characterize at the well–defined research laboratory. Significantly the irradiation intensity level and the angle dependence area unit are highly important. The strength and angle dependences are individually investigated; no systematical collaborative investigations are performed on bidirectional solar system module.

In the old era mono–facial, solar cells were used without any tracking system. These systems were useful but with respect to time technology continuously changing by the research and technology by Scientist and demand by the consumers. They used mono–facial solar cells in combination with single access tracking system to increase the efficiency of the solar tracking system (Khan, *et al.*, 2017). The rule of a bidirectional module is similar to it of a mono–facial one. In a mono–facial module, light radiation enters through the front side that absorbed by the solar PV and reborn into electrons that give electrical power. In this bidirectional module, an equivalent front side light irradiation assortment method happens and, additionally, light radiation is absorbed from the backside of the module (Rajshree, Jaiswal, Chaudhary & Jayswal, 2016). This rear penal gets the solar irradiation source from the reflected collection of the irradiations by the concentrator from the ground or a neighboring row of PV modules. The extra light radiation generates a lot of electrons within the cells that primarily will increase the module efficiency. The voltage of the cell conjointly will increase slightly as the timely increasing irradiation strength so the power is increased because of the increasing voltage proportional relationship with the current. The most typical, bidirectional modules configuration is economical and viable reliable for the local as well as commercial usage. Bi–facial PV systems are highly compatible with already existing PV systems and generally achieve a markedly higher energy yield than mono–facial systems (Brady, Wang, Steenhoff & Brolo, 2019). At the same time, bifacial systems are competitive because the manufacturing costs for the solar cells are slightly lower and the modern cell types are inherently bifacial and do not involve additional costs. Certified production technologies for the large–scale manufacture of bifacial cells and modules are already available on the market. The bifacial systems can be planned in exactly the same way as mono–facial systems, with a few factors demanding the extra attention, for example, the properties of the reflective ground. This attention will, however, be rewarded with a higher energy yield. Bifacial modules are opening up new application possibilities, often arising from the dual use of the installation area. All in all, bifacial modules can be employed to good advantage for most applications in terms of energy yield (Ooshaksaraei, Sopian, Zulkifli, Alghoul & Zaidi, 2013). The single access tracking system is to work only one direction with the help of different microcontrollers. The proposed bifacial modules produce solar power from both sides front and rear side. Whereas the traditional panels are only designed to convert solar irradiance from one side of the module into dc power, the bifacial modules are manufactured with clear plates on both the front and back side of the solar cells. They are designed to convert solar irradiance from both sides into dc power (Solarworld, in google). Similar to mono–facial modules, bifacial modules come in a variety of types including framed and frameless. The reason for this growth in engagement with bifacial technology is

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the capacity to extract maximum power by utilizing the scattered irradiation. It has been calculated from the experiment that this model is able to increase the power output compared to the available solar configuration (Sengupta, 2016).

The bi–facial with the tracking system has been made an effort to track the motion of the sun for collecting maximum energy. The power generation with the help of a bi–facial solar tracking system is much more as compared to the single axis solar tracking system. In two several places, the require generation of the electricity is through the pricy fossil fuels. The user subjected to implies the restriction and pollutant environment that accompanies by fossil fuels (Renewables 2017 Global Status Report, 2017). The value intensive system should be placed in the way to protect the infrastructure and environment pollution. This implies the renewable energy to fulfill the growing demand. Today demand requires an easy plug and play electricity setup which provides an abundant solution in the way of power generation and consumption. This system involves in the autonomous frequent maintenance which will allow the alternative energy generation in an exceeding system which will be carried out in the form of the solar system (Livingston, Sivaram, Freeman & Fiege, 2018).

2. MODEL AND METHODS

The bi–facial solar system model provides an effective measurement of power. The solar radiation such as global, diffuse and direct irradiation is fallen on the design solar system. These models are representing the principal climate phenomena to attain solar electricity. We analyze the output power of the proposed design system which is highly depending upon the Global Horizontal Irradiation (GHI) as well as Global Tilted Irradiation (GTI). The power of the system depends upon solar irradiation received by the surface of photovoltaic modules and the GHI is the sums of the direct and diffuse solar radiation [kWh/m2]. The GHI is considered as a climate reference as it is an important parameter to check for the solar PV installation.

The elevation angle measured relative to the sea level (ELE), also determines the optimum choice of a site and performance for the solar energy system. Elevation Angle can be measured by applying Eq. 1

$$Cos\ \theta = \sin\delta \sin\varphi + Cos\ \delta\ Cos\ \varphi \cos\omega$$

Eq. 1

The zenith angle is the angle between the sun and the vertical. Thus making the zenith angle = 90° – elevation as under Eq. 2.

$$\zeta = 90 - \theta$$

Eq. 2

DNI (Direct Normal Irradiation): Solar radiation component that directly reaches the surface kWh per m square. It is significant for the proposed system as Eq. 3.

$$\mathrm{DNI} = \mathrm{A.exp}(-\mathrm{B}/\mathrm{Cos}\ \theta)$$

Eq. 3

DIF (Diffuse Horizontal Irradiation): Solar radiation component that is scattered by the atmosphere in kWh/m2 Eq. 4.

$$\mathrm{DHI} = \mathrm{C.DNI}$$

Eq. 4

GHI (Global Horizontal Irradiation): The GHI is the Sum of direct and diffuse solar radiation, kWh/m2. It is considered as a climate reference as it is an important parameter to check for the solar PV installation which can be seen in Eq. 5.

$$GHI = DHI + DNI \cdot \cos(\theta)$$

Eq. 5

Atmospheric temperature, known as the air temperature is another most important variable determining the efficient performance of solar power systems.

The air temperature degrees or degrees determines the temperature of PV cells

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and modules and has a direct impact on PV energy conversion efficiency and resulting energy losses. Air temperature also some other weather parameters are the main part of each solar project assessment as they regulate the effective conditions and operation efficiency of the solar power plant (Please refer Eq. 6).

$$\eta = \eta Tref[1 - \beta ref(Tc - Tref)]$$

Eq. 6

The solar module is the most widely applied and also the most versatile technology for the power generation. The solar electricity simulation algorithm, incorporated in the atlas always provides an approximate estimate of the potential photovoltaic energy, which can be produced at any location covered by the interactive map, as shown in Eq. 7.

$$\eta_{pvg} = \eta_r \eta_{pc}[1 - \beta(T_c - T_{ref})]$$

Eq. 7

Air temperature determines the temperature of PV cells and modules and has a direct impact on PV energy conversion efficiency and resulting energy losses. The operating conditions and operation efficiency of the solar power plant can be related to the air temperature model is given to find out the effecting temperature on the system as Eq. 8.

$$T_c = T_a + \left(\frac{NOCT - 20}{800}\right) G_t$$

Eq. 8

The solar radiation model, air temperature model and PV power simulation model. These models provide location–specific solar radiation and temperature data. In order to calculate an on–demand utility by assessing the possible PV system type and configuration, the PV power simulation models are employed. The air temperature model and another PV power simulation model are given to find out the effecting temperature on the system as below Equations Eq. 9–11.

$$P_{pv} = \eta_{pvg} A_{pvg}$$

Eq. 9

$$P_M = I_S V_{oc}.$$

Eq. 10

$$P_{Array} = N_s N_s P_M$$

Eq. 11

The long–term yearly solar resource estimates by satellite–based models can be characterized by calculating the bias (systematic deviation) at the validation sites, where high-quality solar measurement are available. Also the World Bank choose the same as Eq.1-11 for solar potential calculation in the in the solar atlas so here these Eq.1-11 reflect the same model in this design system.

The polynomial function expresses the estimated best fit of the designed solar model at the available irradiation for the efficiency difference measurement of front and rear penal of the proposed solar system on any day of the month line by general polynomial function model, represented as Eq. 12.

$$y = a.x\hat{\ }n + b.x\hat{\ }(n-1) + c.x\hat{\ }(n-2) + \ldots + m$$

Eq. 12

or

$$y = a.x^5 + b.x^4 + c.x^3 + d.x^2 + e.x + m$$

The voltage measurement of the proposed design solar system for the front and rear penal is fitted for the efficiency difference checking as shown in Figure 7. We have selected the dates from 08 to 10 of the Feb 2019 by using the polynomial regression of 6 degrees as, The quality of the best fit for the design system with the measured voltage data is determined by the value of R2 being close by 1. In the case of voltage data the $R^2 = 0.993$ for the front penal and $R^2 = 0.9754$ for the rear panel. With the application, the polynomial of six degrees seems to be the best fit on the available data. The best fit in the case of front penal as shown in the Eq. 13.

y = –0.0002x6 + 0.0102x5 – 0.1795x4 + 1.6129x3 – 7.9224x2 + 21.999x – 15.328

Eq. 13

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And in the case of rear penal shown in the Eq. 14.

$$y = 0.0003x6 - 0.0135x5 + 0.2317x4 - 1.9128x3 + 7.4858x2 - 9.0814x + 3.4818$$

Eq. 14

The measurement of current for front and rear solar penal is fitted for the efficiency difference checking of the designed solar system as shown in Figure 10. We have selected the dates from 08 to 10 of the Feb 2019 with the polynomial regression of 6 degrees as, The quality of the best fit with the irradiation data is determined by the value of R2 being close by 1. In this case $R^2 = 0.9595$ for the front penal and $R^2 = 0.9509$ for the rear penal. With the application of the polynomial to 6th degree seems to be the best fit on the available data. The best fit in the case of front penal as shown in the Eq.15.

$$y = 6E-05x6 - 0.0029x5 + 0.0508x4 - 0.4443x3 + 1.9444x2 - 3.3536x + 1.8066$$

Eq. 15

And in the case of rear penal as shown in the Eq. 16.

$$y = 7E-05x6 - 0.003x5 + 0.0513x4 - 0.4341x3 + 1.849x2 - 3.1683x + 1.7129$$

Eq. 16

The power measurement of front and rear solar penal is fitted for the efficiency difference checking as shown in Figure 13. We have selected the dates from 08 to 10 of the Feb 2019 with the polynomial regression of 6th degree as, The quality of the best fit for the designed bi–facial solar system with the irradiation is determined by the value of R2 being close by 1. In this case $R^2 = 0.9677$ for the front penal and $R^2 = 0.9676$ for the rear penal. With the application of the polynomial 6th degree seems to be the best fit on the available power measurement data. The best fit in the case of front penal as shown in the Eq. 17.

$$y = 0.0007x6 - 0.0323x5 + 0.5627x4 - 5.0022x3 + 23.254x2 - 43.174x + 24.743$$

Eq. 17

And for the case of rear penal as shown in the Eq. 18.

y = 0.0007x6 – 0.0276x5 + 0.4603x4 – 3.9598x3 + 18.306x2 – 34.732x + 20.41

Eq. 18

3. SYSTEM DESIGN AND IMPLEMENTATION

The proposed design solar system have Light dependent resistors (LDR) that use the light sensing element. We are using two 12 volts to a gear dc motor. The dc volt geared the motor so it is used for east–west tracking and other geared dc motor with a threaded rod for the linear up–down motion for north–south movement. The LDR's are sensing the light intensity as shown in Figure 2. The tracking of sun movement, in that way we can get optimum power of the solar system. The main object of the design system is to gain maximum power from the sun. The design system supports the tracking strategy as the annual motion of sun at 23.5o degree in east–west direction is occurred. In this project, the relay module is used for converting binary data to electrical output. The design system is controlled by the microcontroller known as raspberry pi. The raspberry pi is the main control unit of the design system. The raspberry pi microcontroller gets a signal from the sensor that decides the direction of the movement of the motors in the required axis. The python is used to program the raspberry pi for the tracking and control purpose. The Python is associated with the interpreter, interactive programming language. It incorporates modules, exceptions, dynamic writing, and terribly high level of dynamic knowledge.

3.1. BLOCK DIAGRAM

The basic blocks diagram consisting of Solar PV Panel, light dependent resistor (LDR), raspberry pi, relay module, analog to digital converter (ADC), power supply, and battery. The panel gets the irradiation and converts it into electricity or electrical signal. This generated electricity hold in the battery for upcoming use. The power will be flow from solar panels to store in the battery. The battery will be charged fully and get alarms for disconnection within the event of a fault. The microcontroller is placed in between the solar penal and battery for the tracking and the system control. The microcontroller has been used to generate

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the control commands from the LDR sensor. The microcontroller offers the motion to the motor to rotate the parabolic dish. The design system accuracy depends upon sensor and its accuracy is important for the successful performance of the algorithm. The last block is load, we are able to use any kind of dc load here as we have not inserted electrical converter block within the design system. The ac appliances on solar panels we need to feature electrical converter block in on top of the diagram in order that it can convert dc power provided by the solar battery into ac.

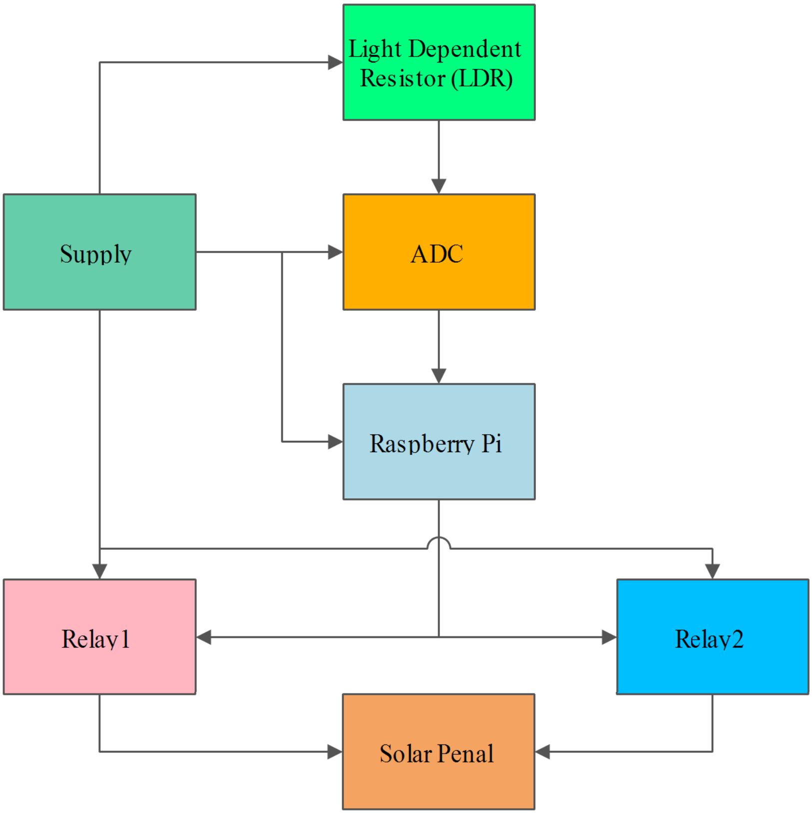

Figure 1. Flow Diagram of the Design Solar System.

3.2. EXPERIMENTATION

The potency of a mono–facial solar module is expected to decrease considerably as compared to the availability of the irradiation thanks to the bi–facial solar system to upgrade the efficiency of the solar system. The proposed design system consists of front and rear solar penal with a solar concentrator that gradually increase the efficiency of the reflected or scattered solar irradiation tipped on the rear side of the system. The solar modules square measure mounted beside one another on a metal frame. Each module is connected to a variable load depending on the requirement. The circuit includes a two–way relay switch that is tailored to the circuit to energize the motor to set the direction of the solar penal module at a time for measurement its output I–V characteristics.

Figure 2. Experimental Setup of Design System.

3.3. MEASUREMENT SETUP

Digital Clamp Meter and Solar Power Meter are used for the measurement. The Digital Clamp Meter measures voltage, current, and power for each selected days and the solar power meter used to measure the solar irradiation.

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Figure 3. Digital Clamp Meter and Solar Power Meter.

4. RESULTS AND DISCUSSION

The specific period of result duration 08 to 10 of the Feb 2019, as of Friday, Saturday and Sunday are chosen for the resulting survey, we have to use the clamp meter for the voltage and the current measurement and solar power meter for the solar irradiation calculation as shown in the Figure 3. The measurement of the entire process proves that the proposed design system is feasible for the all advanced solar power system.

5. SOLAR RADIATION MEASUREMENT

The solar irradiation for each of the selected day is observed as shown in the Figures 4–5. Irradiation and air Temperature measurement analysis for the design solar PV system is shown in Figure 6.

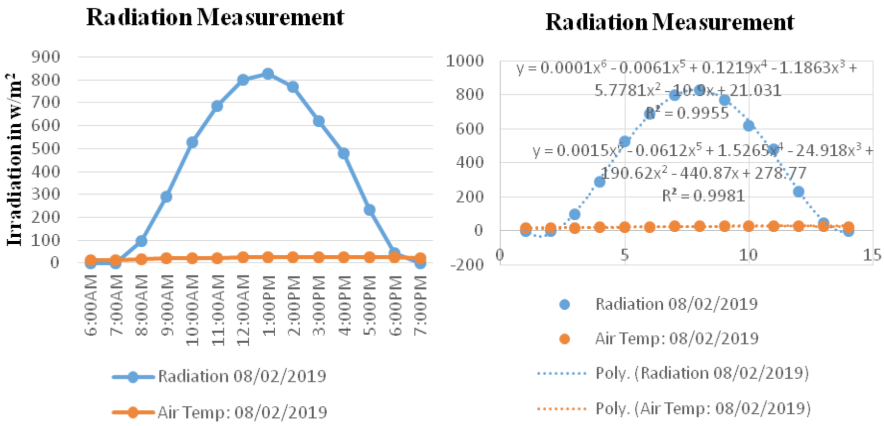

Figure 4. Irradiation and air Temperature measurement for the solar PV (Panel X1 and Y1) for the 1st–day experiment.

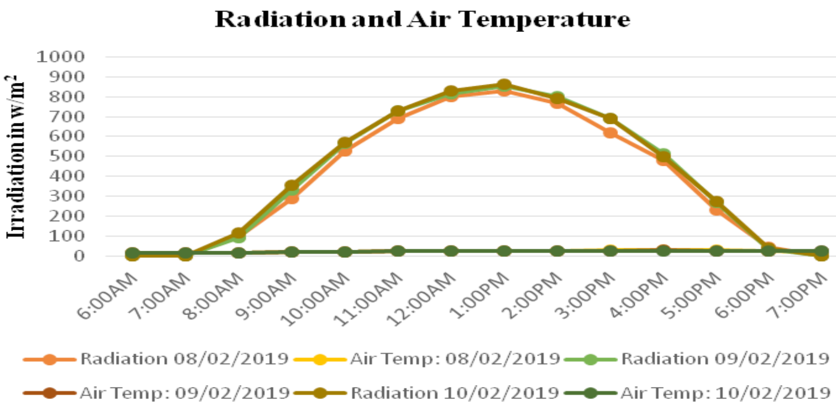

Figure 5. Irradiation and air Temperature measurement for the design solar PV system for 1st, 2nd, and 3rd–day experiment.

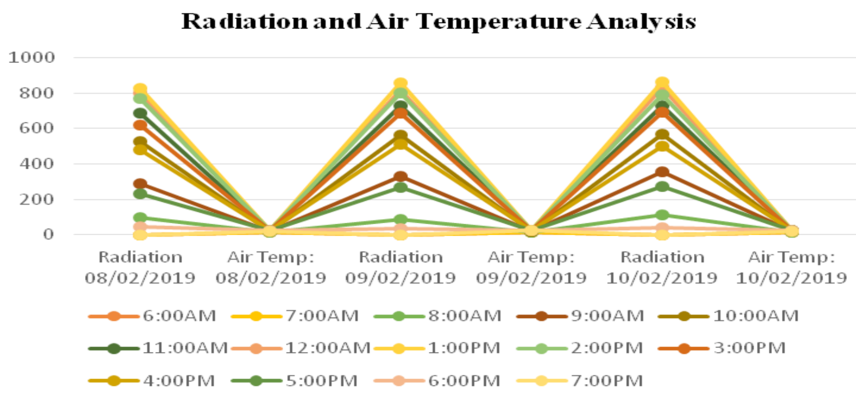

Figure 6. Irradiation and air Temperature measurement analysis for the design solar PV system for 1st, 2nd, and 3rd–day experiment.

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6. VOLTAGE MEASUREMENT

The voltage measurement of the design system is observed for the selected days Friday, Saturday and Sunday under the time frame of 6:00 AM to 7:00 PM. The X and Y show the front and rear side of the designed solar system. The X1, X2, and X3 show the selected 1st, 2nd and 3rd day of the front side measurement similarly Y1, Y2, and Y3 for the rear side measurement. It is observed that the voltage is maximum during 1:00 PM and a minimum at the 6:00 AM and 7:00 PM as shown in Figure 7. The voltage measurement of front and rear solar PV for the three days experiment is observed as shown in Figure 8. From the experiment, it is clearly observed that there is a little bit of output voltage discrimination between the front and rear solar penal. The voltage difference between the front and rear solar penal is due to the direct and scattered fall of solar irradiation. The direct fall of solar irradiation at the front penal and indirect or scattered irradiation fall on the rear solar penal make the difference in the observed voltage output as shown in Figure 9.

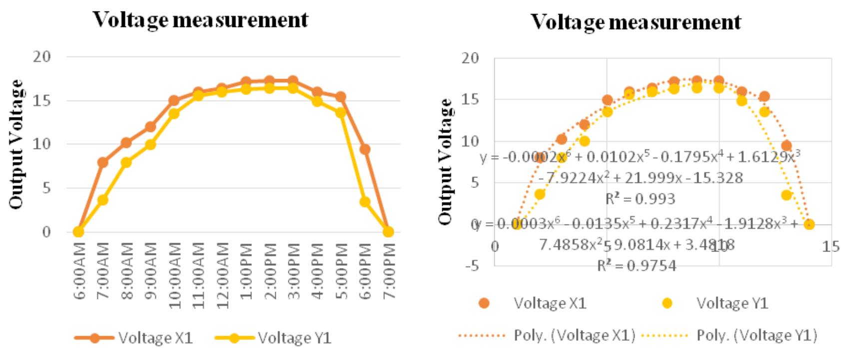

Figure 7. Voltage measurement of front and rear solar PV (Panel X1 and Y1) for the 1st–day experiment.

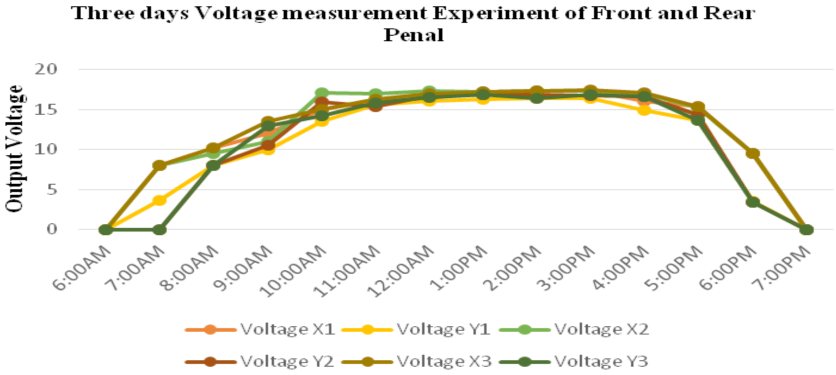

Figure 8. Voltage measurement of front and rear solar PV (Panel X and Y) for 1st, 2nd, and 3rd–day experiment.

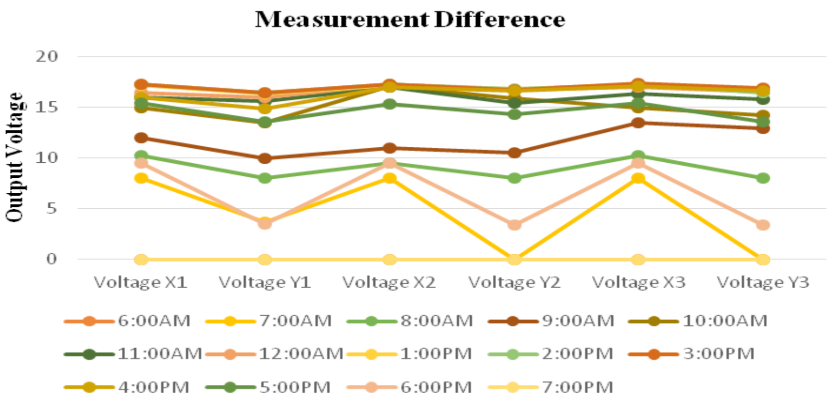

Figure 9. Voltage measurement difference between the front and rear solar PV (Panel X and Y) for 1st, 2nd, and 3rd–day experiment.

7. CURRENT MEASUREMENT

The current measurement of the design system is observed for the selected days Friday, Saturday and Sunday under the time frame of 6:00 AM to 7:00 PM. The X and Y show the front and rear penal of the designed solar system. The X1, X2 and X3 show the selected 1st, 2nd and 3rd days of the front side measurement similarly Y1, Y2, and Y3 for the rear side measurement. It is observed that the current is maximum during 12:00 AM to 1:00 PM and a minimum at 6:00 AM and 7:00 PM as shown in Figure 10. The current measurement of front and rear solar PV (front panel X and rear penal Y) for the three days experiment

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is observed as shown in Figure 11. From the experiment, it is clearly observed that there is a little bit of output current discrimination between the front and rear solar penal. The current difference between the front and rear solar penal is due to the direct and scattered fall of solar irradiation. The direct fall of solar irradiation at the front penal and indirect or scattered irradiation fall on the rear solar penal make the difference in observed current output as shown in Figure 12.

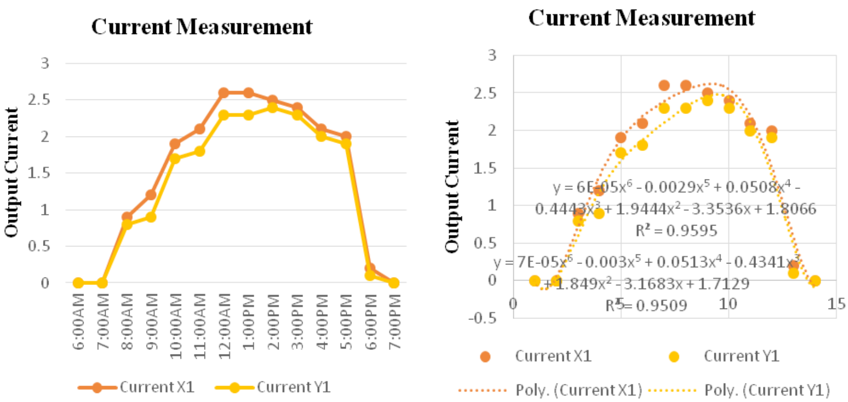

Figure 10. The current measurement of front and rear solar PV (Panel X1 and Y1) for the 1st–day experiment.

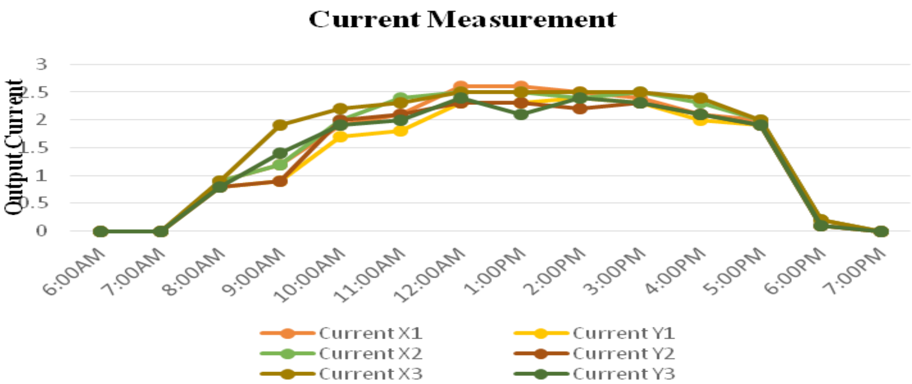

Figure 11. The current measurement of front and rear solar PV (Panel X and Y) for 1st, 2nd, and 3rd–day experiment.

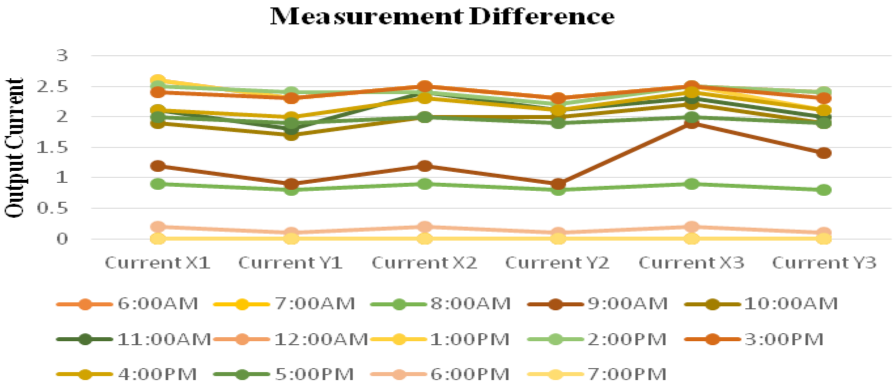

Figure 12. Current measurement difference between the front and rear solar PV (Panel X and Y) for 1st, 2nd, and 3rd–day experiment.

8. POWER MEASUREMENT

The power measurement of the design system is observed for the selected days Friday, Saturday and Sunday under the time frame of 6:00 AM to 7:00 PM. The X and Y show the front and rear side of the designed solar system. The X1, X2 and X3 show the selected 1st, 2nd and 3rd days of the front side measurement similarly Y1, Y2, and Y3 for the rear side measurement. It is observed that the power is maximum during 1:00 PM and minimum at the 6:00 AM and 7:00 PM as shown in Figure 13. The Power measurement of front and rear solar PV (front panel X and rear penal Y) for the three days experiment are observed as shown in Figure 14. From the experiment, it is clearly observed that there is a little bit of output power discrimination between the front and rear solar penal. The power difference between the front and rear solar penal is due to the direct and scattered fall of irradiation. The direct irradiation fall at the front penal and indirect or scattered irradiation fall on the rear penal make the difference in observed output power values as shown in Figure 15.

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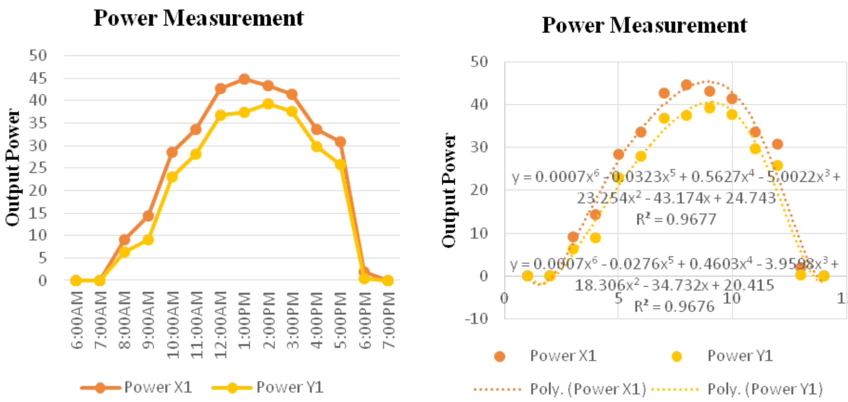

Figure 13. Power measurement of front and rear solar PV (Panel X1 and Y1) for the 1st–day experiment.

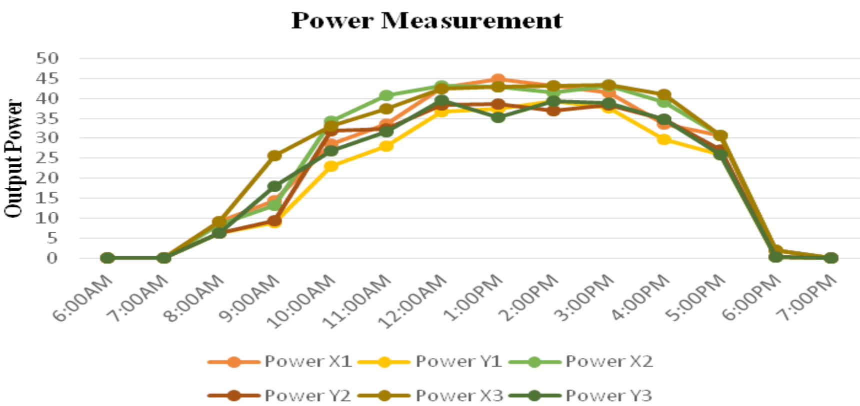

Figure 14. Power measurement of front and rear solar PV (Panel X and Y) for 1st, 2nd, and 3rd–day experiment.

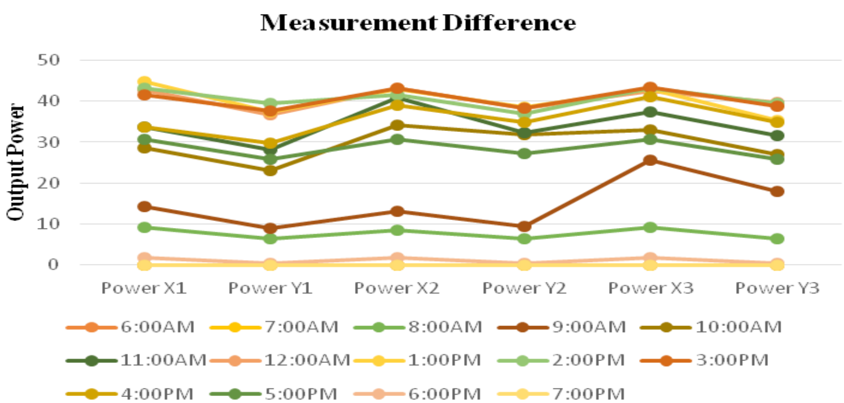

Figure 15. Power measurement difference between the front and rear solar PV (Panel X and Y) for 1st, 2nd, and 3rd–day experiment.

The total three days voltage, current, and the power measurement is observed for the selected days as shown in Figure 16. The total values observation is based upon the addition of the front and rear penal voltage, current and power values.

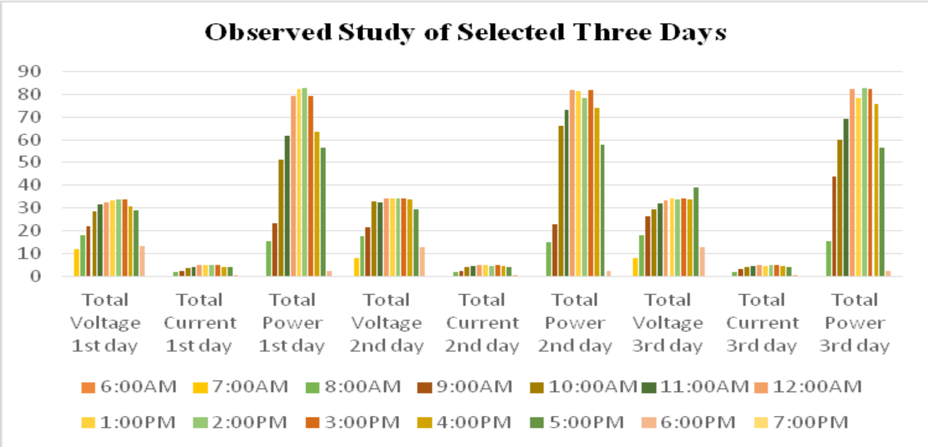

Figure 16. Total voltage, total current and total power measurement of front and rear solar PV (Panel X and Y) for 1st, 2nd and 3rd–day experiment.

9. DISCUSSION

Bifacial solar tracking system performed well while taking results. The power capabilities of the proposed design system had been experimentally tested with two 40W solar panels at different rotations of the time frame under standard test conditions. Hence total 80W solar panel was connected with the different loads and checked one by one in series and in parallel. The tracker was connected in parallel to the voltmeter (0–100 V). The 12 V battery keep in closed circuit voltage at a constant level throughout the experiment. The current and voltages have been measured at various time frames throughout the day as the sun moved. To keep the system simple for experimental purpose, the designed system can be rotated manually with the help of proper gearing and motor, but we can actually rotate the panel with external power supply or from the power generated by itself. The required voltage level to maintain the system is 10V and the standard alignment of the tracker was kept at 45°. Then the tracker was moved with the help of dc gear motors in the direction of incident solar radiation. So the designed system can extract the maximum amount of solar power from the available radiation

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throughout the day as the sun kept moving from east to west. To analyze the performance of the tracker, the measurements take place at different selected days after every hour from 6:00 AM to 7:00 PM. The voltage level was very good while taking the reading in series connection. On the other hand, the while connected in parallel the maximum current was 4.39 amperes and the total power was 82.61 watts that were too good for our experiment and had a good result. Only very minor discrimination was found between the readings of direct facing panels and reflected or back side connected panel. The rear penal of design solar system is supported by the concentrator for amplifying the strength of reflected irradiation. We took the readings of 3 days and got the results which were very successful in our study of this project design to provide the optimal require value.

10. ANALYSIS

The advance bi–facial system is designated for the tracking strategy which enables high collectible energy surplus at medium tracking accuracy which is new and low–cost tracking system with the soft ridge concentrator together. The bi–facial PV panels can double photovoltaic energy harvest in comparison with fixed panels and substantially reduce the price of PV energy which is fundamental aspects of the energy production. The system is designed by combining the two equal watts solar penal having anti–parallel alignment with each other. The rear penal of the design system is supported by concentrator for strengthening the efficiency of the scattered irradiation. The scattered irradiation generates a lot of extra energy due to the design structure of the proposed system. The rear penal of the system primarily increases the efficiency of the module. The voltage of the system is conjoint increases slightly as the timely increasing irradiation strength. The design system illustrates the little bit different in the observed values of front and rear penal of the voltage, current, and power as shown in the Figures 9,12 and 15. The most typically, the designed module's configuration is economical and viable reliable for the local as well as commercial usage.

The measurement of voltage, current, and power for front and rear solar penal is fitted for the efficiency difference checking of the designed solar system as shown in Figures 7, 10, and 13. We have surveyed the proposed system in the dates as 08 to 10 of the Feb 2019 with the polynomial regression of 6 degrees. The quality of the best fit with the irradiation data is determined by the value of R2 being close to 1 in the case of front and rear penal. The below table explores the design system in the way of efficiency enhancement. The front and rear penal show the little bit different in the value of R2 as shown in the Table 1. Hence from the whole observation it is proved that rear penal gives the relatively little bit less value of voltage, current, and power as compared to the front penal. So by adding the values both sides the system expresses the feasible efficiency which is comparatively best then the foreign–based expensive available bi–facial model.

Design Module	Front Penal R^2	Rear Penal R^2
Voltage	0.993	0.9754
Current	0.9595	0.9509
Power	0.9677	0.9676

Table 1. The 6th degree polynomial R2 values.

The output power for a proposed setup is efficient and reliable. This system provides wide–range usage in developing countries. Our goal is to develop an economical and relatively best combination of hardware and software to enable the manufacturers globally to make and improve the design strategy.

11. CONCLUSION

The designed bifacial solar system is more efficient than all other old methods of getting solar power from the sun. The proposed bifacial system is useful for all the off–grid and on–grid areas. The design system is a low–cost solar system that is compatible and reliable. The users are affordable in order to use this system domestically as well as commercially to get great efficiency. The design system is highly efficient and economical reliable in terms of the electrical energy output as compared to the other system.

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TO BUILD CORPUS OF SINDHI LANGUAGE

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ABSTRACT

The present day state of Sindhi corpus construction is elaborated in detail in this paper. The issues like corpus acquisition, tokenization and preprocessing have been analyzed and discussed minutely for Sindhi corpus enhancement. Initial observations and results are included for letter unigram, bigram and trigram frequencies. There has been discussed the present status of Sindhi corpus in perspective of restriction and future work. Orthography and script were also explored in this paper with reference to corpus development. Basically the word corpus was used first time by German Scholar (Das Corpus). The plural of corpus is corpora, which is used for huge text data consists of millions and billions of text data. The task of Natural Language Processing was very challenging because there was the scarcity of resources for computational linguistics and research. Different text corpora have been made in different languages of different countries, after reviewing the corpora of different languages of various countries, we are trying to make the corpus for Sindhi language.

KEYWORDS

We NLP, Corpora, Linguistic, Lexicon, Phoneme.

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1. INTRODUCTION

About thirty to forty million people of Pakistan speak Sindhi language and it is a big language. On internet Sindhi language is vastly used. The number of news papers literary websites and blogs of Sindhi language is increasing daily. The lexicon, fonts and common words processes are included and available for NLP researchers and this is the evidence of usage and popularity of online. In Sindhi language such as linguistic corpora are not initiated for the enhancement of Sindhi language processing resources.

Sindhi language is being used and written in Arabic-Persian, Devanagari and Roman letters. For Sindhi language in India Devanagari letters are also used. Same as the Roman script is getting popularity for Sindhi language. On smart phone devices, cell phones and communications on internet have been used and available in Roman script for very few documents. It is unfortunate that the linguistic corpora and detailed computational lexicon are still not initiated because it was very essential for the development of Sindhi language processing resources. It is factual position that in Sindhi language that excess written material is available for offline and online. Sindhi Corpus the script is Persio-Arabic which has been built in Persio-Arabic script using UTF-16 in coding. In these sections we are discussing the orthography and Sindhi language corpus script which is achieved are results of initial statistical analysis, preprocessing the issues of corpus construction of Pakistani language corpora. In this conclusion we have finally discussed the future work (Mahar & Memon, 2010).

2. PREVIOUS WORK

As for the Sindhi language processing resources concerned, apart from few digital dictionaries, key board design and fonts, these are not generally and publically available. Even in Sindhi language for resources like comprehensive computational lexicon and linguistic corpora, studies or development projects are not even initiated. Because of the improvement of linguistic corpus of various languages of Pakistan the different research organizations and individuals are working. We can give the example of Jang newspaper corpus (Hussain & Durrani, 2008; Becker & Riaz, 2002) .

At the university of Peshawar machine readable Pashto corpus is being developed and the other project BBN Byblos Pashto OCR system is included. The central institute of Indian languages (CIIL) of India had developed first time the Punjabi language corpus. CDAC-Noida which is another useful linguistic corpora has developed Hindi and Punjabi parallel corpus. There are not available such kind of linguistic corpora for many Pakistani languages such as Siraiki, Balochi and Sindhi. It is contrary that Sindhi text is easily available in electronic format and the corpus under discussion is being collected ceaselessly where as Urdu does not possess this facility.

3. SINDHI LANGUAGE HANDWRITING

In Naskh style which is base on elaborated Arabic character, Sindhi is written in Persio-Arabic script. Sindhi letters are 52 in numbers as shown in Figure 1. The basic letters are contains in alphabet like ا,پ,ت and other letters for secondary just like چڳ and ٿڏ which are used in Sindhi language.

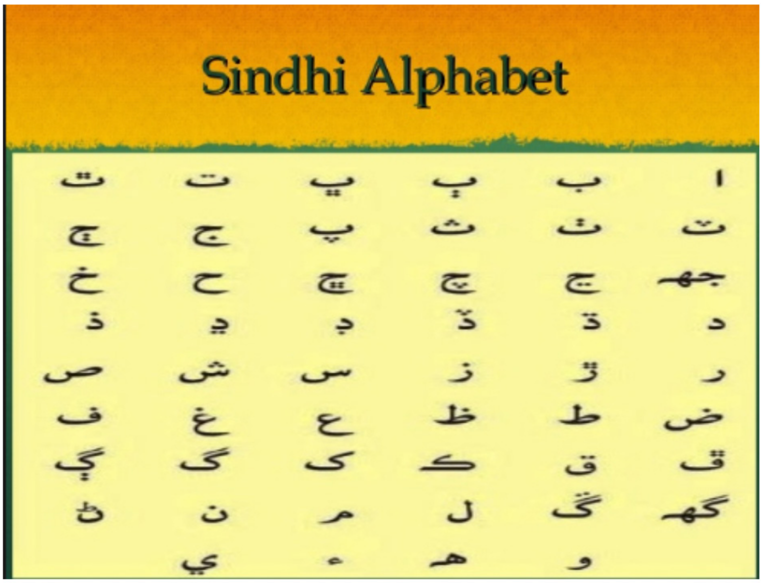

Figure 1. Sindhi Alphabet.

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The words of Sindhi language are constantly ended with vowels. Diacritics in written text optionally Mark this vocalic ending. To represent additional voice features, the diacritics are also use. Sometimes semantic ambiguities are caused by the absence of diacritic in written text.

Having consists of Persio-Arabic digits which are appears in graph 2; Sindhi language has its own numerals. In Sindhi writing numerals are extremely common usage for Hindi-Arabic. In Figure 2 particular symbols are also used.

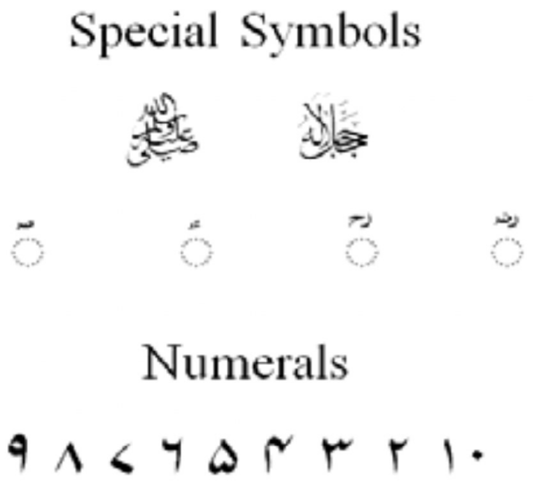

Figure 2. Numerals are used in written text of Sindhi language.

4. THE PROGRESS OF SINDHI LANGUAGE TEXT CORPUS

It is obvious that accessible resources upon internet do not provide huge amount of Sindhi text data. On daily basis for Unicode based Sindhi text on internet is enhancing very fast after Sindhi keyboard based on Unicode and Unicode support. Include e-mail addresses if possible. Follow the author information by two blank lines before main text. The accessibility of Sindhi corpus construction of newspapers, blogs, discussions forums and literary websites is the key factor to motivate Sindhi corpus construction. When we consider the importance of text corpus of Sindhi language along with other NLP improvements and linguistics Sindhi text corpus is fabricated. The corpus of Sindhi is being achieved constantly and the vast amount was not provided by the resource of online. In

"C" utilizing microsoft.net framework libraries the preprocessing tokenization, frequency calculation and normalization are implemented in software routines. To develop the text corpus based Sindhi sentimental analysis, language variation and sentiment analysis of aspect based and for other future research.

4.1. CORPUS ACQUISITION

From various domains which include letters, essays, literature, news and blogs the basic information is collected. Current affairs, short stories, sports, showbiz, opinions and discussions are included in different sub domains.

Table 1. Data collection sources.

Source	Web sites
Jhoongar	www.dailyjhoongar.com
Kawish	www.thekawish.com
Ibrat	www.dailyibrat.com
NLP	www.nlp.com
Sindhi virtual library	www.library.sindhila.org
Awami Awaz	www.awamiawaz.com

4.2. SUBSTANCES AND PROCEDURES

By utilizing the process techniques of text corpus building, the text corpus progress is done. From online blogs, websites, books and newspapers of Sindhi language, the text is achieved. The morphological analysis, Sentiment analysis, stemming, lemmatization, sentiment analysis of aspect based and tagging are the parts of the speech and for tokenization the text corpus of Sindhi is processed.

4.3. NORMALIZATION AND PREPROCESSING

Although all the gathered text has been converted into standard UTF-16 in coding the overall data which was collected and available in Unicode format.

An equivalent representation of data & information together are reduced to same underline form and they are represented by letters. The combination of two Unicode characters are aspirated versions گھ for instance گ and ھ when dealing with text processing they are considered as single letters.

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4.4. HOW DO THE WORDS WORK IN SINDHI AND THEIR IDENTIFICATION?

Words are the identification of experiment and experiences of human being. What we do observe, listen, feel, testify and other actions all of these things are dependent on our thinking, conception and experiences. One who talks or writes tells the same words according to his perspective and assessment. Considering all these things there are some words in the following. Although the same word is being presented in different meanings so that it will clearly be understood and assessed the exits meaning of the word on narration. By the use of machine in proper way, the suffixes and affixes can be removed from inflected text in Sindhi (Rahman, 2009).

Carrying out the analysis of Sindhi text, the discussion on text corpus is very suitable.

Table 2. Sentiments and identified of Sindhi text corpus.

Sindhi words	English Meaning	Usage in English	Sentiments or Usage in Sindhi
مڙس	Brave	No doubt Dodo is brave	دودو بيشڪ **مڙس** آهي. (بهادر)
بالغ	Adult	Earlier Arshid was a child but now he is adult	اختر اڳ ۾ ڇوڪر هو پر هاڻي مڙس ٿيو آهي
شوهر	Husband	Dawood is husband of Zeenat	دائود زينت جو مڙس آهي(شوهر)
ماڻهو	Man	Who is he	هي ڪير مڙس آهي
مرد	Man	The greatness of a person is in keeping promise.	مڙس جو شان آهي ت هو پنهنجي واعدي تي قائم رهي

In data mining application and research, text analysis is an important topic because the scientific text and analysis of educational political and social text are internet resources and they produce large stuff of text. The useful data and information are extracted by organizations to analyze the text corpus therefore it becomes easier to translate the language and for decision makers to take good decisions. The feature distribution and language variation can be observed for the task of information retrieval.

4.5. TOKENIZATION

As $, %, #, etc along with digits are used as word boundaries and for tokenization they are white spaces punctuation markers and special symbols. The problem of embedded space world breaking is called by white space word boundary consideration. For instance any one word is bifurcated in two words نالو and منهجو and by using the same technique for Urdu the problem be resolved (Ijaz & Hussain, 2007).

If we do compare two words which are special ۾ (in) and ۽ (and) are occurred, another problem in Sindhi word tokenization appears ملاءڻ .(milana) and this was tokenize a single work. An example is here that قلم ۽ڪاپي (pen and note book) and these 03 words sans gap are here by tokenized as single word. In Sindh there are the same problems with all the words which have non connective ending.

5. OBSERVATIONS AND RESULTS

In numbers the whole word corpus of 4.1 million have been analyzed. The letter frequency analyzed, letter trigram analysis, analysis of letter bigram, word bigram analysis and word frequency analysis are included in this basic analysis.

5.1. MECHANISM UNDERSTANDABLE CORPUS

The languages of the world can be understood by people with the help of computational technology advancement. In this connection the role of linguists and computational linguistics is very important. It is necessary that the text corpus must be in machine readable form. To read and recognized the Sindhi text corpus through machine, Unicode utp-8 is used. On the basis of polarity analysis the sentiment analysis the sentiment analysis has been carried out. The sentiment analysis of text corpus document is shown by the results and it presents the features of outputs along with opinion and sentiment of each feature independently.

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5.2. FREQUENCIES OF LETTER

When calculating frequencies of letter the aggregate number of 139,886,112 characters was analyzed of corpus. The letter 'آ 'we as well seen a single letter out of 52 letters of Sindhi alphabets and the reason is it is used a single letter in Sindhi keyboard and single Unicode representation. In Sindhi the least frequently occurred letter was consonant ڳ and the most frequently occurred letter was vowel ئ.

Top 20 a most frequently occurred letters with their percentage in Sindhi database are shown in Table 3.

Table 3. Twenty letters for frequent.

S.No.	Letter	Percent	S.No.	Letter	Percent
1	غ	12.25%	11	س	3.25%
2	ق	11.62%	12	ڪ	3.27%
3	و	7.84%	13	د	2.50%
4	ن	8.99%	14	ب	2.00%
5	ر	6.16%	15	پ	1.80%
6	ه	6.26%	16	آ	1.18%
7	م	3.73%	17	ٿ	1.17%
8	ج	3.64%	18	ک	1.15%
9	ل	3.44 %	19	ع	0.98%
10	ت	3.23%	20	ث	0.97%

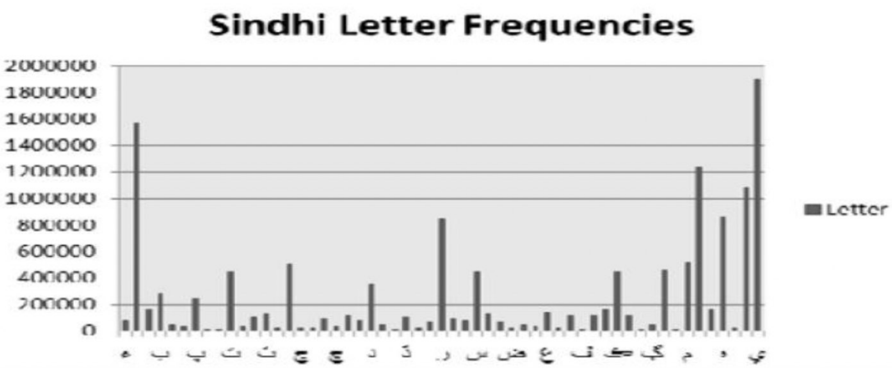

Figure 3. Sindhi Corpus Letter frequency distribution.

5.3. FREQUENCIES OF WORD

In this analysis of research paper we have examined and found 4.1 of millions words & 70,576 differ word forms. There were included most occuring words as container markers(like م، ج an ع) & incomplete / helping verbs like (آهيون and هو).

Table 4. Twenty frequent words in sindhi.

S.No.	Word	Percent	S.No.	Word	Percent
1	۾	2.42%	11	ڪري	0.68%
2	آهي	1.63%	12	ناس	0.69%
3	۽	2.17%	13	ان	0.66%
4	هت	1.78%	14	ناک	0.63%
5	يهآ	1.61%	15	ٿي	0.56%
6	کي	1.61%	16	نهآ	0.55%
7	وج	1.50%	17	ءلاِ	0.51%
8	يت	1.05%	18	نه	0.50%
9	هب	0.82%	19	وه	0.50%
10	نه	0.70%	20	ڪيو	0.45%

6. FUTURE WORK

The results are updated and achieved constantly for corpus. For specific POS tagging, n-gram based text classification for specific annotations the studies are in fast progress.

Table 5. Ten most frequent word bigrams.

S.No.	Word bigram	Percentage
1	هت ويچ	7.52
2	هت يهآ	6.75
3	يج نه	2.66
4	وٽپ ريظنيب	1.93
5	يج ڏنس	1.84
6	يج نا	1.72
7	هت نهڏج	1.60
8	ويچ نه	1.60
9	ويو ويک	1.44
10	يهآ ويو	1.21

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For advance enhancement and maturity of corpus the excess particular Sindhi computational linguistic studies are necessary and essential studies. Before tagging of POS the corpus the Sindhi tag set is to be required for designed. The areas to be extensively worked out which are quantitative improvement, proper annotation, qualitative and comprehensive statistical analysis.

7. CONCLUSION

In the fields of social science, applied science, computer science and other domains the research studies have brought major changes in different topics. It is a continuous process for the benefits for the development of society to make the things perfect. As for the research study is concerned the basic research study is done on analysis and development of Sindhi text corpus. For this purpose the Arabic-Persia script is used and simultaneously for the analysis of Sindhi text corpus the more research work is needed. For this purpose word 2 Vic, similarity analysis, sentiment analysis, topic modeling and cluster analysis are used. For future research the computational linguistics and NLP are contributed in Sindhi text corpora.

The Sindhi corpus construction project is very precious forward in language processing absence sources of Sindhi language. Despite of its magnitude and initial output of the corpus is present position will provide base for advance in studies of Sindhi language it is natural language process. For smart devices and cell phones the script frequencies which include bigram and trigram is providing base for compact keyboard design and intelligent text processing. For the correction of spelling and automatic sentence completion applications, word level unigram and bigram frequencies bring base. For enhanced language processing targets just like information retrieval and extraction and machine translation, semantic analysis, syntax analysis and morphological analysis, further enhancement in corpus will be very beneficial.

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WIND AND SOLAR ENERGY POTENTIALS AROUND SOUTHERN SINDH & SOUTHERN BALUCHISTAN PROVINCES, ESPECIALLY KARACHI OF PAKISTAN

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ABSTRACT

Electrical energy has a vital place as it amounts to being the basic necessity of sustainable life and necessitates itself for the development of human capital leading to the general economic uplift of a nation.

Pakistan has remained in the serious shortage of electric power leading to adverse effects on the state. Around 70 % of Pakistanis are living without stable electric supply. Those who are lucky enough to have access to electricity undergo around 12 to 14 hours of load– shedding. Pakistan is always in the lack of sufficient conventional sources of energy. Adding to this it is the fact that Pakistan has not made any significant steps to tap renewable energy resources like wind and solar energy. It seems very natural for Pakistan to employ the natural resources of energy which are yet to be tapped and are coming into the fulfilment of the shortage in the supply of energy.

In this paper, the existing potential of renewable energy resources is studied as a viable alternative to the current state in the energy supply and demand. Southern Pakistan is presented to hold key renewable resources such as wind and solar energy in order to address the energy shortfall.

Southern Pakistan, mainly coastal regions, possesses wind and solar potentials. The paper chooses selected areas in southern Pakistan containing an adequate level of wind power. The paper attempts to argue that renewable energy resources can meet the energy demand of the southern regions mainly coastal ones. The paper attempts to look at the current and future challenges in the transition to wind and solar power.

KEYWORDS

Renewable Energy, Energy Potential, Energy Shortfall, Coastal Regions Study.

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1. INTRODUCTION

Comparing with other developing countries, Pakistan is facing serious energy crisis since the past several decades leading to an ever–increasing energy demand necessitating making it seriously dependent on import of pricy fossil fuels. In the villages of Pakistan, there is almost no electricity & cities are facing bitter load shedding problems (Ashfaq & Ianakiev, 2018). Load shedding is 14–18 hours in villages and 8–12 hours in cities. The customers located in residential, industrial and commercial sectors are badly affected making it an immense challenge for the government sector power infrastructure to ensure sustainable power. If we do not encounter these burning issues of electrical energy on a priority basis, then in future there will be the worst situations of electricity in Pakistan. A large number of research attempts is needed to explore the renewable energy (RE) resources to attend the gap between the supply and need. However, the renewable energy sector is yet to penetrate in the present conventional energy infrastructure predominantly located in northern and central regions (Kamran, 2018).

Pakistan has energy resources, renewable and non–renewable. Renewable energy is considered environment–friendly while the non–renewable energy is harsh for the environment. The sources of renewable energy are solar, wind, tidal, geothermal, biomass, hydro and thermal. Mostly the developed countries of the world depend on non–renewable energy resources to meet the energy demands. Also, the developing countries especially Pakistan still rely on the expensive fossil fuel based energy system which is expected to deplete shortly (Sher, Murtazs, Addoweesh & Chiaberge, 2015; Tahir & Asim, 2018). The non–conventional energy resources have been exploited to reduce fossil fuel–based local and commercial consumption bit by bit. As such, energy has earned the best quantity of attention globally than ever before. The energy crisis is already affecting the developing countries like Pakistan. Pakistan has 93.5% electricity rely on the oil, natural gas, hydropower, nuclear energy, coal and a little bit on the RE. Pakistan is mostly dependent on expensive fossil fuel. Pakistan utilizes 25.7% of natural gas, 37.2% of oil, 30.7% of hydropower, and 4.8% of nuclear energy (Index

Mundi, 2018). 0.1% of coal and only 0.8% of it is based on the RE to fulfil the energy demand of Pakistan up to 2015 as shown in Figure 1.

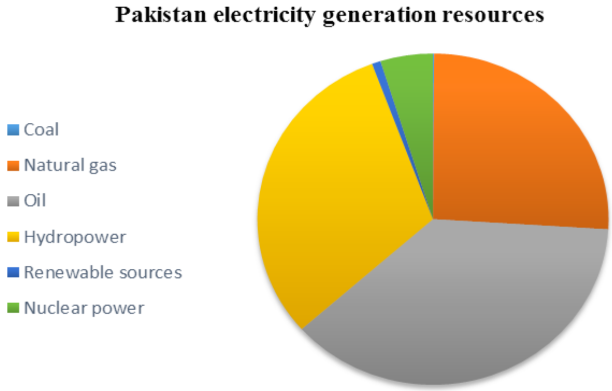

Figure 1. Electricity Sources percentage use in Pakistan. **Source:** Index Mundi.

The past and the present attempts aimed at curtailing the existing energy crisis rendering the most of the urban areas suffering from power outages for 12 hours on a regular basis. According to the International Energy Agency, Pakistan has a vast proportion of its population which does not have access to energy. The most population of the country is even not connected to the national electricity grid. The population with access to on–grid electricity is enduring load shedding on a daily basis. This illustration is shocking which requires immediate attention. The policymakers are required to feature such type of energy resources that overcome the current demand of the country (Best & Burke, 2018; Wakeel, Chen & Jahangir, 2016; Asif, 2009; Harijan, Uqaili, Memon & Mirza, 2009).

The geography of Pakistan is blessed with a lot of solar and wind energy throughout the year. In normal days Pakistan gets 7.5 hours of sunlight each day having 6 kWh/m2 average solar radiations along with most of the territory of the country. In earlier days, Pakistan never utilizes the energy potential but later 1991 the government acquires an interest in the technologies. Then different departments, boards, companies & corporates are working in developing technologies.

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Pakistan is highly relying on foreign expensive fuels. It is, therefore, time to utilize the available rich potential of the renewable energy resources within Pakistan. The solar, wind and biomass are excessively available in Pakistan. These renewable energy resources are economical and environmentally friendly and highly careful regarding sustainability. The renewable energy resources are very much encouraged able at the position of the expensive fossil fuel–based resources. The available unchecked renewable resources can meet the current energy demands that facilitate to conserve the standard of current resources that are early decreasing. This paper provides a detailed description of the unchecked areas in Pakistan where there is a high potential for renewable energy. The proposed research aims to explore the RE potential. The southern Sindh and southern Baluchistan provinces especially Karachi have a lot of opportunities in wind & solar energies. In this paper, these potentials will be explored with the help of real–time analysis of solar & wind measurements (Halacy, 1980; Kumar, 2017; Usman, Hussain, Ahmad. & Javed, 2015; Baloch, Kaloi & Memon, 2016).

There is square measure virtually no grid interconnection of the alternative energy at the established stage. The dynamic circumstances are significantly changing from the conventional power resources to the non–conventional energy resources. Solar and wind are the best resources to contribute to the national grid in the current situation. Pakistan government constructs the three wind farms interconnection network and lots of others in the pipeline. The federal policy on wind energy system has recently modified for the future task. The continued schemes of the wind park have gotten slow because of low maintenance. The planned analysis paper gives detail developments within the wind energy sectors of the country. Additionally, the suggestions which will contribute to boosting the penetration of wind energy within the national sector are highlighted in Pakistan (Shahzada, Nawaz &Alvi, 2018; Farooq & Kumar, 2013).

The wind and solar energy are the cost–effective non–conventional sources of energy. Pakistan has a high potential for renewable energy due to its geographical location. Pakistan has unlimited potential of RE, e.g., 2,900,000MW of solar, 346000 MW of wind, 3000MW of biogas, 2000MW of tiny hydropower and 1000MW from waste. Pakistan has high RE potential but still relies on expensive fossil fuel. Pakistan has so much noted area like southern Sindh and southern Balochistan where there is the great potential of renewable energy to alleviate the current increasing demand. Pakistan is still unable to use these noted sites of the two provinces of the country. The Sindh and Baluchistan have the potential to fulfil the current demand of the country. The proposed study is based upon the potentials of wind and solar energy around southern Sindh and southern Baluchistan Provinces of Pakistan (Mirjat, *et al.*, 2017; Wakeel, *et al.*, 2016; Sadiqa, *et al.*, 2018; Yuan, *et al.*, 2018). This ly among 250 Km of the southeastern and 800 Km of the southwestern regions of Asian nation. The annual wind speed information is reported for variable heights of those predictable sites. The wind energy around these areas that represent to possess an associate degree. The annual average wind speed of 6.63 m/s and 5.33 m/s correspondingly. The facility of yearly generation from these noted locations of two provinces is 7.653 GWh, and 5.456 GWh. This study conjointly elaborates the benefits and side effects. The generation of electricity from the wind and solar within the selected remote zones areas will offer the economical and relatively best implementation to the national off–grid system. The findings of this research can facilitate the government, local and industrial sector. The proposed acceptable research will attract the investment for the wind and solar energy to eradicate the on–going electricity crisis within the country (Moretto, Branca & Colla, 2018; Ishaque, 2016; Ashfaq & Ianakiev, 2018).

In the past, there were no such real–time data of solar and wind measurements in Pakistan. The planner has worked on solar and wind energies in Pakistan. The real–time measurements of solar and wind energies are highly good from all orientation. The Karachi is the biggest city of Pakistan, has great potentials of solar and wind energies. Previously, there is no data available for wind and solar measurements of the megacity. The proposed research sources are depending on the World Bank (WB) data. In Pakistan, WB has

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started to gather data of solar measurements of different cities from April 2015 & wind measurements from September 2016. But in Pakistan, there is no coordination with these real–time data (Ashfaq & Ianakiev, 2018; Shoaib, *et al.*, 2017).

2. MODELS

2.1.SOLAR MODELS

The photovoltaic model provides long–term averages of solar radiation such as global, diffuse and direct normal. The given models are signifying solar efficiency. The solar thermal energy technologies, on the other hand, for example, the Concentrated Solar Power (CSP) and Concentrated Photovoltaic (CPV) rely on Direct Normal Irradiation (DNI). Terrain elevation determines the best site and concert for the solar PV as described in Eq.1.

$$Cos\,\theta = \sin\delta \sin\varphi + Cos\,\delta\, Cos\,\varphi \cos\omega$$
$$Cos\,\theta = \sin\delta \sin\varphi + Cos\,\delta\, Cos\,\varphi \cos\omega$$

Eq.1

DNI is the relevant photovoltaic concentrating technologies as Eq. 2.

$$\mathrm{DNI} = \mathrm{A.\,exp}(-\mathrm{B}/\mathrm{Cos}\,\theta)\mathrm{DNI} = \mathrm{A.\,exp}(-\mathrm{B}/\mathrm{Cos}\,\theta)$$

Eq. 2

DHI is the solar irradiation component as given below in Eq. 3.

$$\mathrm{DHI} = \mathrm{C.\,DNIDHI} = \mathrm{C.\,DNI}$$

Eq. 3

GHI is considered as a climate reference as it enables comparing individual sites or regions as referring to Eq. 4.

$$GHI = DHI + DNI \cdot \cos(\theta) GHI = DHI + DNI \cdot \cos(\theta)$$

Eq.4

Air temperature is taken at 2 meters above the ground. Air temperature, in °C or °F, determines the temperature of PV cells and modules. The air temperature and also some other meteorological parameters are an important part of each solar energy project calculation as they define the functional circumstances and working proficiency of the solar PV as given in Eq.5.

$$\eta = \eta Tref[1-\beta ref(Tc - Tref)]\eta = \eta Tref[1-\beta ref(Tc - Tref)]$$

Eq. 5

Photovoltaic, generally, is the most applied and versatile technology. The Atlas continually indicates the estimation of yearly average values of power generation for PV systems that enormously use the World Bank parameter for installation of the solar power plant. The PV electricity simulation program, based on an algorithm, is combined within the atlas which always provides a secondary approximation of the potential electrical occurrence energy, which may be made at any location ruled by the interactive map as given below in Eq. 6.

$$T_c = T_a + \left(\frac{NOCT-20}{800}\right) G_t T_c = T_a + \left(\frac{NOCT-20}{800}\right) G_t$$

Eq. 6

2.2. IMPORTANT PARAMETERS

A Apparent extraterrestrial irradiance (W/m^2)

B Atmospheric attenuation coefficient (W/m^2)

C A dimensionless constant

Cn Cloud cover index DHI (Diffuse horizontal irradiance) (W/m^2)

DHIcs Diffuse horizontal irradiance under a clear sky

DNI Direct normal irradiance (W/m^2)

DNIcs Direct normal irradiance under a clear sky

DNIcs Maximum direct normal radiation under clear sky during the day (W/m^2)

DNIcn Maximum direct normal radiation under cloudy sky during the day (W/m^2)

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GHI Global horizontal irradiance (W/m^2)

–z solar zenith angle rain Probability of precipitations

RMSE% Root Mean Square Error

2.3. WIND MODELS

Pakistan is the country in the world where there are great wind energy potentials. Electricity, in large quantities, can be produced by taking advantage of the available renewable energies.

$$P_w = \frac{1}{2} C_p(\lambda, \beta) A V^3 P_w = \frac{1}{2} C_p(\lambda, \beta) A V^3$$

Eq. 12

The wind energies of southern Sindh and southern Baluchistan of Pakistan especially Karachi have been investigated with the help of available World Bank data.

The wind energies of the selected regions give the commendable measurement which can be exploited to generate the great amount of wind energy.

$$Q_\omega = P \times Time\,[KWh] Q_\omega = P \times Time\,[KWh]$$

Eq. 13

$$T_t = \frac{1}{2} C_p(\lambda, \beta) A \left(\frac{R}{\lambda}\right) T_t = \frac{1}{2} C_p(\lambda, \beta) A \left(\frac{R}{\lambda}\right)$$

Eq. 14

The required parameters like turbulence intensity, min. wind speed, max, wind speed, mean wind speed & wind speed standard deviation have been studied to extract the wind energy. According to the analysis of the World Bank data, these parameters are based upon the World Bank wind calculations. The parameters are used to show the data of the provinces especially Karachi. The World Bank chooses these parameters to calculate the wind potential of Pakistan as shown in Eq. 12 to Eq. 14.

3. RESULTS

3.1. SOLAR RESULTS FOR SOUTHERN SINDH

In solar energy, some parameters like global horizontal irradiance (ghi), DNI (direct normal irradiance, DHI (diffuse horizontal irradiance), air temperature and relative humidity have been analyzed. According to the analysis, these two provinces including Karachi have the great solar energy potentials as shown in Figure 2. The solar panels in large quantities can be installed in these noted areas to get the maximum amount of electrical energy. Also, the solar potential of the Hyderabad shown the great potential as refer Figure 3.

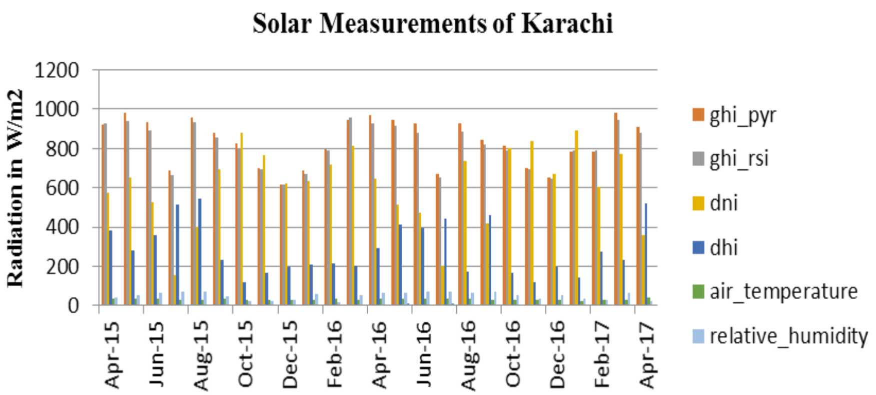

Figure 2. Solar Measurements of Karachi, Sindh. **Source:** The World Bank.

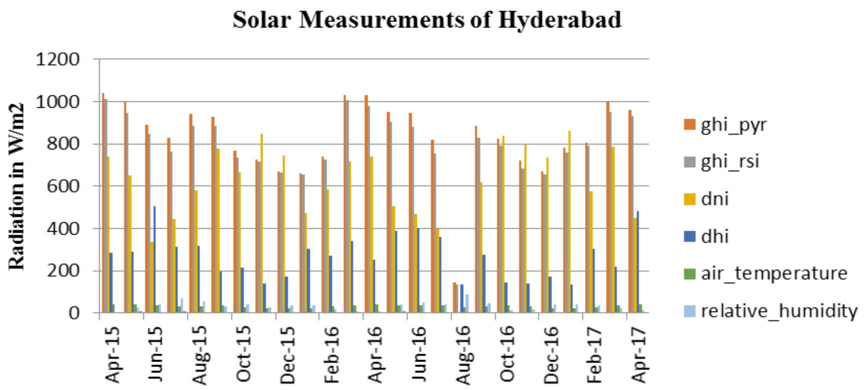

Figure 3. Solar Measurements of Hyderabad, Sindh. **Source:** The World Bank.

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3.2. SOLAR RESULTS FOR SOUTHERN BALOCHISTAN

In solar energy, some parameters like global horizontal irradiance (GHI), DNI (direct normal irradiance, DHI (diffuse horizontal irradiance), air temperature and relative humidity have been analyzed. According to the analysis, these regions including southern Sindh and southern Balochistan have great solar energy potentials. This is proved to form the result of the World Bank group. The solar potential of the southern Balochistan is shown in the Figures 4–5. The solar panels in large quantities can be installed in these noted areas to get the maximum amount of electrical energies.

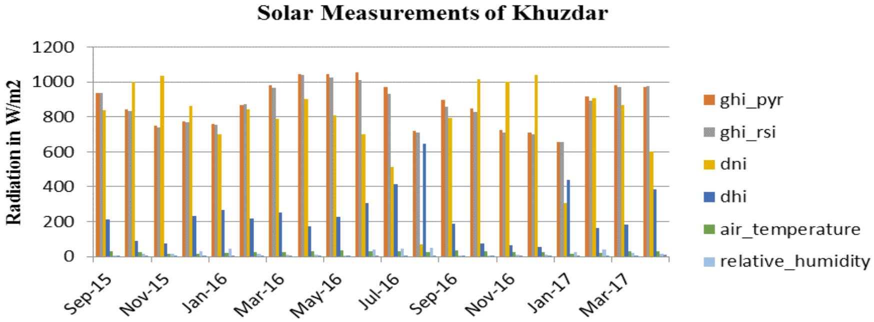

Figure 4. Solar Measurements of Khuzdar, Baluchistan. **Source:** The World Bank.

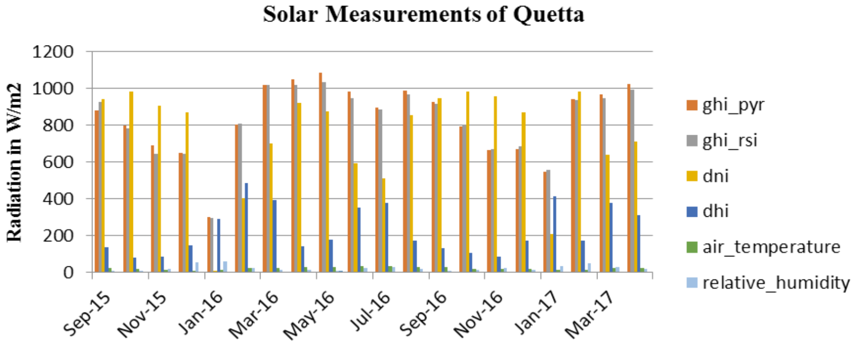

Figure 5. Solar Measurements of Quetta, Baluchistan. **Source:** The World Bank.

3.3. WIND RESULTS FOR SOUTHERN BALOCHISTAN AND SOUTHERN SINDH

Pakistan is one of the countries in the world where there are great wind energy potentials. Electricity, in large quantities, can be produced with the help of these renewable energies.

In this study, the potentials of wind energies of southern Sindh and southern Baluchistan especially Karachi have been analyzed. The real–time data measurements of wind energies of the regions have been examined as shown in Figures 6–9. In wind energy, some parameters like turbulence intensity, min. wind speed, max, wind speed, mean wind speed, and wind speed standard deviation have been investigated. According to the analysis, these provinces especially Karachi have abundant wind potentials. It is proved from the Figures 8–9 that the wind potential of the southern Sindh provinces is more than the southern Balochistan. Wind turbines can be installed in these areas to get a lot of electrical energies. The parameters for the wind installation are the following:

- T_I = a20_turbulence_intensity
- ws_max = a20_wind_speed_max
- ws_min = a20_wind_speed_min
- ws_mean = a20_wind_speed_mean
- ws_sd = a20_wind_speed_stddev

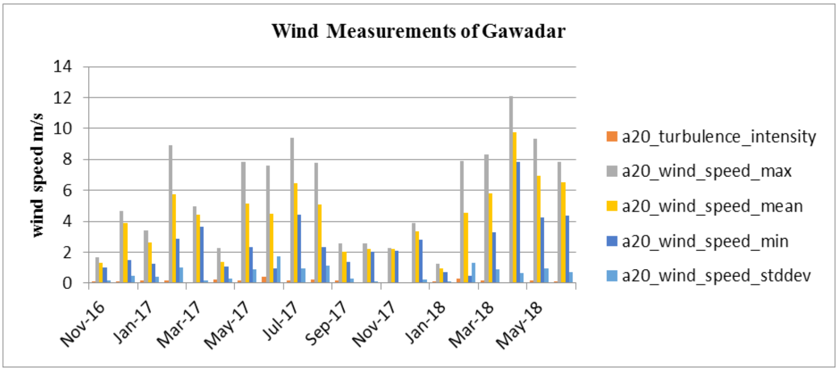

Figure 6. Wind Measurements of Gawadar, Baluchistan. **Source:** The World Bank.

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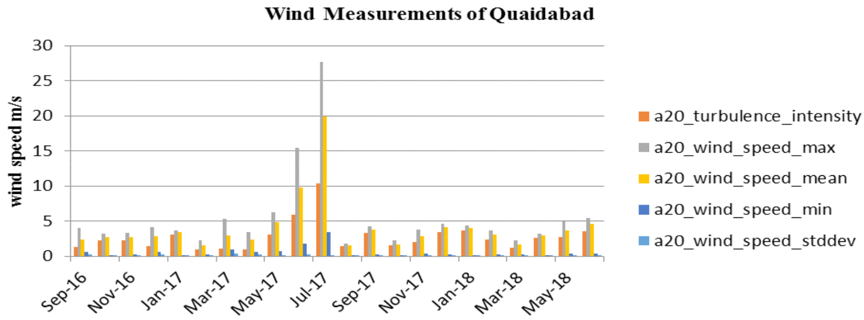

Figure 7. Wind Measurements of Quaidabad, Karachi, Sindh. **Source:** The World Bank.

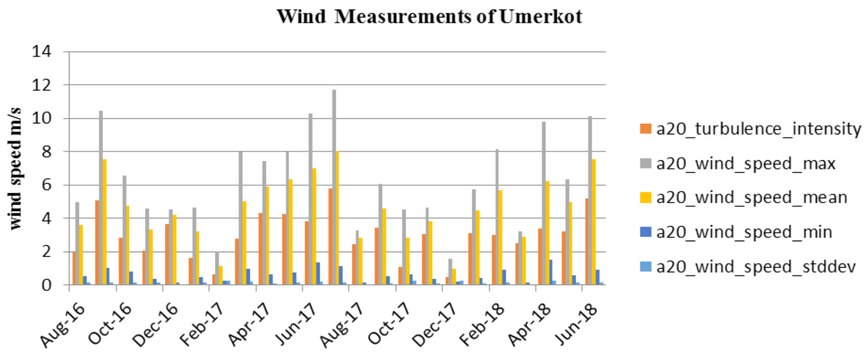

Figure 8. Wind Measurements of Umerkot, Sindh. **Source:** The World Bank.

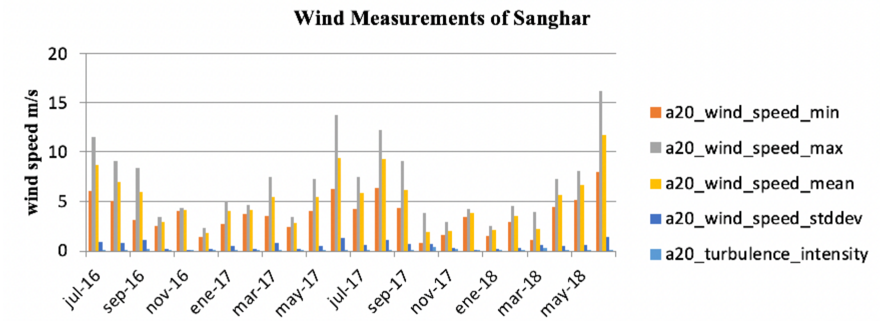

Figure 9. Wind Measurement of Sanghar, Sindh. **Source:** The World Bank.

4. ANALYSIS

4.1. SOLAR POTENTIAL ANALYSIS

In solar energy, some parameters like global horizontal irradiance (GHI), DNI (direct normal irradiance, DHI (diffuse horizontal irradiance), air temperature and relative humidity have been studied. The analysis of southern Sindh and southern Baluchistan provinces has been observed. The selected areas have great solar energy potentials due to the rich amount of irradiation observation. The observed ghi for the Karachi is in the range of minimum 652 in December to maximum 979.3 in the month of March. The observed ghi for the Hyderabad is minimum 670.9 in December to maximum1041 in April. Also, the observation of ghi for the Khuzdar is minimum 712.3 in December to maximum 1056.7 in June. The observation of ghi for the Quetta is minimum 672.3 in the December to maximum 1084.2 in May. The observation of the ghi is the best for the installation of the solar panels. Hence the large quantities of the solar PV can be installed in the noted areas to get the maximum amount of electrical energies. Similarly, DNI, DHI are observed in the selected areas. The observed irradiation is highly abundant in the selected areas of the southern Sindh and southern Balochistan.

The map describes the photovoltaic electricity output (PVOUT) potential in selected areas. It is clear from the World Bank atlas based map that there are a lot of PVOUT potentials as shown in the Figure 10.

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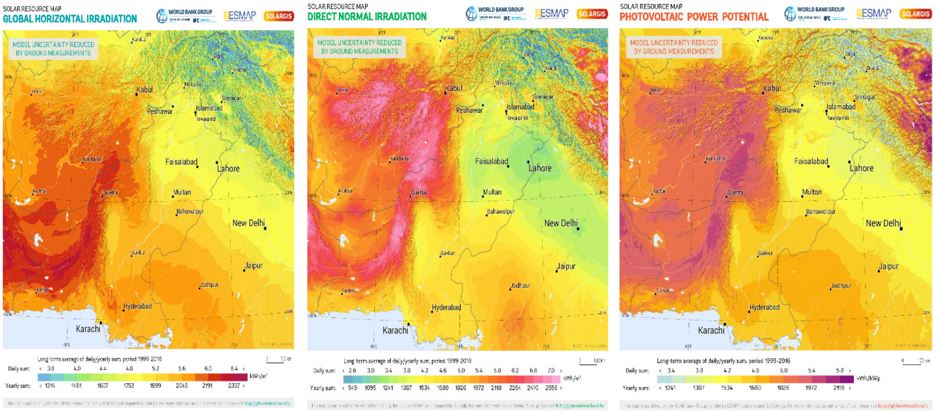

Figure 10. Solar Map Resources Expressing the ghi, dni and PVOUT potential. **Source:** World Bank Group, Solar Resources Map, Solargis.

The below map as shown in the Figure 11 describes the ghi for the Karachi. It is clear from the map that there is very good ghi condition in the selected areas especially Karachi. The map defines the huge amount of irradiation as 1967 KWh/m2 per year which will play a significant role for the power generation.

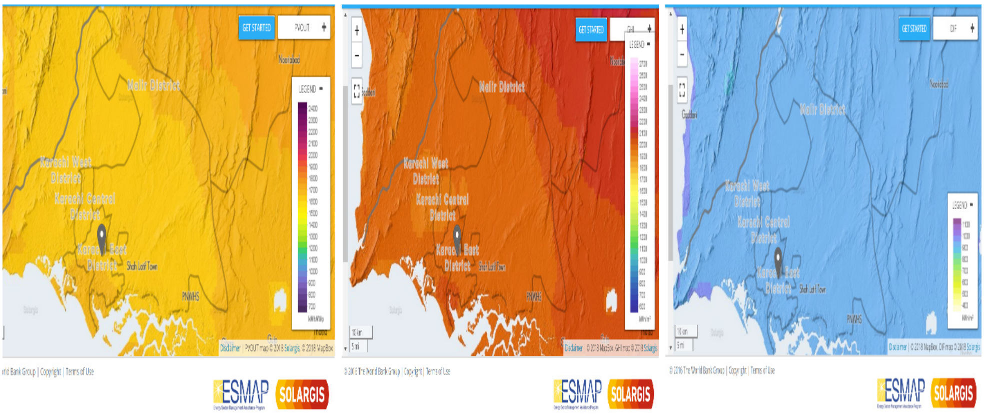

Figure 11. Solar Map Resources Expressing the ghi, dni and PVOUT potential for the Karachi. **Source:** World Bank Group, Solar Resources Map, Solargis.

This map also refers to the DHI of the selected areas, especially for the Karachi. The observation of the irradiation is 917 KWh/m2 per year. The DNI of Karachi is 1564 KWh/m2 per year. The available map is the normal map of the Karachi. The temperature of Karachi is average 26.8oC as shown in the Figure 12.

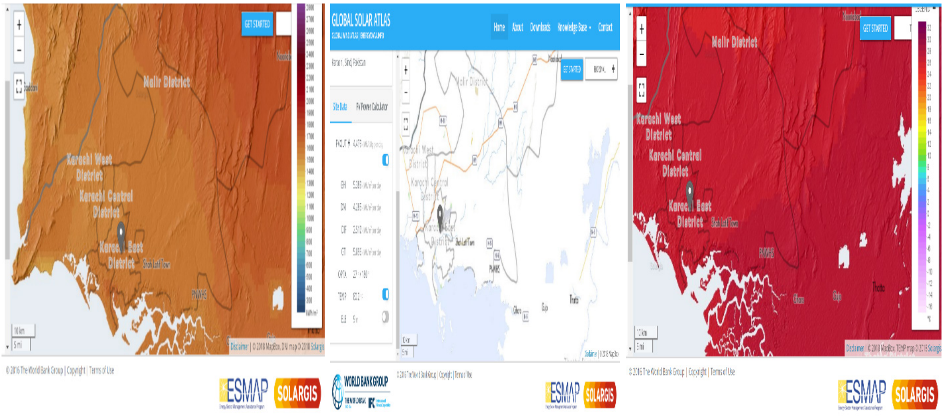

Figure 12. the Solargis Map describes the solar power and temperature of the areas especially Karachi. Sources: World Bank Group, Solar Resources Map, Solargis.

If work is planned to install the solar power project in these noted areas, then the country will never be more dependent on the existing expensive fossil fuel. The southern Sindh and southern Baluchistan have high potential to generate the abundant economy for the country. It is clear from the Solargis model that Pakistan is a geographically rich country and it is the need to fulfil the existing demand by utilizing the proposed study.

4.2. WIND POTENTIAL ANALYSIS

Pakistan is one of the countries in the world where there are great wind energy potentials. The potentials of wind energies of southern Sindh & southern Baluchistan of Pakistan especially Karachi have been analyzed with the help of available World Bank data. The wind energies of the selected regions have been analyzed. The southern Sindh and southern Balochistan have a respectable amount of the wind that can be utilized to generate valuable electricity for the country.

The analysis of proposed study rediscovers the energy potentials of two provinces especially Karachi of Pakistan. The southern Sindh and southern Balochistan have great wind energy potentials as shown in the Figure 13. There is a need to plan to install the wind turbines in these areas to get a lot of electrical energies.

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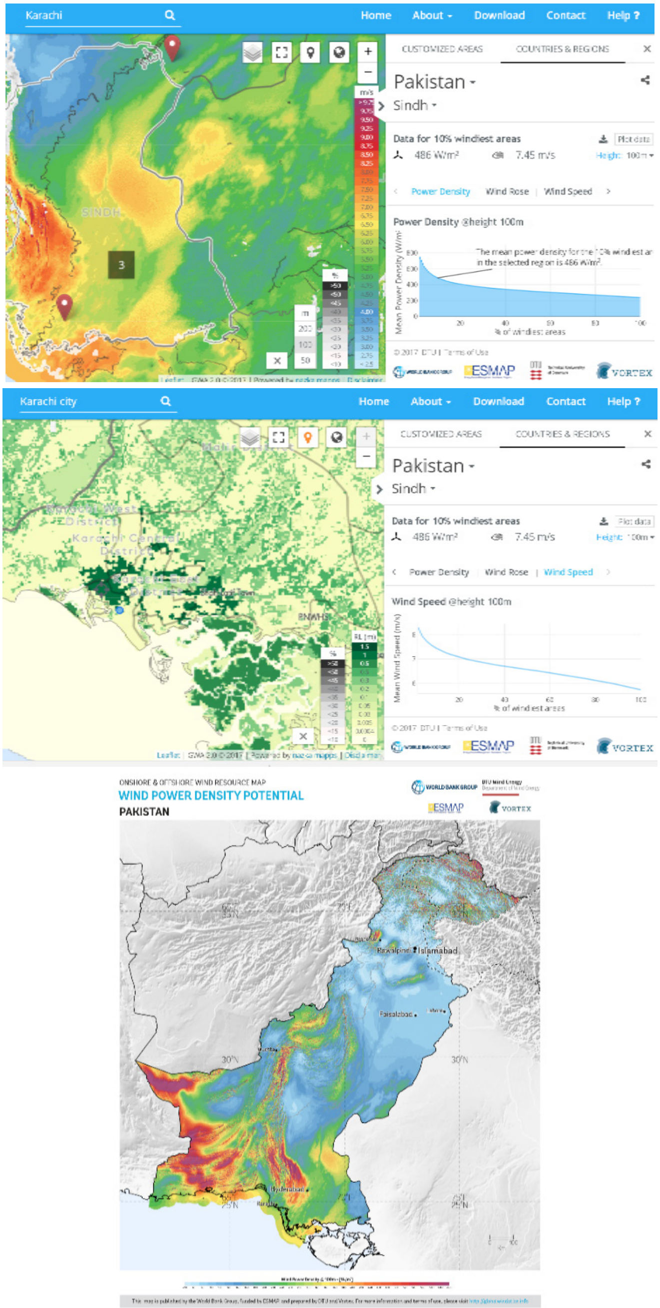

Figure 13. The Wind Map resources describe the wind potentials+ in the selected areas. **Source:** World Bank Group, Wind Resources Map, Wind Measurement.

The wind speed in the coastal area of southern Sindh and southern Baluchistan describes the more availability of the wind energy in these areas as shown in the Figure 13. The below map describes the power density at height 100m for wind measurements in the Sindh province of Pakistan. Also, the map defines the wind power density potential in Pakistan. It is clear from World Bank data that there are a lot of wind energy potentials and overall good wind speed condition in noted areas of Pakistan as shown in the Figure 14.

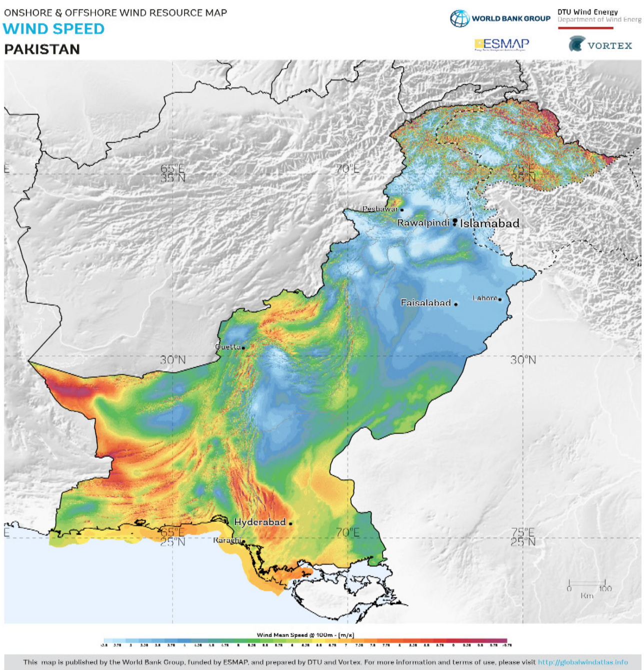

Figure 14. The Onshore and Offshore Wind Map resources show the wind potentials of southern Sindh and southern Baluchistan. **Source:** World Bank Group, Wind Resources Map, Wind Measurement.

5. CONCLUSION

The solar and wind energy potentials have been observed in southern Baluchistan and southern Sindh especially in Karachi region of Pakistan. However, southern Pakistan, mainly coastal region possesses great wind and solar potentials. Also, it has an adequate level of wind as well as solar power generation due to its geographical status. The wind resources can meet the energy demand of the southern regions mainly coastal areas. The southern Sindh and southern

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Baluchistan regions can generate valuable energy by the installation of small and large renewable power plants. The generated renewable energies can be added to the main grid stations to overcome the shortage of electrical energies. The planners need to focus on the proposed areas for renewable energy generations.

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IMPROVED SPIDER MONKEY OPTIMIZATION ALGORITHM TO TRAIN MLP FOR DATA CLASSIFICATION

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ABSTRACT

In this paper, the modified Spider Monkey Optimization (SMO) with Multi-Layer Perceptron (MLP) is utilized to solve the classification problem on five different datasets. The MLP is a widely used Neural Network (NN) variant which requires training on specific application to tackle the slow convergence speed and local minima avoidance. The original SMO with MLP experiences the problem of finding the optimal classification result; due to that, the SMO is enhanced by other meta-heuristics algorithm to train the MLP. Based on the concept of no free lunch theorem, there is always a possibility to improve the algorithm. With the same expectation, the performance of the SMO algorithm is improved by using Differential Evolution (DE) and Grey Wolf Optimizer (GWO) algorithm to train the MLP. Likewise, the SMO-DE and SMO-GWO are two different concepts employed to improve efficiency. The results of proposed algorithms are compared with other well-known algorithms such as BBO, PSO, ES, SVM, KNN, and Logistic Regression. The results show that the proposed algorithm performs better than others or they are more competitive.

KEYWORDS

Classification, Neural Network, FNN, Swarm Intelligence, Evolutionary algorithm.

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1. INTRODUCTION

The Swarm-based intelligence is inspired by the social conduct of creatures, birds, fishes, and insects and other real-world scenario. The spider monkey optimization (SMO) algorithm is a new emerging swarm intelligence algorithm has been inspired from the swarm of spider monkey due to their social foraging behavior (Bansal, Sharma, Jadon & Clerc, 2014). It belongs to the fission-fusion social structure based strategy which splits the larger group into sub-groups and vice-versa in order to find food resources (Symington, 1990). These animals live in groups of up to 50 members generally and mostly led by a female member known as the global leader and responsible for supervising the group. These animals travel for searching for food in different directions as well as to compute the travel position from the leader and group member experiences. Each individual updates their positions within a certain range of core area during the day and at night every member get fused together to share the experience of foraging food at their habitat. In case there is a deficiency of food resource the global leader divides the parent group into smaller groups to forage food separately. During the process of foraging, if any members of different sub-group get closer, the males in each sub- group shows aggressiveness and territorial behavior such as whooping or chattering. Spider monkeys communicate upon the availability of food within groups and their sub-groups maintaining distinct territory boundaries without involving in any physical activities. After returning back to their habitat, they reflect gestures to show they are actually part of a large group.

SMO follows self-organization and fission of labor properties for obtaining swarm intelligence behaviors of animals (Symington, 1990). This research gives a reasonable investigation to change these practices into an algorithmic model, for example, there is a defined search space known as a core area in which a group of the individual need to seek food in various directions based on leader position directions and pursue a similar procedure till they reach the optimum. The SMO algorithm has four control parameters: Local Leader Limit, Global Leader Limit, maximum group (MG) and perturbation rate (pr). The Local Leader Limit indicates that if there is no update in the local group leader in a specified number of times then the point needs to be redirected to a different direction for foraging. After reaching global Leader Limit value without any update, the global leader breaks the group into smaller subgroups. The pr and MG are used to specify the control amount of perturbation in the current iteration and a maximum number of groups in the population respectively. Spider monkey optimization has seven major steps including initialization. All seven different steps are Initialization, Local Leader Phase, Global Leader Phase, Local Leader Learning Phase, Global Leader Learning Phase, Local Leader Decision Phase, and Global Leader Decision Phase.

There are many improvements in SMO has been done in recent years for many different optimization problems (Gupta & Deep, 2016; Gupta, Deep & Bansal, 2017; Sharma, Sharma, Panigrahi, Kiran & Kumar, 2016; Singh, Elaziz & Xiong, 2018).

In this paper, the original SMO algorithm is enhanced in two ways to train the MLP. The first way is to improve the SMO local leader efficiency with DE mutation, and crossover operators which intensify the exploitation ability of algorithm (Storn & Price, 1997; Zaharie, 2009). The other ways are to apply the GWO strategy to select the three best leaders to update the position after the processing of the local leader phase. The GWO selection strategy strengthens the exploration ability (Mirjalili, Mirjalili, & Lewis, 2014a).

There are many meta-heuristic algorithms used to train MLP. These are PSO (Bell & Oommen, 2017; Shi & Eberhart, 1945), BBO (Mirjalili, 2019), ACO (Gutjahr, 2007), ES (Erfani & Erfani, 2015; Li, *et al.*, 2015) and GA (Deep & Thakur, 2007b, 2007a) algorithms. The MLP is a variant of NN in the field of soft computing. The NN is prominent research because of its fast convergence speed and low computational cost. The primary concept of NN is inspired by biological neurons of the human brain which was first mathematically modeled by (Ferris & Mangasarian, 1995). In details the MLP presented under FNN is one of type of NN. The FNN receive input from one side and generates output to another side (Fine, 1999). In between, it is connected with neurons in different

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layers in one direction. The perceptron used in FNN which has two types, first Single-layer perceptron and the second is Multi-layer perceptron. The single layer perceptron is utilized to solve liner problems while the multi-layer perceptron which has more than one perceptron is suitable for solving non-linear problems.

The MLP with one hidden layer can solve continuous and discontinuous functions both stated in (Mirjalili, Mirjalili, & Lewis, 2014b). As the behavior of the human brain, the MLP is progressed from the learning experiences. The observation of learning concept in NN is to find the proper combination between weights and biases to reduce the error for training and test samples. However, the error is still large in some extended period of time and due to that, it can be trapped at local minima rather than global minima. To overcome these problems the meta-heuristic algorithm plays an important role because of its stochastic nature (Hinchey, Sterritt, & Rouff, 2007).

The rest of the paper is structured as follows: Section 2 describes the background of the existing algorithm. The modified version of the SMO algorithm is discussed in Section 3. The datasets and its results are presented in Section 4. The conclusion and future work are mentioned in Section 5.

2. BACKGROUND OF EXISTING ALGORITHMS

2.1. THE SPIDER MONKEY OPTIMIZATION (SMO)

In the algorithmic methodology, the group can be divided into subgroups until the predefined maximum group limit (MG = 4) meet. Finally, the global leader takes the decision to break the groups or simulate into one based on the maximum limit criteria. The algorithm is processed into seven phases such as Initialization phase, Local Leader Phase, Global Leader Phase, Local Leader Learning Phase, Global Leader Learning Phase, Local Leader Decision Phase, and Global Leader Learning Phase. These phases are given as follows:

2.1.1. INITIALIZATION

During the initiation process, there is a single group of all population members where members randomly initialize the position in the search space.

$$P_{i,j} = P_{lb,j} + \left(P_{ub,j} - P_{lb,j}\right) rand\left(0,1\right) \qquad (1)$$

Where $P_{i,j}$ *(i=1,2,.., NP)* is the *i*th population's member in *j*th dimension *(j=1,2,..,D)*. The NP and D are the total number of population and dimensions respectively. Moreover, $P_{lb,j}$ and $P_{ub,j}$ are respectively, the lower and upper bound of the search space in jth dimensions. And the *rand (0, 1)* is representing the uniform random distribution number in [0,1].

2.1.2. LOCAL LEADER PHASE

In this phase, all members of the group update their position from the experience of the local leader and the experiences of local group members as in (2). In this phase, the update process depends on the value of the perturbation rate (*pr*) which is mentioned in (3).

$$P_{i,j} = P_{i,j} + \left(PLL_{g,j} - P_{i,j}\right) rand\left(0,1\right) + \left(P_{r,j} - P_{i,j}\right) rand\left(-1,1\right) \qquad (2)$$

Where $PLL_{g,j}$, is the local leader position of *g*th gthe roup in *j*th dimension and $P_{r,j}$ is the randomly selected member from that group. The value between [-1, 1] is uniformly distributed random number defined as $rand\left(-1,1\right)$ that shows the dispersion or attraction towards $P_{r,j}$.

$$pr_{it} = pr_{it} + 0.4 / maxit \qquad (3)$$

The pr_{it} is the perturbation rate value in the current iteration in (3), (where $pr_1=0.1$).

In Algorithm 1, all details of the method of local leader have been mentioned. The tgr is the total number of the group created up to now. The denoted *gr [lo]* and *gr[hi]* is the range of population members belong to the current group. As for the value of the function, P_{newj} gives the update of the new position $P_{i,j}$. The lowest function value is considered a better in the case of minimization. If the condition is not satisfied then the position of the update will fail.

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2.1.3. GLOBAL LEADER PHASE

The global leader and randomly selected member positions are important for this phase due that the updating process depends on them. Thus the probability value is utilized to determine the current member stat (is allowed to update or not). Therefore, if the probability of current member (*Prob*(P_i)) is satisfied for updating the i^{th} member position then it is selecting the dimension randomly as shown in (4).

The probability of a current value is strongly proportional to the fitness value of that one. Whereas the best function value in the population is called *GlobalMin*. The update process will continue until the termination criteria are respected in Algorithm 2.

$$P_{new\ j} = P_{i,j} + rand(0,1)\left(PGL_j - P_{i,j}\right) + rand(-1,1)\left(P_{r,j} - P_{i,j}\right) \tag{4}$$

where PGL_j is the global leader position in the j^{th} dimension.

Algorithm 1: LOCAL LEADER PHASE

$\boldsymbol{Begin}$

$\boldsymbol{for\ gr = 1\ to\ tgr\ do}$

$\boldsymbol{for\ i = gr[lo]\ to\ gr[hi]\ do}$

$\boldsymbol{randomly\ select\ P_r}$

$\boldsymbol{for\ j = 1\ to\ D\ do}$

$\boldsymbol{if\ rand(0,1) \geq pr_{it}}$ $//\ from\ (2)$

$\boldsymbol{P_{new\,j} = Apply\ (2)}$

$\boldsymbol{else}$

$\boldsymbol{P_{new\,j} = P_{i,j}}$

$\boldsymbol{end\ if}$

$\boldsymbol{end\ for}$

Algorithm 1: LOCAL LEADER PHASE

$\boldsymbol{Calculate\ fun\left(P_{new\,j}\right)}$

$\boldsymbol{if\ fun\left(P_{new\,j}\right) \leq fun\left(P_{i,j}\right)}$

$\boldsymbol{P_{i,j} = P_{new\,j}}$

end

end for

end for

end

2.1.4. LOCAL LEADER LEARNING PHASE

The best member of the group is selected in this phase as the leader of the group. If the leader position is not updating in current iterations then the value is incremented by 1 in *LocalLimitCount*.

2.1.5. GLOBAL LEADER LEARNING PHASE

Thus, it is during this phase that we select the best position for a global leader by using a greedy selection in the total population. The *GlobalLimitCount* is incrementing by 1 if the position of global leader does not get a change until the *global limit (globallimit=NP/4)* is defined.

2.1.6. LOCAL LEADER DECISION PHASE

This phase is based on the result of the value pr in (3). It checks whether there is stagnation or not in the execution process. According to the *LocalLimitCount* is calculated; if this value has reached *LocalLimit (LocalLimit=NP/6)* then all the members of the group will be randomly reset from the experiences of the local and global leader see (5).

$$P_{new\ j} = P_{i,j} + \left(PGL_j - P_{i,j}\right) rand\left(0,1\right) + \left(PLL_{g,j} - P_{i,j}\right) rand\left(0,1\right) \qquad (5)$$

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2.1.7. GLOBAL LEADER DECISION PHASE

During this phase, we check the *GlobalLimitCount* has reached its maximum limit, also called *global limit*. If it has reached means the global leader stuck on local minima thus the groups are created according to the size of the groups reached the maximum limit (*MG*) or not. In case the group's sizes reached to *MG* then the *GL* tie up all groups into 1 and randomly reset.

Algorithm 2: GLOBAL LEADER PHASE

$\textit{Begin}$

$\textit{for } gr = 1 \textit{ to } tgr \textit{ do}$

$t = 1, f = 0$

$i = gr\left[lo\right]$

$GrS = gr^{th} \textit{ group size}$

$prob_i = 0.9\left(fun\left(P_i\right) \big/ GlobalMin \right) + 0.1$

$\textit{while}\left(t < GrS\right)\textit{do}$

$\textit{if } rand\left(0,1\right) \geq prob_i \textit{ then}$

$f = 0;$

$t = t + 1$

$\textit{randomly select dimesion } j$

$\textit{randomly select } P_r$

$\textit{Apply } \left(4\right) \textit{ to find new position}$

$\textit{Calculate } fun\left(P_{new}\right)$

$\textit{if } fun\left(P_{new\,j}\right) \leq fun\left(P_{i,j}\right)$

$P_{i,j} = P_{new\,j}$

Algorithm 2: GLOBAL LEADER PHASE

```
else
f = f + t;
end if
i = i + 1;
if i == gr[hi] then
i = gr[lo]
end if
if f ≥ t
t = t + 1;
end if
end if
end while
end for
end
```

2.2. GREY WOLF OPTIMIZER

The Grey wolf optimizer (GWO) inspired by Grey wolf which is from Canidae family. These species are predators means considered in the top of the food chain. The common thing is the grey wolf live in a group of 4 to 12. As the behaviors of this species are different and strictly followed. In the algorithmic methodology, the leader is called alpha is either male or female member which planned for a place, sleeping time, time to wake, hunting for food and so on. The decision of alpha is influenced by other wolves belongs to the group. The main identification to recognize alpha by holding his/her tails down. There is one more common from SMO algorithm is that the alpha is a dominant member in the group which is a decision maker.

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Similarly as the local leader in SMO, there is a beta member which is either male or female, follow and also instruct to alpha about the group activities. The main work of beta is to deliver the order of alpha to the lower level and regulate the group.

In ranking wise the lowest is called omega wolves which always deliver the information to their dominants. This wolf is only allowed to eat, in some cases, it has been seen that the internal fights occur in the group due to the frustration of omega.

The wolf is not alpha, beta, omega they are called delta. This wolf dominates the omega and delivers the information to alpha and beta.

The main concept of grey wolves is for hunting for target. In that the tracking, chasing, and attacking towards the target behavior is modeled. For that pursuing, harassing and encircling are the special strategies.

For mathematical modeling the social hierarchy, tracking, encircling, and attacking are utilized.

2.2.1. SOCIAL HIERARCHY

For modeling the algorithm the best fitted wolf alpha (α), second best beta (β), and the third best is delta (δ) considered. The rest of the wolves are considered as omega (ω).

2.2.2. ENCIRCLING TARGET AND ATTACKING

The mathematical equation of encircling pray is mentioned below where T ($\vec{T}_1$, $\vec{T}_2$, $\vec{T}_3$) calculated from the three best wolves' position such as $\vec{T}_\propto$, $\vec{T}_\beta$, $\vec{T}_\gamma$ as follows:

$$\vec{E}_\propto = \left|\vec{C}_1\vec{T}_\propto - \vec{T}\right|,\ \vec{E}_\beta = \left|\vec{C}_2\overrightarrow{T_\beta} - \vec{T}\right|, \qquad \vec{E}_\gamma = \left|\vec{C}_3\vec{T}_\gamma - \vec{T}\right| \tag{6}$$

$$\vec{T}_1 = \vec{T}_\propto - \vec{B}_1\vec{E}_\propto,\ \vec{T}_2 = \vec{T}_\beta - \vec{B}_2\vec{E}_\beta, \qquad \vec{T}_3 = \vec{T}_\gamma - \vec{B}_3\vec{E}_3 \tag{7}$$

$$\vec{T}(it+1)=\frac{\vec{T}_1+\vec{T}_{2+}\vec{T}_3}{3} \qquad (8)$$

Where $\vec{b}$ is linearly decreasing from 2 to 0, and $\vec{r}_1$, $\vec{r}_2$ is random number in [0, 1]. The current iteration is denoted by *it.* Moreover $\vec{E}$ is the distance of current position vector to the best.

2.3. DIFFERENTIAL EVOLUTION

The differential evolution is first proposed by Storn and Price (1997). There are three operators used in this algorithm such as Mutation, Crossover and Selection.

2.3.1. MUTATION

A new solution is generated by adding the weight difference between two population members.

Here, $P_{r,j}$ *(r=r1, r2, r3)* is randomly selected r^{th} member position in j^{th} dimensions.

$$PU_{new,j}=\begin{cases} P_{r3,j}+F_w\left(P_{r1,j}-P_{r2,j}\right); & rand(0,1)<0.5 \\ P_{r3,j}+0.5\left(F_w+1\right)\left(P_{r1,j}+P_{r2,j}-2P_{r3,j}\right); & Otherwise \end{cases} \qquad (9)$$

2.3.2. CROSSOVER

The crossover solution is generated after the mutation operation. There are many ways of crossover but in this paper it has omitted. Based on the mutant solution the process is further executed

2.3.3. SELECTION

The better solution in the comparison of current solution and crossover solution is selected for the next iterative process.

$$P_{ij}=\begin{cases} PU_{new,j}; & if\ \ fun\left(PU_{new,j}\right)<fun\left(PU_{new,j}\right) \\ P_{i,j}; & Otherwise \end{cases} \qquad (10)$$

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2.4. MULTI-LAYER PERCEPTRON

Multi-layer perceptron (MLP) is a variant of neural network. In details it belongs to the category of feed forward neural network (FFN). The MLP is used to solve nonlinear problems. The main challenge is to find the proper combination of weight and biases to minimize the error. The output of MLP is as follows:

First, the (11) calculates the inputs weighted sums (Csáji, 2001)force is seldom considered in assessment of competency. The objective of this study was to explore the force applied during orotracheal intubation as a method of further discriminating between levels of competence. We sought evidence of construct validity in the form of discriminant, criterion, and concurrent validity. We hypothesized that the force generated during simulated intubation could serve to discriminate skill level among clinicians. Methods A convenience sample of 35 health-care professionals filled a self-reported questionnaire and were then divided into the following three groups: Group 1, experts (n=16).

$$ws_j = \sum_{i=1}^{n} \left(W_{ij} I_i\right) - \beta_j, \quad j = 1,2,\ldots,h \quad WS_j = sigmoid\left(ws_j\right) = \frac{1}{\left(1+\exp\left(-ws_j\right)\right)}$$

(12)

Where W_{ij} is the connection weight from the i^{th} node in the input layer to j^{th} node in the hidden layer, then n is the number of the input node, afterwards I_i represents the i^{th} input and β_j indicate the bias of the j^{th} hidden node.

$$ho_k = \sum_{j=1}^{n} (W_{jk} WS_j) - \beta_k^{'} \quad , \quad k = 1,2,\ldots,m \qquad (13)$$

$$FO_k = sigmoid\left(ho_k\right) = \frac{1}{\left(1+\exp\left(-ho_k\right)\right)} \qquad (14)$$

Where W_{jk} is the connection weight from the j^{th} node in the hidden layer to k^{th} node in the output layer and is represents the bias (threshold) of the k^{th} output node.

3. PROPOSED ALGORITHM

The SMO is modified in two ways in order to find the optimum result as discussed above. The DE or GWO algorithms are employed after local leader phase. The execution of the DE or GWO algorithm is conditional. In detail, the execution model is depicted in Algorithm 3. The random executions of DE and GWO algorithm after local leader phase improve the exploitation and exploration ability respectively. The proposed SMODE and SMOGWO algorithms fill the drawbacks of converging on local optima rather global optima.

Algorithm 3: GLOBAL LEADER PHASE

Begin

Randomly initialize population using Eq. (1)

Train to MLP and calculate the output

Initialize Global Leader*, *local leader

Create group

while iter $\leq$ ***MaxIter***

for gr $= 1$: ***tgr***

Local leader phase //**See Algorithm 1**

if rand $(0,1) <$ ***rand*** $(0,1)$

Apply mutation from Eq (11) //**For SMODE**

or

Apply GWO Phase from Eq. (10) //For SMOGWO

end if

Update the current position based on the best value calculated from MLP output from Eq. (14)

end for

Global Leader Phase //**See Algorithm 2**

Global Leader Learning Phase

Local Leader Learning Phase

Local Leader Decision Phase **from Eq.** (5)

Global Leader Decision Phase

End while

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Algorithm 3: GLOBAL LEADER PHASE
The classification rate is calculated using MLP in Eq. (14) from the best value of the improved SMO.

End

4. EXPERIMENT AND RESULTS

There are 5 datasets used for classification in this section. These datasets are XOR, heart, balloon, iris, and breast cancer, obtained from the University of California at Irvine (UCI) Machine Learning Repository. The modified SMO algorithm is compared with BBO, PSO, ES, SVM (Hsu, Chang & Lin, 2008), and KNN on these datasets.

The parameters for the execution of BBO, PSO, ES, and SMO are the range of lower and upper boundary is defined in [-10, 10]. The population sizes, a total number of iterations are 200, and 300 respectively. The number of independent execution is defined 10 owing to the stochastic nature of algorithm where the SVM and KNN also have executed 10 times independently to record the average which is Average (MEAN), and standard deviation (STD) to determine the dispersion of results.

4.1. DATA

In this subsection, we detail the different data to handle in the experimentation part. These datasets were retrieved on UCI Machine Learning Repository, and Table 1 completes the other dataset information.

Table 1. Datasets parameters.

Classification datasets	Number of attributes	Number of instances	Number of class
XOR	3	8	2
Balloon	4	16	2
Iris	4	150	3
Breast Cancer	10	599	2
Heart	22	80	2

4.1.1. XOR DATASET CLASSIFICATION PROBLEM

This dataset represents a well-known nonlinear problem, which is the XOR. This XOR has N-bit takes bits and works like this: The XOR result of the input vector must be returned, if the input vector contains an odd number of "1", the output is "1", and if the input vector contains an even number of "1's", the output is "0". In this paper, the XOR 3-bits are used.

4.1.2. BALLOON DATASET CLASSIFICATION PROBLEM

This dataset is one of the most popular datasets in the machine learning area. This dataset makes it possible to determine the state of swelling of a balloon (yes or no). These data are used in cognitive psychology experiments on 4 attributes that are: color, size, action and age.

4.1.3. IRIS DATASET CLASSIFICATION PROBLEM

Iris is a famous dataset introduced in 1936 by Ronald Aylmer Fisher as an example of discriminant analysis and classification. This dataset contains 150 examples of criteria observed on 3 different species of iris (Setosa, Versicolor, Verginica). Each example is composed of four attributes (length and width of the sepals in cm, length and width of the petals in cm) and a class (the species).

4.1.4. CANCER DATASET CLASSIFICATION PROBLEM

Dr William H. Wolbergby of the University of Wisconsin's hospitals, Madison, has collected samples on breast cancer reporting his clinical cases to make a dataset. This dataset contains 10 attributes including Sample code number, Clump Thickness, Uniformity of Cell Size, Uniformity of Cell Shape, Marginal Adhesion, Single Epithelial Cell Size, Bare Nuclei, Bland Chromatin, Normal Nucleoli and Mitoses. And the output (class) is 2 for benign cancers and 4 for malignant cancers.

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4.1.5. HEART DATASET CLASSIFICATION PROBLEM

The dataset on cardiac single proton emission tomography (SPECT) images, each patient categorized into two categories: normal and abnormal. This dataset contains 267 sets of images SPECT (patients) has been processed to extract the features that summarize the original SPECT images. As a result, 44 continuous characteristic patterns were created for each patient. The model was then processed to obtain 22 binary characteristic models and it is the latter one that we will use in this paper, with 80 instances in the training set.

4.2. RESULTS AND DISCUSS

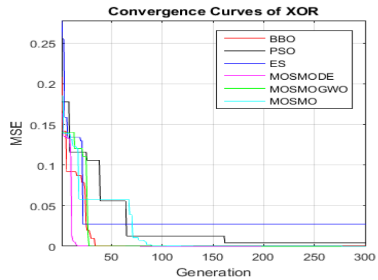
The results show that for all datasets evolutionary algorithms are better than machine learning classical algorithms. In this paper, we use the average (MEAN) and standard deviation (STD) matrices to analyze the performance of the algorithm in 10 independent runs.

Table 2. Results of different algorithms on XOR, Baloon, Iris, Cancer, and Heart datasets.

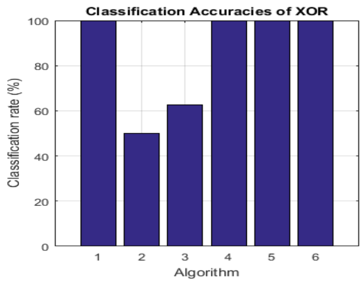
ALGORITHMS	METRICS	DATASETS				
		XOR	*BALLOON*	*IRIS*	*CANCER*	*HEART*
BBO	MEAN	1.11E-08	2.16E-35	**1.78E-02**	1.39E-03	6.41E-02
	STD	0.00E+00	2.82E-51	**3.47E-18**	**2.29E-19**	**1.39E-17**
ES	MEAN	6.36E-02	1.58E-03	3.00E-01	3.80E-02	1.83E-01
	STD	3.65E-02	2.94E-03	6.36E-02	1.59E-03	8.41E-03
SMO	MEAN	1.60E-05	2.19E-08	6.68E-01	1.92E-03	6.68E-01
	STD	1.74E-05	6.94E-08	1.48E-03	2.28E-03	1.48E-03
SMO-DE	MEAN	**0.00E+00**	**0.00E+00**	6.67E-01	**9.53E-04**	**5.53E-02**
	STD	**0.00E+00**	**0.00E+00**	1.38E-06	8.75E-05	1.65E-02
SMO-GWO	MEAN	7.96E-06	2.24E-24	6.84E-02	1.13E-03	6.84E-02
	STD	1.29E-05	7.07E-24	8.06E-03	9.02E-05	8.06E-03
PSO	MEAN	2.72E-02	2.57E-05	2.19E-01	2.85E-02	1.86E-01
	STD	1.97E-02	4.97E-05	2.20E-02	3.85E-03	1.03E-02
SVM	MEAN	2.50E-02	1.00E+00	9.65E-01	9.65E-01	7.01E-01
	STD	7.50E-02	0.00E+00	7.21E-03	3.30E-03	1.93E-02
KNN	MEAN	3.75E-01	9.80E-01	9.40E-01	9.67E-01	3.98E-01
	STD	0.00E+00	3.32E-02	8.38E-03	1.43E-03	2.95E-02
LR	MEAN	2.50E-02	1.00E+00	4.98E-03	9.55E-01	5.98E-01
	STD	7.50E-02	0.00E+00	6.21E-03	4.42E-03	3.47E-02

According to those metrics the proposed algorithm gives best results for all datasets. Thus we can see that for XOR and Balloon datasets SMO-DE gives the best result. Afterwards for IRIS dataset BBO algorithm is the best. In addition, for CANCER and HEART datasets the average (MEAN) over 10 runs the SMO-DE algorithm is better.

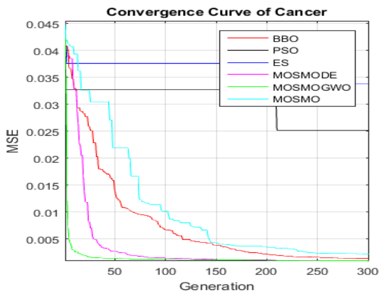
In Figure 1, the convergence curve and classification accuracy of XOR, Cancer, and Heart datasets are depicted. The SVM, KNN, and LR are excluded from the graphical representation. In the figure the X-axis of classification accuracy graph has mentioned like 1 for BBO, 2- PSO, 3- ES, 4-MOSMODE, 5-MOSMOGWO, and 6- MOSMO. The convergence curves in (A1) and the classification accuracy in (A2) on XOR dataset except PSO and ES other algorithms are performing well. In that, the convergence speed in (A1) of MOSMODE is faster than others. However, (B1) is showing that the speed of MOSMOGWO is better than others but from (B2), the classification accuracy of MOSMODE is better. Similarly, C1, is showing better convergence speed of MOSMODE while C2 is showing the similar classification accuracy rate as MOSMO algorithm.



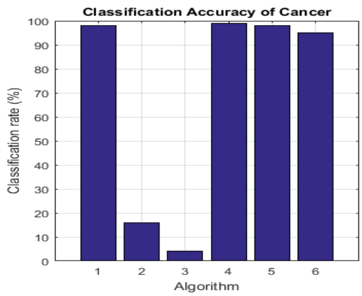
(A1)



(A2)



(B1)



(B2)

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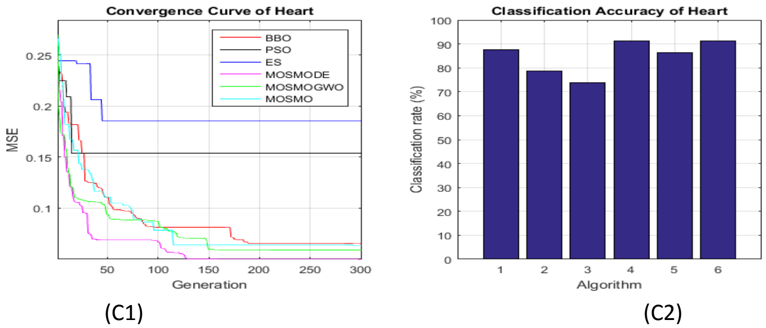

Figure 1. Convergence curve and Classification rate of different datasets.

5. CONCLUSION

From overall results, the performance of the proposed algorithm is better than other competitive algorithms. The results on XOR, and Baloon datasets the performance of SMO-DE is best while on Iris dataset it is very competitive. There are two other datasets Such as Breast cancer, and Heart the average of SMO-DE is better. Also, the proposed algorithm is more competitive than machine learning classical algorithms, for example, KNN, SVM and LR shown in Table 2.

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/8/

IMPLEMENTATION & PERFORMANCE ANALYSIS OF BIDIRECTIONAL FSO CHANNEL IN HYBRID TDM/WDM GIGABIT PASSIVE OPTICAL NETWORK

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ABSTRACT

In this paper, experimental work is performed on hybrid TDM/WDM Gigabit Passive Optical Network by replacing the last mile optical fiber with Free Space Optical channel. A Hybrid GPON system is a more intelligent choice of today's passive optical networks because it provides benefits of both TDM as well as WDM technologies at Giga b/s. And the use of Free Space Optical channel will bring the last mile network to its peak performance. This paper demonstrates the performance of hybrid TDM/WDM GPON system utilizing FSO channel in terms of Quality of factor and Bit error rate along with eye diagrams. This system is a full bidirectional system working on 2.5Gb/s downstream and 1.244Gb/s upstream transmission. The system is using varying lengths of FSO channel to analyze the GPON network performance. The simulation results using Optisystem v.15 verify the fully functional bidirectional transmission of FSO link between OLT and ONU and achieve BER of the order of 10^{-16} and 10^{-12} at a distance of 100 m for both upstream and downstream respectively.

KEYWORDS

Passive Optical Networks, Hybrid TDM/WDM GPON, Free Space Optics, Optisystem.

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1. INTRODUCTION

The growth of sophisticated and intelligent devices which brings the need of virtually always stay connected with anything and everything we can think of is creating a demand of high data rates which could support the triple play. So there is a massive deployment of FTTH (Fiber –To–The –Home) to serve more number of users with increased bandwidth (Kaur, Kaur & Singh, 2017). Passive Optical Network (PON) architecture is adopted across the globe in order to provide higher bandwidth support (Ahsan, Lee, Newaz & Asif, 2011). More specifically, the Gigabit PON or GPON provide a powerful point–to multipoint solution to satisfy the increasing capacity demand in the access part of the communication infrastructure, between service provider central office (CO) and a number of Optical Network Units (ONUs) at the consumer premises (Skubic, Chen, Ahmed, Wosinska & Mukherjee, 2009).The hybrid GPON is a hybrid passive optical network, where WDM–GPON and TDM–GPON are integrated into a single passive optical network (Liu, Zhang & Li, 2011). Hybrid TDM/WDM means for downstream we are using wavelength division multiplexing only and in the upstream we are using Wavelength Division along with Time Division so that multiple Optical Network Units (ONUs) which are using the same wavelength do not send overlapping data. At the user end the deployment of Free Space Optical (FSO) channel instead of Optical fiber is the main focus of this work. FSO can be considered as an alternative to the Optical Fiber cable or RF/Microwave systems especially when the physical connections are impractical due to several considerations and it has become the ideal choice for the access technology (Memon, Umrani, Unar, Shah & Chowdhry, 2018).

Pla (2011) has worked on the TDM/WDM GPON utilizing a 2.5Gbps rate for downstream and 1.244GBps rate for upstream communication. The author has taken five areas and the system is completely optical fiber based. The main bidirectional optical fiber connecting the Optical Line Terminal (OLT) to Optical Distribution Network (ODN) is of 5Km in length. At the access network side the lengths of bidirectional optical fiber in each area are different depending upon the requirements of that area. In this work, we are implementing the FSO channel at the ODN/ONU side. The main backbone fiber cable has a length of 50Km. and two different areas are simulated namely hospital block and building block. Each block has an FSO channel for upstream and downstream. The FSO channel length is one of the major issues which can impact the performance of the system. So the objective of this work is to take five different ranges, from 50m to 250m and analyze the system performance. Considering the tropical environment such as of Pakistan, this system is going to provide performance in terms of Q factor and BER along with eye diagrams.

The remaining sections are organized as follows. In section II system architecture is discussed highlighting separately the downstream and upstream components, its communication system and parameters. Section III discusses the experimental results and gives the performance analysis in the form of eye diagrams, Quality of factor and BER with respect to the multiple ranges of FSO channel. Section IV concludes the paper. This is followed by section V and VI for acknowledgement and references.

2. SYSTEM ARCHITECTURE

Figure 1 shows the complete system design of a hybrid TDM/WDM GPON. For understanding, first the downstream connectivity is explained which is from OLT to ONUs and then upstream connectivity is explained i–e from ONUs to OLT. As seen in Figure 1 the system comprises of three main sections, first is OLT, followed by backbone channel and finally the Access network. The bit rate used in this system is 2.5Gbps. The system is based on two areas namely Hospital block and Building block. Therefore, two wavelengths will be used.

2.1. DOWNSTREAM ARCHITECTURE

Referring to Figure 1, the Optical Line Terminal (OLT) consist of WDM Transmitter that can provide multiple wavelengths. These wavelengths are multiplexed by WDM multiplexer. We are using 2 different wavelengths $\lambda1=$ 1450nm and $\lambda2=$1470nm with frequency spacing of 20nm. The extinction

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ratio is set on 10dB. WDM Mux is required to combine the wavelengths to be transmitted on a single fiber. The WDM mux has a bandwidth of 80nm with an insertion loss of 2dB. To ensure a good quality signal transmission an optical amplifier with a 15dB gain is also used. A Bidirectional circulator is used to transmit downstream data to the ONUs and to receive upstream traffic from the ONUs. The downstream optical signal is passed through the main backbone channel which is a bidirectional optical fiber having a length of 50Km. Table 1 gives the parameters of bidirectional optical fiber.

Next comes the access network / (ODN) which comprises of a splitter and two units namely hospital and buildings blocks. The first branch of the splitter is connected to hospital block and the second is connected with the building block.

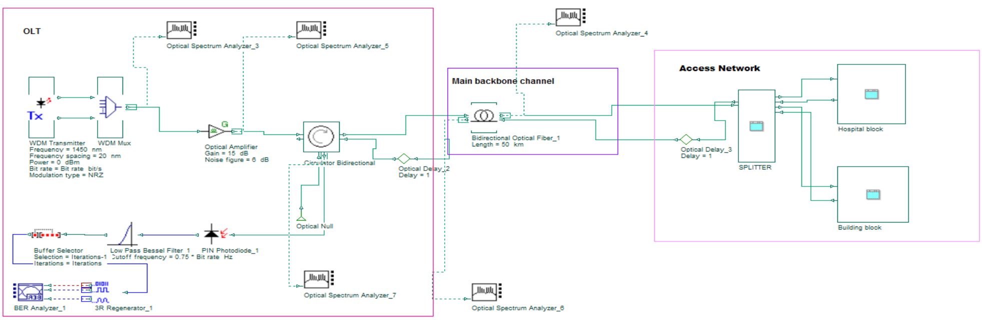

Figure 1. TDM/WDM GPON complete design.

Table 1. Parameters of Bidirectional Optical Fiber.

Parameters	Value
Reference wavelength	1450nm
Length	50km
Attenuation	0.2dB/km
Dispersion	16.75ps/nm/km
Dispersion slope	0.075ps/nm^2/km
Effective area	80um^2

Figure 2 shows the hospital block, which contains the FSO channel for downstream. The FSO channel parameters are given in Table 2. The length of the FSO varies from 50m to 250m. This channel is connected to the ONU of hospital block (figure 3) where downstream data is detected by PIN photodetector which will transform the optical signal into electrical. This output is connected to a Low pass Bessel filter and finally to a 3R generator which is connected to the BER analyzer for detecting the performance in terms of Q factor, eye diagram etc. The other part of ONU is discussed in upstream architecture.

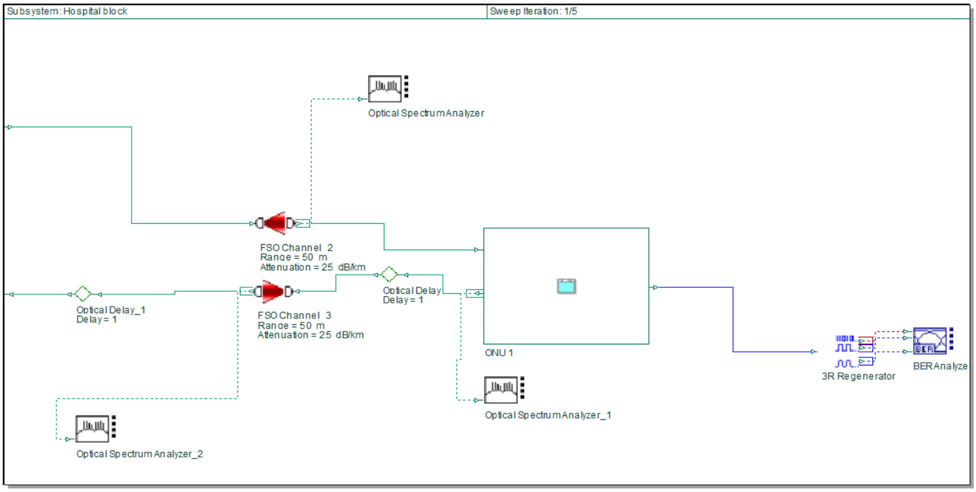

Figure 2. Hospital Block.

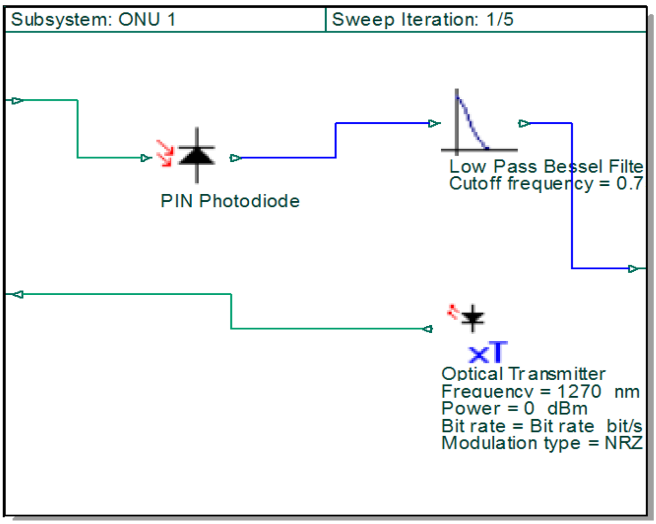

Figure 3. ONU for hospital block.

Table 2. FSO channel parameters.

Parameter	Value
Range	50 to 250m
Attenuation	25dB/km
Transmitter aperture diameter	5cm

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Parameter	Value
Beam divergence	2mrad
Receiver aperture diameter	20cm

The second branch of the splitter is connected to Building block which is shown in Figure 4. This block contains two sections of buildings and both will receive λ2=1470nm.

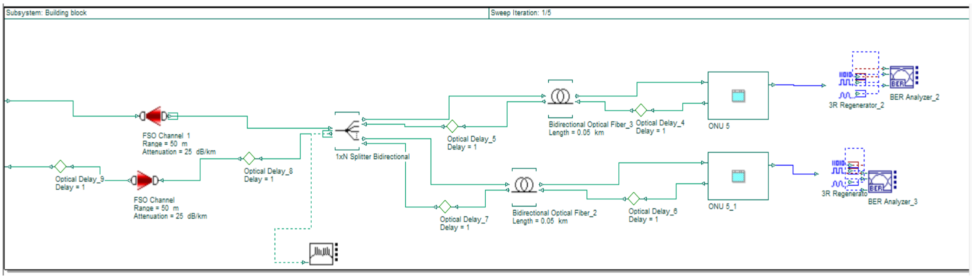

Figure 4. Building block.

In Figure 5 it is shown that FSO channel is used for downstream as well as for upstream, and its output is again connected to a 1:2 splitter because there are two ONUs or two sections of the building each receiving the same wavelength in the downstream. Inside the building unit, there is again a 50m bidirectional optical fiber which is used control both upstream and downstream data from both ONUs. The ONU structure is shown in Figure 5.

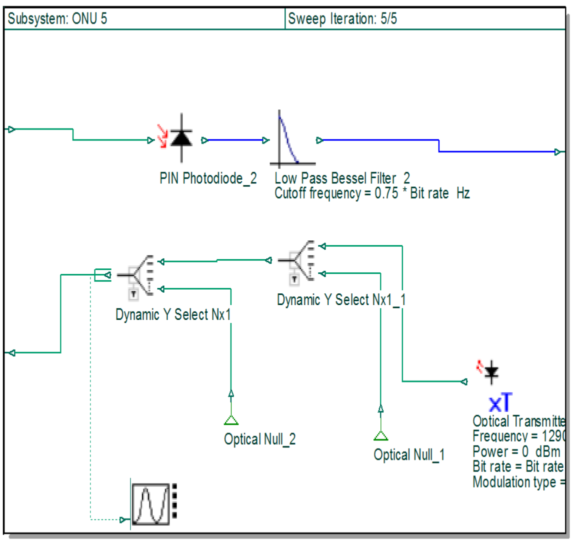

Figure 5. ONU for building block.

Figure 5 also contains the same detection mechanism i–e PIN photodetector which is connected to loss pass Bessel filter that is connected to the 3R generator and BER analyzer. The other part is upstream which is discussed in the upstream architecture.

2.2. UPSTREAM ARCHITECTURE

In the upstream direction, the optical signal will travel from each end user (ONU) to the OLT, Pla (2011). So now the OLT is the receiver and each ONU will work as a transmitter. Refer to Figure 3 for ONU of the hospital block. Here there is only one ONU, the optical transmitter will transmit at 1270nm with the power of 0dB. This data will be sent to the OLT via FSO channel having the same parameters as shown in Table 2. The output of this FSO is connected to the splitter which is now working as a multiplexer. This splitter output is connected to the backbone bidirectional optical fiber which will send the upstream data to the OLT. In the OLT the circulator is bidirectional hence the upstream data will be received separately in the OLT via PIN photodetector, LP filter, buffer selector, 3R generator and finally BER analyzer.

In Figure 4 there are two sections for building block hence both will share the same wavelength 1290nm. In this case, we can utilize the benefit of TDMA by allotting a specific time slot to each ONU so that the data don't get overlapped. Therefore as shown in Figure 5 the ONU of building block contains an optical transmitter whose output is connected to dynamic y select which will allow the ONU to send its data in its specific time duration. The output of the dynamic y select is connected to other devices which are already explained and are shown in Figure 4.

3. EXPERIMENTAL RESULTS

With the above explanation of complete system architecture, the experimental results are discussed here. The results are in shape of Eye diagrams, Max. Q factor, Min. BER with respect to the range of FSO channel. Therefore in this section, we determine the feasibility of the FSO channel in the last mile network.

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3.1. DOWNSTREAM PERFORMANCE ANALYSIS

In the case of ONU for hospital block, Figure 6 shows the eye diagram results when the FSO channel range is 50m and 100m. After 100m the eye diagram degrades significantly. Table 3 gives the BER analyzer values for hospital block which clearly shows that FSO channel is giving its peak performance from 50 to 100m range. Figure 7 and 8 shows the Min. log of BER and Q factor with respect to the FSO channel range and it shows that after 100m the BER and Q factor shows poor performance and hence FSO channel is best suited for range from 50 to 100m.

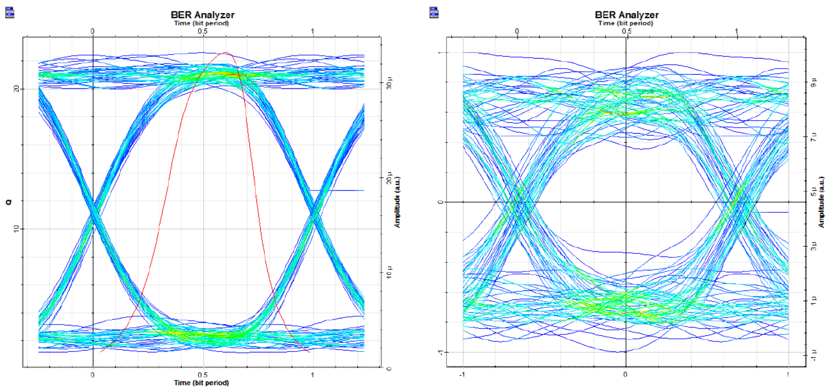

Figure 6. Downstream for Hospital block FSO channel range 50m and 100m.

Table 3. Hospital block BER analyzer values.

Range (m)	Max. Q Factor	Min. BER	Min. log of BER
50	22.58	3.40298e–113	–112.468
100	6.2209	2.46883e–010	–9.60751
150	2.14274	0.0159928	–1.79608
200	0	1	0
250	0	1	0

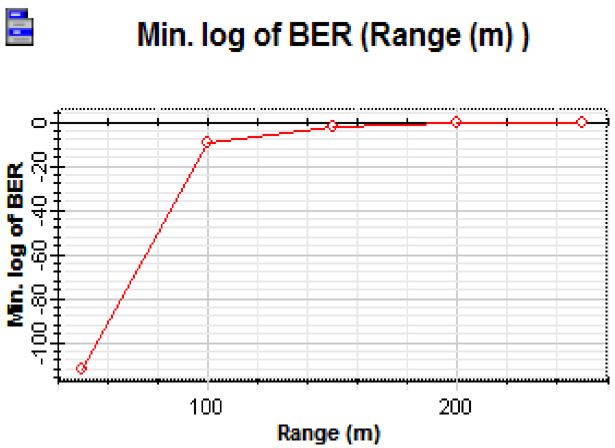

Figure 7. Min. log of BER Vs FSO channel range for hospital block.

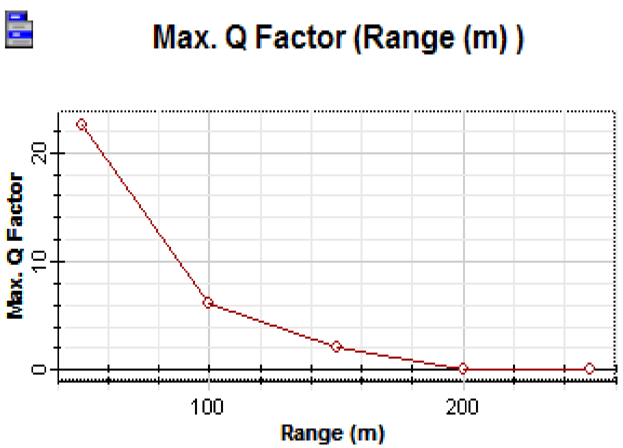

Figure 8. Max. Q Factor Vs FSO channel range for Hospital block.

For the Building block the eye diagrams are shown in Figure 9 and they appear nearly the same as for hospital block hence all other graphs are deliberately not shown for simplicity because both the blocks at the ONU side are providing similar performance for FSO channel range from 50 to 100m. Table 4 is giving the BER analyzer values for both building sections hence validating this point.

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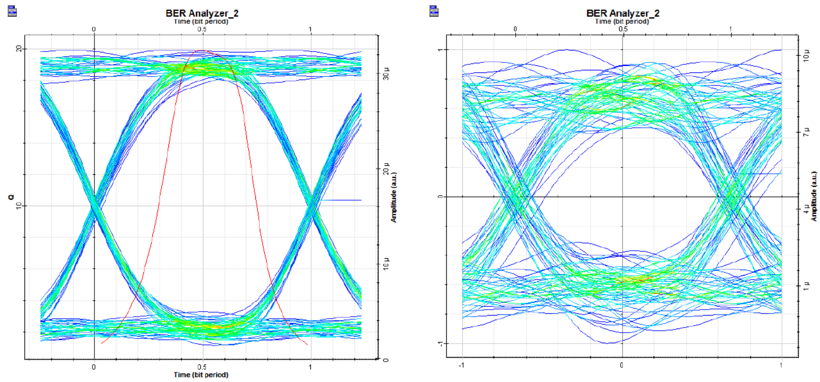

Figure 9. Downstream for Building block FSO channel range 50m and 100m.

Table 4. Building block BER analyzers values.

Range (m) of FSO channel	BER analyzer_2			BER analyzer_3		
	Max. Q Factor	Min. BER	Min. log of BER	Max. Q Factor	Min. BER	Min. log of BER
50	19.913	1.56954e–088	–87.8042	21.4066	5.78105e–102	–101.238
100	5.47108	2.2316e–008	–7.65138	5.57135	1.2635e–008	–7.89842
150	2.39446	0.00831056	–2.08037	2.67231	0.00376535	–2.42419
200	0	1	0	0	1	0
250	0	1	0	0	1	0

Also, Figure 10 shows the cumulative response of Q factor with respect to the range of the FSO channel used building block. Note that the quality of signal drops from 150m to onwards.

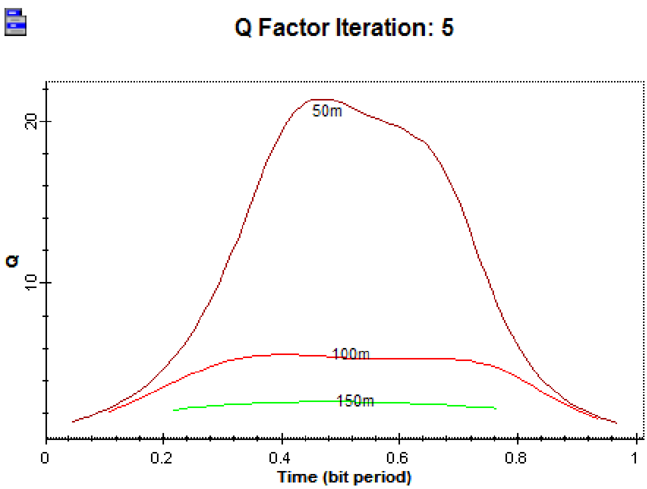

Figure 10. Cumulative response of Q factor in building block w.r.t FSO channel range.

Finally, Figure 11 shows the min. log of BER vs total power in dBm comparison of all users.

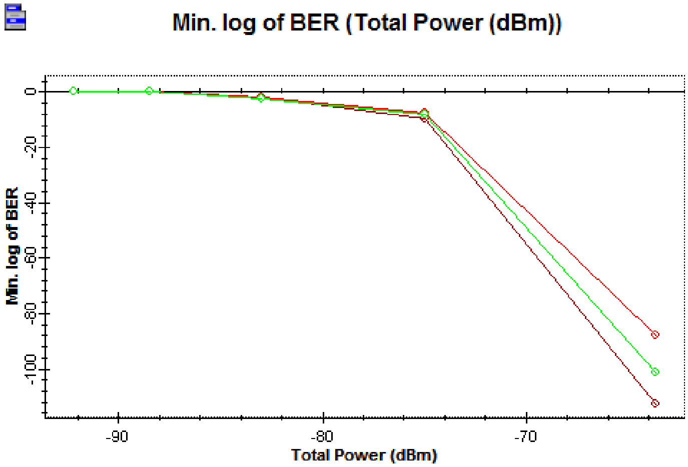

Figure 11. Min. log of BER vs Total power for all users.

3.2. UPSTREAM PERFORMANCE ANALYSIS

In the case of upstream communication, the OLT becomes receiver as shown in Figure 1. Hence the results are shown in Figure 12 where eye diagrams for upstream FSO channel range 50m and 150m is shown. It is to note here that in the upstream the eye–opening at the 150m range is a little bit better as compared to the transmission in downstream. But the peak performance is still from 50 to 100m.

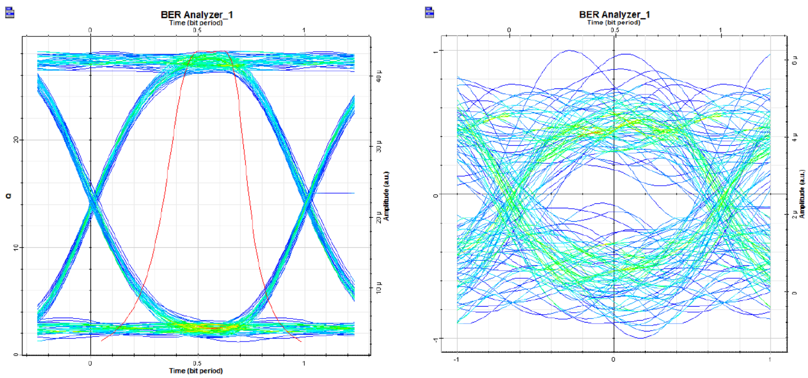

Figure 12. Eye diagrams for upstream FSO channel 50m and 150m.

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Table 5 gives the complete set of BER analyzer values for upstream communication, showing the ideal performance is up to 100m range. Figure 13 gives the graph of min log of BER at the OLT side for upstream at different ranges of FSO channel. Note that at 50m the BER produces peak performance as at this point the BER achieved is 5.75 x10–176. At 100m the BER value is 4.91x10–16 and after that BER degrades significantly.

Table 5. BER analyzer values for upstream.

Range (m)	Max. Q Factor	Min. BER	Min. log of BER
50	28.2572	5.75632e–176	–175.24
100	8.02883	4.91682e–016	–15.3083
150	3.14412	0.000830138	–3.08085
200	0	1	0
250	0	1	0

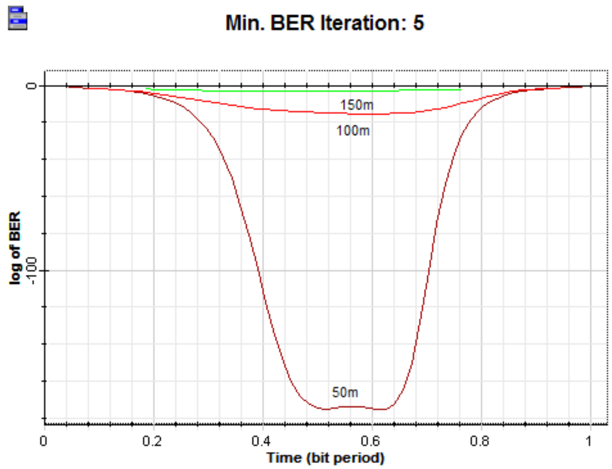

Figure 13. Min. log of BER at the OLT side for upstream at different ranges of FSO channel.

4. CONCLUSION

With the above discussion and results it can be concluded here that bidirectional free–space optical channels are providing good quality data transmission in hybrid TDM/WDM GPON system at the range from 50m to 100m. BER of the order of 10^{-16} and 10^{-12} at a distance of 100 m for both upstream and downstream is achieved which means it can be practically implemented. But if the range is greater than 100m the system performance deteriorates significantly. Therefore careful considerations must be taken while installing the FSO channel.

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DECENTRALIZED APPROACH TO SECURE IOT BASED NETWORKS USING BLOCKCHAIN TECHNOLOGY

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ABSTRACT

Emerging Technologies of Fourth Industrial Revolution such as Internet of Things has the potential to change the way we are living today and interact with information systems and devices. From a small device like a simple glucose monitor of healthcare sector to Autonomous cars from transportation industry, IoT plays a vital role in connected information, human interaction and data. At the same instance, IoT deals with personalized human and quite important data from various types of devices, a small loophole can be a reason to bring disastrous impact on human lives, a minor vulnerability in IoT networks may challenge the complete cycle of IoT network. It may generate calamity type of event, not only in information systems but also on the physical human lives as well, because of a single point of failure as IoT based networks usually deployed on centralized systems. In this paper, we are proposing a decentralized approach to remove single point of failure with the help of new layer of security based on Blockchain technology as advancement in securing IoT networks.

KEYWORDS

Internet of Things, Decentralized Network of IoT, IoT Security, Convergence of IoT & Blockchain, IoT Data Security and Privacy, IoT Authentication, IoT Network Distribution.

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1. INTRODUCTION

1.1. INTERNET OF THINGS (IOT)

The concept of IoT came into existence in 1980's but in 1990's this concept become talk of the town (Farooq, *et al.*, 2015). Internet of Things evolved rapidly with the advancement in many related industries (Brody & Pureswaran, 2014). Through Internet of things we can reshape our standards of living, because of its important role in everyday life like in medical science, home appliances automation, transport management system (Farooq, *et al.*, 2015). The research conducted by Federal Trade Commission (TFC), the ratio between number of IoT devices and number of people has increased tremendously (Alphand, *et al.*, 2018). It is also stated that wireless device which will be connected to Internet of Thing will approximately reach the count of above 26 billion by the end of 2020, this number will exceed the devices worked as hub (Dorri, *et al.*, 2017).

The state of the art nature of the IoT services are based on the usage and combination of different data extracted from various heterogeneous devices. (Axon, 2015). IoT application system is multi farious because of its capability to: sense and extract information from environment, collect data operated by machines, classify humans, animals, information and other ongoing happenings (Brody & Pureswaran, 2014).

Figure 1. Block Diagram of Internet of Thing.

IoT also has ability to convert data into programmed instructions that "feedback through the communication networks to other things with actuating capabilities". The ability of conversion eliminates the need of human interference at every state of computation. Due to the extension in the internet boundary which now focuses on the connectivity of traditional computing devices as well as nontraditional devices, this fills the gap of connecting real and virtual world more tightly (Bahga & Madisetti, 2016). On the other hand, the Internet of Things model has diversity and complexity which brings the challenges like security, naming, privacy, mobility etc. Through studying the management and security aspect of IoT we will grasp the distinctive and innovative nature of IoT (Farooq, *et al.*, 2015). There also rises the need to cope the count of connected devices and generating large traffic. New solutions were proposed to overcome mentioned challenges.

1.2. BLOCKCHAIN

A Blockchain consists of records arranged in crypt graphical joined list that maintains a publicly empirical ledger which doesn't require a centralized authority; intrinsically, it's a replacement paradigm of assurance between units in varied application domains (Hammi, *et al.*, 2018). It consists of blocks of information in a chain like structure that automatically update whenever a new block is attached. The Blockchain utilizes "elliptic bend cryptography (ECC)" and "SHA–256 hashing" to give solid cryptographic confirmation to information verification and honesty (Xu, *et al.*, 2018). The Historically Blockchain has all things worldwide–dispersed trust. Confided in Third Parties or unified specialists and administrations can be upset, bargained or hacked. They can likewise get rowdy and wind up degenerate later on, regardless of whether they are reliable at this point. Each transaction of Blockchain's shared public ledger is checked by a majority consent of the mining nodes who are actively involved in transaction verification and validation. Blockchain initially is the technology originated from cryptocurrency, while their progress in existing architectures has led researchers to use them in areas that rank security. The advantages of new structure are localized nature, inherent darkness, resilience, security, security, autonomy (Khan, 2018).

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1.3. CHARACTERISTICS OF BLOCKCHAIN

The different factors involved in making Blockchain a promising Technology are described below.

Table 1. Characteristics of Blockchain.

Decentralization	In centralized transaction processing environment, each transaction needs to be validated through the centralized trusted party (e.g., banking system), that resulting to the cost and the performance decrees at the central point. With respect to the centralized IOT model, third party is no longer needed in Blockchain. Consensus algorithms in Blockchain are used to maintain data integrity and consistency (Qian, *et al.*, 2018).
Persistency	Once a transaction record is validated by a miner node (special nodes that validate the transaction) in a Blockchain network its copy is broadcasted on the entire network and that record is not deleted or rolled back from entire Blockchain (Christidis & Devetsikiotis, 2014).
Anonymity	In Blockchain nodes interact with the network using public key that use to addresses the node on entire Blockchain network but not acknowledge the real identities of the user (Xu, *et al.*, 2018).
Security	Blockchain use the asymmetric cryptographic technique to secure the entire network. Asymmetric or public key cryptography contain 2 keys one public key and second private key. Public key is used by the node to addresses in Blockchain network and private key is use by the node to signs the transaction that it initiates. Other nodes use their public key and compare it after hashing to their signature for checking the initiator node identification (Banerjee, *et al.*, 2018).
Scalability	Blockchain address space consists of 160–bit on the other hand IPv6 address space contains 128–bits, A Blockchain address is 20 bytes or 160–bit hash of the general public key generated by ECDSA (Elliptic Curve Digital Signature Algorithm). Blockchain have 4.3 billion more Addresses over IPv6 (Otte, *et al.*, 2017).
Resilient backend	Every distributed node within the Blockchain IOT network maintains a replica of the whole ledger. This helps in safeguarding the network form any potential failures and attacks (Ouaddah, *et al.*, 2016).
High efficiency	Since the transaction removes the involvement of the third party and may proceed in Low–trust condition, the number of your time spent is obviously decrees whereas the efficiency is clearly increases (Qian, *et al.*, 2018).
Transparency	Changes made to public Blockchain network are publicly viewable by all participants in the network. Moreover, all transactions are immutable, meaning they cannot be altered or deleted (Otte, *et al.*, 2017).

2. LITERATURE REVIEW

2.1. INTERNET OF THINGS ARCHITECTURE

Two word, "Internet" & "Things" composed idea of IoT (Bahga & Madisetti, 2016). But putting these words together gives an idea of a huge network connected with different types of objects, addressed uniquely and established on standard communication protocols (Zhang & Wen, 2015).

A normal IoT system include diversified devices with built–in sensors interconnected through a system (Zyskind, *et al.*, 2015). The devices in IoT are particularly recognizable and are for the most part portrayed by low power, little memory and restricted preparing ability (Di Pietro, *et al.*, 2018, June). The passages are conveyed to associate IoT gadgets to the outside world for remote arrangement of information and administrations to IoT clients (Wörner & Bomhard, 2014). Its architecture based on layers, every layer has different functions. IoT mainly operates on three layered structure according to many researchers (Hammi, *et al.*, 2018). The IoT layers include Perception Layer, Network Layer, and Application Layer (Kouzinopoulos, *et al.*, 2018).

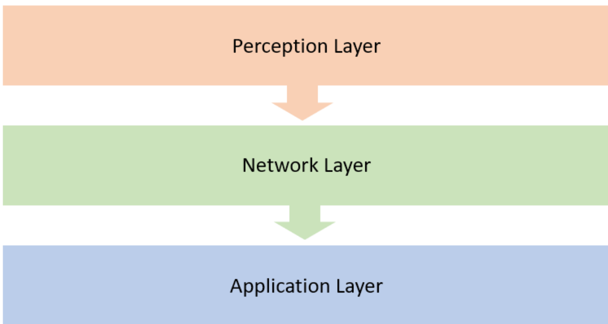

Figure 2. Layers of IoT.

Architecture Layers	Description
Perception Layer	It is also to be known as "Sensors" layer. With the assistance of actuators & sensors. It accumulates information from the surroundings. It transmits gathered and processed data to the network layer (Hammi, *et al.*, 2018).
Network Layer	The motivation behind this level is to forward the data received from the observation level to a frame of explicit logical order through existing correspondence systems such as the web, the mobile network or the other very solid system (Christidis & Devetsikiotis, 2014).
Application layer	This layer is the most surprising and most terminal layer. The application level affects organizations modified according to the client's prerequisites. With the application of television, PC or compact equipment, etc. The purpose of this level is to transfer the collected information from the perceptual level to explicit information, taking care of the structure through existing correspondence structures, such as the Internet, the mobile network or some other type of reliable structure (Mahmoud, *et al.*, 2015).

Table 2. IoT Layer based Architecture.

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2.2. DECENTRALIZED NETWORKS

Many questions above are easy to address through a decentralized approach in IoT networks by adopting P2P communication in a standardized way (Farooq, *et al.*, 2015). This decentralized model in IoT will be able to process many transactions, up to billions between interconnected devices of IoT networks (Khan & Salah, 2018). It dramatically reduces the cost of installation and maintenance of centralized data centers (Di Pietro, *et al.*, 2018). Decentralized practically divide the overall computations and storage across connected devices across IoT networks (Brody & Pureswaran, 2014). Failure of a single node still prevent or halt the whole network (Ouaddah, *et al.*, 2016). P2P approach has its own challenges and measures of security (Conoscenti, *et al.*, 2016). IoT security is not only about securing data but providing security for the data belongs to a very personalized form (Di Pietro, *et al.*, 2018). The solution we are proposing have to support the security of that type of network dealing with thousands of nodes and billions of devices, privacy is also be equally entertained, additionally, the consensus among network participants are required to deal with data theft and spoofing (Antonopoulos, 2014). To achieve the characteristics and functionalities of seasoned IoT systems without a single point failure and centralized control, P2P messaging, distributed environment and automated coordination among devices are required (Kouzinopoulos, *et al.*, 2018).

2.3. BLOCKCHAIN ARCHITECTURE

IoT can also be made secure by the emerging technology known as Blockchain. The Blockchain technology transform the traditional mechanism of management and securing the operation technology. Because the device, sensor and controller are not changeable when in usage (Yousuf, *et al.*, 2015). With known vulnerabilities of securities as well it is not possible to fix the problem of avoid the problem because the problem may occur somewhere else in the system (Dorri, *et al.*, 2017). As described by researchers the Cloud Computing shows may failure when it operates on very large amount of data. It is very difficult to tackle data of large scale that are fragile and not resilient to failure – "as is the case with many current industrial IoT and OT systems" (Friese, *et al.*, 2010). This problem can be solved by allowing the constant arrangement of updating software, as well as Blockchain technology after devices have been deployed, with little or no downtime through an over–the–air update system (Dorri, *et al.*, 2017). Using this solution system will be available to the network most of the time (Banerjee, *et al.*, 2018). "Therefore, a cost and operationally efficient way of providing over–the–air updates and patching to IoT devices and sensors would greatly benefit the industry as a whole" (Kouzinopoulos, *et al.*, 2018).

3. THE PROBLEMS OF A CENTRALIZED IOT NETWORK

The centralized model considers as the backbone and supporting element of IoT environments. Connect and validate different types of devices by means of a group consisting of cloud–based servers, without physically connected, both devices communicate with each other over the Internet. A network is responsible for providing a domain to identify, connect and validate over cloud on the base of large storages of data centers. The maintenance cost of a centralized environment is hefty and to integrate IoT based solutions are somewhat required high–end budgets. Economic is a point need to be addressed at the designing phase before the implementation phase to understand the number of upcoming devices, the data they will share with each other and the volume of bandwidth required to support the massive network of IoT to encounter beforehand the issues may arise due to technical and non–technical ends such as scalability.

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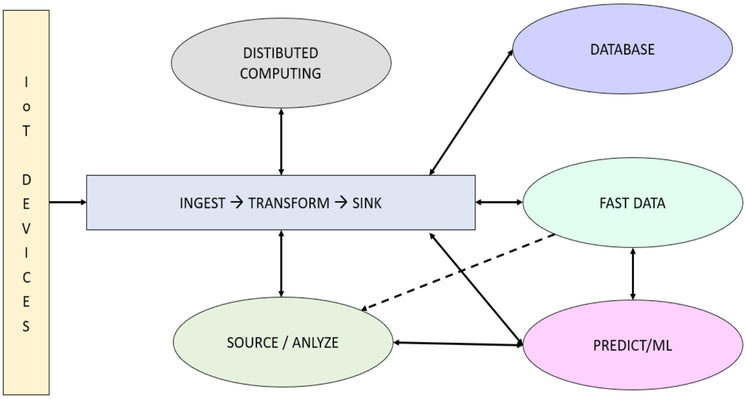

Figure 3. Centralized IoT Architecture.

The fact and attraction of IoT are whether the devices placed nearby or far from it, they are supposed to communicate over the internet using the server–client approach. A server act and privileges to each device such as identification, authentication and then allow to communicate and interact with the IoT network. Full cycle permissioned network by means of high storage data and communication processing e.g. Genetic Computing devices, which we are using for decades. As it is a generic and decade long, so is only possible to provide support for very small IoT networks, several basics and unforeseen reasons may occur when we deploy IoT networks on large scale projects such as Autonomous Cars, Smart Cities and etc. which is the growing need of tomorrow. About ultra–computation, availability of network, bandwidth and huge data storages at the time of deployment and at maintained, IoT infrastructure are high in costs. Additionally, it is also clearly explained that the cloud server's vulnerabilities and loopholes are still there, and the points discussed so far in single point failure which can fail the whole network that's the critical tasks. M2M Communications are not as easy as by definition its elaborate, there is no assurance of manufacturers about compatibility and interoperability of IoT devices, also there is not a single platform which provides a multi–manufacturer device connection hub. These are unignorably factors, which enforces us to think out of the box design and deployment strategy to maintain sustainability.

4. DEALING WITH CHALLENGES & THREATS

Accessibility can be compromised with the threats defined below:

4.1. DENIAL OF SERVICE (DOS) ATTACK

A DOS, the attacker's objective is to render the service or data unaccusable to the valid users. In the anticipated architecture, an overlay network or for a specific smart home can be attacked by sending false transactions or blocks. The effects of such an attack can however be minimized by the usage of requester and requestee PK lists in CHs. If PKs of both the requester and the requestee's of a multisig transaction are absent in these two lists, then the transaction is passed along to other CHs. A PK is blocked and remains inoperable if numerous failed access attempts are received by the CH. However, an adversary using various PKs to launch an attack can succeed.

4.2. MODIFICATION ATTACK

The assailant would have to elude the cloud storage security to launch this attack. The aim of this attack is to modify or delete the saved data of a certain user. However, by comparing hashes of the cloud data and its local BC the user would be able to realize if his data has been altered. In case of a data breach, a transaction is generated by the user that firstly references the valid multisig transaction that contains the actual hash of the data and is signed by both the user and the cloud storage and secondly it references the access transaction containing fabricated hash of the data and is signed by both the cloud storage and the user. Once various CHs receive this transaction, they authenticate the valid transactions referenced in it. If the two hashes are found inconsistent, the CH notifies its nodes of malicious activities by the cloud storage. Unfortunately, the data is unrecoverable for the user.

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4.3. DROPPING ATTACK

Initiating a dropping attack requires the assailant to take over a CH or a group of CHs. The CHs controlled by the adversary drops every single transaction and block it receives. However, such an attack would be detected by the nodes in the constituent clusters since no transactions or service would be acknowledged from the network. If such a scenario arises, all the nodes in a cluster of our suggested architecture are informed about an unresponsive CH and they elect a new CH.

5. CHALLENGES TO SECURE IOT DEPLOYMENTS

Internet of Things ecosystem is diversified, and a single deployment required multiple

roles such as manufacturers, solution providers, researchers, programmers, vendors and cloud centers (Christidis & Devetsikiotis, 2014). Together, they create an environment and give necessary support for the deployments. Each role must be aware of to get the greatest benefit from IoT technologies, which is changing and expanding rapidly.

IoT systems are all about data, the data that is highly personalized or a highly sensitive, security, data management, network management and there are many complexities are involved to handle the enormous volume of users. To transform data into actions are seemingly impossible, as a number of challenges are present at the time of deployment and maintenance. These challenges turn IoT systems towards vulnerable and risky (Ouaddah, 2016). The aim of data security is all about such system availability, security and adaptability.

6. BLOCKCHAIN TECHNOLOGY AND ITS ADVANTAGES

Blockchain technology is the cornerstone of decentralized and data handling using cryptography on the distributed ledger. Each transaction done by network nodes or peers in a sequential block–by–block way with time stamping and few headers and relevant information for the reference and retrieval purposes. No central authority or no specific users across a network may act as an administrator (Conoscenti, *et al.*, 2016). This type of network or systems never responsible for any approval of transactions, participants across network develop consensus to accept any new block into the chain. Through Blockchain, the traditional and conventional centralized system will have no future especially those systems based on escrow service or intermediaries. High security, cost reduction, immutability, time savings are firsthand benefits through Blockchain (Hammi, 2018). Blockchain is based on cryptography algorithms developed to prevent data manipulation but make sure high security. Each block has a hash of the previous block so any hacker cannot temper any block in between any two blocks. Blockchain is high immutable so it's impossible to delete or revert changes.

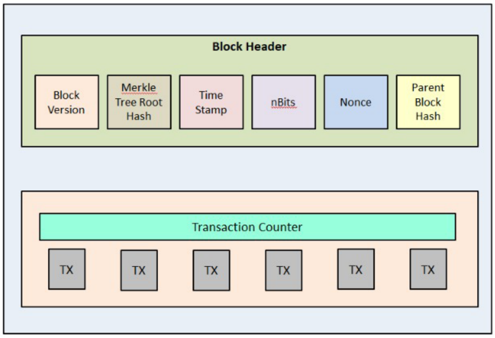

Figure 4. Blockchain Architecture.

"The Blockchain is an incorruptible digital ledger of economic transactions that can be programmed to record not just financial transactions but almost everything of value." (Farooq, *et al.*, 2015). Investments from government, public and private sectors injected and capital is rising into the global Blockchain. It is greatly predicted that many more industries and thousands of new applications will be introduced to start a new era of Blockchain technology.

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7. SECURITY NECESSITIES FOR IOT

7.1. DATA PRIVACY

It is necessary because of a diversified integration of services and network the data recorded on a device is vulnerable to attack by compromising nodes existing in associate IoT network. Moreover, attacker Access the data without owner permission.

7.2. DATA INTEGRITY

It is required in centralized client server model the attacker may gain unauthorized access to the network and change the original data or information and forward it. For example, Alice sends data to Bob. Watson the middle guy might get data first and forward the data after modification.

7.3. THIRD PARTY DATA COLLECTED

It is primary concern in centralized environment is stored and controlled by a third centralized entity that may miss use this data or provide it to someone else.

7.4. TRUSTED DATA ORIGIN

It based in IOT environment it is difficult to know generated data come from which device that is stored in the entire network and can be altered by anyone.

7.5. ACCESS CONTROL

It is one off the main issue in IoT network. To define which node have the right to access and perform different function in entire IOT network may be difficult.

7.6. SINGLE POINTS OF FAILURE

It requires for continuous growth of centralized networks for the IoT based infrastructure could expose single–points–of–failure. Because all data of entire network store and verified by a central authority. If the central point is failing or down the whole network is down.

7.7. SCALABILITY

Internet of thing connects many sensors and other devices for information sharing and a large number of applications via internet. It challenges the structure and the rapid growth of the system to meet scalability.

8. METHODOLOGY

There is an issue, presented because of the architectural model, the issue is really seasoned and traditional in centralized servers, it acts as single authority to grant access and verify the identity of all devices and entities that interact and transact on a network. One problem arises if someone would like to exploit the system, it must do the less hard job into hacking the system. Once the system is compromised, a hacker may act like existed devices and impersonate within the system to do dangerous activities. Usually, in IoT networks, the data from devices considered as highly sensitive. In IoT network single point of failure is unignorably arises because of centralized approach. It may create many loopholes and make IoT systems vulnerable to be hacked or crashed. To provide better security, privacy and scalability following factors are involved. The role of Blockchain is diversified and highly recommends being used in IoT networks by security experts. Blockchain is a problem–solving element if it revamps with IoT networks. Authentication, Distribution and Shared responsibilities are a few key benefits of Blockchain into IoT networks.

Suppose Device A, B and C would like to access IoT environment. These three devices need to interact with following three factors; Authentication, Distribution – Child Chain, Distribution – Parent Chain Thoroughly defined as Decentralized IoT Network using Blockchain Technology. The first factor "Authentication" ensure access to the system completely based on Distributed Ledger Technology (DLT) to have data security, privacy, immutability and resistance of censorship. Each device to follow criteria of DLT based encrypted Authentication. Once device granted access by Authentication factor. Blockchain is the cornerstone of the decentralized strategy. It acts as a distribution model and support two–way P2P communication. The centralized system provides a

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point, which is vulnerable and exploitable by hackers, but Blockchain gives us a unique model of authentication and distribution. This helps us to give to attacks because it is difficult to attacks hundreds and thousands of nodes at the same time. It freely entering into environment, DLT based Authentication maintains complete information of devices, such as device unique identification number and demographics related information into public ledger. It will help traceability among all participants accessed to IoT network.

When Device A would like to communicate with Device B, our architecture designed in such a way that a separate child chain will create to provide independent, on network, safe and secure P2P communication between Device A and Device B. Both devices can exchange standardized operations (hashing is simultaneously be performed) in a decentralized way. After size of Block, communication end trigger or some trigger defined already in child chain operations, generate a new Block into Parent Chain. In this way, whenever any device communication to any other device, separate child chain be created to facilitate the communication by hashing and when triggered out, the information recorded to the Parent Chain through newly generated Block.

The function of Parent Chain is to maintain record, logs, tracks, act as a Master Ledger. Web Blockchain Explorer will be provided to trace and audit the complete communication authentication pattern among the devices. These factors will help to operate and maintain Decentralized IoT Network using Blockchain Technology. Ensure better security, privacy, availability, scalability, auditing, traceability and interoperability of IoT systems. This type of architecture has an ability and feasibility to resolve many issued discussed so far in this paper. In depth study, research outcomes and simulation will be provided in the next paper.

DDoS attacks and data tampering are general issues to every other application. Because centralized systems open to many vulnerabilities itself. Single point of failure provides a chance to attackers. Blockchain is the key answer to safeguarding the systems against hackers. Authentication based in a decentralized way allows each device to find, validate and grant access to interact with IoT system.

Blockchain already proved its security, privacy and resistance against hacking and data tampering. Blockchain based decentralized authentication way of more so–called secure layer enable IoT devices to the communication directly with each other than a central point. This is the future of connected devices.

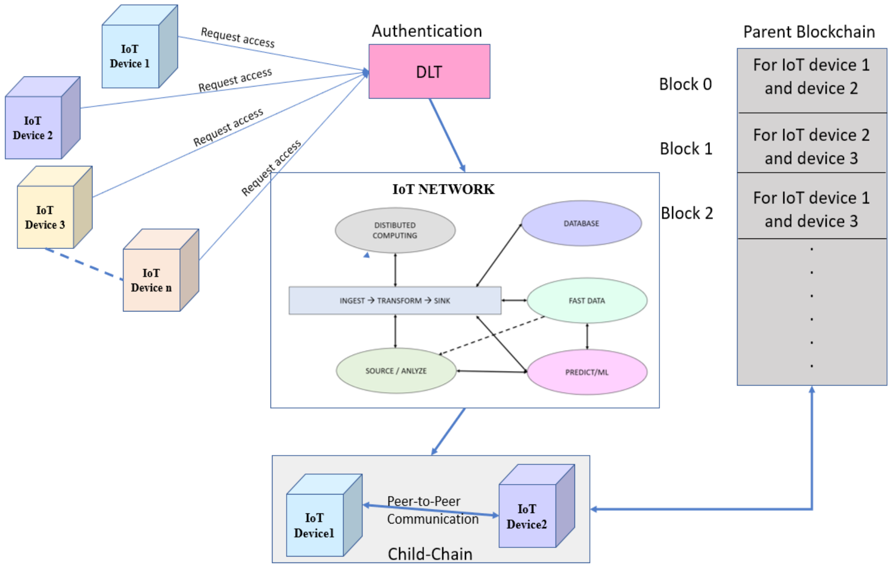

Figure 5. Proposed Blockchain based IoT Architecture.

9. CONCLUSION

Internet of Things is the key to provide us a futuristic lifestyle of automated homes and intelligent devices from transportation to healthcare industries. Even a minor vulnerability in the processing and security needs of the personalized data generated by the IoT devices can have a severe impact on human lives. In the centralized IoT networks, a single point of failure may lead to disastrous effects on information systems but can also cause catastrophic real–life incidents. In this paper, we propose to decentralize the IoT networks through Blockchain technology to overcome the susceptibilities of a centralized network. This paper reviews the literature to recognize the integral parts of IoT and Blockchain, their primary characteristics for integrating both into a solitary environment. We have examined the decentralized networks and how Blockchain will cater the

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challenges and threats for a more secure deployment of IoT networks to provide a better understanding for our readers. The proposed architecture not only provides decentralization but also improves the scalability, security, transparency, anonymity and efficiency of IoT networks. The paper ends with our complete proposed Blockchain architecture based on uniform scheme, authentication and distribution.

10. FUTURE WORK

To check and ensure the impact and quality assurance in lieu of security, privacy, scalability, feasibility, storage and interoperability, Hyperledger Fabric and Swath will be used for Authentication and Distributing factors. Provided a Blockchain explorer to track parent chain. Sort of simulation will be presented in a detail manner to determine the contrast and possible outcomes from this scheme. However, conventional model of IoT – M2M data transportation remain unchanged. Main objective will be practically making possible of additional layer of security using a new scheme of authentication and distribution on top of Blockchain and Distributed Ledger.

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DATA PREPROCESSING: A PRELIMINARY STEP FOR WEB DATA MINING

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ABSTRACT

In recent years immense growth of data i.e. big data is observed resulting in a brighter and more optimized future. Big Data demands large computational infrastructure with high–performance processing capabilities. Preparing big data for mining and analysis is a challenging task and requires data to be preprocessed to improve the quality of raw data. The data instance representation and quality are foremost. Data preprocessing is preliminary data mining practice in which raw data is transformed into a format suitable for another processing procedure. Data preprocessing improves the data quality by cleaning, normalizing, transforming and extracting relevant feature from raw data. Data preprocessing significantly improve the performance of machine learning algorithms which in turn leads to accurate data mining. Knowledge discovery from noisy, irrelevant and redundant data is a difficult task therefore precise identification of extreme values and outlier, filling up missing values poses challenges. This paper discusses various big data pre–processing techniques in order to prepare it for mining and analysis tasks.

KEYWORDS

Big Data, Data Pre–processing, Data mining, Data preparation, Text Pre–processing.

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1. INTRODUCTION

Year after year, organizations have realized the benefits that big data analytics provides. Data scientist and researchers demands for the evolution of current practices for processing raw data. Automated Information extraction is impossible from the huge data repository as most data is unstructured. Cloud computing services have also lead us with a growing rate of data on the web as these services are cost–effective and easy to use. This phenomenon undoubtedly signifies a challenge for the data scientist and analyst, therefore Big Data characterized as very high volume, velocity and variety require new high–performance processing (Xindong, Xingquan, Gong–Qing & Ding, 2014). Process of extraction of relevant and useful information from the data deluge is known as data mining which is utterly dependent on the quality of data. The raw data is usually vulnerable to noise, and is incomplete or inconsistent and contain outlier values. Thus, this data has to be processed prior to the application of data mining (Alasadi & Bhaya, 2017).

Data preprocessing involves the transformation of the raw dataset into an understandable format. Preprocessing data is a fundamental stage in data mining to improve data efficiency. The data preprocessing methods directly affect the outcomes of any analytic algorithm; however, the methods of pre–processing may vary for the area of application. Data pre–processing is a significant stage in the data mining process. According to a report by Aberdeen Group, data preparation refers to any action intended to increase the quality, usability, accessibility, or portability of data. The ultimate objective of data preparation is to allow analytical systems with clean and consumable data to be transformed into actionable insights. Data preprocessing embrace numerous practices such as cleaning, integration, transformation and reduction. The preprocessing phase may consume a substantial amount of time but the outcome is a final data set, which is anticipated correct and beneficial for further data mining algorithms.

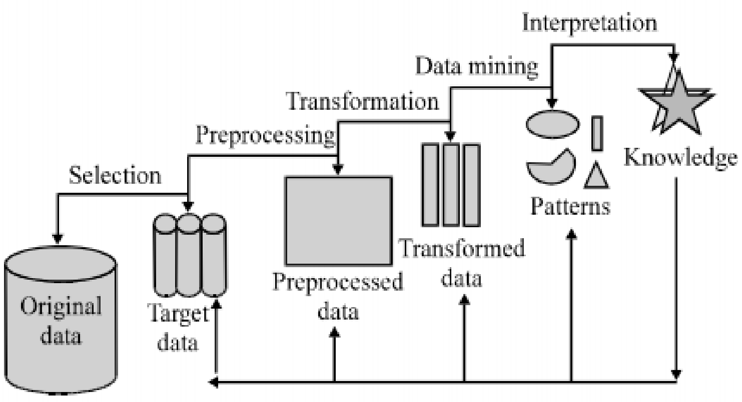

Figure 1. Knowledge Discovery Process in Data Mining.

2. BACKGROUND

The raw data available on data warehouse, data marts, database files (Jiawei, Micheline & Jian, 2012) are generally not organized for analysis as it may be incomplete, inconsistent or it may be distributed into a various table or represented in a different format, in short, it is dirty. The process of discovering knowledge from the massive chronological data sources is called as Knowledge Discovery in databases (KDD) or Data Mining (Malley, Ramazzotti & Wu, 2016; Gupta & Gurpreet, 2009). It is the era of big data and every field of life are generating data at a drastic level. The most challenging task is to gain the right information from present data sources.

The task of reorganizing data is known as data preparation. It is used to discover the anticipated knowledge. It incorporates understanding domain based problem under consideration and then a collection of targeted data to achieve anticipated goals (Gülser, İnci & Murat, 2011). Forrester estimates up to 80 per cent of data analyst time is consumed in preparing data (Goetz, 2015). The selected data can then be preprocessed for data mining. Data pre–processing is the finest solution to increase data quality. Data preprocessing includes cleansing of data, normalization of data, transformation, feature extraction and selection, etc. The processed data is the training set for the machine learning algorithm.

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3. DATA PRE–PROCESSING STAGES

3.1. DATA CLEANING

The first stage of data preprocessing is Data cleaning which recognizes partial, incorrect, imprecise or inappropriate parts of the data from datasets (Tamraparni & Theodore, 2003). Data cleaning may eliminate typographical errors. It may ignore tuple contains missing values or alter values compared to a known list of entities. The data then becomes consistent with other data sets available in the system. Precisely, data cleaning comprises the following four basic steps as described in Table 1.

Table 1. Data Cleaning Steps.

Steps	Description
Data Analysis	Dirty data detection by reviewing dataset, quality of data, meta data.
Define Work Flow	Define the cleaning rules by considering heterogeneity degree among diverse data source, then make the work flow order of cleaning rules such as cleaning particular data type, condition, strategy to apply etc.
Execute defined rules	Rendering the defined rules on source dataset process, and display resulted in clean data to the user.
Verification	Verify the accuracy and efficiency of the cleaning rules whether it content user requirements.

Step 2–3 repetitively executed till all problems related to data quality get solved. Repeat steps 1–4 until user requirements are met to clean the data. Handling missing values is difficult as improperly handled the missing values may lead to poor knowledge extracted (Hai & Shouhong, 2009). Expectation–Maximization (EM) algorithm, Imputation, filtering are generally considered for handling missing values ("Expectation maximization algorithm"). Various data cleansing solutions apply validated data set on dirty data in–order to clean it. Some tools use data enhancement techniques which makes incomplete data set complete by the addition of related information. Binning methods can be used to remove noisy data. Clustering technique is used to detect outliers (Jiawei, *et al.*, 2012). Data can also be smooth out by fitting it into a regression function. Numerous regression procedures such as linear, multiple or logistic regression are used to regulate regression function.

3.2. DATA INTEGRATION

Data Integration is the method of merging data derived from different sources of data into a consistent dataset. Data on the web is expanding in size and complexity, and is either unstructured or semi–structures. Integration of data is an extremely cumbersome and iterative process. The considerations during the integration process are mostly related to standards of heterogeneous data sources. Secondly, the process of integrating new data sources to the existing dataset is time–consuming, ultimately results in inappropriate consumption of valuable information. ELT (Extract–Transform–Load) tools are used to handle a larger volume of data; it integrates diverse sources into a single physical location, provides uniform conceptual schemas and provides querying capabilities.

3.3. DATA TRANSFORMATION

Raw data is usually transformed into a format suitable for analysis. Data can be normalized for instance transformation of the numerical variable to a common range. Data normalization can be achieved using range normalization technique or z–score method. Categorical data can also be transformed using aggregation which merges two or more attributes into a single attribute. Generalization can be applied on low–level attributes which are transformed to a higher level.

3.4. DATA REDUCTION

Multifaceted exploration of huge data sources may consume considerable time or even be infeasible. When the number of predictor variables or the number of instances becomes large, mining algorithms suffer from dimensionality handling problems (Jiawei, *et al.*, 2012). The last stage of data preprocessing is data reduction. Data reduction makes input data more effective in representation without loosening its integrity. Data reduction may or may not be lossless. The end database may contain all the information of the original database in well–organized format (Bellatreche & Chakravarthy, 2017). Encoding techniques, hierarchy distribution data cube aggregation can be used to reduce the size of the dataset. Data reduction harmonizes feature selection process. Instance

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selection (Vijayarani, Ilamathi & Nithya, 2015) and Instance generation are two approaches used by data mining algorithm to reduce data size.

4. WEB DATA PREPROCESSING FRAMEWORK

World Wide Web is a huge repository of an awful textual data most of it being created on a daily basis, reaching from structured to semi–structured to completely unstructured (Andrew, 2015). How can we utilize that data in a productive way? What can we do with it? The answer to these two questions is totally dependent on what is our objective.

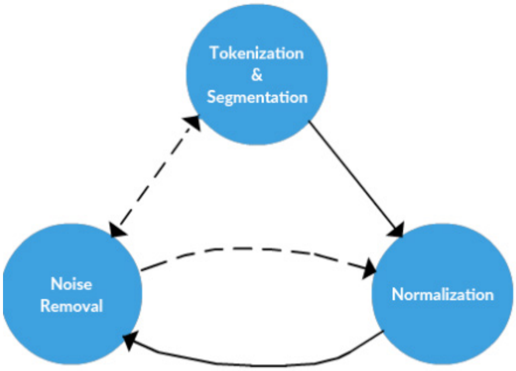

Figure 2. Framework for web content Pre–processing.

To leverage the availability of all of this data, it has to be preprocessed which entails various steps but it may or not apply to a given task, but usually plunge below the broad categories of tokenization, normalization, and substitution.

- Tokenization; in textual data preprocessing tokenization is used to spit long strings of text into smaller one for example sentences can be tokenized into words, etc. It is also known as text segmentation or lexical analysis.
- Normalization; It generally refers to a series of related tasks in order to places all words on equal footing or uniformity. For instance performing stemming, lemmatization, changing the case upper to lower or lower to upper, punctuation, space or stop words removal, the substitution of numbers with their equivalent words etc.

- Substitution or Noise Removal; text data on websites is wrapped in HTML or XML tags, pattern matching or regular expression can be used to extract desired text by removing HTML, XML, etc. markup and metadata.

5. CASE STUDY

Our objective is to do preprocessing on the predetermined body of text; so that we are left with artifact's which will be more valuable and meaningful for any text mining algorithm. The approach proposed here is fully applicable to any web page content. We will remove noise, in our case, it is HTML tags and substitutes English language contraction. Then the content will be tokenized and finally, we are going to normalize the text. We have used PHP as a scripting language to perform preprocessing on the text. We have explored PHP Natural Language Toolkit for tokenization. Figure 3 shows a dummy HTML page content certainly, but the steps to preprocessing this data are fully transferable.

```
sample = """<h1>Title Goes Here</h1>
<b>Bolded Text</b>
<i>Italicized Text</i>
<img src="this should all be gone"/>
<a href="this will be gone, too">But this will still be here!</a>
I run. He ran. She is running. Will they stop running?
I talked. She was talking. They talked to them about running. Who ran to the talking runner?
[Some text we don't want to keep is in here]
¡Sebastián, Nicolás, Alejandro and Jéronimo are going to the store tomorrow morning!
something... is! wrong() with.,; this :: sentence.
I can't do this anymore. I didn't know them.
Why couldn't you have dinner at the restaurant?
My favorite movie franchises, in order: Indiana Jones;
Marvel Cinematic Universe; Star Wars; Back to the Future; Harry Potter.
Don't do it.... Just don't. Billy! I know what you're doing.
This is a great little house you've got here.
[This is some other unwanted text]
John: "Well, well, well."
James: "There, there. There, there."
  
There are a lot of reasons not to do this. There are 101 reasons not to do it. 1000000 reasons, actually.
I have to go get 2 tutus from 2 different stores, too.
22    45   1067   445
{{Here is some stuff inside of double curly braces.}}
{Here is more stuff in single curly braces.}
[DELETE]
</body>
</html>"""
```

Figure 3. Basic HTML page content.

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5.1. NOISE REMOVAL AND SUBSTITUTION

The data preprocessing pipeline will start with noise removal as it is not task depended. The line of codes in Figure 4 reads in the text file called sample.txt which contains dummy HTML data shown in Figure 3. It calls PHP built–in function to strip of HTML tags.

```
$file_to_read="C:\\xammp\\sample.txt";
$page_contents = file_get_contents($file_to_read);
$plain_text= strip_tags($page_contents);
```

Figure 4. Code to strip HTML tags.

It is beneficial to remove English language contraction with their expansion before tokenization as it will split word such as "didn't" into "did" and "n't" rather than "did" and "not". We implemented contradiction expansion by calling list of contraction available in MYSQL database and then comparing it with our content. It then replaced every occurrence of matched contraction will expansion.

```
$conn = mysqli_connect('servername', 'username', 'password');
 if (!$conn)
 {
   die("Database Connection Failed" . mysqli_error());
 }

 $select_db = mysqli_select_db($conn, 'databasename');
 if (!$select_db)
 {
   die("Database Selection Failed" . mysqli_error());
 }
$str = $plain_text;
$query=mysqli_query($conn, "select * from contradiction_list")
or die(mysqli_error($conn));
    while($row=mysqli_fetch_array($query))
         {
             $word=$row['contraction'];
             $str= str_replace($word, $row['meaning'], $str);

            }
```

Figure 5. Substitution of contractions.

```
Title Goes Here
Bolded Text
Italicized Text

But this will still be here!

I run. He ran. She is running. Will they stop running?

I talked. She was talking. They talked to them about running. Who ran to the talking


¡Sebastián, Nicolás, Alejandro and Jéronimo are going to the store tomorrow morning!

something... is! wrong() with.,; this :: sentence.

I cannot do this anymore. I did not know them. Why could not you have dinner at the

My favorite movie franchises, in order: Indiana Jones; Marvel Cinematic Universe; St

do not do it.... Just do not. Billy! I know what you are doing. This is a great litt


John: "Well, well, well."
James: "There, there. There, there."


There are a lot of reasons not to do this. There are 101 reasons not to do it. 10000
I have to go get 2 tutus from 2 different stores, too.

22    45    1067    445

{{Here is some stuff inside of double curly braces.}}
{Here is more stuff in single curly braces.}
```

Figure 6. Text after de–noising.

5.2. TOKENIZATION

For tokenization, we have used PHP Natural Language Processing (NLP) toolkit. PHP supports various kinds of tokenization under tokenizers namespace. We are using RegexTokenizer.

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```
//Toekenization
use NlpTools\Tokenizers\RegexTokenizer;

$s = $str;

$rtok = new RegexTokenizer(array(
    array("/\s+/"," "),
    // replace many spaces with a single space
    array("/'(m|ve|d|s)/", " '\$1"),
    // split I've, it's, we've, we'd, ..
    "/ /"
    // split on every space
));

print_r($rtok->tokenize($s));
```

Figure 7. Tokenization using PHP NLP toolkit.

```
['Title', 'Goes', 'Here', 'Bolded', 'Text', 'Italicized', 'Text', 'But', 'this', 'wil
'be', 'here', '!', 'I', 'run', '.', 'He', 'ran', '.', 'She', 'is', 'running', '.', 'W
'stop', 'running', '?', 'I', 'talked', '.', 'She', 'was', 'talking', '.', 'They', 'ta
'about', 'running', '.', 'Who', 'ran', 'to', 'the', 'talking', 'runner', '?', '¡Sebas
'Nicolás', ',', 'Alejandro', 'and', 'Jéronimo', 'are', 'going', 'tot', 'he', 'store',
'morning', '!', 'something', '...', 'is', '!', 'wrong', '(', ')', 'with.', ',', ';',
'sentence', '.', 'I', 'can', 'not', 'do', 'this', 'anymore', '.', 'I', 'did', 'not',
'Why', 'could', 'not', 'you', 'have', 'dinner', 'at', 'the', 'restaurant', '?', 'My',
'movie', 'franchises', ',', 'in', 'order', ':', 'Indiana', 'Jones', ';', 'Star', 'War
'Cinematic', 'Universe', ';', 'Back', 'to', 'the', 'Future', ';', 'Harry', 'Potter',
'do', 'it', '...', '.', 'Just', 'do', 'not', '.', 'Billy', '!', 'I', 'know', 'what',
'doing', '.', 'This', 'is', 'a', 'great', 'little', 'house', 'you', 'have', 'got', 'h
':', '``', 'Well', ',', 'well', ',', 'well', '.', "''", 'James', ':', '``', 'There',
'There', ',', 'there', '.', "''", 'There', 'are', 'a', 'lot', 'of', 'reasons', 'not',
'.', 'There', 'are', '101', 'reasons', 'not', 'to', 'do', 'it', '.', '1000000', 'reas
'actually', '.', 'I', 'have', 'to', 'go', 'get', '2', 'tutus', 'from', '2', 'differen
'too', '.', '22', '45', '1067', '445', '{', '{', 'Here', 'is', 'some', 'stuff', 'insi
'curly', 'braces', '.', '}', '}', '{', 'Here', 'is', 'more', 'stuff', 'in', 'single',
'.', '}']
```

Figure 8. Words Token.

5.3. NORMALIZATION

For text normalizing we will perform (1) stemming (2) everything else.

Stemming: The aim of this step is to condense inflectional forms of a word to a common base form. For instance: cars to car

```
//stemming

foreach ($rtok as &$value) {
$stem_words[]= stemword($value, 'english', 'UTF_8');
}
```

Figure 9. Stemming English language words.

Everything Else: This step will transform all word into lowercase, remove non–ascii words, remove punctuations, replace numbers, and remove stop word.

```
//remove non ascii
function convert_to_normal_text($stem_words) {
    $new_words;
    $normal_characters = "a-zA-Z0-9\s`~!@#$%^&*()_+-={}|:;<>?,.\/\"\'\\\[\]";
    foreach ($stem_words as $value) {
    $normal_text = preg_replace("/[^$normal_characters]/", '', $value);
    $new_word[]=$normal_text;
    }

    return $new_word;
}
//remove stop words
function removeCommonWords($input){

    // EEEEEEK Stop words
    $new_words;
    foreach ($input as $value) {
    $new_word[]= preg_replace('/\b('.implode('|',$stopWords).')\b/','',$value);
    }
    return $new_word;
}
//convert to lowercase
function wordlowercase($words){

    $new_words;
    foreach ($words as $value) {
    $new_word[]= strtolower($value);
    }
    return $new_word;
}
//remove punctuation
function strip_punctuation($words) {

    $new_words;
    foreach ($words as $value) {
     $string = preg_replace("/[:punct:]+/", "", $value);
    $string = str_replace(" +", "", $string);
    if ($string !="")
    {
    $new_words[]=$string;
    }
    return $new_word;
}
/// number to word
function convert_number_toword($words) {

    $new_words;
    foreach ($words as $value) {
    if (is_numeric($value))
    {
    $value = number_to_word($vlaue);
    }
    $new_words[]=$value;
    }
    return $new_word;
}
```

Figure 10. PHP functions for text normalization.

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```
['title', 'go', 'bolded', 'text', 'italicize', 'text', 'still', 'run', 'run', 'run',
'talk', 'talk', 'talk', 'run', 'run', 'talk', 'runner', 'sebastian', 'nicolas', 'alej
'go', 'store', 'tomorrow', 'morning', 'something', 'wrong', 'sentence', 'anymore', 'k
'dinner', 'restaurant', 'favorite', 'movie', 'franchise', 'order', 'indiana', 'jones'
'cinematic', 'universe', 'star', 'war', 'back', 'future', 'harry', 'potter', 'billy',
'little', 'house', 'get', 'john', 'well', 'well', 'well', 'jam', 'lot', 'reason', 'on
'reason', 'one million', 'reason', 'actually', 'go', 'get', 'two', 'tutus', 'two', 'd
'twenty-two', 'forty-five', 'one thousand and sixty-seven', 'four hundred and forty-f
'inside', 'double', 'curly', 'brace', 'stuff', 'single', 'curly', 'brace']
```

Figure 11. Final output after applying all preprocessing steps.

The simple text data preprocessing process results are shown in Figure 11.

6. CONCLUSION

Any data analysis algorithm will fail to discover hidden pattern or trend from data if the dataset under observation is inadequate, irrelevant or incomplete. Thus data preprocessing is a central phase in any data analysis process. The preprocessing of data resolves numerous kinds of problems such as noisy, redundancy, missing values, etc. High quality results are only achievable with high quality of data which in turn also reduce the cost for data mining. The foundation of decision making system in any organization is the three C's properties of data i.e. Completeness, Consistency and Correctness. Deprived quality of data quality effects decision making process which eventually decreases customer's satisfaction. Furthermore larger dataset affects the performance of any machine learning algorithm, therefore instance selection lessens data and is efficient approach to make machine learning algorithm work effectively.

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/11/

THE IMPLEMENTATION OF M–COMMERCE IN SUPPLY CHAIN MANAGEMENT SYSTEM

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ABSTRACT

The progression of wireless technologies will dramatically and fundamentally transform the supply chain management, through the imminent mobile revolution. Many aspects of organizational life will be impacted by the revolution. Firstly, the crucial data will be presented in real time to help the decision makers while the ways businesses communicate, and the relationships with consumers and suppliers will dramatically change, all of which, will transform how the supply chain is managed. Issues related to the integration of Mobile Commerce (M–Commerce) and Supply Chain Management (SCM) including the dearth of killer applications, mobile device limits, networking issues, infrastructure restrictions, security matters, and user distrust in mobile applications, are examined in this paper. There are also highlights on issues including usability, user interfaces, mobile access to databases, agent technologies, and models of mobile business.

KEYWORDS

Supply Chain Management (SCM), Information Systems (IS), E–Commerce, M–Commerce, Mobile Commerce, Wireless Technology.

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1. INTRODUCTION

Progresses in wireless technology and mobile devices have resulted in a novel type of e–commerce known as mobile commerce, whose transactions are carried out with mobile devices through wireless telecommunication networks and other wired technologies associated with e–commerce. Mobile commerce or m–commerce offers users with ubiquity, personalization, localization, and convenience, and its application has expanded the Internet sales channels into mobile environments that are more direct and personalized. In the domain of business, the use of m–commerce, therefore, offers incredible opportunities for the provision of value–added services to not only consumers but corporate users as well (Goolsbee & Klenow, 2018).

The present paper looks into the mobile commerce application within supply chain management. For a company, its supply chain generally entails all stages that are directly or indirectly involved in meeting the demands of the customers (El–Ebiary & Hilles, 2017). This chain of supply includes many parties including suppliers, manufacturers, transporters, warehouses, retailers, as well as customers. Inside a given organization, the supply chain for certain product or service involves each activity carried out by each precursor within the value chain for designing, generating, promoting, marketing, delivering, and supporting every individual constituent of that product or service. Hence, the aim of Supply Chain Management (SCM) is to connect the market–place, the network of distribution, the process of manufacturing and the activity of procurement, in a manner, that customers receive higher levels of services at a lower cost in total (Ciccullo, Caridi, Gosling & Purvis, 2018).

Mobile Commence allows users access to the Internet irrespective of time and location. As such, its ability in detecting the location of an individual mobile terminal user in addition to its functionality in information access when necessitated can potentially decrease the administrative overhead while increasing efficiency (Hassan, Manna, El–Ebiary & Al–Sammarraie, 2018). Not only that, the use of m–commerce allows the information to be dispersed more quickly through the organization. With mobile commerce information exchange and purchases are possible and for a lot of parties linked to the supply chain, this is of use. For instance, in the context of customers, mobile commerce denotes convenience, while in the context of sales professionals, mobile commerce allows immediate sales, whereas, for managers who are on the move, mobile commerce enables communication and exchange of information. Mobile commerce, therefore, proves its ability in improving customer service, improving responsiveness, generating fresh channels of distribution, easing management of inventory, while also substantially improving the supply chain particularly in terms of performance (Hugos, 2018).

In essence, the organization of this paper follows the following structure: the ensuing section looks into the challenges in supply chain management, followed by a section that examines mobile commerce (Ciccullo, *et al.*, 2018). Then highlights the mobile application challenges in supply chain management, while next elaborates the arising research issues in the integration of mobile commerce into supply chain management.

2. CHALLENGES FOR SCM

As can be referred to in Figure 1, the supply chain in a company usually includes countless departments and people, with information as the main determinant of supply chain management success. Along this chain, the products/services and funds flow to create information about massive quantities. At the same time, the information provides a direct linkage between customers and suppliers, and this allows real–time responses from the suppliers' side towards the market changes (Behzadi, O'Sullivan, Olsen & Zhang, 2018). As such, the supply and demand for tailored goods can be appropriately matched at very brief time frames. In supply chain management, the function of information systems is to assure the accurateness and accessibility of the right information in a timely manner.

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The intense expansion of the Internet has also resulted in thriving e–commerce that has transformed how people execute their business, and such trend has equally presented fresh demands to the systems of the supply chain with features as detailed below:

- *Information Sharing*: The swift e–commerce expansion has resulted in the demand that corporations furnish more information to more internal users, and to certain outside vendors and customers as well. However, the traditional supply chain systems including ERP are mainly concerned with the internal operations including finance, human resources, and manufacturing which are accessible only to select users (El–Ebiary, Al–Sammarraie, Al Moaiad & Alzubi, 2016).
- *Optimization Focus:* Supply chains are expanded with e–commerce has extended, and within the extended value chain, more optimization is needed bye–commerce. Relevantly, the conventional systems of the supply chain are aimed at optimizing the business processes within the company. Still, when considered from the viewpoint of the total value chain, the aforementioned processes may not be optimized (El–Ebiary, Najam & Abu–Ulbeh, 2018).
- *Internet Substitute*. The emergence of the Internet has destroyed the long–established notion that there exists a single system with the capacity to meet all needs of an organization. In fact, the functionalities of enterprise systems including payroll processing or transportation management could bit by bit be taken over by individual company of the Internet which offers a distinctive set of features linkable via a single inter–connected network (Alzubi, Alkhawlani & El–Ebiary, 2017).

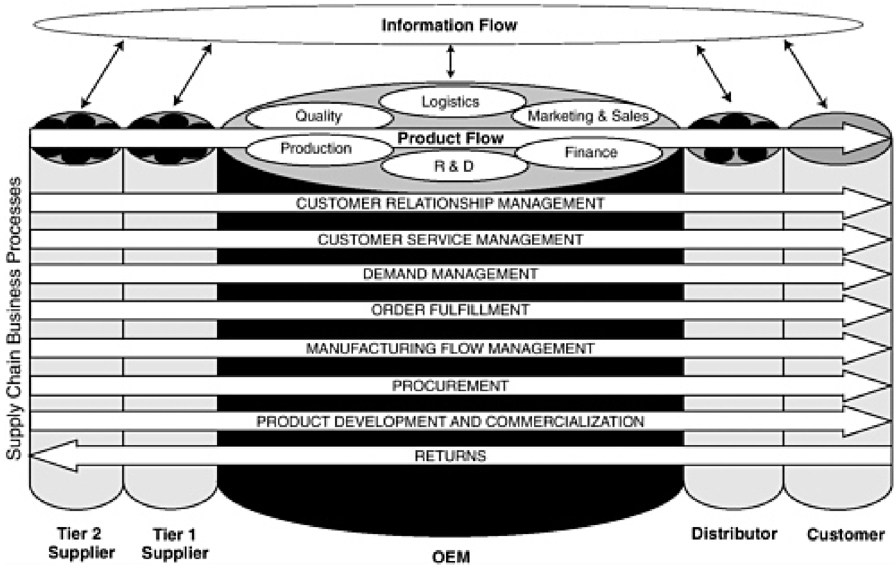

Figure 1. The Extension of Supply Chain and Supply Chain Flow.

Technology Obstacle. The incompatibility of hardware and software has caused an inability to a lot of the presently available supply chain systems in supporting interactive e–commerce. Considering that the aim of these systems is to connect the application systems within the bounds of the enterprise, the established infrastructures support specific EDI protocols only (El–Ebiary, Abu–Ulbeh, Alaesa & Hilles, 2018). For this reason, the aforesaid enterprise applications cannot become the basis for an e–commerce infrastructure, considering that open standards are required by e–commerce infrastructure.

3. MOBILE COMMERCE

Wireless and mobile networking is an entirely novel method that can be employed by companies in further expanding their supply–chain mobile commerce. The functions of e–commerce are expanded through mobile commerce, resulting in the expansion of the e–supply chain system to the dimensions that were never aspired before. Mobile applications allow the user to access the supply chain system at all times and from all locations via the use of many different devices (e.g., cellular phones, PDAs, PCs, and TVs) (Hassan, Manna, & El–Ebiary,

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2017). Accordingly, the concept of mobile commerce, its distinguishing features, important empowering technologies, and prospective applications are elaborated in this section to address the challenges facing supply chain management.

3.1. DISTINCTIVE FEATURES

Mobile commerce is essentially associated with reaching to the customers, suppliers, and employees, notwithstanding their location, and in fact, mobile commerce relates to the dispersal of the correct information to the correct time and location. This ability implies the flexibility of mobile commerce, and such flexibility is driven by the incorporation of the Internet, enterprise applications, and wireless technology. The distinctive features of mobile commerce are as described below:

- *Ubiquity*: Mobile devices enable business organizations to get to their customers anywhere at any time, while users are able to obtain any information that they seek, no matter where they are, with the use of Internet–enabled mobile devices. Mobile commerce, therefore, allows the provision of the needed service or application at all times and places.
- *Personalization*: The Internet is currently offering a massive amount of information, services, and applications, and the applicability of information received by users is of great significance. Also, considering that mobile devices owners frequently need diverse groups of applications and services, mobile commerce applications can be tailored to cater to the need of the specific user in terms of their desired information or services.
- *Flexibility*: Considering the portability of mobile devices, mobile users may perform transactions or receive information via their Internet–enabled mobile devices while engaging in other activities such as travelling.
- *Dissemination:* In a certain geographical area, there are wireless infrastructures that support instantaneous data delivery to all mobile users, offering an efficient way to deliver information to a vast population of consumers.

3.2. KEY M–COMMERCE ENABLING TECHNOLOGY

Mobile commerce needs the development and deployment of the required facilitating technologies in order that it could expand substantially. Examples of these technologies include service technologies, network technologies, mobile personalization technologies, mobile commerce terminals, mobile middleware, mobile location technologies, as well as content delivery and format. Some of the leading technologies responsible for the materialization of mobile commerce are as follows:

- *Global System for Mobile Communication orGSM*: This technology is the dominant mobile standard in Europe and also in most part of the Asia–Pacific region, and this technology operates using the 900 MHz and the 1,800 MHz (1,900 MHz in the USA) frequency band. GSM also has been the foundation for other technologies of the network, and these include HSCSD (High–Speed Circuit Switched Data) and GPRS (General Packet Radio Service). As GSM standard is widely adopted nowadays, the establishment of innovative mobile applications and services is economically practicable.
- *Short Message Service or SMS*: This technology allows the conveyance and reception of text messages to and from mobile phones. An SMS can contain 160 alphanumeric characters'maximum, in each exchange. The use of SMS is very common in Europe and the two major forms of SMS message are simple person–to–person messaging and voice mail notice. Additionally, SMS can contain mobile information services including news, weather updates, sports, stock quotes and so forth.SMS chat and ringing tones downloads are also available.
- *Wireless Application Protocol or WAP*: This technology encompasses an open and global standard for mobile solutions, involving the delivery of web information to mobile terminals. WAP entails an end–to–end application protocol and it presents resolutions to the issues that arise in the development of mobile applications. These include the connection of mobile terminals to the Internet and the transformation of mobile terminals into communication devices, with

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the capacity of communicating with other devices with the utilization of a wireless network. The design of interactive and real–time mobile services can be employed as well.

- *Bluetooth*: This technology encompasses a low power radio technology for the purpose of communicating and exchange of data. It is a low–cost short–range wireless standard utilizing a single chip with fitted radio–transmission circuitry, and it supports local area networks (LANs). Bluetooth is a replacement of cables and infrared links, and it can be used within a ten–meter diameter. With this technology, electronic devices (e.g., mobile devices, PCs, printers, and PDAs) can be connected to wireless data networks.
- *Global Positioning System or GPS:* Initially created for US military use, this technology encompasses a system involving satellites that orbit the earth. Satellites constantly broadcast their position and direction, and this allows the receivers of GPS to accurately identify the specific geographic location. The use of GPS is presently common among civilians, and GPS is most commonly employed in car navigation systems.
- *eXtensible Markup Language or XML*: This technology encompasses a meta–language that was created for the purpose of conveying the data meaning with the utilization of a self–describing mechanism. XML tags data and places content into context, and this allows the providers of content to encode semantics into their documents. For XML compliant information systems, data can be directly exchanged even between organizations with dissimilar operation systems and data models but with the condition that the organizations are in agreement regarding the data meaning being exchanged.
- *Wireless Markup Language or WML:* This technology originates XML and its usage is for WAP especially. WML enables the representation of information in the form of cards that are appropriate for display on mobile devices. As a comparison, WML to WAP is HTML to the Internet.

3.3. MOBILE APPLICATIONS IN SCM

Mobile commerce characteristics and its empowering technologies can increase the efficiency of information flows, and synchronise the operations within the extended enterprise. This will generate better supply chain management. Accordingly, the different uses of mobile commerce in prepping the organizations in facing the challenges in supply chain management are detailed as follows:

- *Mobile email and Internet for corporate users:* In wireless data usage, mobile email is the primary application, as it functions as the main line of communication for corporate users in order that they could remain connected with their organizations while travelling. Accordingly, the needed devices include a laptop, a GSM modem and a connected mobile phone, and corporate users use these devices to gain access to the mail server of the corporate network. Both mobile email and the mobile Internet allows the mobile professionals comprising sales professionals and customer care staff to engage in customer related tasks including tracking the order status, accessing the marketing information, checking the customer feedback, reporting the problems, consulting with the technicians, and identify the locations, irrespective of any time and anywhere. Similarly, mobile devices can be employed by field technicians in the communication of customer information, machine status, logistics, and order and billing information. Also, considering that mobile commerce enables instant data and exchange of information within organizations and among business associates, it eases the sharing of information and interactivity within the supply chain network, and this allows businesses to tackle the complex business environments.
- *Mobile customer care*: Through mobile commerce, customers can enjoy automated and independent operations directly from mobile terminals. UPS (United Parcel Services) is among the organizations that have started employing wireless devices in tracking shipments. Also, using PDA or mobile phone, customers can find out the estimated delivery time of their items. Additionally, mobility provides powerful channels to business units including financial institutions, to allow reaching out to their customers, via the use of

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mobile devices that are handy at all times. Mobile commerce essentially can intensify customer satisfaction through the push of information to mobile users, and place them in a superior informed position.

- *Mobile enterprise implementations*: Mobile commerce is usable in the management of logistics and workflow, as well as in streamlining inventory and the control of distribution. Bluetooth devices are an example of an appropriate inventory control tool – it allows automatic connection and communication, in place of manual connection. It is also easy to handle, in addition to fast data sharing and stock check, and sharing of stock data among supply chain members. For example, the use of Numoda which is a wireless provider, allows companies to gather and spread corporate data using handheld devices. Accordingly, wireless data gathering, instant wireless communication and exchange of information, and reporting and management of logistics and workflow are among the offered applications.

4. MOBILE APPLICATION CHALLENGES IN SCM

The potential of mobile commerce applications in the context of supply chain management may seem palpable. However, the success path may not be so simple. In fact, the real–world utilization of mobile commerce in the context of supply chain management can be inhibited by the technical limits of mobile devices and wireless communication, and business concerns. Hence in this section, the challenges that are faced by mobile commerce applications in the context of supply chain management are elaborated, as below:

- *Absence of killer application(s)*: Within a computing platform, a killer application comprises an application that is sufficiently compelling in motivating purchases of that platform. In this regard, within the second half of the 1990s, access to the Internet is regarded as the killer application as it stimulates purchases of PC. Appositely, to assure the success of mobile commerce in supply chain management, it is important to add one or more killer applications in order to coerce organizations to acquire and utilize mobile devices in their day–to–

day operations. It is crucial that the killer application(s) for mobile commerce comprehensively utilize mobility, furnish services that are directly applicable to mobile needs, and benefit users in terms of immediacy and efficiency.

- *Mobile devices limitations:* At the present time, the wireless devices consist of phones, laptops, computers (hand–held or palm–sized), and vehicle–mounted interfaces. Somehow, even though mobile terminals evidence a bigger scope of mobility and flexibility, in some respects, they seem inferior, as opposed to personal computers. For instance, mobile devices have a screen that is small while their display resolution appears to be low. Also, user input can be impeded by the small and multifunction keypad. Additionally, owing to the need to be light and small physically, the mechanisms of input and output appear to encumber the establishment of user–friendly interfaces and graphical applications for mobile devices. Besides that, the computational power, capacity of memory and disk, battery lifespan, and surfability, are among the limitations of mobile phones, as they do not support the multifaceted applications and transactions. Subsequently, they restrict the utilization of mobile commerce in this complex supply chain management environments.
- *Incompatible networks*: In the cellular network standards today, there are numerous, complex and conflicting protocols. For instance, GSM encompasses a single standard utilized by the operators of the network in the Pacific Asian region and Europe. On the other hand, TDMA (Time–division multiple access) and CDMA (Code division multiple access) that employ different standards are widely utilized in the US. Owing to the differences of this used standard, there are discordancy among cellular phones globally, which cause problems to organizations in communicating and cooperating with their suppliers, distributors, retailers, as well as customers.
- *Competing for web languages*: There are a number of rival web languages available today. For instance, newer mobile phones operate on WAP and its WML. Conversely, NTT DoCoMo’s iMode employs condensed Hyper–Text Markup Language or HTML. The use of incompatible standards in mobile devices today has increased the challenges in the establishment of successful

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applications of m–commerce. Meanwhile, the increase in the number of companies that integrate mobile commerce with supply chain management has greatly intensified the need for having standardized web languages. Indeed, the problem of contending web languages needs to be tackled, in order to significantly improve mobile communications within organizations, and also the interactions between organizations and their business associates.

- *Security concerns*: Wireless communications appear to have a higher vulnerability, as opposed to wired communications. Notably, wireless data networks today mostly offer judicious encryption and security levels. Somehow, within the network infrastructure, the technology does not ensure the security of transmission. For instance, malfunctions of the mobile terminal can cause data loss, and these terminals can even be stolen while the ongoing transactions can be changed. In other words, the mobility of m–commerce also brings a lot more perplexing security tasks. Considering that the applications of mobile commerce are increasingly integral in supply chain management, addressing the security issue highly crucial.
- *User distrust*: The parties involved in any transaction, need to have the capacity in authenticating their counterparts. This is to assure that the received messages are not disturbed, the communication content remains confidential, and that the received messages originate from the right senders. However, considering that the mobile environment is essentially vulnerable, mobile commerce users appear to show great concern towards the issues of security in mobile transactions. It is therefore important that mobile commerce users are guaranteed their financial information security, and of the security of the wireless transaction. Trust of users towards mobile commerce is crucial in order that the mass adoption of mobile commerce in supply chain management can be achieved.

5. CONCLUSION

Supply chain management can be positively impacted by mobile commerce. Still, there are several technical, regulatory, and social issues that need to be addressed. In the coming years, however, mobile devices are expected to continue developing, with the incorporation of more functionality. Expectantly, mobile commerce will be incorporated in supply chain management in numerous aspects.

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MODIFICATION IN HILL CIPHER FOR CRYPTOGRAPHIC APPLICATION

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ABSTRACT

In order to keep the information secure from various contenders is an important factor for data security. For any organization, it is an incredibly important feature to timely transmit secured data. Optimized techniques for key management and protected encryption algorithms are always helpful for reducing the overhead of the system and maintain the integrity, authentication and confidentiality of data. Cryptographic applications play an important role in our daily lives through sending emails, exchanging bank account transaction information, through mobile communication and through ATM card transaction. To secure our information from unauthorized users, Hill Cipher is one of the most well-known symmetric cryptosystems. For Hill Cipher, here we are proposed an algorithm for encryption and decryption which is based upon the transposition, substitution and left-right shift.

KEYWORDS

Traditional Hill Cipher (THC), Transposition Substitution (TS), Transposition Substitution & Left Right Shift (TSLRS), Cryptography, Encryption, Decryption.

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1. INTRODUCTION

In today's era of information technology, security is highly essential for our sensitive or important data. Our primary concern is to transmit data or information in a secured manner. Cryptography not only protects our information from intruders but also maintains the data integrity, confidentiality and user authenticity. We have proposed a new and secured procedure in the paper (Khan, Shams, Qazi & Agha, 2015) for generating orthogonal matrix which uses as a key matrix in Hill Cipher for enhancing the security, as well as minimize the cost of time in decryption procedure. In another paper (Khan & Qazi, 2018) we have presented a procedure of encryption and decryption to improve the security of Hill Cipher by adopting transposition and substitution technique.

In the current paper, we have to use transposition and substitution technique as defined in (Khan & Qazi, 2018). To reduce the computational complexity orthogonal key matrix is used as described in (Khan, *et al.*, 2015). An advanced procedure for encryption and decryption is proposed for making Hill Cipher more secure and efficient. Hill cipher can be more secure by applying transposition, substitution and bit shifting on original message for encryption because Hill cipher is vulnerable to a known-plaintext attack and it is completely linear but here we combined it with other non-linear operations (transposition, substitution and left-right bit shifting) which provide good diffusion. In this methodology TSLRS techniques have applied on Hill Cipher due to this, efficient outputs are obtained.

2. LITERATURE REVIEW

Saeednia (2000) presents modification on Hill Cipher and proposed a symmetric cipher. Generate a key for encryption of message by applying random permutation on rows and columns. Mohsen and Abolfazl (2011) presented an encryption algorithm to improved the modification of the Affin Hill Cipher and have introduced two more protocols. Through affine transformation, an efficient cryptosystem has created. Kim and Lee (2004) have worked on private and public key crypto processor regarding its design and implementation. The main goal for creating this cryptographic algorithm is to optimize the execution of the microprocessor. Various security applications can apply this crypto processor like: network router security, storage devices and embedded systems. Sukhraliya, Chaudhary and Solanki (2013) presented an algorithm in which numbers are randomly generated and calculate the modulus and remainder of the numbers. Due to this new method for encrypting and decrypting, three or more keys are generated which make the ciphering technique more complicated. Acharya, Rath, Patra and Panigrahy (2007) have proposed a method of generating self-invertible matrix for Hill Cipher. For encrypting the plaintext we need the inverse of the matrix. Decryption cannot be performed on data if the matrix is not invertible.

Magamba, Kadaleka and Kasambara (2012) worked on Hill Cipher. According to the technique, the plaintext is broken into blocks of m size and multiply it by m*m matrix obtaining variable-key length matrix from Maximum Distance Separable (MDS) master key matrix. Sastry and Janaki (2008) developed a block cipher technique by modifying the Hill Cipher. They have mixed binary bits of key matrix and plaintext at a different level of iteration. Krishna and Madhuravani (2012) proposed a randomized approach for Hill Cipher; broken the plaintext into equal block size and encrypt the block one by one. The output is randomized for one plaintext that is able to generate multiple ciphertext. Sastry, *et al.* (2009) proposed an iterative method of modification in Hill Cipher in three stages. Different functions are used in these stages like inverse, matrix mixing and XOR. Hamamreh and Farajallah (2009) have presented a new model of Hill Cipher by using quadratic residue. Sastry, *et al.* (2011) proposed the new idea of permuted key and presented as a generalized advanced hill cipher. In the iterations, we find the arithmetic and mix column operation which entailed in the cipher. Binary bits of the key mix with the plaintext in a detailed manner and due to this avalanche effect and cryptanalysis makes the ciphertext more strong. Varanasi, *et al.* (2011) presented a symmetric block cipher which contains a pair of keys, iteration process, modular arithmetic addition, substitution and mixing. To strengthen the cipher significantly, they have mixed the bits and substitution in each round of iteration.

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Keliher and Delaney (2013) worked on two variants of the classical hill cipher introduced by Toorani and Falahati. They have designed a system having an ability to overcome the weaknesses of the hill cipher and are resistant to any of the attacks i-e. ciphertext attack, known-plaintext attack, chosen-plaintext attack or chosen-ciphertext attack. Toorani-Falahati hill cipher can easily break through the described chosen-plaintext attack and confirms the effectiveness of the presented attack. Levine and Chandler (1989) proposed an algorithm of cryptographic equations relating ciphertext, plaintext and if the cipher letters are unknown the elements of the key matrix of hill system have a non-linear system of equations. To reduce these equations to the linear system they had introduced a large set of the unknown, if the plaintext is known. Sharma and Rehan (2013) proposed two-fold securities to the existing hill cipher by using logical operations and elements of the finite field.

3. PROPOSED METHODOLOGY

In this procedure, we combine previously proposed traditional hill cipher procedures with additional transposition, substitution and left-right shifting functions.

In this method, transposition and substitution of plaintext are performed on n*n matrix respectively. After this second procedure of right and left shifting is applied on the encryption process, all encryption functions are applied in reverse order to perform the decryption process.

Previously we have described the complete procedure of key generation (Khan, *et al.*, 2015). The generated orthogonal key is,

$$k = \begin{bmatrix} k_{11} & k_{12} & k_{13} & k_{14} \\ k_{21} & k_{22} & k_{23} & k_{24} \\ k_{31} & k_{32} & k_{33} & k_{34} \\ k_{41} & k_{42} & k_{43} & k_{44} \end{bmatrix}$$

We have some negative values in the generated key so, by taking additive inverse in mod 26 make all the values positive and for further simplification, we will take mod 26, due to this secured key will be generated, after that $\boldsymbol{k}$ will turn into $\boldsymbol{k'}$:

$$k'=\begin{bmatrix} k'_{11} & k'_{12} & k'_{13} & k'_{14} \\ k'_{21} & k'_{22} & k'_{23} & k'_{24} \\ k'_{31} & k'_{32} & k'_{33} & k'_{34} \\ k'_{41} & k'_{42} & k'_{43} & k'_{44} \end{bmatrix} \tag{1}$$

3.1. PROPOSED METHOD FOR ENCRYPTION

Previously we have introduced a new method for securing the hill cipher algorithm. To make hill cipher algorithm more secure and more powerful we can combine both methods consider any plaintext :

$$p=\begin{bmatrix} p_1 \\ p_2 \\ p_3 \\ p_4 \end{bmatrix}$$

The first step is to apply transposition on plaintext in reverse order so, plaintext becomes:

$$p'=\begin{bmatrix} p_4 \\ p_3 \\ p_2 \\ p_1 \end{bmatrix}$$

In this way generate a new key by using the Caesar cipher substitution on $\boldsymbol{p'}$, which is obtained by picking the values,

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$$p" = \begin{bmatrix} p"_4 \\ p"_3 \\ p"_2 \\ p"_1 \end{bmatrix}$$

convert the above plaintext into binary form then perform right shifting so, will be similar to:

$$p''' = \begin{bmatrix} b_4 \\ b_3 \\ b_2 \\ b_1 \end{bmatrix}$$

Convert into decimal number so, is newly produces plaintext:

$$p"" = \begin{bmatrix} b'_4 \\ b'_3 \\ b'_2 \\ b'_1 \end{bmatrix}$$

Now, applying the general method of hill cipher for encryption so will be similar to:

$$\begin{bmatrix} k'_{11} & k'_{12} & k'_{13} & k'_{14} \\ k'_{21} & k'_{22} & k'_{23} & k'_{24} \\ k'_{31} & k'_{32} & k'_{33} & k'_{34} \\ k'_{41} & k'_{42} & k'_{43} & k'_{44} \end{bmatrix} * \begin{bmatrix} b'_4 \\ b'_3 \\ b'_2 \\ b'_1 \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \end{bmatrix} \quad (2)$$

Where **c** is the newly generated ciphertext**.**

3.2. PROPOSED METHOD FOR DECRYPTION

As we discuss in the beginning we are using orthogonal key, therefore, the inverse of the orthogonal key will be the transpose of :

$$\boldsymbol{k'} = \boldsymbol{k'^{t}} = \boldsymbol{k'^{-1}}$$

$$\boldsymbol{k'^{-1}} * \boldsymbol{k'^{t}} = \boldsymbol{I}$$

Later than, apply the general method of decryption for hill cipher so, will be produced

$$\begin{bmatrix} k'_{11} & k'_{12} & k'_{13} & k'_{14} \\ k'_{21} & k'_{22} & k'_{23} & k'_{24} \\ k'_{31} & k'_{32} & k'_{33} & k'_{34} \\ k'_{41} & k'_{42} & k'_{43} & k'_{44} \end{bmatrix} * \begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \end{bmatrix} = \begin{bmatrix} b'_4 \\ b'_3 \\ b'_2 \\ b'_1 \end{bmatrix} \quad (3)$$

Now, convert into binary form and perform left shifting on it

$$p''' = \begin{bmatrix} b_4 \\ b_3 \\ b_2 \\ b_1 \end{bmatrix}$$

Apply back substitution of poly alphabetic technique on so, it will similar to:

$$p'' = \begin{bmatrix} p''_4 \\ p''_3 \\ p''_2 \\ p''_1 \end{bmatrix}$$

Apply transposition in reverse order and get the original text

$$\begin{bmatrix} p_4 \\ p_3 \\ p_2 \\ p_1 \end{bmatrix} = \begin{bmatrix} p_1 \\ p_2 \\ p_3 \\ p_4 \end{bmatrix}$$

4. ALGORITHM

i. Step 1: Take any plain text.

ii. Step 2: Apply the simple transposition on the plane text as defined in section.

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iii. Step 3: Apply the Caesar cipher substitution as defined in section

iv. Step 4: Apply the right shift procedure after step 3.

v. Step 5: Apply the procedure of encryption defined by section 3.1.

vi. Step 6: Perform the procedure of decryption explained in section 3.2.

5. EXAMPLE

In this procedure, the plaintext "SECURITY" is divided into a block size of four letters with the key size of 4*4. For encryption process, we can apply simple transposition, Caesar cipher substitution and one-bit right shift operation on the plaintext. After this apply the regular procedure of Hill cipher and obtain the ciphertext. For decryption process, multiply the inverse of the key with the ciphertext then apply one bit left shift operation, reverse substitution and reverse transposition so, we get the original plaintext "SECU".

Consider an orthogonal key which we have generated through the previous defined procedure.

$$K = \begin{bmatrix} 77 & -14 & -42 & -56 \\ -14 & 98 & -21 & -28 \\ -42 & -21 & 42 & -84 \\ -56 & -28 & -84 & -7 \end{bmatrix}$$

After taking additive inverse and mod 26, ***k*** will become ***k'***:

$$k' = \begin{bmatrix} 25 & 12 & 10 & 22 \\ 12 & 20 & 05 & 24 \\ 10 & 05 & 16 & 20 \\ 22 & 24 & 20 & 19 \end{bmatrix}$$

Encryption

Consider any plaintext :

plaintext = SECURITY

We are taking four (4) letters of the plaintext at a time:

$$p = \begin{bmatrix} S \\ E \\ C \\ U \end{bmatrix} = \begin{bmatrix} 18 \\ 4 \\ 2 \\ 20 \end{bmatrix}$$

Applying transposition

$$p' = \begin{bmatrix} U \\ C \\ E \\ S \end{bmatrix} = \begin{bmatrix} 20 \\ 2 \\ 4 \\ 18 \end{bmatrix}$$

Applying Caesar Cipher Substitution

$$p'' = \begin{bmatrix} 20+7 \\ 2+7 \\ 4+7 \\ 18+7 \end{bmatrix} = \begin{bmatrix} 27 \\ 9 \\ 11 \\ 25 \end{bmatrix} (\text{mod } 26) = \begin{bmatrix} 1 \\ 9 \\ 11 \\ 25 \end{bmatrix}$$

Right Shifting

$$p''' = \begin{bmatrix} 1 \\ 9 \\ 11 \\ 25 \end{bmatrix} = \begin{bmatrix} 00000001 \\ 00001001 \\ 00001011 \\ 00011001 \end{bmatrix} = \begin{bmatrix} 00000000 \\ 00000100 \\ 00000101 \\ 00001100 \end{bmatrix}$$

Save the shifted bits in a variable **shft**

$$\text{Shft} = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}$$

Binary to decimal conversion

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$$p''''= \begin{bmatrix} 0 \\ 4 \\ 5 \\ 12 \end{bmatrix}$$

For encryption follow the normal method of hill cipher, so, will be as follow:

$$\begin{bmatrix} 25 & 12 & 10 & 22 \\ 12 & 20 & 05 & 24 \\ 10 & 05 & 16 & 20 \\ 22 & 24 & 20 & 19 \end{bmatrix} * \begin{bmatrix} 0 \\ 4 \\ 5 \\ 12 \end{bmatrix} = \begin{bmatrix} 362 \\ 393 \\ 340 \\ 424 \end{bmatrix} (\text{mod } 26)$$

$$\mathrm{c} = \begin{bmatrix} 24 \\ 3 \\ 2 \\ 8 \end{bmatrix}$$

Decryption

After the regular procedure of decryption of hill cipher we produce the plaintext:

$$\begin{bmatrix} 25 & 12 & 10 & 22 \\ 12 & 20 & 05 & 24 \\ 10 & 05 & 16 & 20 \\ 22 & 24 & 20 & 19 \end{bmatrix} * \begin{bmatrix} 24 \\ 3 \\ 2 \\ 8 \end{bmatrix} = \begin{bmatrix} 832 \\ 550 \\ 447 \\ 792 \end{bmatrix} (\text{mod } 26)$$

$$p'''' = \begin{bmatrix} 0 \\ 4 \\ 5 \\ 12 \end{bmatrix}$$

Left Shifting

$$p''' = \begin{bmatrix} 0 \\ 4 \\ 5 \\ 12 \end{bmatrix} = \begin{bmatrix} 00000000 \\ 00000100 \\ 00000101 \\ 00001100 \end{bmatrix} = \begin{bmatrix} 00000000 \\ 00001000 \\ 00001010 \\ 00011000 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} 00000001 \\ 00001001 \\ 00001011 \\ 00011001 \end{bmatrix}$$

Binary to decimal conversion

$$p" = \begin{bmatrix} 1 \\ 9 \\ 11 \\ 25 \end{bmatrix}$$

Perform back substitution

$$p" = \begin{bmatrix} 1-7 \\ 9-7 \\ 11-7 \\ 25-7 \end{bmatrix} = \begin{bmatrix} -6 \\ 2 \\ 4 \\ 18 \end{bmatrix} (\text{mod } 26) = \begin{bmatrix} 20 \\ 2 \\ 4 \\ 18 \end{bmatrix}$$

Perform back transposition and get original plaintext

$$\begin{bmatrix} 20 \\ 2 \\ 4 \\ 18 \end{bmatrix} = \begin{bmatrix} 18 \\ 4 \\ 2 \\ 20 \end{bmatrix} = \begin{bmatrix} S \\ E \\ C \\ U \end{bmatrix}$$

In the way, the plain text will be recover.

6. EXPERIMENTAL RESULTS

To quantify the experimental results different parameters are used to obtain the execution of this algorithm and their comparison with the existing method. Through simulation, experimental results are obtained by using MATLAB. Table 1 shows the overall performance evaluation and encryption time, decryption time and the orthogonal key evaluation time.

Table 1. Encryption & Decryption execution time of Actual and Proposed algorithms.

File Size (bytes)	Encryption & Decryption Execution Time (msec)	
	THC	TSLRS
10	67	65
14	109	106
18	132	116
Total: 42	308	287

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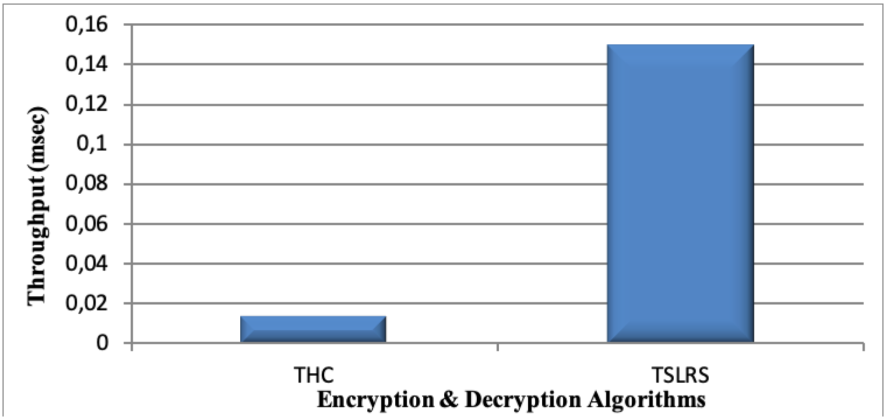

Figure 1. Encryption & Decryption execution time comparison of the actual algorithm with the proposed algorithms using the different file size.

Calculation of Encryption & Decryption Throughput:

Decryption Throughput (bytes/sec) = Σ Input File Size/Σ Encryption & Decryption Execution Time

Σ Input file Size = 10 + 14 + 18

Σ Input file Size = 42 bytes.

Encryption & Decryption Throughput for THC:

Σ Encryption & Decryption Execution Time [THC] = 67+109+132

Σ Encryption & Decryption Execution Time [THC] = 308

Encryption & Decryption Throughput [THC] =42/308

Encryption & Decryption Throughput [THC] = 0.014 bytes/msec.

Encryption & Decryption Throughput for TSLRS:

Σ Encryption & Decryption Execution Time [TSLRS] = 65+106+116

Σ Encryption & Decryption Execution Time [TSLRS] = 287

Encryption & Decryption Throughput [TSLRS] =42/287

Encryption & Decryption Throughput [TSLRS] = 0.15 bytes/msec.

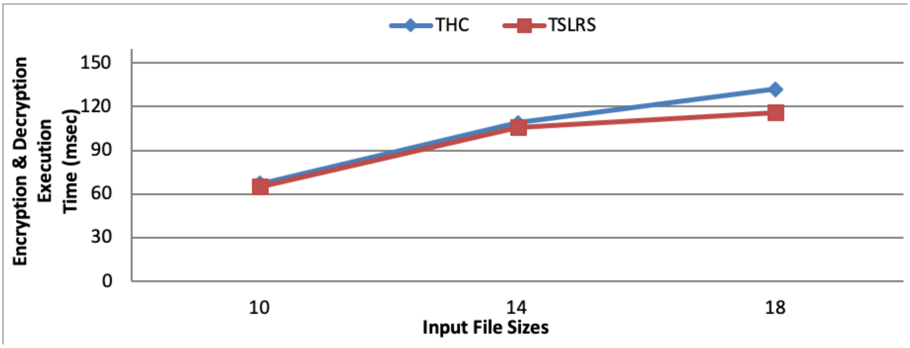

Figure 2. Throughput of THC & TSLRS Encryption & Decryption Algorithms.

7. CONCLUSION

From the above experimental results, it has examined that the proposed algorithm provides optimized results in comparison with the inverse process as well as the encryption and decryption algorithms. This algorithm provides better throughput for file sizes of any type when compared with the actual algorithm.

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MAPPING LAND COVER DAMAGES IN MEGA FLOODS THROUGH INTEGRATION OF REMOTE SENSING AND GIS TECHNIQUES

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ABSTRACT

Today we are encircled by multiple problems, such as global warming, drought, wildfires, Hurricanes and tropical storms etc; among them, flooding is one of the major problems; however, the flood hazards are probably rising due to an amalgamation of environmental and socio–economic effects. Therefore flood safety measurements are more essential to avoid barriers toward major development in society associated with the environment, which requires modern and accurate steps for preventing the impacts of the flood on population and properties. Floods are among the most destructive physical vulnerabilities on the earth's surface, which cause major economic and social damages rather than any other natural incidence. However, the flood problem begins because human beings are using river floodplains.

In this research our focus is to identify and measure extent and impacts such as Infrastructural, loss of Agriculture, Built–up (Houses), natural vegetation and property along Indus river due to heavy flooding of 2010, to achieve our purpose, two different years Landsat imageries before and after flood i.e September 2009 and September 2010 have been applied and the desired results were achieved through the integration of Remote Sensing (RS) and Geographical Information System (GIS) techniques.

With the help of RS data, hazardous impacts of flooding 2010 have been observed on the bases of different factors which were performed on Arc Map 10.3.1, Erdas Imagine 9.2, eCognition Developer 64. After performing different analysis the major losses have been observed which are shown in table 1to4 and further highlighted in Figure 5a to 8g.

KEYWORDS

Land–sat 5 Thematic Mapper (TM), Flood Hazards, OBE classification, Error Matrix, Accuracy assessment.

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1. INTRODUCTION

According to the worldwide climatic researcher, they believe that all climatic changing is caused by human activities, and it will increase unless any mitigation actions are successfully applied (Anderegg, Prall, Harold & Schneider, 2010; Sellers, 1969). The flood hazards are probably to rise due to an amalgamation of environmental and socio–economic effects. It directs to various floodplains are debarred from sustainable development. Therefore its safety is more essential towards the development of society, which requires modern and accurate measures to prevent the impacts of the flood on people and properties.

The flood which may cause property at high risk including housing, transportation and public service, infrastructure, commercial, industrial and agricultural areas. It is a familiar natural disaster which added approximately 40% of a worldwide natural hazard (Fedorov, Badenko, Maslikov & Chusov, 2016) (Hapuarachchi, Wang & Pagano, 2011). Floods are among the most destructive physical vulnerabilities on the earth's surface, which cause major economic and social damages rather than any other natural incidence. While through assessment and analysis it has been observed that flood hazard is a serious problem of human beings, because mostly they are using river floodplains that create huge physically and mentally disturbance (Irimescu, Stancalie, Craciunescu, Flueraru & Anderson, 2009). During flood time mapping of the flood area is more essential for emergency planning but it needs fast acquirement, processing and data analysis to accomplish the requirement. However accessibility in a few hours sustains emergency relief planning and assists to coordination of the response activities of different decision makers so they require two kinds of rapid mapping products, an overview maps of flooded areas and damage maps united with extra information, such as flood extent distinction or land–use types within the flooded area (Trianni & Gamba, 2008). The remote sensing is a significant field which gives rapid information of an area, thus it has more useful and extensive applications in the field of disaster management. Generally, space–based platforms give extensive spatial coverage without access restrictions while ground–based observing networks are unable to provide sufficient information because of the low density of monitoring points.

Although in this scenario flood risk zones can be mapped and monitor through Satellite observation (Irimescu, Craciunescu, Stancalie & Nertan, 2010). With the help of remote sensing data, we can map flooded risky areas, land cover, drainage networks, specific river basin modelling, and a post–event estimation of damaged areas (Trianni & Gamba, 2008).

The flood hazard measurement needs integrative approaches and studies, the possible flood hazard may be decreased by reducing the intensity of vulnerability, decreasing the exposure value and decreasing the risk (Dang, Babel & Luong, 2011). It is world widely accepted that flood is the major indicator of hazardous damages and associated damages are categorized as direct or indirect. The environmental and agricultural damages are the results of the directly associated flood while indirect damages effect on the regional or national economy such as business interruption. Also, indirect damages have health and psychological losses ("A mathematical model for flood loss estimation," 2003). It has been observed that during the monsoon period between July and September river flood generally occurs as a consequence of serious rainfall in the stream drainage area, which causes the flood usually in dry areas due to high water volume in the river.

Pakistan is a flood–prone country with a history of extensive and continual flooding, almost average floods in Pakistan are observed in monsoon periods and the most hazardous flood was occurred on mid July 2010 which caused by serious monsoon rainfall in most regions of the country, about $1/5^{th}$ total land area was affected mostly Punjab, KPK, Baluchistan and Sindh.

According to Metrological Department of Pakistan the regular rainfall in the months of July and August 2010 was evaluated (Forecast 2010), and the flood wave progression monitored (Monsoon 2010), the discharge levels were compared with the floods of 1988, 1995, and 1997 (Past floods 2010), as a result overall the monsoon rainfall of 2010 was the highest since 1994 throughout the preceding 50 years. Since 1947–2014, floods in Pakistan especially in the Indus River Basin have been caused loss of lives, million acres and enormous infrastructure and crop losses (Haq, Memon, Muhammad,

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Sidiqui, & Rahmatullah, 2012). The destruction during the flooding 2010 that harm to the economy of the country which is estimated more than US$4 billion (Flood Events, 2010). the flood was destroyed different areas from upper Punjab and moved southward along the Indus basin toward the southern areas of Sindh province (BBC 2010), and the most seriously damaged areas were as Kashmore, Ghotki, Sukkur, Shikarpur, Jacobabad, (PDMA. Sindh, 2011).

2. STUDY AREA

The whole province was damaged by the flood of 2010 but most vulnerable districts such as Kashmore, Ghotki, Sukkur, and Shikarpur with 10 flooded talukas were selected for the studies along Indus River which are shown in Figure 1. These districts are located on both sides of Indus River on the North West and North East portion of Sindh province, Pakistan. Geographically Study area extends from 28°25'39.69"N, 69°42'47.34"E to 27°42'3.38"N 68°28'34.42"E with a mean elevation of 55±4 m. covering an area of 2619.91 km².

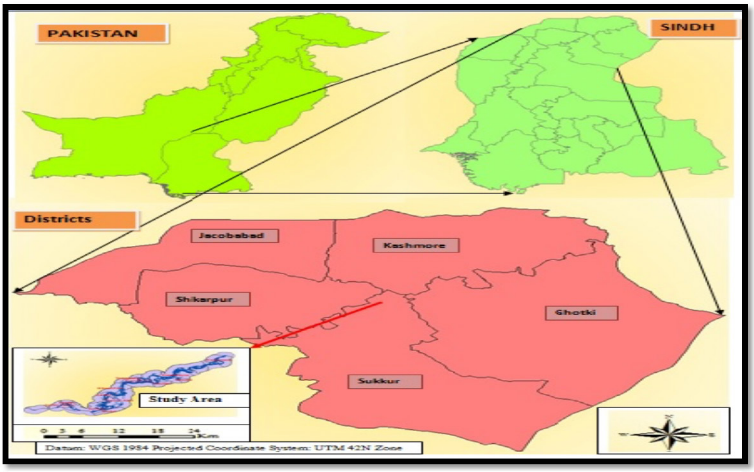

Figure 1. Location of Study area.

The study area has a monsoon climatic region at an average maximum and minimum temperatures are 42°C and 31°C, respectively, June is the hottest month of the year. While in the month of January the lowest average temperatures reach approximately 14.8 °C. During the year precipitation in the region is about 130 mm, the lowest in the month of October, with an average of 2 mm, which is not sufficient for crop water requirements. However, mostly region is agricultural region. These areas are most cultivated and common rotation crops are as rice, cotton, maize, mash, fodder, sugarcane and wheat while these crops are divided into two types such as summer (Kharif) and winter (Rabi). The rice and cotton crops sown in the month of June to September on most of the agricultural lands while it's harvesting starts in the middle of October and continues to the end of November, whereas wheat sown in Rabi season which starts November to March and approximately 30% of the area covered by Rabi types of crops . it has been observed that before flooding 2010 most area was cultivated by Kharif type of crops i.e rice and cotton which were hazardously damaged by flooding 2010 which was begun in late July 2010.

3. METHODOLOGY

The Figures 2 and 3 show the process of flood hazard, where data have been collected, processed and analyzed the major flood damages then finalized through efficiently techniques of remote sensing (RS) and Geographical Information system (GIS).

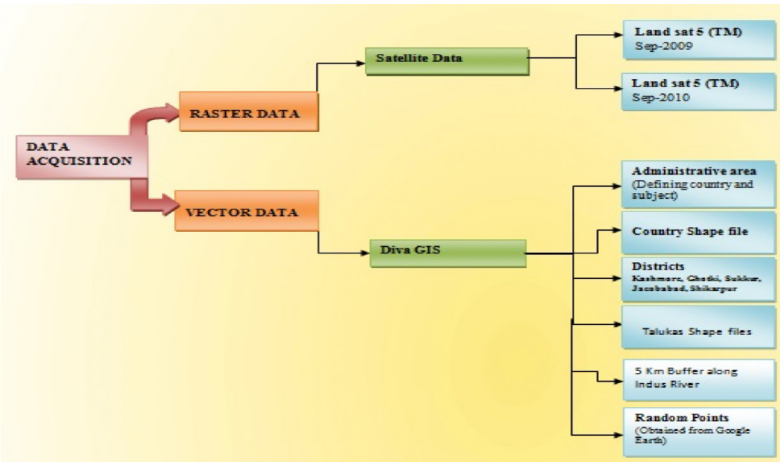

Figure 2. Flow chart shows data Acquisition.

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In data pre–processing the geometric and radiometric correction were carried out and then imageries stacked by selected required bands, after stacking layer the images were mosaic by using ERDAS Imagine 9.2 software, while using clip tool on ArcMap10.3.1software, the study area/Area Of Interest (AOI) with 5km buffer on both sides of Indus river was developed and classified to recognize different types of land–use and land–cover (LULC) before and after flood.

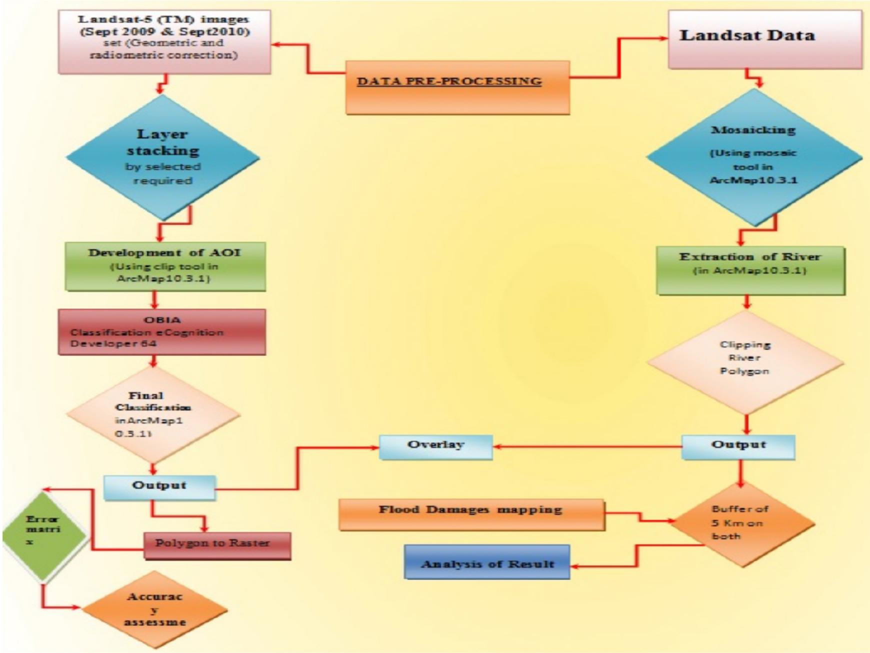

Figure 3. Flowchart shows Data Pre-Processing.

The determination and analysis of flood was carried out by using the two different years image sets, on these sets of image the classification was carried out through Object–Based Image Analysis (OBIA) method, which was performed by using e–Cognition Developer 64(Desktop application), NIR, Green and Red Bands of Landsat–5 (TM) were used to distinguish among Agricultural land, Barren Land (Unused land), Built–up(Roads Settlements etc), vegetation and Water bodies on the different percentage levels of absorption of the spectrum. The river was extracted from Land–sat imageries and overlaid with the land use and land cover (LULC) classification by using map algebra, this layer was used to refine flood damages. Thus the river was overlaid with imagery classifications to obtain final desirable results and finally the flooded area was calculated and analyzed with the help of remote sensed data and integration of remote sensing & GIS tools.

4. RESULTS AND DISCUSSION

Floods are common and are costly natural disasters. Generally, floods are local, short–term events which can occur rapidly, sometimes with little or no warning. In this research, a simple and price efficient method was applied to recognize major flood damages along the Indus river basin especially in the upper region of Sindh province including the districts i.e. Kashmore, Ghotki, Sukkur, Shikarpur. Each district has been with the same types of Land use and Land cover (LULC) to recognize the major losses of Crops, Vacant Land, Settlements, vegetation and water bodies as shown in Figure 4.

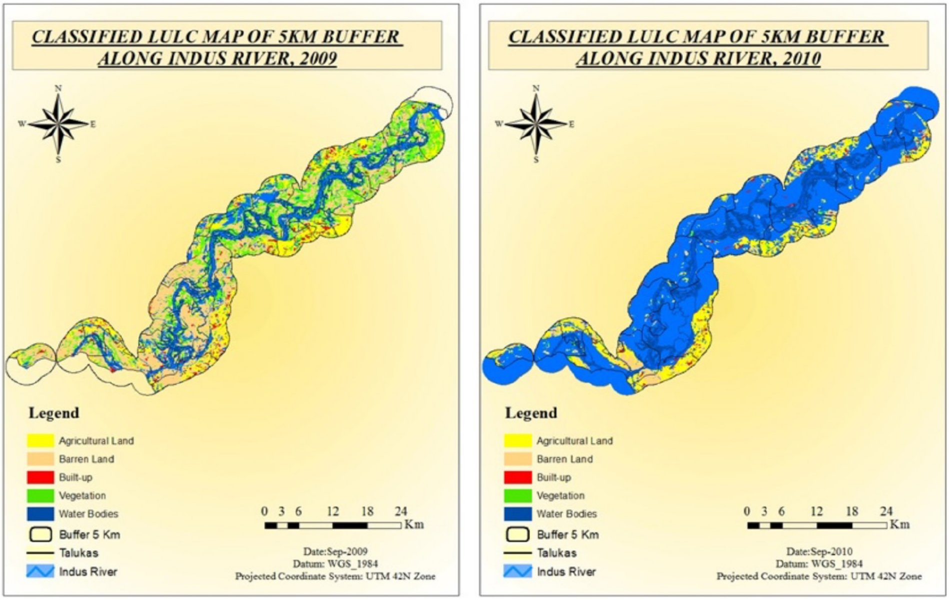

Figure 4. LULC map of the study area.

Landsat–5(TM) imagery of–Sept–2009–Sep 2010 the district Kashmore its three Talukas namely Kashmore, Kandh Kot, and Tangwani having collectively area of 3151.881km^2, while along the river under the 5 km buffer, area was 1371.615 km^2 which classified into (1) Agricultural land(during the summer (Kharif) period

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from June to September mostly area was covered with rice and cotton & other crops) which was (11.117 %) in 2009 and (8.544% in Sept 2010) and; (2) Barren Land (including vacant, not suitable for growth of seed, crops, unproductive, and desert land (30.100 % in 2009 and 4.579% in 2010); (3) Built–up (including small villages to towns and cities roads) (2.695% in 2009 and 1.541% in 2010); (4) Vegetation (35.843% in 2009 and 0.526% in 2010); (5) Water Bodies (20.243%in 2009 and 84.808% in 2010) these are shown in Table 1 and Figure 5.

Table 1. Different type losses in district Kashmore.

Land use	Image of Sep–2009		Image of 22–Sep–2010		Difference	
Category	Area in Sq Km	Area %	Area in Sq Km	Area %	km^2	%
Agricultural Land	152.495	11.118	117.289	8.545	–35.207	–2.573
Built–up	36.968	2.695	21.153	1.541	–15.815	–1.154
Barren Land	412.859	30.100	62.858	4.579	–350.001	–25.521
Vegetation	491.633	35.843	7.225	0.526	–484.408	–35.317
Water Bodies	277.660	20.243	1164.110	84.808	886.450	64.565
Total	1371.615	100.000	1372.635	100.000		

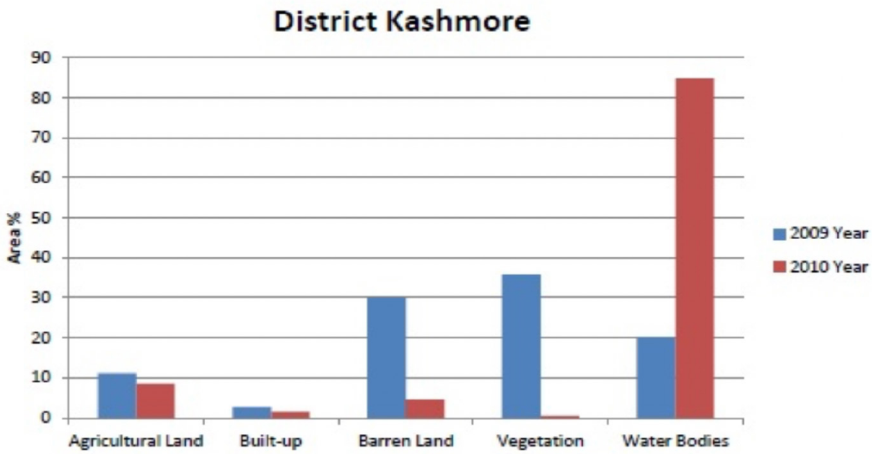

Figure 5. Losses in District Kashmore due to heavy flooding of 2010.

The district Ghotki having an area 5714.004 km^2, its only one Taluka namely Ghotki, lies along the river having an area about 112.853 km^2 which classified into (1) Agricultural land which was (52.598%) in 2009; and (45.208%) in 2010; (2) Barren Land was (14.201%) in 2009; and (5.304% in 2010); (3) Built–up (7.007%) in 2009; and (1.652%) in 2010); (4) Vegetation (15.671%) in 2009; and

1.058 % in 2010); (5) Water Bodies (10.5260% in 2009 and 46.775 % in 2010) are shown in Table 2 and Figure 6.

Table 2. Different type losses in district Ghotki.

Land use	Image of Sep–2009		Image of 22–Sep–2010		Difference	
Category	Area in Km2	Area %	Area in Km2	Area %	km²	%
Agricultural Land	59.359	52.598	50.826	45.209	–8.533	–7.390
Built–up	7.908	7.007	1.858	1.652	–6.050	–5.355
Barren Land	16.028	14.203	5.964	5.305	–10.064	–8.898
Vegetation	17.685	15.671	1.190	1.058	–16.496	–14.613
Water Bodies	11.873	10.521	52.588	46.776	40.715	36.255
Total	112.853	100.000	112.425	100.000		

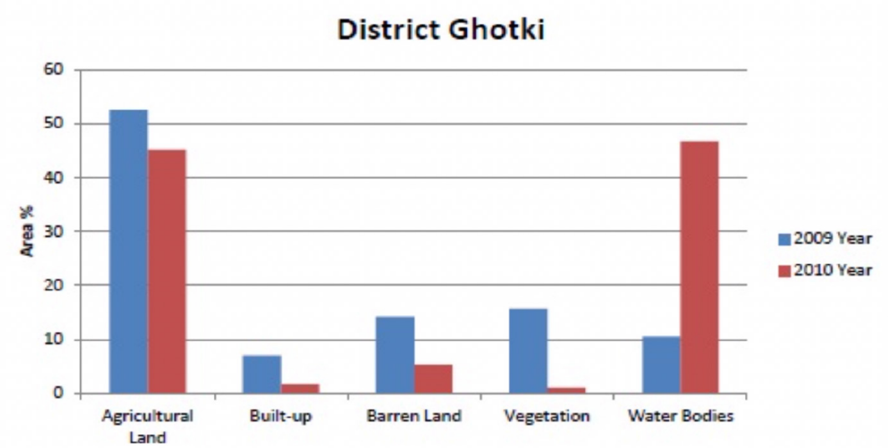

Figure 6. Losses in District Ghotki due to heavy flooding of 2010.

District Sukkur has an area 4720.27 km², while along the River under the 5 km buffered area was 707.861 km² area which classified into (1) Agricultural land was (18.541%) in 2009 and (21.056%) in Sept 2010; (2) Barren Land (46.966%) in 2009 and (66.584 %) in 2010; (3) Built–up (3.885%) in 2009 and (2.428%) in 2010); (4) Vegetation (9.815%) in 2009 and (0.3788%) in 2010; (5) Water Bodies (20.784%) in 2009 and (66.739% in 2010) are shown in Table 3 and Figure 7.

Table 3. Different type losses in Sukkur.

Land use	Image of Sep–2009		Image of 22–Sep–2010		Difference	
Category	Area in Sq Km	Area %	Area in Sq Km	Area %	km²	%
Agricultural Land	131.295	18.548	149.214	21.057	17.919	2.509
Built–up	27.507	3.886	17.207	2.428	–10.300	–1.458
Barren Land	332.455	46.966	66.590	9.397	–265.865	–37.569

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Land use	Image of Sep–2009		Image of 22–Sep–2010		Difference	
Category	Area in Sq Km	Area %	Area in Sq Km	Area %	km²	%
Vegetation	69.478	9.815	2.685	0.379	–66.793	–9.436
Water Bodies	147.127	20.785	472.933	66.739	325.807	45.955
Total	707.862	100.000	708.629	100.000		

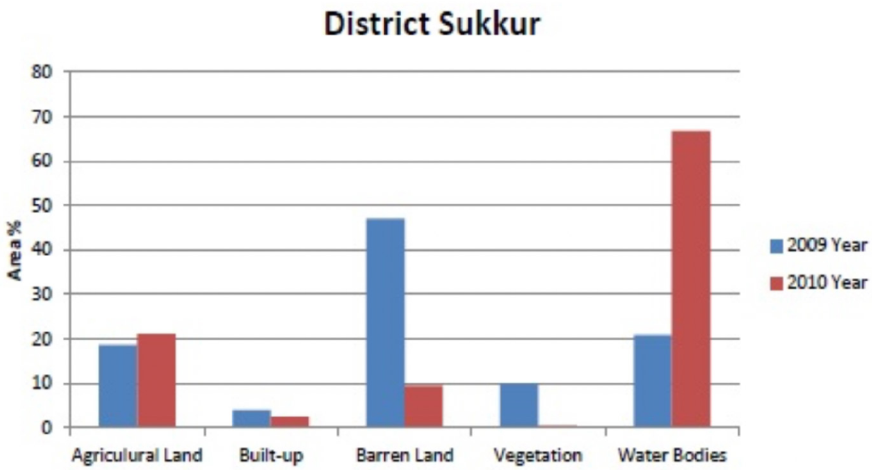

Figure 7. Losses in District Sukkur due to heavy flooding of 2010.

District Shikarpur and its three Talukas such as Garhi Yasin, Khan Pur, Khan Pur, have collectively area 806.846 km² while along the River under the 5 km buffered area was 566.911 km² which classified into (1) Agricultural land which was (10.392%) in 2009 and (8.592%) in Sept 2010); (2) Barren Land (53.013%) in 2009 and (6.120%) in 2010; (3) Built–up (2.337%) in 2009; and (0.970%) in 2010; (4) Vegetation (18.879%) in 2009 and (1.606%) in 2010; (5) Water Bodies (15.377%) in 2009 and (66.739%) in 2010) which is shown in Table 4 and Figure 8.

Table 4. Different type losses in district Shikarpur.

Land use	Image of Sep–2009		Image of 22–Sep–2010		Difference	
Category	Area in Sq Km	Area %	Area in Sq Km	Area %	km²	%
Agricultural Land	58.919	10.393	49.119	8.593	–9.799	–1.800
Built–up	13.249	2.337	5.582	0.976	–7.667	–1.361
Barren Land	300.538	53.013	34.986	6.120	–265.552	–46.893
Vegetation	107.031	18.880	9.186	1.607	–97.845	–17.273
Water Bodies	87.174	15.377	472.759	82.703	385.585	67.326
Total	566.911	100.000	571.633	100.000		

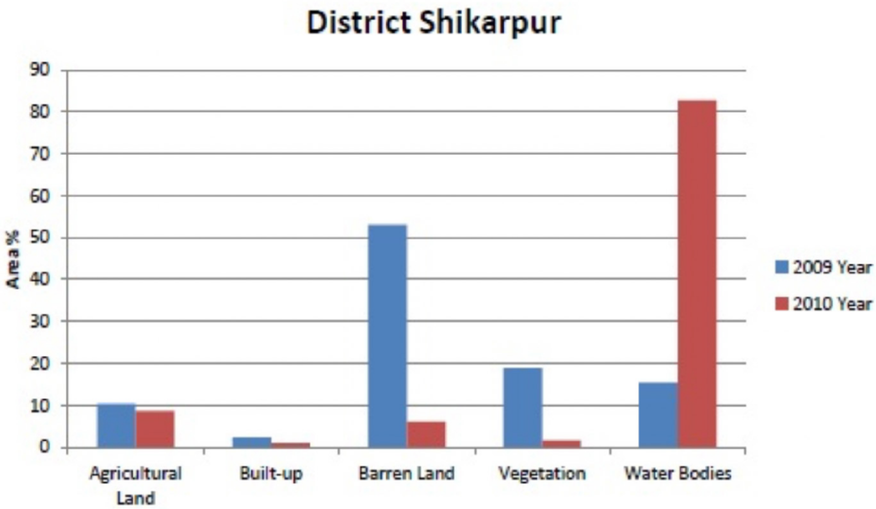

Figure 8. Losses in District Shikarpur due to heavy flooding of 2010.

The LULC classification explained loss of Agricultural land Barren Land, Built–up, Vegetation caused by flooding of 2010, also the flood map of the study region which is shown in Figure 4, indicated that around the 5km on both sides the area which is under Indus basin is destroyed including Kashmore, its three talukas namely Kashmore, Kandhkot and Tagwani, District Ghotki its Ghotki Taluka, District Sukkur its three Talukas such as Rohri, Sukkur and Pano Akil District Shikarpur its three Talukas such as Garhi Yasin, lakhi and Khan Pur.

6. ACCURACY ASSESSMENT

For the accuracy assessment, the Kappa coefficient and overall accuracy techniques have been applied to verify the land use classification. While an analytical technique i.e. the error matrix was also used and calculated, then producer's accuracy was determined, it is the possibility in which a pixel in the recognized image is positioned in the similar class on the ground. Meanwhile, the true pixel in every class is divided by the sum of the pixel class which is obtained from the reference data. The possibility of reference pixels which are properly classified is called a producer's accuracy. Whereas the accuracy in which overall

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true pixels of the ground is divided by the sun of pixels which classified in a class is called as user's accuracy, it is an analytical possibility in which the pixels are classified on the image that actually shows the category on the ground. However, the user's accuracy is the possibility of a specific class of ground which is classified in similar class on the classified image as shown in Table 5 and 6.

Table 5. Error matrix used to assess the accuracy of a classification of the Sept 2009 Landsat TM image.

Reference Data Landsat 5 Sep–2009							
Classified							
Data	Agricultural Land	Built–up	Barren Land	Vegetation	Water Bodies	Total	User Accuracy %
Agricultural Land	256	0	0	10	0	266	96.24
Built–up	0	129	0	0	0	129	100
Barren Land	0	8	32	4	0	40	80
Vegetation	2	0	0	1098	4	1100	99.81
Water Bodies	1	0	0	21	454	476	95.45
Total	259	137	32	1133	1133		
Producer Accuracy %	98.84	94.16	100	96.91	98.84		

Table 6. Error matrix used to assess the accuracy of a classification of the Sept 2010 Landsat_8 image.

Reference Data Land–sat 5 TM 2010							
Classified							
Data	Agricultural Land	Built–up	Barren Land	Vegetation	Water Bodies	Total	User Accuracy %
Agricultural Land	1104	0	0	82	0	1186	96.24
Built–up	0	342	0	3	0	3	96.24
Barren Land	0	6	65	0	0	0	96.24
Vegetation	3	0	1	11610	0	11613	96.24
Water Bodies	0	0	0	17	66	83	96.24
Total	1107	348	66	11712	66		
Producer Accuracy %	98.84	98.84	98.84	98.84	98.84		

7. CONCLUSION

The availability of remote sensing data and GIS techniques helped to recognize the major flood impacts before and after the flooding of 2010 along the Indus river basin. However the flood damages such as Infrastructural, loss of Agriculture, Built–up (Houses), natural vegetation and property have been identified and also its extent has been measured by using Landsat imageries i.e. September 2009 and September 2010, and the results have been achieved through integration of Remote Sensing (RS) and Geographical Information System (GIS) techniques.

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/14/

A STUDY OF MOBILITY MODELS FOR UAV COMMUNICATION NETWORKS

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ABSTRACT

The Unmanned aerial vehicle communication network (UAVCN) is a group or swarm of unmanned aerial vehicles which can be used for specific military and civilian applications without human intercession. This network faces the design problem which is based on network mobility. The frequent topology changes affect communication and collaboration among the UAVs (Unmanned aerial vehicles). To govern the movement pattern of UAVCN different mobility models needed to be studied in order to solve this communication issue. In this paper, mobility models are explored which provides the particular mobility pattern to resolve the problem of collaboration, communication and cooperation of UAVs. These models have been categorized into five groups and classified each group in detail. These mobility models provide the platform to understand and implement the unmanned aerial communication network for specific environment scenarios. The mobisim simulator tool is used to generate the mobility model s trajectories for different mobility models.

KEYWORDS

Mobility models, Unmanned aerial vehicles, Unmanned aerial vehicle communication networks, Wireless communication.

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1. INTRODUCTION

Recently the UAVCN is growing technology in the field of wireless communication and ad–hoc networking. The UAVs establish networking to communicate in the air which increases the demand to attain the larger area for a specific mission. Nowadays, it is an economic solution for different civilian and military monitoring and surveillance applications. These nodes mover freely in free space with a speed of 30 to 460 km/h. However, it creates problems in communication due to the high (Bujari, Calafate, Cano, Manzoni, Palazzi & Ronzani, 2017). Eventually, this problem is not avoided due to sensitive and reliable real–time applications. However, researchers develop the new mobility models for a specific environment and applications to cope with the challenges of mobility. The routing is important in the communication of UAVs that depends upon the mobility models. These models of mobility cope with the speed deviations of UAVs. The random movement of nodes due to environment and location changes that needed to redefining the paths. However, the random mobility model is used to model UAVs communication scenarios. For the correlated movement of UAVs, the temporal–based model is used for critical situations or missions where the systematic movement of nodes needed. The group of UAVs which can fly in the space and collaborate with each other for a specific application. Figure.1 depicts the UAVCN network.

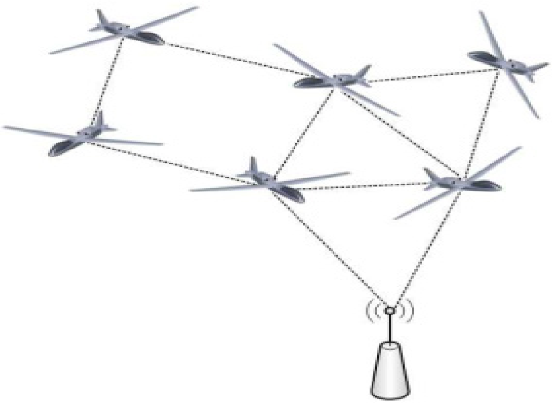

Figure 1. UAVCN Network.

Generally, the mobility models have a greater role in the communication that provides the mobility patterns to generate pathways for UAVs communication. The novelty of this paper is to study the several mobility models suitable for Unmanned aerial vehicle communication networks for different situations and for different applications in this domain.

2. LITERATURE REVIEW

The UAVCN performance varies by mobility models and the type of applications. However, the movement patterns of UAVs are important for communication. The dynamic nature of these network nodes impacts on network features such as connectivity, distance, and density or capacity of the network. In the real world, dynamic and random patterns are different from actual patterns of movement (Yassein & Damer, 2016). Therefore, the researchers explored this area by classifying the mobility models. In ad–hoc networking, the mobility models split into two classes. One of them is an entity and another is mobility models (Wang, Guan, Wang & Wang, 2010). In this research, the authors explored the multi–hop routing and using different models evaluated and observed the significant impact on performance. It has studied that many authors explored existing mobile ad–hoc network mobility models, although the few have focused on UAVs ad–hoc mobility models. In Wan, Namuduri, Zhou and Fu (2013) authors proposed AN (AirBrone) network in which smooth turn mobility model has used which accounts for spatial and temporal dependency. The nodes trajectory could be predicted by speed and acceleration correlated information. In (Kuiper & Nadjm–Tehrani, 2006) authors have discussed the scenarios of UAVs which having the memoryless pattern of mobility models. In the first scenario, the nodes have the memoryless movement and another scenario using the pattern of pheromones that help coordination among UAVs. In Ribeiro and Sofia (2011) authors discussed the Paparazzi mobility model for UAVs communication and compared with another random waypoint. Paparazzi mobility model has five movement patterns stayAt, waypoint, eight, oval and scan. In Bouachir, Abrassart, Garcia and Larrieu (2014) authors proposed Semi–Random Circular Movement mobi-

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lity model for UAV ad–hoc network. In Erim and Wright (2017), this paper, authors have examined RPGM (Reference Point Group Mobility model), GMMM (Gauss Markov mobility model), RWP (Radom Waypoint) and MGMM (Manhattan Grid mobility model) by using temporal dependent, spatial dependant, geographic–based and random based mobility model families. To create realistic ad–hoc network simulation environment these models are indispensable (Aschenbruck, Gerhards–Padilla & Martini, 2008). For exploring of ad–hoc network protocol performance in mobile ad–hoc networking is varying significantly as compared to studying the unmanned aerial vehicle communication network. A survey carried out by authors for Airbrone Networks in which the mobility models are classified into two categories. One is traditional mobility models another is aerial ad–hoc network mobility models (Xie, Wan, Kim, Fu & Namuduri, 2014).

3. MOBILITY MODEL

The UAVCN network mobility is contingent on two fundamental aspects, one of them is nodes location another is velocity change with respect to time (Yassein & Damer, 2016). The study of node movement can be carried out by mathematical equations, mathematical modelling or simulation method. The simulation method is more reliable for mobility modelling and provides a better solution for complex problems. The mobility models which can be used for UAVCN are categorized as pure randomized mobility model, time dependant mobility model, path planned mobility mode, group mobility model and topology control based mobility model which are further classified and discussed as under.

3.1. PURE RANDOMIZED MOBILITY MODELS

The PRMM (Pure Randomized Mobility Models) are randomized in nature. UAVs are hovering in the environment randomly in terms of direction, movement time and speed (Kumari, *et al.*, 2015). These models are commonly used to explore the area according to the mission by using UAVCN. The randomized models are simple and mostly used in research. The types of pure randomized models are RWP (Random Way Point) Mobility Model, RW (Random Walk) mobility model, RD (Random Direction) mobility model and MGM (Manhattan grid mobility model).

3.1.1. RWP (RANDOM WAY POINT) MOBILITY MODEL

The gap of time among the node direction and speed changes are coming under the umbrella of the RWP mobility model (Kumari, *et al.*, 2015). Through this models UAV, s move in random positions in a particular region. This model supports the network nodes to move left, move right, and going straight. Figure 2. depict the RWP mobility model.

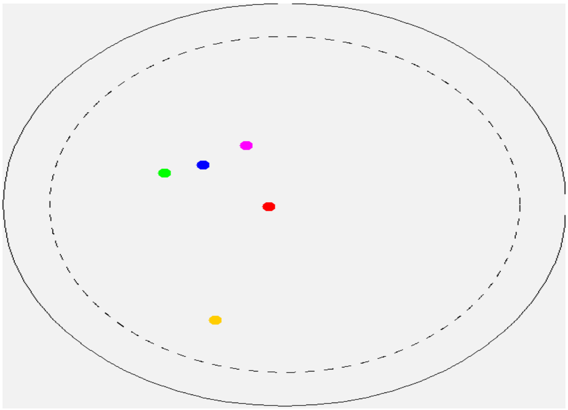

Figure 2. The random waypoint mobility model.

3.1.2. RW (RANDOM WALK) MOBILITY MODEL

The RW mobility model introduced for unpredictable random movement of numerous entities in the environment. It is based on the Brownian motion which mathematically described in 1926 by Einstein. In RW mobility model, the UAVs simulate this rough association preferring, each time, a random path. Every progress takes place in a constant time gap t and travelled distance d, finally, at the ending, a new direction and velocity are calculated. However, a UAV jump the boundary of simulation region, the fresh direction is computed. It is known as memoryless mobility model because RW doesn't accumulate the information of its precedent position and movement. Figure 3 depict the RW mobility model.

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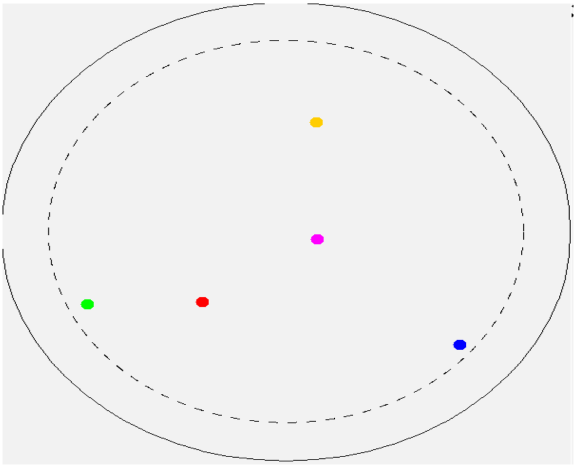

Figure 3. The random walk mobility model.

3.1.3. RD (RANDOM DIRECTION) MOBILITY MODEL

This mobility model was introduced to handle the problems of concentration of UAVs in the central part of the simulation region in the random waypoint mobility model because of the greater probability of movement towards the fresh destination close to the middle of simulation area. By random direction mobility model, every UAV choose a destination towards the edge of the simulation region. As the node reaches the edge, it yet again chooses an additional random destination position at the edge (Bujari, *et al.*, 2017). Figure 4 depicts the RD mobility model.

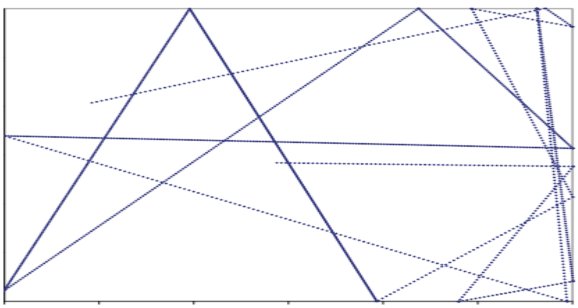

Figure 4. The random direction mobility model

3.1.4. MGM (MANHATTAN GRID MOBILITY MODEL)

This model is used on the basis of the map–based approach. Where the UAVs movement takes place in the geographic boundaries. It indicates that the nodes travel in the predefined straight and perpendicular grids. The UAVs are permitted to move in the direction of north, south, east or west. At the defined grid the horizontal movement of node takes place with a probability of 0.5 and UAV can turn towards the corner with a probability of 0.25 (Wang, *et al.*, 2010). This mobility model utilizes a grid path topology. GM mobility model was generally projected for the movement of the urban region, wherever the road design is extremely normal. This mobility model has also used an urban map for the movement of the straight and perpendicular direction. It utilizes a probabilistic approach for the choosing UAV movements, because, at every crossroads, a vehicle prefers whether to carry on moving in the similar path or to rotate. Figure 5 depicts the Manhattan grid mobility model.

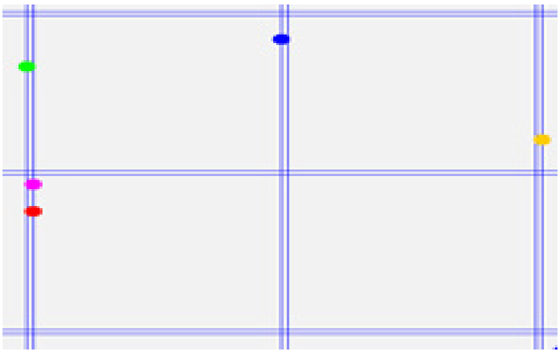

Figure 5. Manhattan grid mobility model.

3.2. TDMM (TIME–DEPENDENT MOBILITY MODELS)

The TDMM (Time–dependent mobility models) tries to avoid sharp changes in network nodes speed and direction. The smoothly changes in movement can be controlled by using different mathematical function. In these models UAVs depends upon the previous or earlier speed and direction (Guillen–Perez & Cano, 2018). The types of time–dependent mobility models are BSA (Boundless simulation area) mobility model GMM (Gauss–Markov mobility model) (Regis, Bhunia & Sengupta, 2016) and ST (Smooth turn) mobility model.

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3.2.1. BSA (BOUNDLESS SIMULATION AREA) MOBILITY MODEL

The BSA mobility model (Bujari, *et al.*, 2017) employs an association among the earlier direction and speed and to the present one's conversation. It permits the UAV to move freely in the simulation region, do away with any edge effects on the simulation evaluation. Nevertheless, many simulation scenarios might discover unattractive the no–side effects that happen since the moving elsewhere of an edge and toward the inside from an additional one. Due to the teleportation effect, it would not fulfil the important conditions for the mission area of 2D applications.

3.2.2. GMM (GAUSS–MARKOV MOBILITY) MODEL

The GMM model based on the tuning constraint which contrasts the degree of unpredictability in the mobility or movement pattern. It is used for simulation of ad–hoc networks. This model is dissimilar with RWP due to simulation area is varied. In GMM (Gauss–Markov mobility) model, every UAV is primarily set to a particular speed and direction, later with respect to time, movement of UAV does randomly update the direction and the speed. Both parameters are measured based on the last position due to the fast movement (Bilal & Khan, 2017). Figure 6 depicts the GMM model.

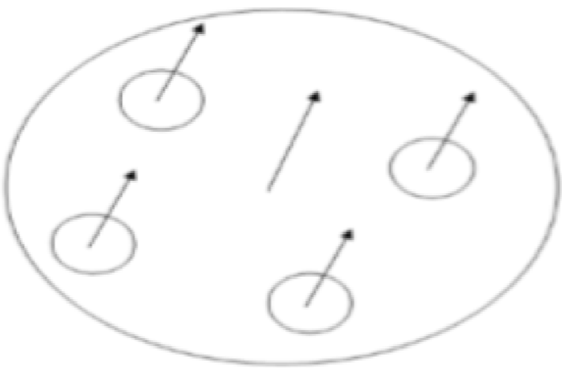

Figure 6. Gauss Markov mobility model.

3.2.3. ST (SMOOTH TURN) MOBILITY MODEL

This mobility model (Wan, *et al.*, 2013) permits the UAVs to travel in supple trajectories, comparing the increase of velocity rate of the UAVs across sequential and spatial coordinate. By means of this mobility model, every node selects a position in the space and then circle around it in anticipation of the node selects an additional turning point. The selected position should be vertical to the node direction, to make sure a horizontal trajectory. The period for the aeroplane to round in the region of the present circle position is formed to be exponentially distributed. Different conventional mobility models which strengthen vehicles to get ready quick turns, smooth turn practically capture the horizontal movement prototype of unmanned vehicles exclusive of insertion supplementary parameters. It has been studied that the cons of this model are lacking collision prevention method and boundary indication possessions due to the force of the moveable UAV on the region boundaries, which forces the UAV to unexpectedly amend its direction.

3.3. PPMM (PATH PLANNED MOBILITY MODELS)

The PPMM (Path planned mobility models) provides predefined path scheme to the network nodes. The UAVs follow that pattern and change the pattern at the end randomly. Similarly, change the pattern end to end in communication. The types of path planned mobility models are SRCM (Semi–random circular movement) mobility model and PPRZM (Paparazzi mobility model).

3.3.1. SRCM (SEMI–RANDOM CIRCULAR MOVEMENT) MOBILITY MODEL

SRCM mobility model is designed for the UAV's node which travels in a curving or bending manner. This model is employed for capturing of data and information through deploying UAVs in a specific area. Hence, every UAV is observing the specific area as permission. SCRM supports UAVs to communicate in a curved manner (Wang, *et al.*, 2010). Figure 7 depict the SCRM mobility model.

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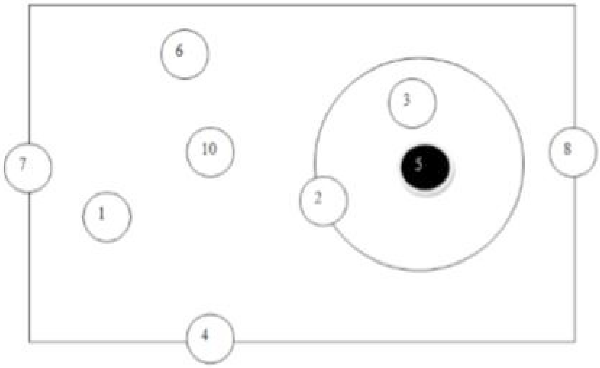

Figure 7. Semi–random circular movement mobility model.

3.3.2. PPRZM (PAPARAZZI MOBILITY MODEL)

The PPRZM is a stochastic flexibility exhibit that the copies paparazzi UAV conduct in light of the state machine. This model has 5 types of movements: one of them is staying at; this means over a fixed position UAV can hover, second is waypoint; In this movement UAV moves towards destination by using straight path, third is eight; In this movement UAV trajectory has the 8 shape from one place to another, scan; it scans the area by defining the two points through round trip, fifth is oval; it shifts round trip among 2 points and turn around when passing both points (Bouachir, Abrassart, Garcia & Larrieu, 2014). Furthermore, this model can control a task since it accumulates utmost UAV imaginable progress by altering the opportunity of each growth sort as required. Figure 8 represents the paparazzi mobility model.

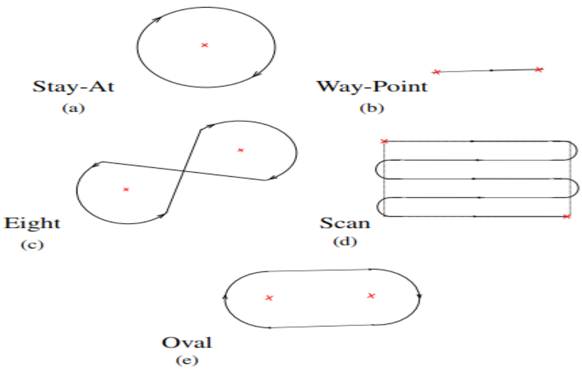

Figure 8. Paparazzi mobility model.

3.4. GMM (GROUP MOBILITY MODELS)

The group mobility models are having spatial constraint among the UAVs. These nodes movement is controlled by a reference point. The UAVs randomly move around the reference point in a defined area. The GMM types are column mobility model and the nomadic community mobility model (Bujari, *et al.*, 2017).

3.4.1 CLMN (COLUMN MOBILITY MODEL)

It was projected for inspecting or searching targeted application scenarios. Every UAV moves in the region of a reference position located on a specified line, which is moving in a frontward direction (Gupta, Sadawarti & Verma, 2013). In specific, every UAV arbitrarily turns in the region of the reference position from beginning to end an entity mobility model, for example, an easy Random way. This model can avoid collision among UAVs, while every node moves in the region of a permanent position, individually these positions located distant commencing every one node. On the other hand, horizontal roll and speed modify are not there in this mobility model. Figure 9. represent the CLMN mobility model.

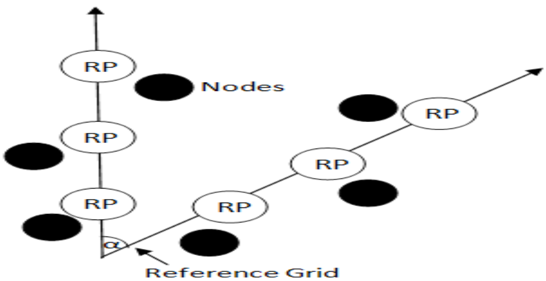

Figure 9. Column mobility model.

3.4.2. NC (NOMADIC COMMUNITY) MOBILITY MODEL

In this model UAVs moves arbitrarily in the region of a specified reference position, not including any constraint as compared to CLMN). The 5 nodes stirring around a mention position, it moves and turns in a definite direction. These nodes are able to move surrounded by rmax (maximum distance) as of the

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reference position. With respect to every time interval by using RWP (random waypoint), model reference position moves at a specific distance d. In Li, Zhang & Li (2017), NC UAVs that split general spaces, generating collision events among the UAVs. Figure 10 depicts the NC mobility model.

Figure 10. The nomadic community mobility model

3.4.3. PRS (PURSUE) MOBILITY MODEL

This mobility model is analogous to the Nomadic Community. In which UAVs endeavour to trail a specific target that is in a movement in a specific direction. The UAVs utilizes a simple random motion at the same time as trailing the target. For example, it performs the operation as similar to forces that try to catch the criminal by pursuing behind them (Singh & Verma, 2014). Figure 11 depicts the PRS mobility model.

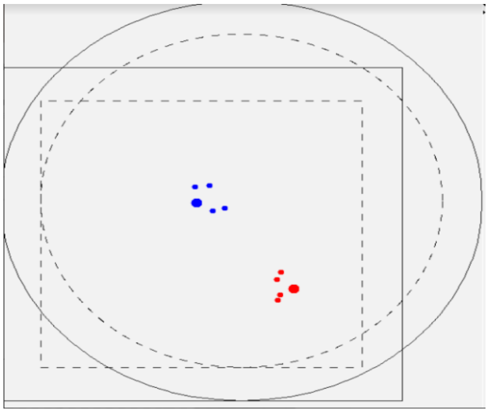

Figure 11. Pursue a mobility model.

3.5. TCMM (TOPOLOGY CONTROL MOBILITY MODEL)

3.5.1. PPR (DISTRIBUTED PHEROMONE REPEL) MOBILITY MODEL

In Kuiper & Nadjm–Tehrani (2006) DPR mobility model is projected, by means of to accomplish the objective of relating a vigorous and random movement mobile nodes that carry out an inspection to sense antagonistic earth targets. Every UAV preserve its individual pheromone map, it is a network of the region somewhere every cell enclose a time stamp on behalf of the previous time the cell was inspected. Just the once a UAV inspect the region, that marked on the map (Sanchez–Garcia, Garcia–Campos, Toral, Reina & Barrero, 2015). This inspected region information is broadcasted to UAVs on a regular basis. In this model, UAV behaves like similar to the pheromone map. DPR is the enhanced version of the pheromone map.

3.5.2. PHEROMONE–BASED MOBILITY MODEL

Pheromone helps each UAV in the area of coverage for the development of UAV networks (Kuiper & Nadjm–Tehrani, 2006). Every UAV highlights the zone and guide the other UAV in a specified area. In a sequence to increase the capacity, UAVs bring round in the direction of the expansion from beginning to end the zone with that does not find output till now. Similarly observed that the asymmetrical model is noticeably uncomplicated; nevertheless, it prompts ordinary results (Bouachir, *et al.*, 2014). On the other hand, the pheromone base model has tremendously trustworthy scrutiny properties. This pheromone gives you an idea about, a pheromone guide is used to administer UAVs. Aerial Nodes trade data about their inspection region and turn right, left and proceed. Figure 12 represents the pheromone–based mobility model.

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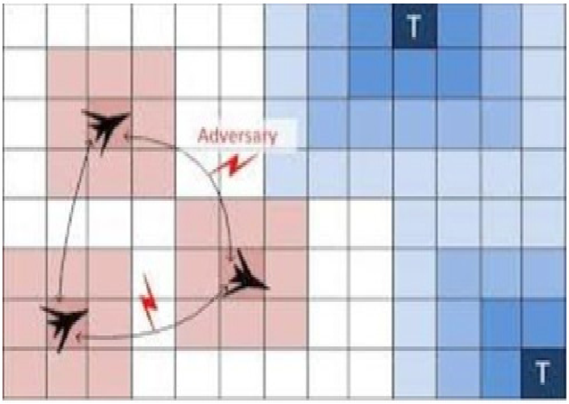

Figure 12. Pheromone–Based mobility model.

3.5.3. MPB (MISSION PLAN–BASED) MOBILITY MODEL

In MPB, flying idea information is predefined as well as the UAV's be capable to move further on by means of this plan (Kumari, *et al.*, 2015). It entails that UAV's be in motion beside the strategic track every time, somewhere the UAV can arrive at the site of the mission and target area from where data is accessible. By using MPB when the mission is completed, the mobility records are generated and rationalized. Each UAV start and end drive are arbitrarily designated while flight time and the rate are mentioned. When a UAV touches destination before the completion of flight time, for continuous flying the UAV change the direction and starts new flight trip. Figure 13 depicts the MPB mobility model.

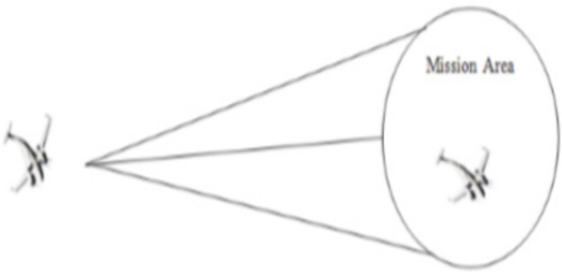

Figure 13. Mission–Based mobility model.

3.5.4. SDPC (SELF–DEPLOYABLE POINT COVERAGE) MOBILITY MODEL

In Sanchez–Garcia, *et al.* (2015) this mobility model introduced for the scenarios of disaster. SDPC mobility model uses UAVs for a particular mission of disaster region, in order to construct a communication system that inspects the losses of the disaster which it happened. The objective of every UAV is to cover the maximum area. Figure 14 depicts the summary of mobility models.

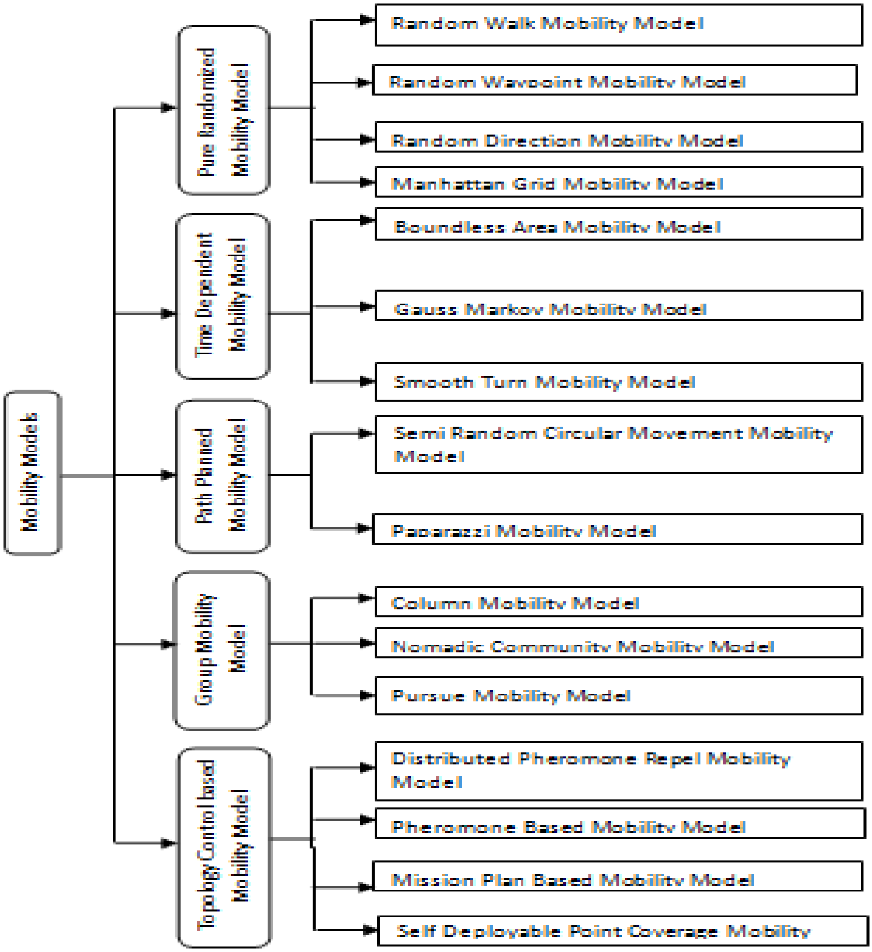

Figure 14. Summary of Mobility Models.

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Table 1. Categories of Mobility Models.

Categories	Mobility pattern
Pure randomized MM	RWMM
	RWPMM
	RDMM
	RGMM
Time dependant MM	BAMM
	GMMM
	STMM
Path planned MM	SRCMM
	PMM
Group–based MM	CMM
	NCMM
	PMM
Topology control based MM	DPRMM
	PBMM
	MPBMM
	SDPCMM

Table 1 Shows the five categories of mobility models and each category have different mobility patterns.

4. CONCLUSION

In this work, we have studied the state of the art related mobility models for specific environment scenarios trajectories in unmanned aerial vehicle communication network. The research community focused on the state of the art problem of a swarm of UAVs communication in this domain. However, in light of this, we have carried out the study which fulfil the current need of the research community in this domain. In this paper, we have explored the mobility models which provide the particular mobility pattern to resolve the problem of collaboration, communication and cooperation of UAVs. These models have been categorized into five groups and classified each group in detail. These mobility models provide the platform to understand and implement the unmanned aerial communication network for specific environment scenarios. The mobisim simulator tool we used to generate the mobility models trajectories for different mobility patterns. This facilitates the researchers to explore the emerging research area, ad hoc networking and UAV Communication Networks domain.

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INCREASING THE EFFICIENCY OF SMART PATIENT ROOM USING INTERNET OF THINGS (IOT)

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ABSTRACT

Researchers are developing more applications based on Internet of Things (IoT) in healthcare services. Proper health care services are the major requirements now a days due to constant increase in the population. These days a major problem faced by critical patients or victims of any kind of accident is of receiving treatment on time, which in some cases becomes a huge problem specially when hospitals refused to take patients in their ER due to unavailability of beds. Travel time consumed while moving patients from one hospital to another at times results in death. The modern technology is able to manage the needs by using IoT technologies that can connect smart objects together. This paper provides the solution to the users who want prompt and timely medical treatment for their loved ones, especially in case of emergency. Smart IoT based patient room is a system that enables paramedic staff /user to get the information about beds availability in the Emergency Room in real time. The smart patient room is different from other emergency rooms by allowing the user to see the status of bed inside emergency room from anywhere in the world through internet using Raspberry Pi. This application also helps hospital staff to monitor basic vitals of patient including the body temperature, heart beat etc. and helps user to save life by saving time searching for hospitals where bed is available for treatment in Emergency room. Smart IoT based emergency room consist of android mobile device, cloud network, wireless means of communication, hardware having Wi–Fi module, that sends the data to the cloud which indicates the users about the status of bed. This system deploys pressure sensors on beds that will automatically sense pressure and indicates users regarding the status of the bed inside the emergency room of the desired hospital.

KEYWORDS

Internet of Things; wireless fidelity, Electromyography, Electroencephalography, Electrocardiography, Blood Pressure, Emergency Room, Database.

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1. INTRODUCTION

Internet of things (IoT) is the system or network connectivity of physical devices, home equipment/appliances, vehicles and other objects fixed with electronic, sensors, actuators, software, which permit these entities to connect and interchange the data. Through the embedded system of computing, each item is uniquely recognizable but is inter–operated within the present internet set–up. The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer–based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention (Sharma & Tiwari, 2016). It is a continually growing system consist of physical entities having an IP address linked with it for addressing and connectivity with internet, and for communication that happens between other Internet supported systems and devices that permits in some decision–making processes for assembly line scheduling, health care monitoring applications and many more etc. (Sharma, Kumar & Mehta, 2018).

Reinforcing IoT with actuators and sensors (Ghayvat, Mukhopadhyay, Gui & Suryadevara, 2015), it grows into a case of the more universal group of cyber–physical structures, which also covers technologies like smart homes, smart grids, virtual power plant, smart cities and intelligent transportation. Connectivity is already provided to an extensive range of devices through mobile systems. This new surge of connectivity is moving away from the laptops and tables, to connected buildings, and cars, traffic control and smart meters, by the vision of wisely linking virtually everyone and everything.

Recent researches show more potential applications for IoT in healthcare services. The use of IoT technology in applications has spurred the increase of real–time data, which makes data storage more challenging.

This research is about designing and developing a system which will work in real time in case of Emergency. When the person or a paramedic staff with patient is in emergency so he/she is facing a biggest difficulty to select the hospital which is nearby and which has beds available in an emergency room this is the major issue in developing countries. The designed application provides a solution in choosing the correct hospital in case of emergency which in turn saves life and increased treatment time for patient. Registered user can check the available hospitals in the vicinity and also check the availability of bed in an Emergency Room in that hospital. This research will help people to save life of a person by saving time in visiting different hospitals in case of emergency. Implementation of this technique in the prototype IoT based Emergency Room application is discussed in this paper.

The research goal is to present IoT applications for the health care emergency problems. The paper is structured as; Section 1 provide Introduction of IoT, Section 2 describe the literature review/background of the research, Section 3 delivers the system design and implementation of the IoT based emergency room system. In section 4 the results obtained from this research are discussed. Section 5 will provide Conclusion. Section 6 gives future guidelines and the challenges that can be faced using IoT.

2. LITERATURE REVIEW

With the increase in use of IoT technologies, every field of industry is trying to adopt this technology because, the "Internet of Things" (IoT) is in great need (Yun & Yuxin, 2010). By applying these technologies, a person can easily store and access a large amount of data.

Many researchers are using IoT for Information Desk system. The researchers in (Rafique, *et al.*, 2015) established an Electronic Information Desk System. They have used SMS based method, however in a different way. The designed system works autonomously without the requirement of any human operator. When any information is required by an employee or a student, simply an SMS is to be sent to the system, which will provide the required data to the user. The scholars (Dogo, *et al.*, 2015) designed Digital display board, which is gaining recognition and application in diverse domains of life, containing community or utility places,

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educational institutes, and in advertisement. Use of IoT system can be applied for assistance for aged or disabled persons living independent. It can also help in monitoring and controlling the condition of medicine inside freezers which are used for storing vaccines, and other health products and for patient's surveillance. It is helpful for monitoring of patient's conditions inside and outside hospitals and in old age homes.

In the medical service industry, the IoT technology is facilitating user in emergency medical findings, and minimizing costs in the process (Xu, Xu, Cai, Xie, Hu & Bu, 2014). Number of researchers have published their IoT based work related to healthcare issues (Darwish & Hassanien, 2011; Lee & Lee, 2015; Sermakani, 2014; Rghioui, L'aarje, Elouaai & Bouhorma 2014). When patients are continuously monitored it allows health care suppliers to access real time data to treat diseases before they get out of hand. By the help of IoT technology we can get the real time data by using sensors. IoT is helping in every way to make emergency department respond more quickly, faster and accurate so the doctors can treat patients as quick as possible.

(Xu, *et al.*, 2014) has proposed a method that provide support for the emergency medical services which enables collects, integrate, and interoperate IoT data flexibly. This method supports data accessing periodically and universally in a cloud and mobile computing platform. The scholars have introduced application for RFID to gathered in–formation about the users living environment. It helps to get the detail about the temperature, humidity, and other gases around human (Amendola, Lodato, Manzanari, Occhiuzzi & Marrocco, 2014).

Yun and Yuxin (2010) tells us about the key technology of IoT and explains it's working. Sensors in IoT systems formulate real–time interactive network connection between the power equipment and to make data interpretation in real–time. Dhar, Bhunia and Mukherjee (2014) has introduced IoT technology for Health Monitoring. Where the medical facility is provided after the direction of the specialized doctors present all over the globe on the Cloud. This helps to treat a large population when there is lack of doctors in that area.

The scholars developed the Smart Home/Building, which has been implemented in different home or building that allows monitoring the activities of an inhabitant detection. Due to this a user will be able to monitor the activities inside the home even when he/she is far away from the home (Ghayvat, *et al.*, 2015). (Gope, *et al.*, 2015) develops a health monitoring system using the response from Electromyography (EMG), Electroencephalography (EEG), Electrocardiography (ECG), Blood Pressure (BP) Motion, and Thermometer. The system develop use to fetch the data from Body Sensor Network with the help of IoT and send it to the server. The system provides bene ts in generation of the proper reports about the patient status e.g. condition, history etc.

Zhanlin, *et al.* (2014) implements a cloud–based Information Centre of smart city, which provides transportation services to users like control and monitoring traffic, car parking service, route planning. The author proposed three layers for Business IoT implementation. I.e. Sensor, communication and application layer. IoT is a latest technology that's why there is still a paucity of studies on the social, managerial, behavioral, and economic, aspects of the IoT (Lee & Lee, 2015). IoT utilize Raspberry pi board that reads data from different devices and send it to the cloud so that user will receive update in real time (Laila, Khan, Shaikh, Mazhar & Mehboob, 2017).

All the above work and studies tell us about the need and advantage of IoT technology. IoT has been massively used in medical services in emergency. Therefore, there is a need to propose an application for the users to know about the availability of beds in emergency rooms.

3. SYSTEM DESIGN & IMPLEMENTATION

The system consists of two modules as shown in Figure 1; software module and hardware module. Software module is designed using android studio which is compatible with android version 4.1 or greater.

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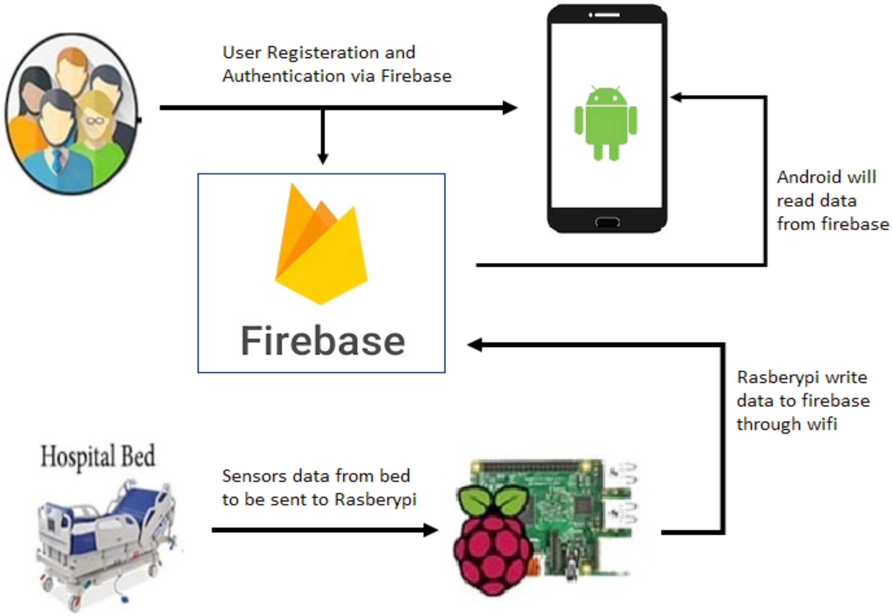

Figure 1. System Design.

This system consists of software module and hardware module. The software module comprises of three parts. All of them are incorporated with authentication mechanism.

4. SOFTWARE MODULE FOR USER

The designed android application is based on emergency services. IoT based Emergency Room helps users to check the status of beds inside emergency room.

Login/Registration

The application requires authentication of user by utilizing one–time Login/sign up. The Login screen display is shown in Figure 2.

Figure 2. Login Screen.

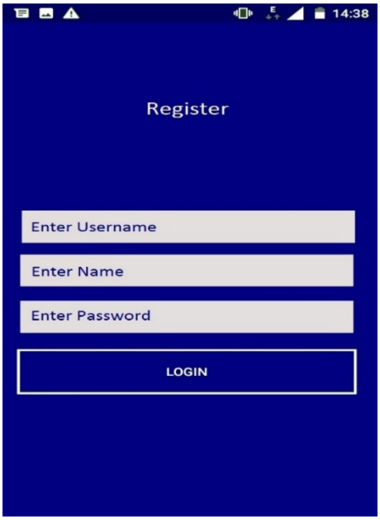

Figure 3. Registration Screen.

Dash Board

After the sign–up process user will be able to access the features of the application via dash board. The features include the hospital list, area wise hospital list, profile, emergency room map and location sharing.

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Figure 4. DashBoard Screen.

Hospital List

The user searches the hospital available in town. This list has been maintained by admin.

Figure 5. Hospital List.

Area wise Hospital List

The user searches the nearest hospital available within 5 to 10 km vicinity (Figure 6). This feature is very important in case where user did not know about the nearby hospital after facing any emergency situation. This will reduce the time the user waste in finding hospital.

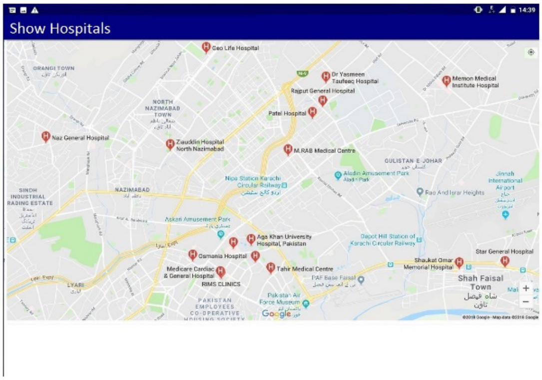

Figure 6. Nearby Hospital Screen .

A database is maintained for all hospitals and data will be parsed to android device when required. Longitude and latitude of all hospital are saved in the database.

Profile Management

This feature of adding friend and family contact numbers to a registered user profile will enhance the abilities of the application to generate real time alert messages in case of emergency, user can inform registered friend and family member in case of accident or any emergency by clicking just one button. Alerts can be in form of push notification or SMS. Currently this application utilize real time SMS functionality making it real time SMS enabled application which is cost effective as well as in easy reach. Figure 7. Depict the profile management screen.

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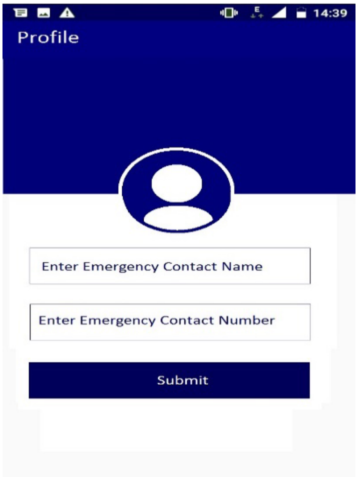

Figure 7. Profile Management.

Emergency Room map

Rooms in ER (Emergency Room) bed status of any hospital can be checked easily via software module. Each bed in the emergency room has been incorporated with pressure sensors attached to it. When a patient is present on the bed, sensor will be activated, data will be read by Raspberry Pi and sent to database through Wi–Fi module.

Our hardware will monitor three states of beds 1) checks if the bed is occupied 2) monitors if the bed is vacant and 3) This is used for monitoring the functionality of the hardware which is the case where any technical issues like hardware failure, power failure etc. happens. The third state helps us to figure out if the hardware is not functioning properly.

Application will update the status of the bed in the database which indicates user regarding the status of the bed. The emergency room map is shown in Figure 7 If bed indication color is green it ensures the availability of bed i.e ideal status and if the indication color is red that states the bed is occupied. Grey color is used for bed that is not operational i.e. there is some problem associated with the hardware. Pressure sensors will be used to synchronize bed status with the server. Pressure will be monitored periodically, so that if patient go for some medical tests the system will not update the status of bed to ideal.

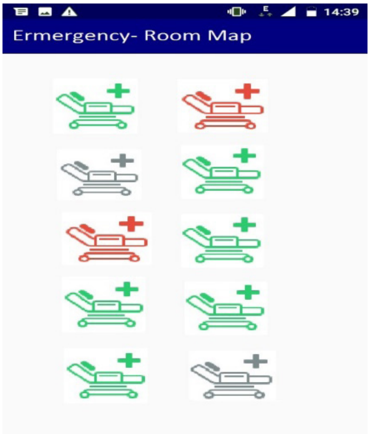

Figure 8. Emergency room Bed Map.

When the user selects the hospital the ER map will be displayed on the user application along with beds status. If all beds occupied then user will take the patient to some other hospital without wasting time. This feature will fast track the time to reach hospital for treatment which will decrease risk of any mishap.

Location Sharing

In case of emergency user can share his/her real time location to his/her family members. To use this feature user has to save the contact numbers of his/her family member at the time of profile management.

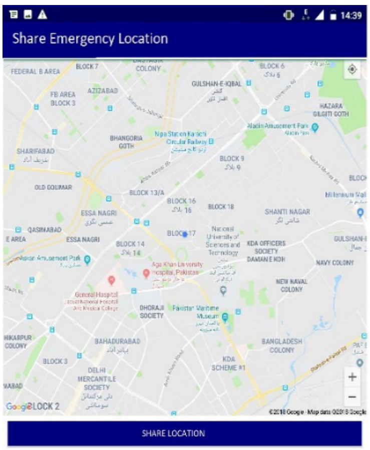

Figure 9. Location sharing.

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5. SOFTWARE MODULE FOR ADMIN

The most important module of our application is the admin module this module has live connection with our firebase database, user registers or assigned an admin role have the ability to make all changes required in the live system they can not only add or delete data but can also monitor the way any user is using the application. Admin may also have the privileges to enable or disable any registered user. With respect to mobile app which is specifically and separately developed for an admin will allow him to make any changes he wants to hospital live details. These changes can be made on the go and he can remotely add delete or update a hospital. In order to enhance the abilities of our application and make it more accurate for user to track based on GPS coordinates, hence in order to achieve this ability we have incorporated a key element in library from google map repository. The library we are using is of google places as this API not only provide the ability of a live places search to our edit text field but also help us design filters and restrict areas as per location. For example, as the scope of the application is for Pakistan only hence the places that will be displayed will be from Pakistan only. By adding this functionality once user select any place we will be able to fetch the longitude, latitude and address of that respective place using methods available in places API.

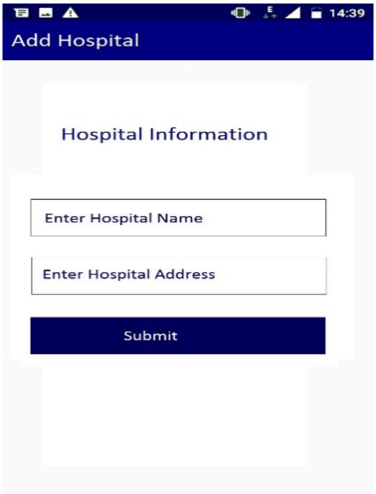

Figure 10. Add new Hospital.

6. SOFTWARE MODULE FOR HOSPITAL STAFF

In order to remove any kind of restrictions from the application and not to make any user feel restricted this system also developed a hospital module. This module is specifically designed for our hospital staff. This module has certain major feature which provides the ability to the hospital staff to update bed status. This feature will enhance future ability that could be incorporated in case of making bookings of bed in advance or when the ambulance is on the way. The application has a single interface which provide ER room map of the hospital by clicking at any bed a dialogue will be open through which the hospital staff can change bed state from available occupied and nonoperational as already discussed the available state means bed is available occupied state mean bed is in use of any patient and the last state is if the bed is not working that can be any problem either with respect to hardware attached its functionality or bed itself i.e its mattress or any other manual mechanism. In the way the hospital staff can share live on ground information of the ER room and save user to reach a wrong hospital and facing a problem of delay in receiving treatment due to any technical difficulty. Figure 10 shows ER bed status management screen.

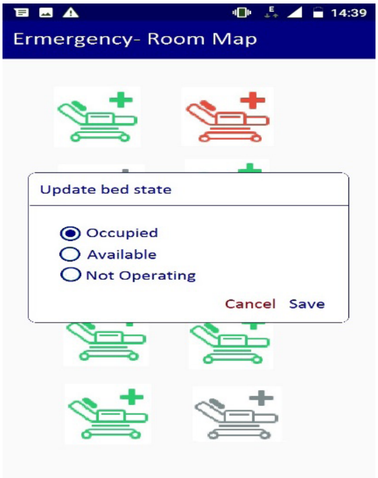

Figure 11. ER bed status Management screen.

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7. HARDWARE MODULE

The hardware module contains Raspberry Pi 3 along with pressure sensors. The pressure sensors will read the status of the bed and update it to the Database server firebase. Firebase is a web application and mobile application development platform used for real time database operations. A real time data update will help user to get recent status of bed. This thing will help to check the status of the bed in present. The given proposed system is automatic and can send/receive automatic messages to the database.

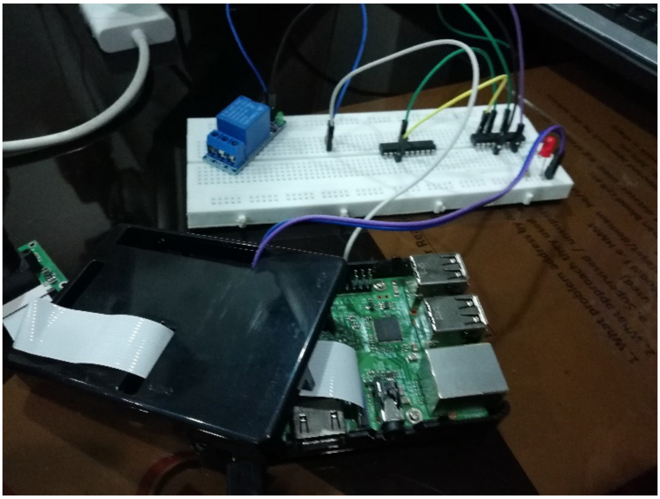

Figure 12. Hardware Module of ER System.

A key component of our entire system is integration of hardware module with every bed of a hospital emergency room. The features integrated into the hardware module includes a set of various sensors. The sensors included are pressure sensor for monitoring the availability of the bed. The availability is tracked based on the pressure been placed over the bed excluding the pressure of the mattress these pressure values help our system analyses weather the bed is occupied by a patient or not. Our hardware has some additional features which will help us monitor basic vitals of our patient including the body temperature and heart beat these vitals will be shared with hospital stuff in future which will help them remotely monitor their patients, this data will be limited to hospital staff application only. Once hardware receives values from the sensor the values are uploaded on an online database which is been designed and developed on firebase. The reason for choosing real time database of firebase is it allows user to developed live application without having any complexity of developing time consuming API for live DB integrations. With help of development of this hardware module live values can be updated on the database which will be later received on our android application. The android application is linked with firebase database and with help of firebase the data will be shared with respective users automatically filtered and sorted. The system kept a track of the voltage consumed by the hardware and the heat generated by the component, as this has enhanced the optimization of the hardware module and can be later enhanced by adding more advance features

8. FLOW OF PROPOSED SYSTEM

The overall work flow of Smart ER is depicted in the flow diagram, Figure 13.

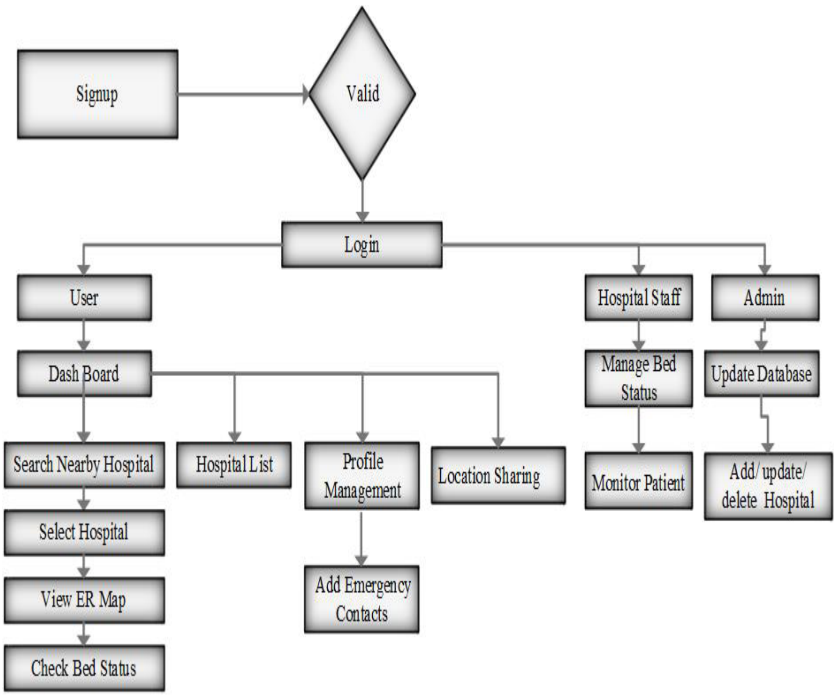

Figure 13. Flow Diagram of Proposed System.

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9. RESULT

The desired results are obtained by running the application in real time environment.

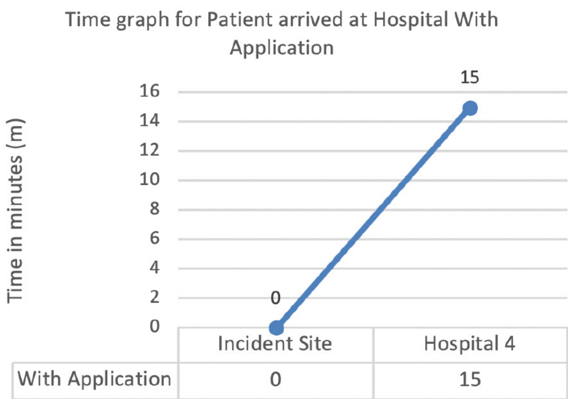

Figure 14. Time graph of Patient with application.

The system searches for the nearby hospitals in the radius of 5–10 km of the user. Practical testing is performed in the thickly populated city Karachi Pakistan. From the emergency location, the application search is performed for selecting the right hospital having available bed in the vicinity.

Figure 14 shows the Incident site where emergency occurred and the selected hospital Vs Time graph. The approx. estimated time to reach hospital is about 15 minutes. Whereas if the conventional search is performed by visiting all the nearby hospitals 1, 2, 3 and 4, the approx. time consumed to reach the same right hospital 4 is about 50 minutes.

The results showed that the designed IoT based system solves the problem of identifying the available rooms in nearby hospitals in quick time and patients can reach their destination covering shorter possible distance in emergency cases as compared to the finding the right hospital without running the application as shown in the Figure 15.

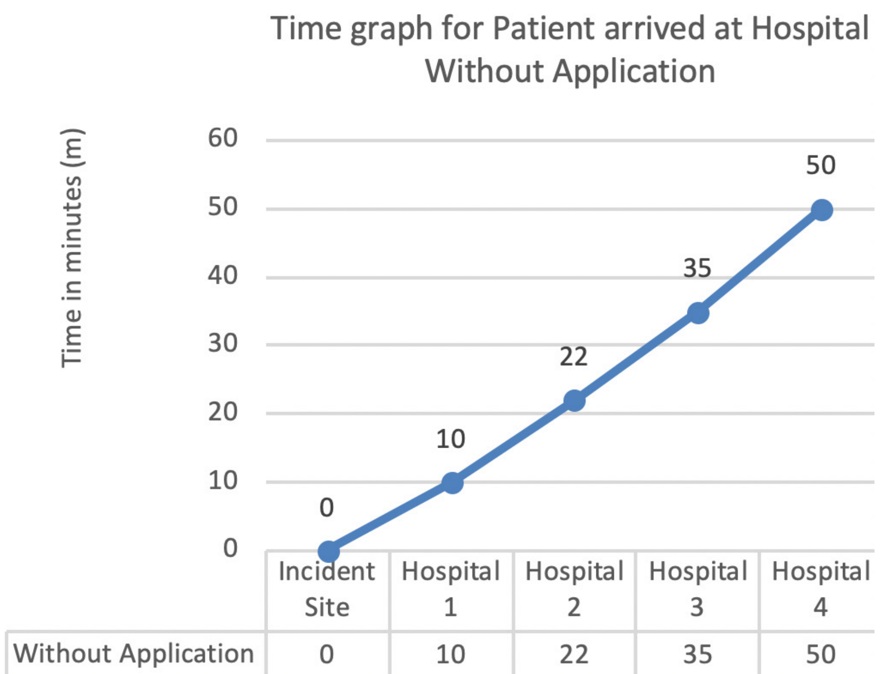

Figure 15. Time graph of Patient with application.

10. CONCLUSION

This application is designed to help the user who are in emergency and unable to find the hospital which can entertain according to his/her sickness. It is an application where user just need to login at once. Admin panel has the rights to unregister the users. This application is very user friendly and smart. There is no feature that the user is not able to understand. It is an emergency–based application. The results showed that the designed IoT based system solved the problem of identifying the available rooms in nearby hospitals in quick time and patients can reach their destination covering shorter possible distance in emergency cases. It allows paramedics and individuals to search the hospitals in the vicinity and check the availability of rooms in emergency situation.

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11. FUTURE WORK

The future includes calculation of the actual weight of the patient on bed that helps in sensing/ monitoring coma patient's movements. The area or range could be increased to search a greater number of hospitals and also allows user to reserve the bed online via android application before reaching hospital. The system can be enhanced to check the available rooms, available services/ expertise and other biomedical equipment provided by the hospital.

IoT and medical are vast fields according to their importance and the joining of both can bring a huge change at the time of Emergency to rescue the life of critical patients.

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/16/

SERIES SOLUTION OF FRACTIONAL PANTOGRAPH EQUATIONS VIA TAYLOR SERIES

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ABSTRACT

This article is devoted to develop a numerical approximation called Taylor minimization method for initial and boundary value fractional Pantograph equations, which governs the modelling of the train system, with neutral and multi-term delays. Taylor optimization technique is basically composed of truncated Taylor series approximation of unknown function while employment of procedure is accompanied by an optimization strategy that is simulated annealing for carrying out the learning phase of unknown Taylor series coefficients. The proposed technique is implemented on various models of Pantograph equations to study the applicability and effectiveness of the planned scheme while error analysis and comparison with previous methods are performed to validate the results. To measure the capability of convergence the data for 100 numbers of independent runs is demonstrated in the form of pictorial presentation.

KEYWORDS

Taylor series, Fractional Pantograph equation, Simulated annealing, Proportional delays.

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1. INTRODUCTION

Several physical phenomena in diverse research areas are modeled in the form of fractional order differential or integro differential equations. For instance, to describe the viscid interactions in human cancellous bone by using Biot's theory (Sebaa, *et al.*, 2006), study of cardiac tissue by using electrode interface (Magin & Ovadia, 2008), for comprehensive study of vestibule-ocular reflex model (Robinson, 1981), modeling of phenomena in fluid mechanics (Kulish & Lage, 2002) and introducing fractional order impedance in electric circuits (LeMahute & Crepy, 1983; Kaplan, Gray & Liu, 1987). Due to the diverse applications of fractional calculus in real life phenomena, numerous numerical techniques have been developed to solve the fractional order differential and integral equations (Arikoglu & Ozkol, 2007; Diethelm, Ford & Freed, 2002; Bai & Lü, 2005; Agarwal, Lakshmikantham & Nieto, 2010).

In this effort, we are developing Taylor minimization method (TMM) based on Taylor series. Taylor series is a useful tool for attaining the approximate solution of differential equations on a continuous domain. Various methods have been developed to investigate the solution of differential equations (DEs) by Taylor series. A computational scheme for converting Partial differential equations (PDEs) into algebraic equations based on Taylor series expansion was developed in (Groza & Razzaghi, 2013). Singular boundary value problems with exponential nonlinearity were solved effectively by using the Taylor series method (Chang, 2014). Some other notable methods of obtaining the solution of delay systems by employing Taylor series can be seen in (Marzban & Razzaghi, 2006; Razzaghi & Razzaghi, 1989). But here we are using optimization strategy i.e. simulated annealing (SA) to solve the minimization problem formed by Taylor series approximation of fractional differential equations (FDEs). Simulated annealing is a meta heuristic algorithm inspired by the cooling schedule of metals. Advantage of using this method is its strong ability of escaping from local minima and acquiring global minima with efficiency (Kirkpatrick, Gelatt & Vecchi, 1983). To demonstrate the applicability and efficiency of method simulation is carried out for fractional pantograph equation in (Rahimkhani, Ordokhani & Babolian, 2018).

$$D^{\alpha} f(t) = f(t) + \sum_{n=1}^{l} f_n(t) D^{\alpha n} f(q_n t), \qquad m-1 < \alpha \leq m,\ \mathrm{m} \in \mathrm{N},\ t \in \left[0, h\right] \quad (1)$$

subject to the initial conditions.

$$f^{(i)}\left(0\right) = \beta_i, \qquad i = 0, 1, \ldots, m-1$$

It is a functional differential equation with proportional delays. Due to its vast applications in science and engineering it took the attention of many researchers to propose numerous schemes for the simulation of Pantograph equation (Rahimkhani, *et al.*, 2018; Iqbal, Saeed & Mohyud-Din, 2015; Raja, 2014; Bharawy, Al-Zahrani, Alhamed & Baleanu, 2014; Saadatmandi & Dehghan, 2009; Isah, Phang & Phang, 2017; Syam & Jaradat, 2017).

In the proposed scheme, the unknown function is approximated in terms of Taylor series which will be transformed into a trial solution by imposing initial and boundary conditions. The same procedure will be adopted for delay terms. Later required derivatives of trial solution, delay trial solution and a trial solution will be substituted in the differential equation to calculate MSE or fitness function with the help of trial points. The substitution will give rise to a minimization problem that was solved by simulated annealing for unknown Taylor series coefficients. Later the coefficients will be utilized to find the Taylor series of unknown function at the domain $\left[0, h\right]$. To demonstrate the efficiency of employed scheme various numerical experiments of fractional pantograph equations have been discussed for error analysis and numerical simulation.

2. PRELIMINARIES

In the following section we are introducing some basic definitions regarding fractional calculus and Taylor series.

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2.1. DEFINITION No1

If a function φ is defined on interval $[\alpha,\beta]$ and holds the following conditions

- $(\varphi^{(k-1)})$ is continuous on $[\alpha,\beta]$
- φ^{k} exist on $]\alpha,\beta[$

and $x\in[\alpha,\beta]$ then from (Malik & Arora, 1992)

$$\varphi(x)=\left(\sum_{\mu=0}^{k-1}\frac{\varphi^{(\mu)}(\alpha)(x-\alpha)^{(\mu)}}{\mu\,!}\right)+\frac{(x-\alpha)^{(k)}(1-\theta)^{k-p}}{p[(k-1)!]}\varphi^{(k)}(c) \tag{2}$$

where $0<\theta<1$, $p>0$ and $\alpha<c<x$. For $\alpha=0$ and truncated to k th term Eq. (2) can be expressed as

$$\varphi(x)=\left(\sum_{\mu=0}^{k-1}\frac{\varphi^{(\mu)}(0)\ (x)^{(\mu)}}{\mu\,!}\right) \tag{3}$$

with Lagrange's form of the remainder after k terms as

$$R_n=\frac{(x)^{k}}{k\,!}\varphi^{(k)}(\theta\ \mathrm{x}) \tag{4}$$

2.2. DEFINITION No 2

Fractional derivative in sense of Caputo for the order $\kappa\geq 0$ can be described as in (Heydari, *et al.*, 2015)

$$D^{\kappa}f(t)=\frac{1}{\Gamma(m-\kappa)}\int_0^t(t-s)^{m-\kappa-1}f^{(n)}(s)\ ds,\ \ m-1<\kappa<m,\ \mathrm{m}\in\mathrm{N}.$$

with the fulfillment of following properties

- $D^{\kappa}I^{\kappa}f(t)=f(t)$,
- $I^{\kappa}D^{\kappa}f(t)=f(t)-\sum_{j=0}^{m-1}f^{(j)}(0)\frac{x^{j}}{j\,!}$,
- $D^{\kappa}c=0$, where c is a constant

- $$D^{\kappa}\left(t^{\beta}\right)=\begin{cases} 0, & \kappa \in \mathrm{N}_0,\ \beta<\kappa \\ \dfrac{\Gamma(\beta+1)}{\Gamma(\beta+1-\kappa)} t^{\beta-\kappa}, & \text{otherwise} \end{cases}$$

3. TAYLOR MINIMIZATION METHOD

3.1. TAYLOR SERIES APPROXIMATION

The Taylor series expansion of an analytic function $f(t)$ about $t=0$ upto η terms can be given as:

$$f(t)=\sum_{k=0}^{\eta} \left.\frac{d^k f(t)}{dt^k}\right|_{t=0} \frac{t^k}{k\,!} \qquad (2)$$

$$f(t)=f(0)+\mathrm{t} f'(0)+\frac{t^2}{2\,!} f''(0)+\sum_{k=3}^{\eta} \left.\frac{d^k f(t)}{dt^k}\right|_{t=0} \frac{t^k}{k\,!} \qquad (3)$$

while Taylor series expansion of an analytical function with delay can be expressed as:

$$f(qt)=\sum_{k=0}^{\eta} \left.\frac{d^k f(qt)}{dt^k}\right|_{t=0} \frac{t^k}{k\,!} \qquad (4)$$

$$f(qt)=f(0)+qt f'(0)+\frac{q^2 t^2}{2\,!} f''(0)+\sum_{k=3}^{\eta} \left.\frac{d^k f(t)}{dt^k}\right|_{t=0} \frac{q^k t^k}{k\,!} \qquad (5)$$

the generalized fractional pantograph equation can be written as:

$$D^{\alpha} f(t)=f(t)+\sum_{n=1}^{l} f_n(t) D^{\alpha n} f(q_n t), \qquad m-1<\alpha \le m,\ \mathrm{m}\in \mathrm{N},\ t\in[0,h] \quad (6)$$

Subject to the initial conditions and boundary conditions:

$$f^{(i)}(0)=\beta_i, \qquad i=0,1,\ldots,m-1 \qquad (7)$$

$$f^{(i)}(\alpha)=\alpha_i, \qquad i=0,1,\ldots,m-1 \qquad (8)$$

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Now generate the trial solution by substituting values from Eq. (7) and Eq. (8) in Eq. (3) and Eq. (5). For $i = 0$ in Eq. (3) and $i = 1$ in Eq.(5):

$$f(t) = \beta_0 + \mathrm{t} f'(0) + \frac{t^2}{2\,!} f''(0) + \sum_{k=3}^{\eta} \left. \frac{d^k f(t)}{dt^k} \right|_{t=0} \frac{t^k}{k\,!} \tag{9}$$

for introducing boundary conditions put $t = \alpha$ in Eq.(9):

$$f(\alpha) = \beta_0 + \alpha f'(0) + \frac{\alpha^2}{2\,!} f''(0) + \sum_{k=3}^{\eta} \left. \frac{d^k f(t)}{dt^k} \right|_{t=0} \frac{\alpha^k}{k\,!} \tag{10}$$

substituting values from Eq.(8) we get:

$$\alpha_1 = \beta_0 + \alpha f'(0) + \frac{\alpha^2}{2\,!} f''(0) + \sum_{k=3}^{\eta} \left. \frac{d^k f(t)}{dt^k} \right|_{t=0} \frac{\alpha^k}{k\,!} \tag{11}$$

solve Eq. (11) $f'(0)$ and substitute it in Eq. (9) we get:

$$f(t) = \beta_0 + \frac{\mathrm{t}}{\alpha} \left(\alpha_1 - \beta_0 - \frac{\alpha^2}{2\,!} f''(0) - \sum_{k=3}^{\eta} \left. \frac{d^k f(t)}{dt^k} \right|_{t=0} \frac{\alpha^k}{k\,!} \right) + \frac{t^2}{2\,!} f''(0) + \sum_{k=3}^{\eta} \left. \frac{d^k f(t)}{dt^k} \right|_{t=0} \frac{t^k}{k\,!} \tag{12}$$

Eq. (9) will be trial solution for initial value problem while Eq. (12) will be trial solution for boundary value problem. For obtaining delay trial solution same procedure will be adopted for Eq. (5). Substitute the values of trial solution, delay trial solution and their required derivatives by definition No 2 in Eq.(6) and MSE as:

$$MSE = \sum_{j=0}^{\gamma} \left(D^{\alpha} f(t_j) - f(t_j) - \sum_{n=1}^{l} f_n(t_j) D^{\alpha n} f(q_n t_j) \right)^2, m-1 < \alpha \le m,\ \mathrm{m} \in \mathrm{N},\ t \in [0,h] \tag{13}$$

After discretizing the domain the differential equation has been transformed into a minimization problem that can be solved by simulated annealing to obtain the values of unknown $f^{(i)}(0)$ that can be substituted in Eq. (1) to get the required solution. The procedure can be further analyzed through Figure 1.

3.2. SIMULATED ANNEALING

Process of Simulated annealing is a generic probabilistic meta-algorithm that is an advancement of Genetic algorithms to improve the convergence of procedure and to avoid local optima with simple applicability. Here the objective function is the MSE of fractional Pantograph delay differential equation. Following parameters are marked noteworthy in the implication of procedure.

- T_K represents the value of temperature at the end of each iteration while $T_0 = 1$. At the end of each iteration value of T will be changed by the following way $T_K = \chi \; T_{K-1}, \chi \in \left[0.8, 0.99\right], k > 0$

- $P_a = \begin{cases} e^{\frac{-\rho \nabla \delta}{T}}, & \nabla \delta > 1 \\ 1, & \nabla \delta < 1 \end{cases}$, represents the probability of acceptance.

- $\nabla \delta$ is the difference between solution errors of consecutive perturbations.

- $\rho = \dfrac{1}{k_b}$, where k_b is the Boltzman constant. Boltzman constant is commonly replaced by 1 from the probability of acceptance when there is no need to cope with different materials.

Simulated annealing algorithm is initiated by a random solution guess and a high temperature usually 1. The energy of the system is calculated at random guess and then again at random neighboring solution. The neighbouring solution is accepted using the probability returned by the above formula by comparing it with a random number ranged between 0 and 1. The temperature is declined each time, as described above, after processing a certain number of iterations at each temperature value. This is repeated until the system freezes into a steady state. With a declining temperature value of the system, the probability of accepting a worse move is also reduced. Procedure is performed here by *Mathematica 11* with default options provided by the software.

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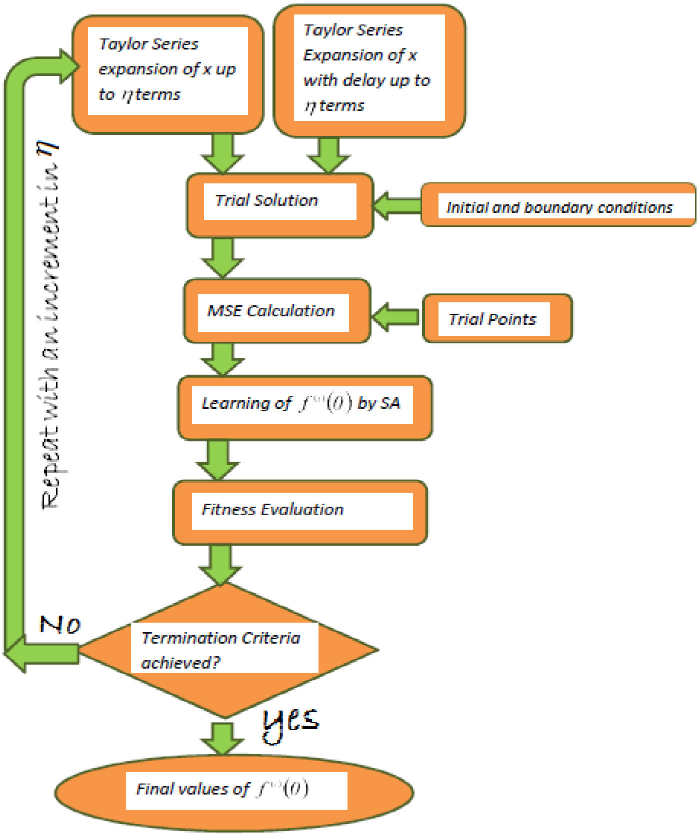

Figure 1. Flow chart of the algorithm.

4. RESIDUAL ERROR

For FDEs the exact solution is generally not known so to demonstrate the efficiency of the proposed technique here we are analyzing the error of numerical experiments by the following procedure. Since the approximated solution of fractional pantograph equation can be given by Eq. (3) substituting the obtained values of $f^{(i)}(0)$, $f(t)$, $D^{\alpha} f(t)$ and $D^{\alpha k} f(t)$ for $k = 1,2,3,\ldots,l$ in generalized fractional pantograph equation the obtained result at $t \in [0,h]$ will be approximately equal to zero that can be represented by:

$$Er\left(t\right)=\left|D^{\alpha}f(t)-f(t)-\sum_{n=1}^{l}f_n(t)D^{\alpha n}f(q_n t)\right|\cong 0 \qquad (14)$$

While $f\left(t\right)$ is the obtained approximated continuous solution by TMM.

$Er\left(t_i\right)\rightarrow 0$ as the value of MSE obtained by TMM is sufficiently small enough.

The error analysis for each numerical experiment will be performed by the above equation. The convergence of TMM is completely dependent on the convergence of simulated annealing. If $MSE\rightarrow 0$ as $j\rightarrow\gamma$ the Eq. (2) will converge.

5. NUMERICAL EXPERIMENTS:

Experiment No 1

Consider the following linear fractional Pantograph equation with delay,

$$D^{\lambda}f\left(t\right)=\frac{3}{4}f\left(t\right)+f\left(\frac{1}{2}t\right)-t^2+2, \qquad 1<\lambda\leq 2, \qquad \mathrm{f}\left(0\right)=0, \quad \mathrm{f}'\left(0\right)=0$$

By applying the TMM on the above linear pantograph fractional differential model, for $\lambda=2$ *and* $\mathrm{k}=3$, unknown coefficients are found to be 2 and 3.95×10^{-17}. By substituting these values in trial solution the required solution is found to be $f\left(t\right)=t^2+0.67\times 10^{-16}t^3$ which is approximately equal to the true solution $f\left(t\right)=t^2$. Figure 2 is exhibiting solution of experiment No 1 for $\lambda=1.7,1.8,1.9,2$ and exact solution for $\lambda=2$. Final values of Taylor coefficients can be visualized in pictorial form for different fractional order derivatives in Figure 3 while residual error according to section 4 and MSE for different fractional values of derivatives on the domain of [0,10] can be grasped through Table 1. For ascertaining the efficacy and power of offered scheme, data of 100 numbers of independent runs of the algorithm by altering the perturbation scale can be envisioned through Figure 4.

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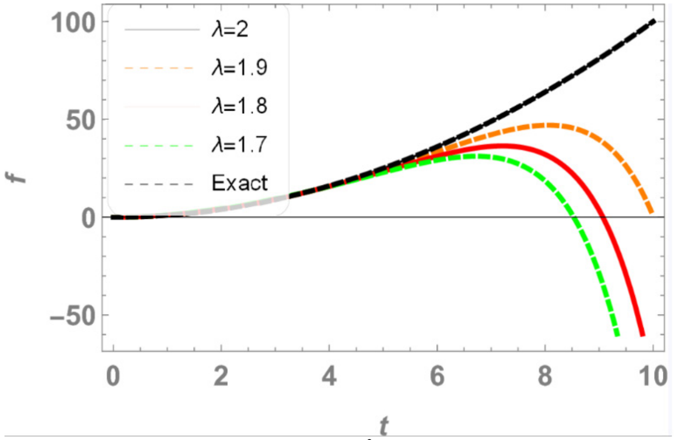

Figure 2. Solution of Example 1 at different values of λ .

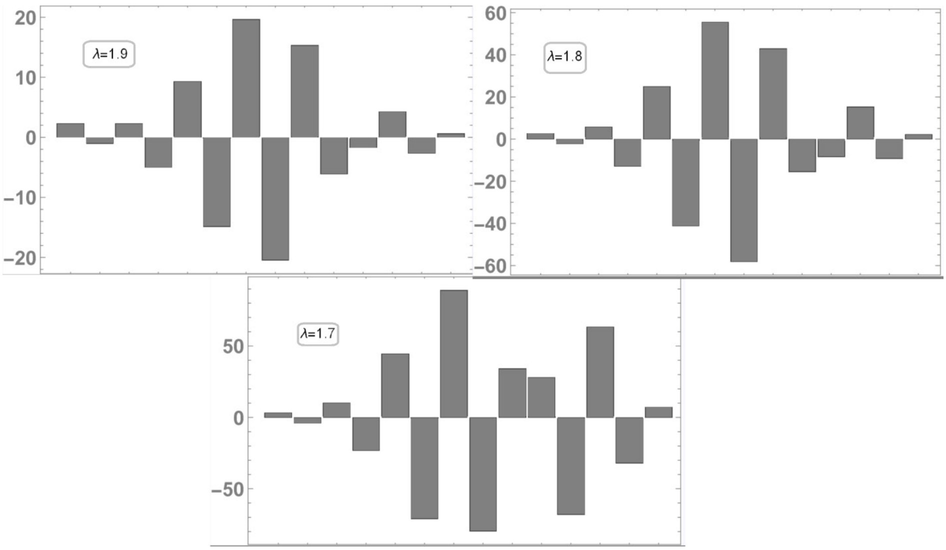

Figure 3. Final values of Unknown Taylor coefficients, for example, No 1 for $k = 15$.

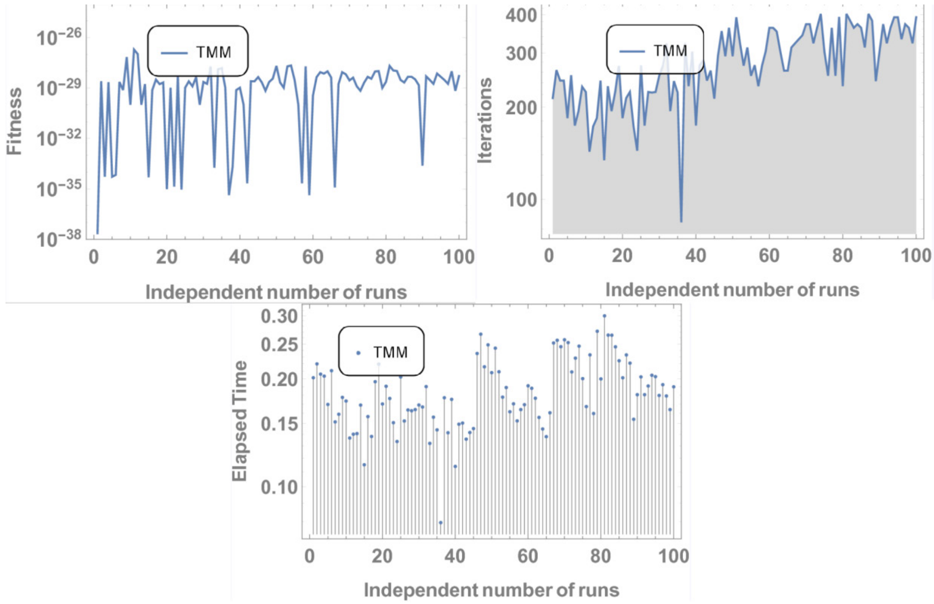

Figure 4. Data of 100 number of Independent runs of example No 1 for $\lambda = 2$.

Table 1. Residual error for example No 1.

t	Residual error $\lambda = 1.9$	Residual error $\lambda = 1.8$	Residual error $\lambda = 1.7$
1	1.4885×10-5	3.6715×10-5	1.1074×10-4
2	7.4028×10-5	1.9065×10-4	4.3967×10-4
3	2.9014×10-5	7.4914×10-5	2.0889×10-4
4	2.0656×10-5	5.3673×10-5	1.5509×10-4
5	2.1182×10-5	5.9538×10-5	1.5409×10-4
6	2.4591×10-5	6.8656×10-5	1.5993×10-4
7	2.5200×10-5	7.2173×10-5	1.5883×10-4
8	2.0192×10-5	5.8111×10-5	1.3101×10-4
9	2.2069×10-5	6.8332×10-5	1.2009×10-4
10	7.3279×10-7	2.3416×10-5	3.7734×10-6
MSE	1.9065×10-10	1.4138×10-9	6.6420×10-9

Experiment No 2

Consider the following nonlinear fractional pantograph equation with delay:

$$D^{\lambda} f(t) = 1 - 2 f^{2}\left(\frac{1}{2}t\right), \qquad 1 < \lambda \le 2, \qquad f(0) = 1, \quad f'(0) = 0$$

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Simulation of above nonlinear Pantograph equation by TMM with $\lambda = 2$ *and* $\mathrm{k} = 12$ gives the following series solution.

$$f(t) = 1 - 0.500004t^2 - 0.00001851t^3 + 0.042t^4 - 0.00006t^5 - 0.001t^6 + \ldots$$

while the true solution of the above equation is given by $\cos(t)$.Figure 5 demonstrates the graphical comparison of true and TMM solution for $\lambda = 2$ at [0,6] Furthermore, solution at fractional values of λ can also be visualized in Figure 5. Table 2 is displaying the comparison of the proposed scheme with some recent studies of Bernoulli and Laquerre wavelets methods while Table 3 is demonstrating the residual error that has been described through Eq. 10, for the above differential equation. Last row of Table 3 is reserved to represent the final values of MSE obtained after the learning process of unknown Taylor coefficients however corresponding to the MSE final values of unknown taylor coefficients can be envisioned in Figure 6. Data for 100 numbers of independent runs of algorithm for above delay differential equation can be visualized in Figure 7.

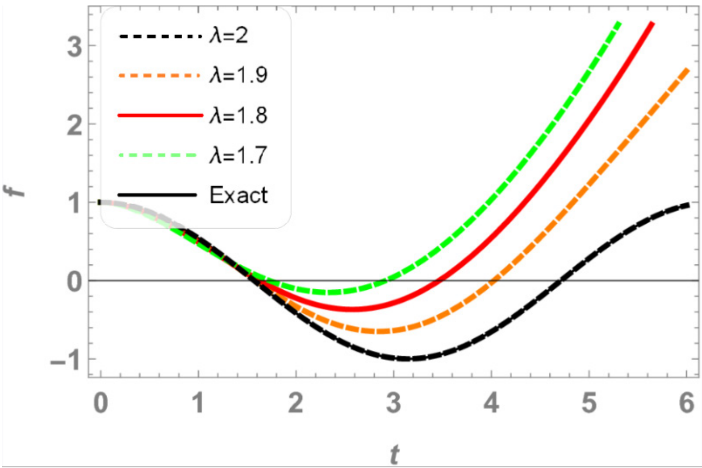

Figure 5. Solution of Example 2 at different values of λ .

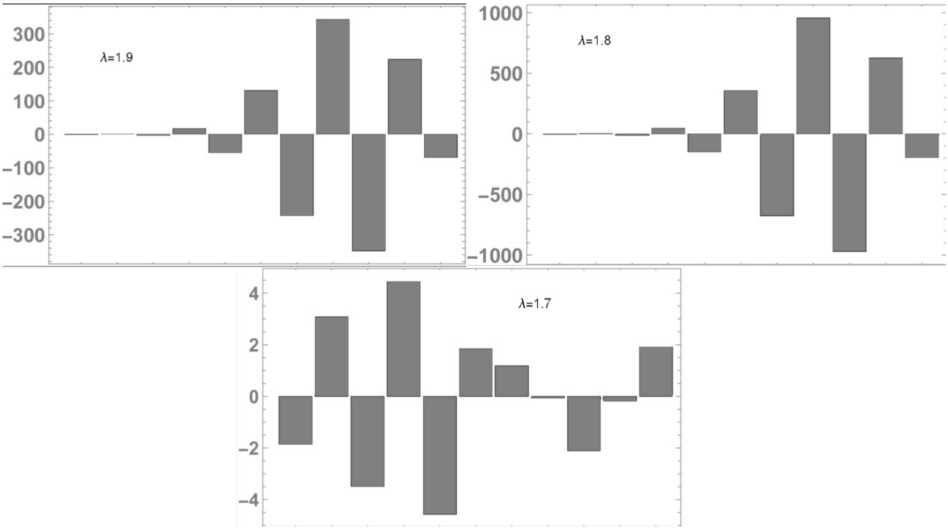

Figure 6. Final values of Unknown Taylor coefficients for example No 2 for $k = 12$.

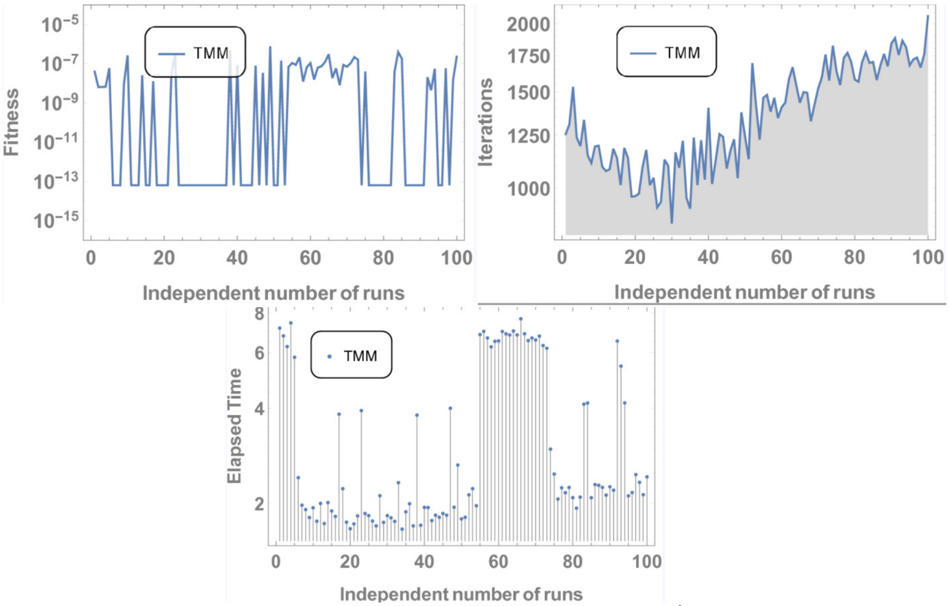

Figure 7. Data of 100 number of Independent runs of example No 2 for $\lambda = 2$.

Table 2. Comparison of absolute error for example No 2.

t	Absolute error $\lambda = 2$	Absolute error $\lambda = 1.9$	Absolute error $\lambda = 1.8$
0.1	2.2880×10-8	-	2.1000×10-8
0.2	5.7153×10-8	5.78×10-11	2.0900×10-8

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t	Absolute error $\lambda=2$	Absolute error $\lambda=1.9$	Absolute error $\lambda=1.8$
0.3	8.4235×10-8	-	2.0900×10-8
0.4	1.0627×10-7	6.25×10-11	2.0800×10-8
0.5	1.3043×10-7	-	2.0600×10-8
0.6	1.6246×10-7	3.01×10-11	2.0400×10-8
0.7	2.0511×10-7	-	2.0300×10-8
0.8	2.5853×10-8	2.62×10-7	2.0000×10-8
0.9	3.2171×10-7	-	1.9900×10-8
1.0	3.9421×10-7	3.46×10-7	1.9700×10-8

Table 3. Residual error for example No 2.

t	Residual error $\lambda=2$	Residual error $\lambda=1.9$	Residual error $\lambda=1.8$	Residual error $\lambda=1.7$
1	5.1393×10-7	1.4006×10-3	3.1913×10-3	1.8266×10-2
2	1.3659×10-7	3.8499×10-4	1.2004×10-3	1.1830×10-2
3	2.4985×10-7	2.1263×10-4	3.0410×10-4	8.0982×10-3
4	3.1538×10-7	5.4257×10-4	1.2117×10-3	5.7085×10-3
5	6.3298×10-8	5.3086×10-4	1.3318×10-3	6.7070×10-3
6	4.0145×10-8	7.5912×10-4	1.7963×10-3	1.1744×10-2
MSE	1.0563×10-13	1.1642×10-6	6.9963×10-6	2.3044×10-4

Experiment No 3

Consider the following nonlinear fractional pantograph differential equation with multiple proportional delays.

$$D^{\lambda} f(t) = -f(t) - \left(D^{\lambda} f\left(\frac{t}{3}\right)\right)^3 + f\left(\frac{t}{2}\right) + 2t + \frac{3}{4}t^2 + \frac{8}{7}t^3, \quad 0 < \lambda \leq 1,$$

$$f(0) = 0$$

By applying the TMM on above nonlinear pantograph fractional differential model, with fractional delay for $\lambda = 1$ *and* $k = 3$, unknown coefficients are found to be 1.97151×10^{-15}, 2 and 4.79185×10^{-16}. By substituting these values in Eq. 2 the required solution is found to be $f(t) = 1.97151\times10^{-15}t + t^2 + 7.98642\times10^{-17}t^3$ which is approximately equal to the true solution $f(t) = t^2$. For the fractional values of λ the obtained MSE for the above example are found to be $2.64798\times10^{-7}, 2.3042\times10^{-6}$ *and* 1.24327×10^{-6} for $\lambda =$ 0.9, 0.8 *and* 0..7 respectively. Figure 8 is demonstrating the solution at different values of λ by proposed method with an exact solution at $\lambda = 1$ while Figures 9 and 10 are representing the final values of Taylor coefficients and data of 100 number of independent runs respectively. Error analysis at different values of λ on domain $t \in [0, h]$ can be observed in Figure 11.

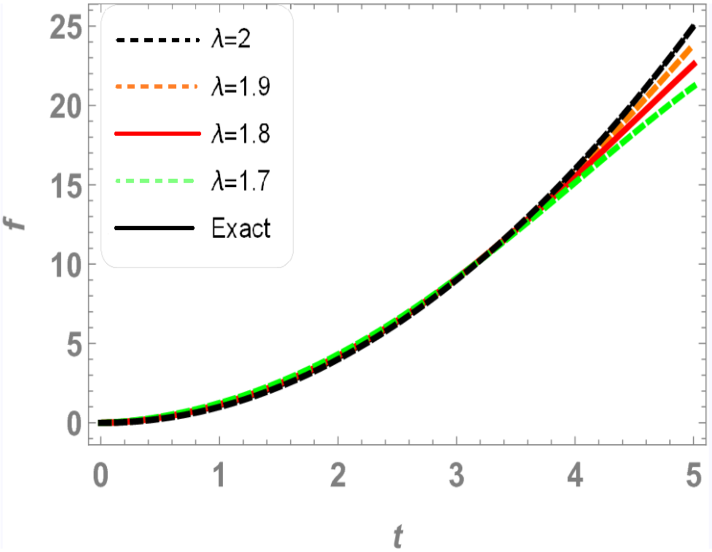

Figure 8. Solution of Example 3 at different values of λ.

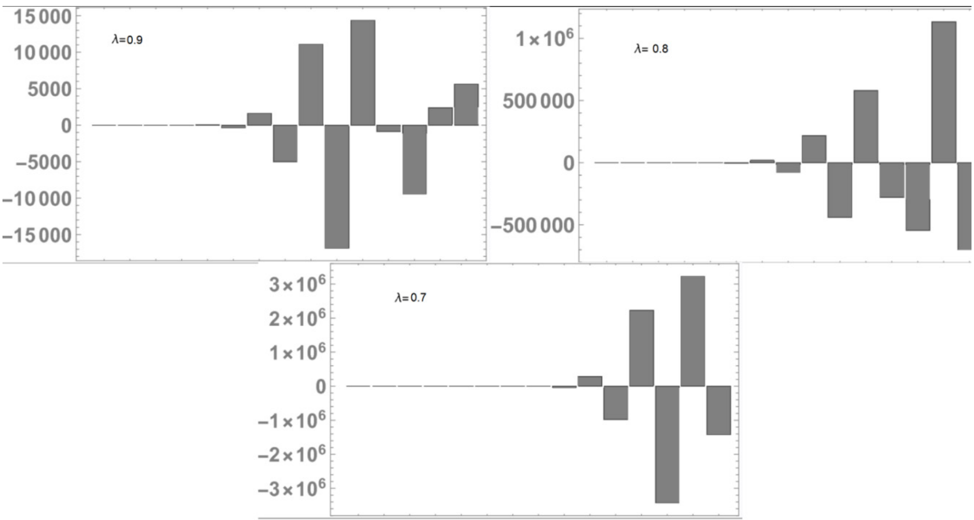

Figure 9. Final values of Unknown Taylor coefficients, for example, No 3 for $k = 15$.

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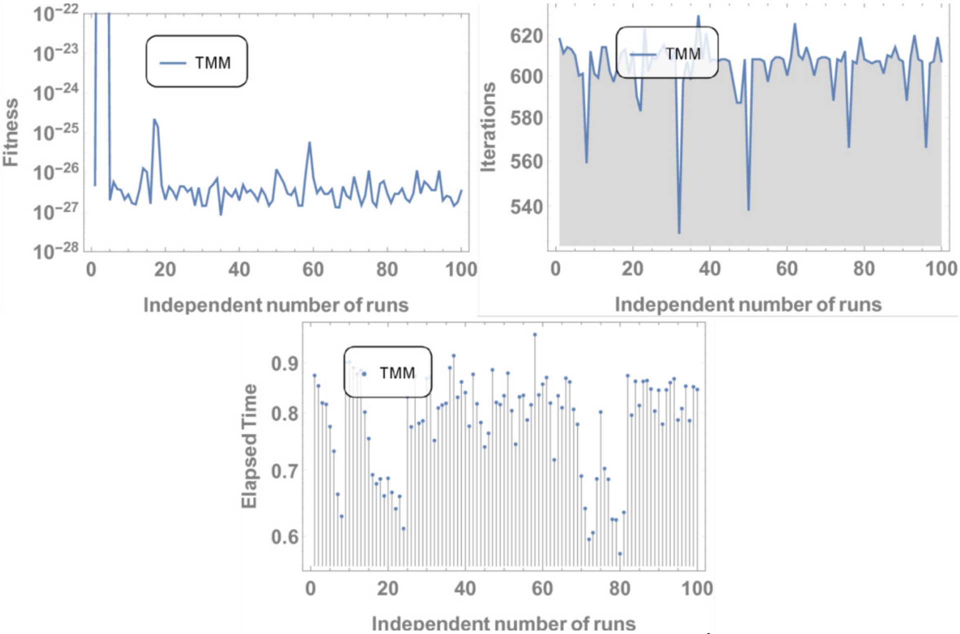

Figure 10. Data of 100 number of Independent runs of example No 3 for $\lambda = 2$.

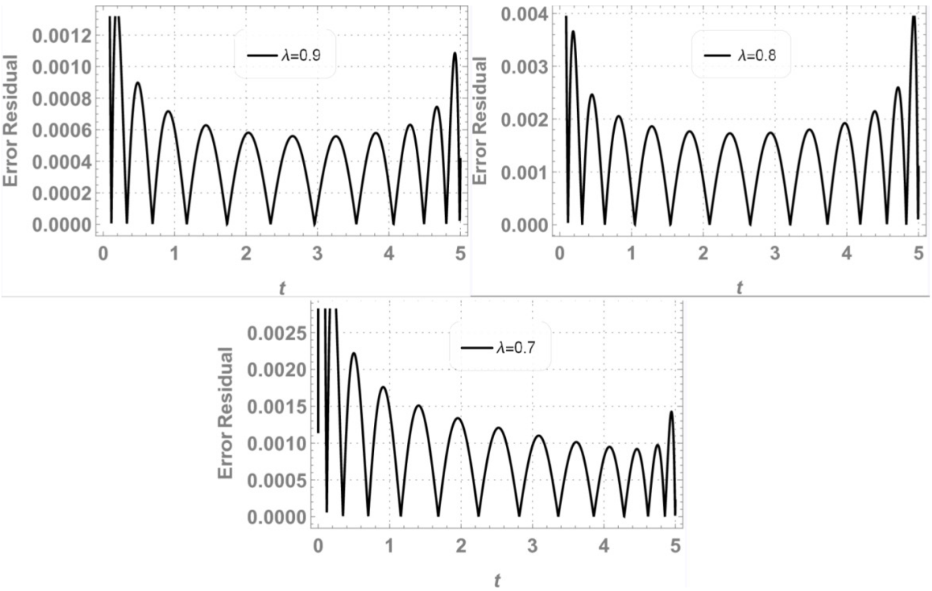

Figure 11. Residual error for fractional values λ, for example, No 3.

Experiment No 4

Consider the following nonlinear boundary value fractional pantograph differential equation with multiple proportional delays.

$$D^{\lambda} f(t) = \left(f(t)^2 + |f(t)|^3 \right) f(t/2), \quad 1 < \lambda \le 2,$$

$$f(0) = 1 \; and \; f(1) = \frac{1}{2}$$

By applying the TMM on above nonlinear boundary value pantograph fractional differential model, with fractional delay for $\lambda = 2 \; and \; k = 15$, results can be visualized in Figure 12. The true solution for $\lambda = 1$ is given by $f(t) = \frac{1}{1+t}$. For the fractional values of λ the obtained MSE for the above example are found to be $3.16567 \times 10^{-6}, 1.45514 \times 10^{-5} \; and \; 4.14856 \times 10^{-5}$ for $\lambda = 0.9, 0.8 \; and \; 0..7$ respectively. Table 4 exhibits the comparison at different fractional values. Figure 12 is demonstrating the solution at different values of λ by proposed method with an exact solution at $\lambda = 2$ while Figures 13 and 14 are representing the final values of Taylor coefficients and data of 100 number of independent runs respectively.

Table 4. Absolute Error Comparison for experiment 4.

t	Absolute error $\lambda = 2$	Absolute error $\lambda = 1.9$
0.1	8.0504×10-6	1.38×10-4
0.2	5.0102×10-6	2.17×10-4
0.3	5.3252×10-6	2.44×10-4
0.4	3.5795×10-6	2.50×10-4
0.5	1.1812×10-6	2.34×10-4
0.6	7.5917×10-7	2.11×10-4
0.7	1.5928×10-6	1.77×10-5
0.8	1.2997×10-6	1.39×10-5
0.9	1.0732×10-7	9.53×10-5
1.0	0	0

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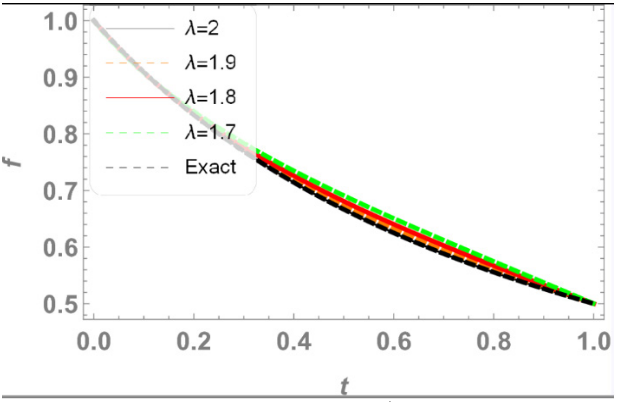

Figure 12. The solution of Example 4 at different values of λ.

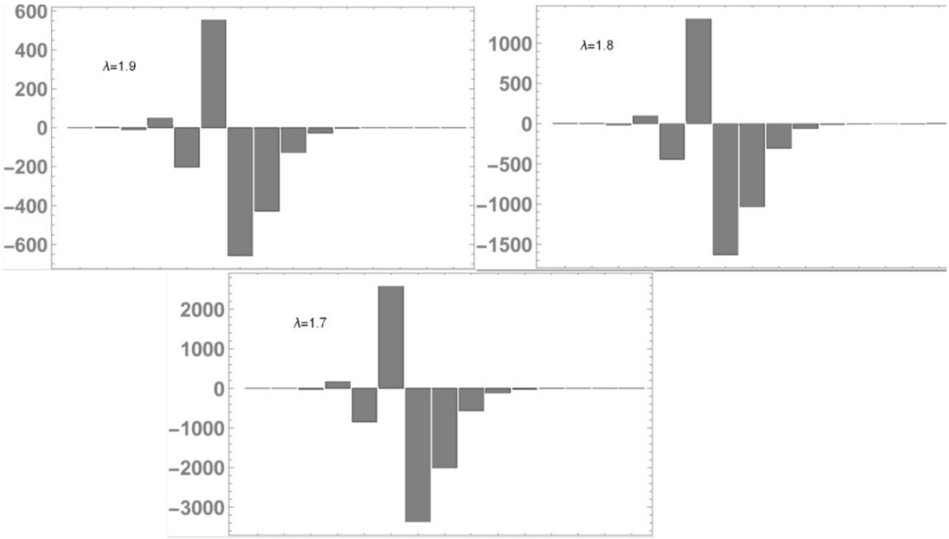

Figure 13. Final values of Unknown Taylor coefficients, for example, No 4 for $k = 15$.

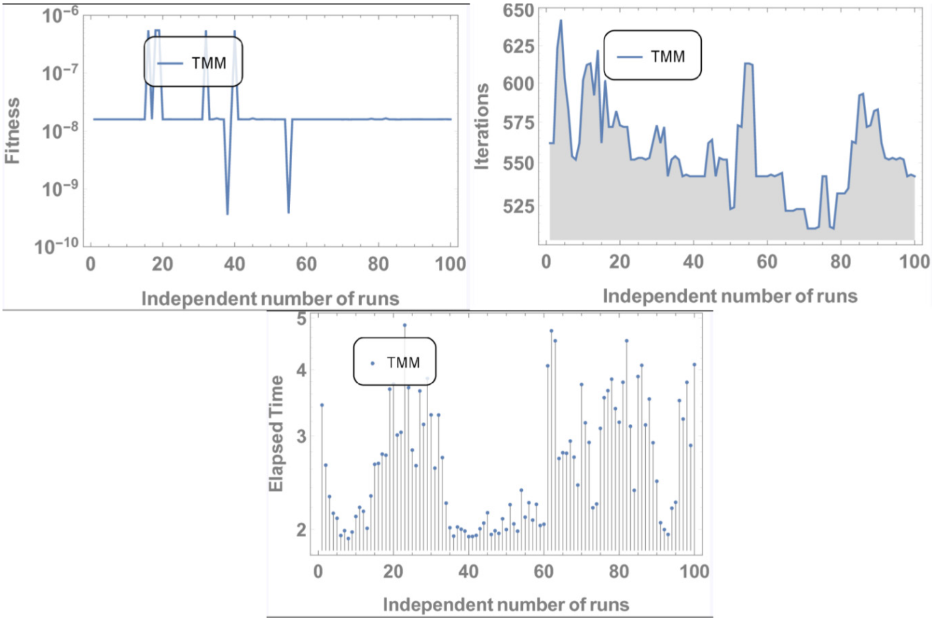

Figure 14. Data of 100 number of Independent runs of example No 4 for $\lambda = 2$.

6. DISCUSSION

The effort, that is performed above is mainly dealt with the effective implementation of TMM on initial and boundary value fractional Pantograph differential equations with multiple proportional delays. To validate the strength of employed methodology some linear and nonlinear test experiments have been efficaciously simulated through TMM. Absolute and residual errors have been calculated to compare the effectiveness of TMM with other methods. Different type of data, related to Taylor coefficients and multiple runs of the procedure, has also been demonstrated above to make the procedure well comprehensible.

Considering the results of test experiment 1, that is a linear initial value fractional Pantograph differential equation with single proportional delay, it is obvious that TMM has provided an excellent solution with $k = 3$ and $\lambda = 2$ that can be visualised through Figure 2 with overlapping lines of exact and TMM solution at $\lambda = 2$. Values of residual error, which has been calculated according to the explained procedure in section 4 of this paper, is demonstrating prominent values

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ranged between 10^{-4} $to\,10^{-5}$ that, can be witnessed from Table 1. Final values of unknown Taylor coefficients after learning through thermal minimization algorithm can be seen in Figure 3 while Figure 4 is establishing the results of multiple runs of an algorithm for fitness function, a number of iterations and elapsed time in seconds. It can be envisioned through Figure 4 that fitness function for experiment No 1 ranged between $10^{-26}-10^{-36}$, number of iterations during learning procedure by SA ranged between $100-400$ iterations while elapsed time in seconds is less than 0.3 seconds with Core i 5 processor and 2 GB RAM.

Problem took for experiment No 2 is a nonlinear initial value fractional Pantograph differential equation with single proportional delay term. Solution by TMM simulation for experiment number 2 can be seen in Figure 5 at different values of λ from which strength of proposed methodology can be observed. Comparison with a similar type of methods has been demonstrated in Table 2 that is witnessing method more powerful but here benefit of TMM is an effortless mechanism with the larger domain of implementation and less time consumption. Table 4 is depicting the values of residual error and MSE for fractional values of λ that is demonstrating the ability of TMM to handle the nonlinear problems smoothly. Final values of unknown Taylor coefficients have been displayed in Figure 6 for the ease of reader moreover elapsed time for the above nonlinear problem is less than 8 seconds for all while for most of the time it is less than 3 seconds that can be witnessed through Figure 7. A number of iterations and fitness function are ranged $800-2000$ and $10^{-6}-10^{-13}$ respectively.

Experiment number 3 is showing a similar trend like the other two examples but this problem is a nonlinear fractional differential equation with multiple delays. TMM showed a promising solution for this experimental case that can be envisioned through Figure 8. Residual error for different fractional values of λ has been presented in Figure 11 that is exhibiting the successful implementation of TMM. Time elapsed for this problem is under 0.9 seconds which is giving advantage to TMM over other methods to present effortless scheme with less time consumption. Other results are following the above trends.

Experiment number 4 is a boundary value problem with nonlinear and delay terms. Solution provided by TMM can be seen in Figure12 that is showing the efficacy of the proposed scheme. Comparison of the proposed scheme with a meta heuristic method can be seen in Table 4 but the author proposed the solution only for $\lambda = 2$ while the current method has also simulated the problem for fractional values of λ. Elapsed time in seconds for this experiment is under five seconds with similar processor conditions as described for above problems that can be observed in Figure 14. Number of iterations during the learning process is varied between $500 - 650$.

7. CONCLUSION

In this effort, we studied the fractional pantograph equation via TMM. The accuracy and strength of the proposed method are ascertained by observing the error analysis for diverse numerical experiments. The obtained results show that linear and nonlinear neutral fractional Pantograph equations with proportional delays type differential equations can be cracked by this scheme with less effort and more accuracy. Results obtained from the above numerical experiments can be concluded as:

- For integer value of derivative TMM exhibits exceptionally excellent results that can be visualized in Figures 2, 5, 8 and 12.
- TMM converts the differential equations into a minimization problem so the accuracy of the method is merely dependent on obtained MSE or fitness function by implementation of SA and advancements in SA for better minimization can further develop the TMM for better results.
- Graphical representation of Error analysis for the above numerical experiments depicts that TMM can be employed on larger domains with accuracy.
- Challenging nonlinearities, boundary conditions and proportional delays can be handled with this scheme effortlessly.
- The proposed scheme can be further developed to obtain the solutions of complex differential models.

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- TMM can be employed to nonlinear FDEs without applying any perturbations and linearization.

Data Availability Statement

All data are provided in full in a different section of this paper.

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OPTIMAL BALANCING AND CONTROL OF A DYNAMIC LOAD DEMAND IN A GRID CONNECTED HYBRID SYSTEM USING FEED–IN TARIFF APPROACH

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ABSTRACT

In this paper, we have proposed, designed and simulated a grid connected residential smart home system benefiting from hybrid energy system (HES) for optimal balancing and control of a dynamic load using Feed–in Tariffs (FiT) tariffs by increasing the onsite self–consumption of solar PV system. To achieve the object function, two different PV system configuration scenarios were designed, simulated and analyzed for different case studies. In first scenario, PV system without battery backup storage system (BBSS) under FiT scheme with flat tariffs was investigated for a typical day of winter and summer. In second scenario, PV system with BBSS under FiT scheme with ToU tariffs was investigated again for a typical day of winter and summer. The optimal balancing and dynamic load control can be achieved by increasing the penetration level of solar PV by maximizing the onsite self–consumption of PV system, minimizing the grid electricity import in high ToU tariff periods, charging the battery during low ToU tariffs, discharging the battery during high ToU tariffs and exporting the excessive PV generation in peak PV generation periods especially in summer season. The simulated results suggest that significant revenue can be saved, and optimal balancing and control can be achieved when PV system is configured with BBSS under FiT scheme by utilizing ToU tariffs. The proposed will be more cost effective and optimal control can be achieved if implemented to residential community microgrids by using cooperative game theory approach.

KEYWORDS

Solar PV system, Battery Backup storage system, Hybrid Energy System, Feed–in Tariffs, Time of Use tariffs.

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1. INTRODUCTION

The superfluous usage of energy resources by humans for the luxurious living standards and ever increasing industrialization and commercialization for sustainable growth have put the serious stress on energy reserves especially on non–renewable as in near past no major discovery of energy source reserves have been found around the globe (Halepoto, Uqaili & Chowdhry, 2014). This is a gigantic concerned situation as this can limit the sustainable growth around the globe. According to world energy reports, it is anticipated that with current rate of energy resources utilization, the oil, natural gas and coal reserves will last to only for 50, 75 and 140 years for an average to the globe if no other major discovery is being made (Narula, 2019). This situation has shifted the more focus on the utilization of renewable energy resources (solar, wind) and energy conservation techniques in form of Demand Side Management (Sahito, Halepoto, Uqaili, Memon, Larik & Mahar, 2015). As the matter of fact, this world has strong solar irradiation potential and wind belts which are being used but the penetration level needs to be increased (Sahito, Arain, Halepoto, Soomro & Jumani, 2016). As compared to wind turbines, the solar irradiation intensity is easily available and can be utilize optimally for energy generation (Kaplan, Agalar & Bildircin, 2019). Similarly Demand Side Management (DSM) being the promising approach is the main research area and resulting significantly to reduce, schedule, manage and optimize the energy consumption at consumer side of the power utility distribution system (Ahmed, Levorato & Li, 2018). With DSM, the utility can introduce the price incentive in form of ToU. During high load stress periods, high on peak ToU tariffs and during low load stress, low ToU tariffs can be offered. This will mutually benefit the consumer in billing and utility grid in reducing the system stress load. If these two promising areas can be integrated in a systematic way that a grid connected HES can be developed to utilize both the renewable distributed energy resources (DERs) like solar or wind turbine when they are available naturally and at the same time in the periods when these sources are not available, then optionally utility grid can be utilized accordingly where utility can offer ToU tariffs conditionally. This will form a type of grid connected microgrid system, such HES will not only increase the DERs penetration level but will also reduce the stress to non–renewable resources and at the same can be cost effective and will reduce carbon emission significantly (Ju, Wang, Goel & Xu, 2018).

In this connection a major concern is that when the conventional utility grid is to be utilize and when non–conventional DERs to be utilized. The optimal balancing and control of such HES need to be investigated especially considering the availability of DERs and DSM. In this paper we are proposing an optimal balancing and control of a dynamic load demand in a grid connected HES system (solar PV and utility grid) using DSM techniques. The PV system will be integrated with utility grid and based on requirement the load can be import and to and from utility grid and PV generation system. This will generate different scenario of utilizing the onsite PV system generation and utilization, PV to be export to grid, generated PV load to be stored in batteries, load directly utilized the utility grid based on flat and ToU tariffs prices offered by utilities.

The rest of paper is organized as under: In section 2, the proposed system under the study is presented by considering different input parameters and an object function is formulated to achieve the optimal balancing and control of dynamic load. In section 3, a PV system is configured by using two case scenarios to investigate the impact of battery storage and incentive based pricing. The work is concluded in section 4.

2. SYSTEM UNDER STUDY– INPUT PARAMETERS AND MODELING

In this paper, system under study is a grid connected residential microgrid considering of a utility grid, smart meter for consumer–utility bidirectional communication and to update about the electricity pricing, solar photovoltaic (PV) system, solar PV generation meter, a BBSS, DC to AC inverter and charger, residential consumer load data profile as shown in **Figure 1.** The system configuration of the proposed residential home model is based on object function

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formulation, 24 hour load profile, flat and ToU tariffs, solar PV generation and feed in tariff (FiT) data.

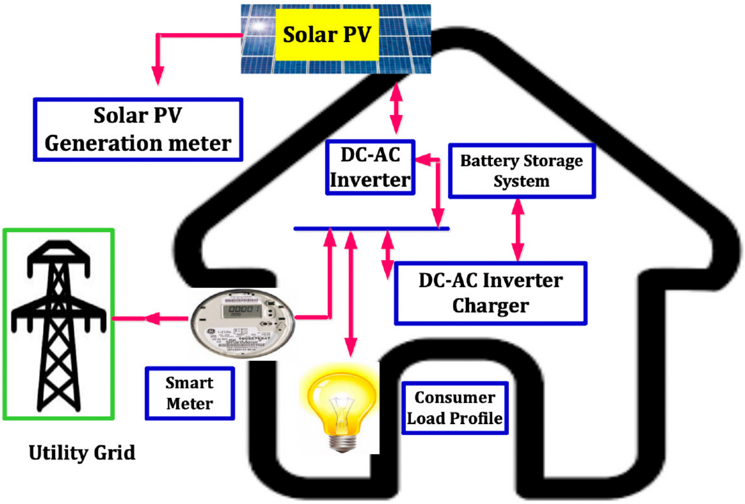

Figure 1. System under Study with Residential PV–Battery Storage Configuration.

2.1. MATHEMATICAL OBJECT FUNCTION FORMULATION

The two main parameters of object function are where defines the selected days of year and is the of set of one hour periods in selected days . This object function is formulated by Eq. 1 and 2. Eq. 1 maximize the solar PV self–consumption through FiT and Eq. 2 minimize the utility grid import using flat and ToU tariff cases with and without BBSS. The formulated object function is evaluated for FiT scheme, flat tariff and ToU tariffs.

$$Object\ Function = max \sum_{(d_y,t_h)} PV(d_y,t_h) \times PV_{FiT} + PV_{on\ site\ genreation} + PV_{\ battery\ charging} + PV_{export} \times \Delta t\,..\,(1)$$

$$Object\ Function = min \sum_{(d_y,t_h)} PV(d_y,t_h) \times PV_{FiT} - Grid_{flat\ traiff} - Grid_{\ ToU\ taraiff} - Grid_{electrcity\ import} - Grid_{\ battery\ chrgging} \times \Delta t..(2)$$

2.2. LOAD PROFILE DATA

The selected residential smart home load data were measured and recorded by using smart meter for 365 days. The minimum recorded load was 0.7 kW and the maximum recorded load was 6 kW.

2.3. FEED IN TARIFFS (FIT)

The FiT tariff combines the generation and export tariffs. The generation tariffs define every kWh of PV generated energy being paid and the export tariff defines every kWh of energy being exported.

2.4. FLAT TARIFFS

Although nowadays in developed countries ToU tariffs are being implemented but in countries like Pakistan we still do have flat tariff system which is mostly are slab based tariffs. In this work, to import the electricity, flat tariffs are proposed at Rs. 12/kWh for 24–hour load on a selected day.

2.5. TOU TARIFFS

The load profile is very dynamic as it depends on many factors, but this variability of load profile can be managed if ToU tariffs to be during on and off peak periods in form high and low tariffs than routine tariffs. This will give an option to a consumer to get benefit of ToU to reduce electricity bill and at the same reducing utility system stress in on peak hours. This approach is mutually beneficial for both consumer and the utility. The proposed ToU tariffs are shown in Figure 2.

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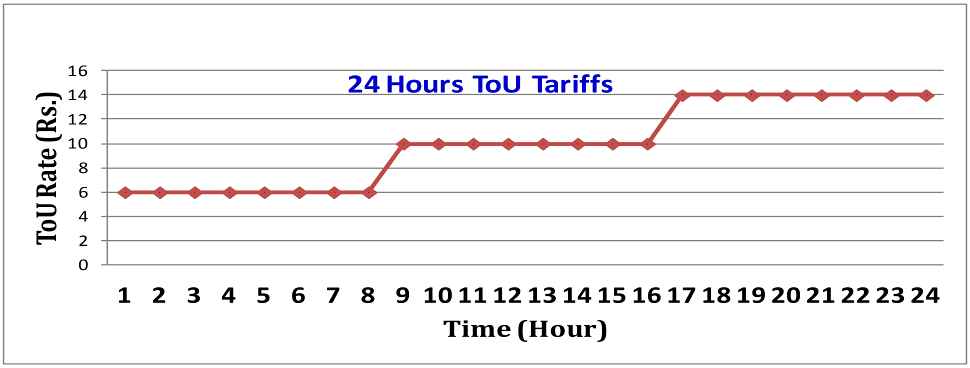

Figure 2. Proposed ToU tariffs.

Although, ToU approach is very attractive for residential consumer when utility offers off peak periods but in periods of on peak hours, the potential of solar PV can be used as an grid connected microgrid source not only to fulfill own needs in on peak periods but can export to the utility in case surplus through battery backup storage system.

2.6. SOLAR PV GENERATION DATA AND TARIFFS

The total installed solar PV generation capacity of the proposed system is 6.5 kW. The PV generation data is obtained and recorded through hourly smart meter readings. The cost of PV generation is estimated by FiT scheme, where 14.5 Rs/kWh is set as an import generation tariff and 7.5 Rs/kWh is finalized as export tariff.

2.7. BATTERY BACKUP STORAGE SYSTEM

Due to the intermittent nature of solar PV and non–linear load consumer requirements, BBSS is the potential solution to maximize the self–consumption of solar PV and to optimize the import generation tariffs and export tariffs by benefiting from the FiT scheme and ToU tariffs (Bakhshi & Sadeh, 2018). Figure 3 shows the 24 hour load profile of a selected day illustrating the actual and average load consumption profile of test case home which confirms load unevenness.

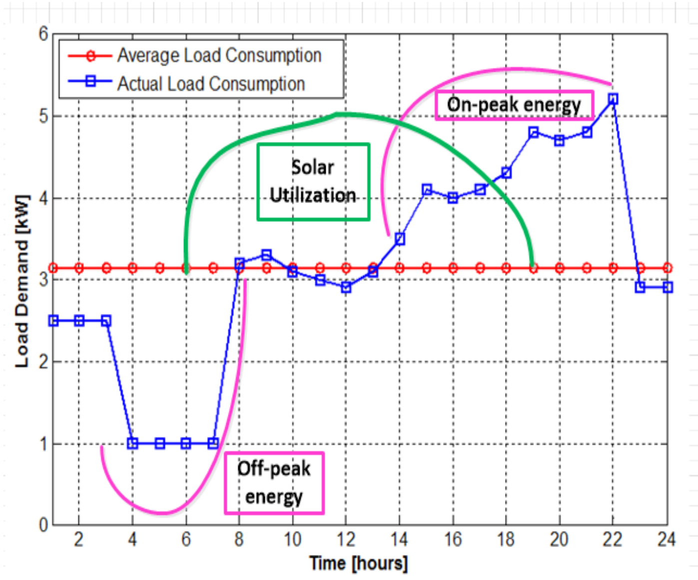

Figure 3. Solar power utilization into BBSS for energy shifting during on–off periods.

The high peak load is 5.2kWh at 22nd hour of the day, while off peak load is 1kWh between 4 to 7 hours of the day. The average load consumption is 3.14kWh. This graph confirms the presence of both the on peak and off peak periods. The BBSS will maximize the solar PV usage periods by storing the excess PV power during on peak hours tariff.

3. SYSTEM DESIGN SCENARIOS: SIMULATION RESULTS AND ANALYSIS

Two case scenarios are designed, modeled and simulated two objective functions as described in Eq. 1 and 2. Test case scenario 1 and 2 are designed, simulated and analyzed for PV System under FiT scheme without BSS at Flat Tariff and PV System under FiT scheme with BSS at ToU.

3.1. CASE SCENARIO 1: PV SYSTEM UNDER FIT SCHEME WITHOUT BSS AT FLAT TARIFFS

In this case scenario, as there is no battery storage system, so the smart home consumer is supposed to buy and use the grid electricity at flat tariffs set by utility

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grid. The designed PV generation system configuration without BSS for case scenario 1 is shown in Figure 4. At the utility grid side, smart meters indicate the electricity import (to be purchased from PV) and export rates (to be sell to PV consumer) through import and export meters. On the other hand, solar PV generation meter indicate the overall PV generation over the defined periods. Based on PV generation and load demand consumer decide to sell or purchase the electricity to and from utility grid. Based on object function presented in Eq. 1 and 2, system designed in Figure 4 is simulated for the 365 days of the year. To represent the seasonal cases the one day is selected from winter and summer to analyses the both the grid and PV generation, load demand and electricity import or export without BSS.

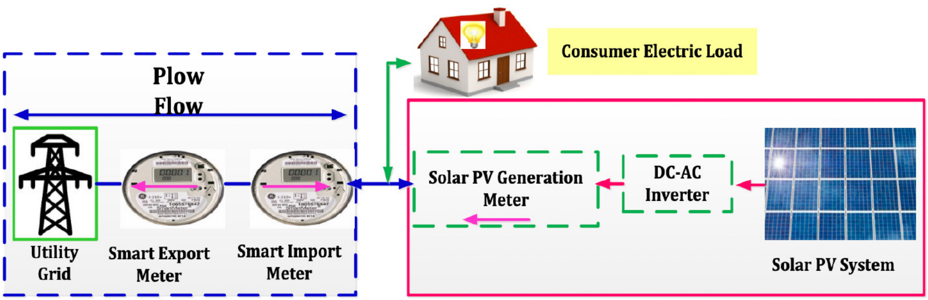

Figure 4. PV system design configuration without BSS under FiT and Flat Tariffs.

Traditionally winter season represents the low PV generation and maximum grid electricity loads due to low solar irradiance. Based on object function presented in Eq. 1, the system designed in Figure 4 is trained for the 365 days and simulated and analyzed for one selected day of the winter. On a selected day of winter, in early hours of the morning, the meet the load demand, the electricity is required to be imported from the utility, as the solar irradiance will be low. As the day progress, the solar irradiance increases so the PV generation thus electricity import from the grid decreases accordingly. Similarly PV used onsite for self–consumption and PV exported in cases when the PV generation meets and excess the load demand accordingly. These results are shown in Figure 5. During winter due to low PV generation most of power is consumed onsite and PV export is very low. On the period of day (after 17th hour) when the PV generation is not available, the grid electricity is imported to meet the load demand at flat tariffs defined by utility grid. This will increase the increase the cost or consumer electricity bill.

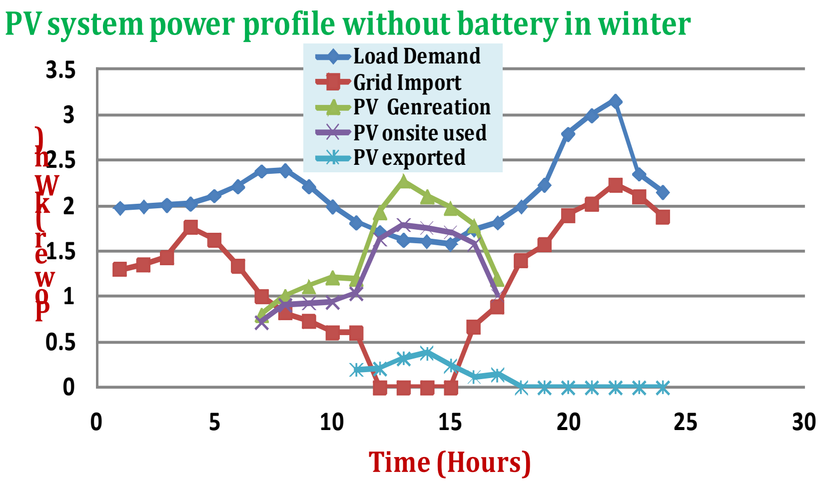

Figure 5. Power profiles of the PV system without battery storage system in winter.

In summer, the potential solar irradiance will be at its maximum intensity while electric grid requirements can be low but overall load demand can be increased due to high temperature. The results of power profile without BSS in summer are shown in Figure 6.

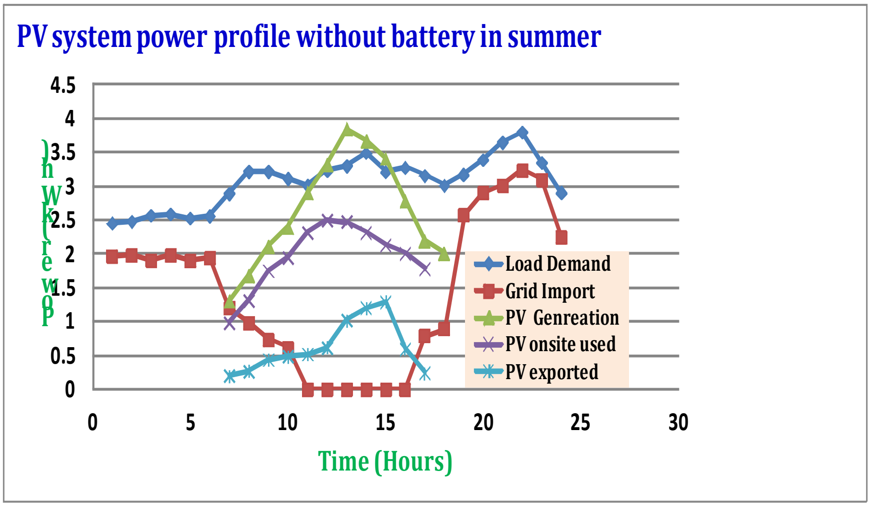

Figure 6. Power profiles of the PV system without battery storage system in summer.

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The results confirm that there is a significant PV generation especially at mid of the day and reaches to its peak at 13th hour of the day. During PV generation periods, the grid electricity import is zero as PV power is more than onsite requirement and can be exported to the utility. But as there is no BSS installed, so the excess PV power is sold to the utility grid at low export tariffs.

3.2. CASE SCENARIO 2: PV SYSTEM UNDER FIT SCHEME WITH BSS AT TOU TARIFFS

This case scenario a PV system configuration is designed with BSS with FiT scheme by using ToU tariffs. The system configuration is shown in Figure 7.

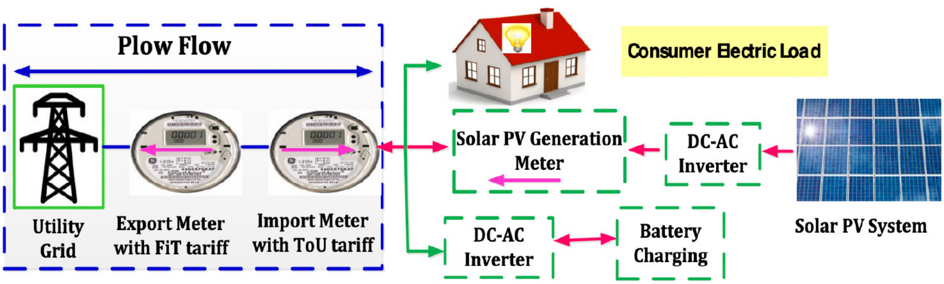

Figure 7. PV system design configuration with BSS under FiT and ToU Tariffs.

Figure 8 shows the results of PV system power profiles under FiT scheme and ToU tariffs on a selected day of winter. Load demand of the selected home is considered same as presented in Figure 5.

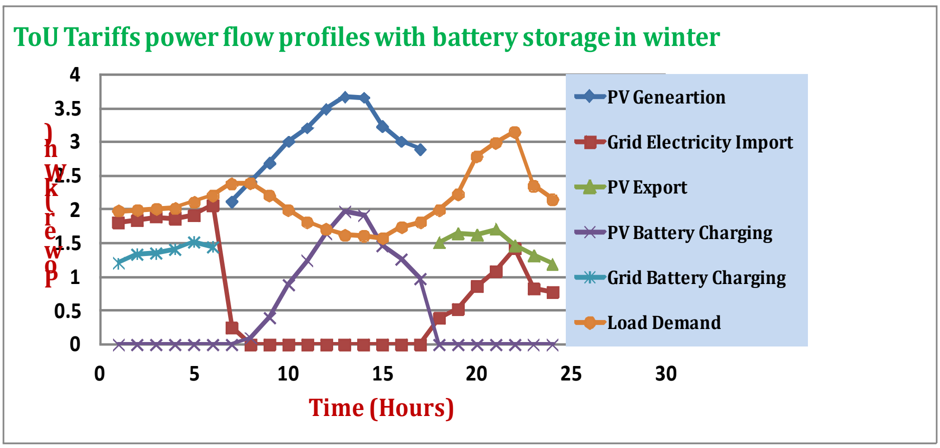

Figure 8. ToU tariff power profiles in winter.

Considering the ToU tariffs presented in Figure 2, during low ToU tariff periods (between 1:00 to 6:00 hours), the maximum electricity is purchased from the utility grid and at the same time BBSS is also charged from the utility grid. Similarity during maximum PV irradiation periods, BBSS is charged from solar PV (between 8:00 to 17:00 hours). This BBSS from the both grid charging and PV charging is utilized optimally when ToU tariffs are high (between 17:00 to 24:00 hours). On the contrary, the selected day power profiles of winter are shown in Figure 9 Load demand of the selected home is considered same as presented in Figure 6.

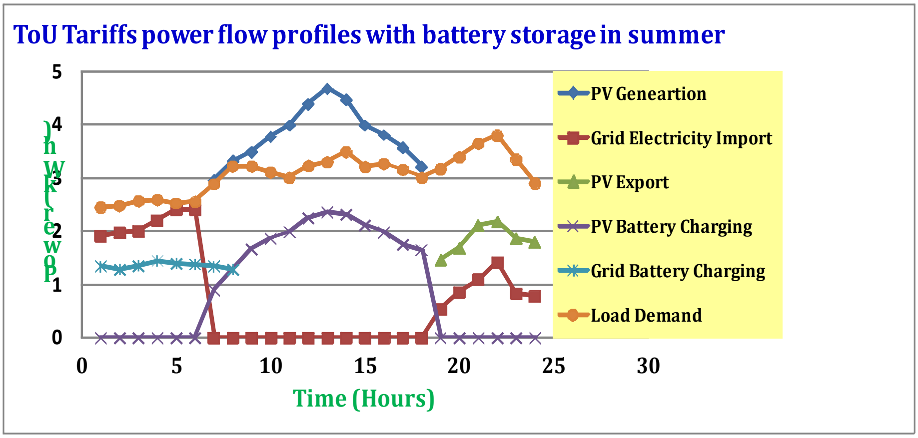

Figure 9. ToU tariff power profiles in winter.

Since in summer the generation from solar PV is significantly higher than the load demand, so battery charging either from PV or from utility grid is not required in typical PV generation hours (between 6:00 to 19:00) and after meeting own load requirements the excessive PV generation is exported to the utility grid at the low FiT export tariffs. This confirms that in summer the battery charging requirement is significantly low than in winter, whereas the required battery charging for usage of hours when no PV generation is available on site (between 19:00 to 6:00 hours), either low ToU tariffs or optimal FiT tariffs can be opted.

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4. CONCLUSION

The main objective of this research work is to propose an optimal balancing and control of dynamic load demand in a grid connected hybrid system using PV system with and without battery backup storage system. For this purpose two different PV system configuration were designed, modeled and evaluated for different case studies. In first scenario, PV system without BBSS under FiT scheme with flat tariffs was investigated for a typical day of winter and summer. In second scenario, PV system with BBSS under FiT scheme with ToU tariffs was investigated again for a typical day of winter and summer. After detailed analysis of case scenario's it was concluded a significant economy can be saved and optimal balancing and control can be achieved when PV system is configured with BBSS under FiT scheme by utilizing ToU tariffs.

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PREDICTING STUDENT ACADEMIC PERFORMANCE USING DATA GENERATED IN HIGHER EDUCATIONAL INSTITUTES

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ABSTRACT

The analysis of data generated by higher educational institutes has the potential of revealing interesting facets of student learning behavior. Classification is a popularly explored area in Educational Data Mining for predicting student performance. Using student behavioral data, this study compares the performance of a broad range of classification techniques to find a qualitative model for the prediction of student performance. Rebalancing of data has also been explored to verify if it leads to the creation of better classification models. The experimental results, validated using well–established evaluation matrices, presented potentially significant outcomes which may be used for reshaping the learning paradigm.

KEYWORDS

Educational data mining, Student performance prediction, Education, Machine learning.

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1. INTRODUCTION

Educational institutes generate massive amounts of student data which can broadly be categorized as descriptive, behavioral, attitudinal and interactional (Meghji, Mahoto, Unar & Shaikh, 2018). In recent years, there has been growing interest in analyzing this data to better understand student learning behavior (Casey & Azcona, 2017). The prediction and understanding of student performance are essential for the establishment of a student centric learning environment; if educators can predict student performance, they can have mechanisms in place to ensure this performance constantly improves or, at any rate, does not fall beneath an acceptable threshold. Educational Data Mining (EDM) is a field dedicated towards the application of data mining and machine learning strategies on data emerging from educational institutes (Baker & de Carvalho, 2008). The goal of EDM is to explore educational data to gain insights into how individuals learn (Meghji & Mahoto, 2016). Classification is a popularly explored area in EDM for predicting student performance. This method is used to assign items to a class, from a set of pre–specified classes, based on certain known properties of the items (Hämäläinen & Vinni, 2011). The process of classification can be implemented using various algorithms, usually referred to as classifiers (Tan, Steinbach, & Kumar, 2006).

Using behavioral data belonging to students of the Department of Software Engineering (SWE), Mehran University of Engineering and Technology (MUET), Pakistan, this research aims at determining the impact of behavioral attributes on overall student academic performance. Using classifiers belonging to four classification families i.e., rule–based, decision tree, probabilistic and instance–based, this study attempts to find a qualitative model that best predicts student performance based on in–class face–to–face behavioral data. Although the prediction of student performance has been previously addressed, to the best of our knowledge, the specific behavioral attributes considered in this research have not been used in existing scientific literature for student performance prediction. The findings of this study provide opportunities for improved pedagogical decision–making and can be used to enrich the existing teaching practices. This paper has been organized as follows: Section 2 describes the classification process and the families of classification methods used in this paper, Section 3 presents a literature review of previous studies, Section 4 outlines the experimental setup of this paper, Section 5 presents the results and discussion followed by a conclusion in Section 6.

2. CLASSIFICATION

The process of classification can fundamentally be broken down into two steps. Using certain training data, a classifier first produces a classification model; the classification model is then used to predict the target class for new items – items that were not used during the training process to prepare the classification model (Aggarwal, 2014). The goal of the classification process is identification of a classification model that fits the relation between the known properties and class label of the input data in the best manner. Apart from fitting the data well, the model generated by the classifier should accurately predict the class of new/unseen data items.

Classification methods differ from each other based on their internal mechanism of processing and extracting relevant features from training data for the creation of a classification model. Some popular categories of classification methods include:

Decision Tree: A decision tree represents a tree–like hierarchical structure comprising of a set of conditions. This predictive model consists of nodes and leaves. Each node in the tree represents a logical test; based on the outcome of the test, the node branches to one child or another. New instances of data are classified into classes based on the path of satisfied conditions until a leaf node is reached; the leaf node represents a class label (Witten, Frank, Hall & Pal, 2016). J48 and REPTree are decision tree based algorithms.

Rule–Based: Rule induction comprises of the generation of a set of If–Then relational rules based on a set of training observations (Hand, Mannila & Smyth, 2001). Some algorithms in this category include OneR and PART.

Probabilistic: Rather than predicting the output class of an instance of data, the classifiers in this category predict the probability distribution over the label classes

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based on the observation of an instance of data. The Bayes theorem is utilized for calculating the probability of an item belonging to a class (Han, Pei & Kamber, 2011). Naïve Bayes and Bayes Net belong to this class of classifiers.

Instance–Based: Unlike the classifiers that create a model/generalized explicit description based on which future data items are to be classified, the classifiers in this category postpone this step until data items need to be classified. The new data item is examined at run–time to find its relationship with the previously stored training data. It is due to this reason that these classifiers are also called memory–based or lazy (Aha, Kibler & Albert, 1991). The IBK belongs to this category of classifiers.

3. LITERATURE REVIEW

Educators have utilized classifiers for predicting different facets of student learning. Working on student demographic data and grades obtained in an introductory level test, decision tree and probabilistic classification algorithms have been used by Sivasakthi (2017) to predict the initial programming performance of students in the first year of bachelor's in computer applications.

Using data of 72 freshman students on parameters based on student background and characteristics exhibited by students during their class, the probabilistic classifier Naïve Bayes has been used by Purwaningsih and Arief (2018) to predict student performance in the subject of English.

Experimenting on data of 231 students, Shah (2012) used several algorithms, including J48, RandomForest, REPTree, Bayes and NaiveBayes to predict student academic performance. This study demonstrated that re–sampling of data has a significant effect on the improvement of prediction accuracy.

Experimenting on attributes relating to student demographics and performance, Alharbi, Cornford, Dolder and De La Iglesia (2016) used a decision tree classifier to predict students in danger of not achieving their honors degree.

Chau and Phung (2013) used sampling with C4.5, Naïve Bayes and Random Forests to devise early predictions of student final–status based performance. Their study suggests that sampling imbalanced data directly influences the improvement of algorithm accuracy.

4. EXPERIMENTAL SETUP

4.1. DATA COLLECTION

This research uses behavioral data of 2nd year students studying B.E in the department of SWE, MUET, Pakistan. The data for this study has been collected through qualitative class observations which were carried out over a period of one semester (i.e., six months). The dataset comprises of 176 student records.

4.2. DATA PREPARATION

Data preparation is an imperative step of the EDM process. The collected data has been processed to remove any erroneous or missing data and transformed into a format that can facilitate maximum extraction of knowledge. Table 1 presents attributes considered in this study. Possible values for attributes 1–8 are excellent, good, average, below average and poor. Possible values for attributes 9–11 are always, mostly, average, rarely and never. Attribute 12 can have the values of front, mid or back. Finally, attribute 13 is the label class with possible values of pass or fail.

Table 1. Data Attributes and their Possible Values

S#	Attribute	Description
1.	class_performance	Overall performance of the student
2.	attention	Student attention towards lectures
3.	interaction_class	Student tendency to clear confusions in–class
4.	interaction_afterclass	Student tendency to clear confusions after–class
5.	note_taking	Student tendency to take and maintain notes
6.	assignment_submission	Assignment submission record of the student
7.	attendance	Attendance record of the student
8.	test_marks	Marks obtained by student in class tests
9.	excuses_leave	Does student make excuses to skip lectures?
10.	assignment_self	Are assignments actually made by the student?
11.	project	How often does the student participate in class projects?

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S#	Attribute	Description
12.	seating_position	Where does the student sit during lectures?
13.	verdict	Student exam outcome

Next, the considered behavioral attributes were visualized to better understand the distribution of various attribute values (see Figure 1). By breaking down the data in terms of number of students exhibiting various behavioral attributes and the pass and fail ratio within each attribute value, it was observed that the label class (verdict) is not equally represented – most of the data belongs to class 'Pass'. Algorithms are data driven; most state of the art classification approaches are developed with the assumption that the underlying data is evenly distributed (Wang, Xu, Wang & Zhang, 2006). The performance of an algorithm can, thus, greatly vary if it is trained for classification using disproportioned data.

To ensure that algorithms function optimally, the Synthetic Minority Over–sampling TEchnique (SMOTE) has been applied on the dataset to oversample the minority (Fail) class. This technique works by creating new synthetic samples of the minority class – in this case, the 'Fail' class. The newly generated samples are introduced along the line joining all or any of the specified (K) minority class nearest neighbors. The algorithm randomly selects the K nearest neighbors (Chawla, Bowyer, Hall & Kegelmeyer, 2002). As the new synthetic examples are added to the bottom of the dataset, the dataset was shuffled using the randomize filter of WEKA tool. The original student dataset comprised of 176 records (dataset–1) whereas the SMOTE dataset comprises of 221 records (dataset–2).

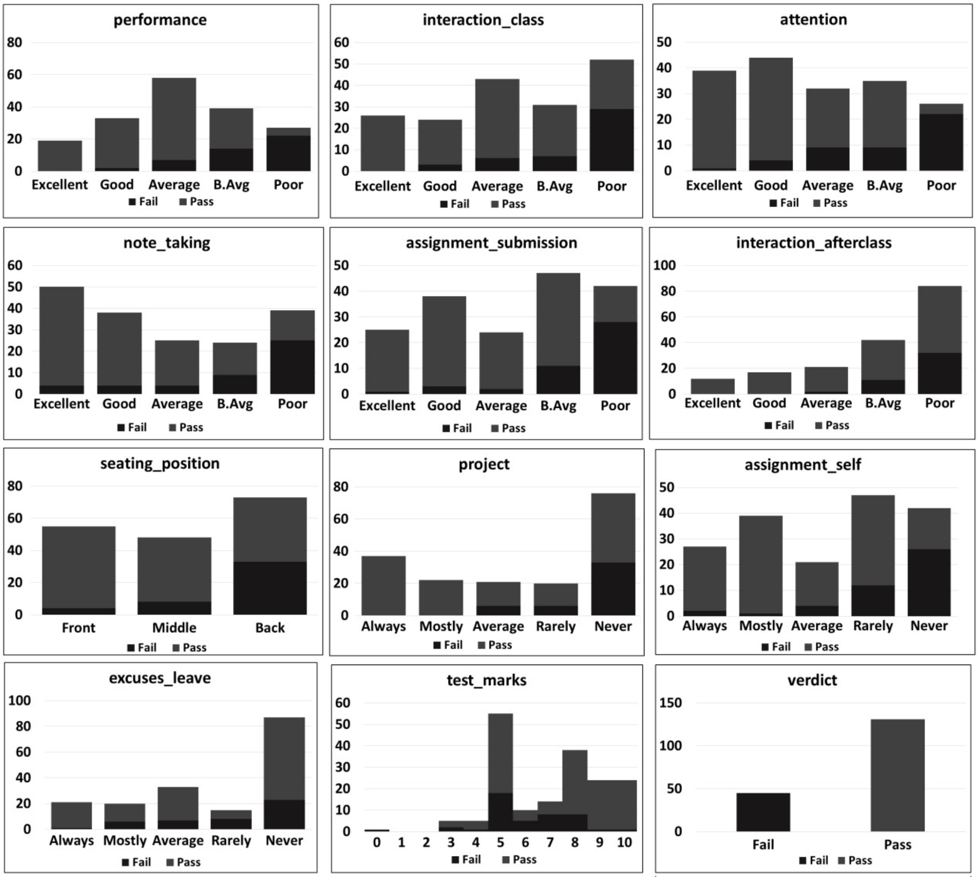

Figure 1. Visualization of the Collected Student Data.

Dataset–2 has also been visually represented to better understand the breakdown in terms of number of students exhibiting various behavioral attributes (see Figure 2).

4.3. DATA ANALYSIS APPROACH

This paper uses prominent algorithms from four classification families for predicting students into two classes – pass and fail. Specifically, the J48, REPTree and Random Forests from decision tree; OneR and PART from rule–based; Naïve Bayes and Bayes Net from probabilistic; and the IBK classifier from the instance–based family of classifiers have been used. The reason for using a diverse array of classifiers is twofold. First, since classification algorithms are data driven with their

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performance being influenced by the dataset being used, an algorithm that works well with one form of data might not present equally striking results when the underlying data is changed. Second, using a wide–range of algorithms increases the likelihood of finding the better and most efficient classification model in terms of accuracy and allows a better comparison of overall performance.

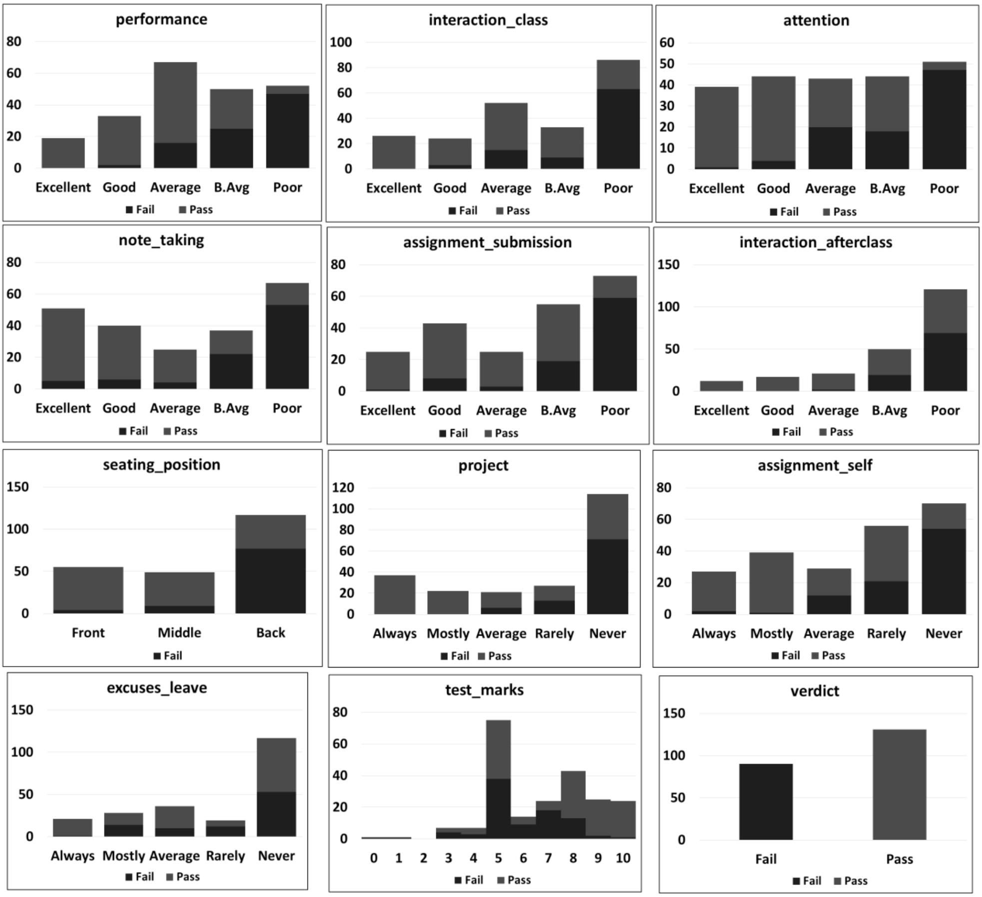

Figure 2. Visualization of Student Data after SMOTE (dataset–2).

4.4. PERFORMANCE EVALUATION

It is essential to evaluate the performance and usefulness of the classifiers before their results can be used to practically predict and/or improve students' performance. The classifiers used in this paper have been evaluated using two evaluation metrics – Accuracy which the measure is, in percentage, of the number of correct predictions made by the classifier and Kappa Statistic which takes randomness or chance of predictions into considerations and essentially is a measure of how better a classifier is performing when compared to a classifier that simply guesses the target class label (Nasa & Suman, 2012). Kappa is especially useful when working with imbalanced datasets. The value of kappa ranges between 0 and 1, a higher value signifying better performance.

5. RESULTS AND DISCUSSION

The collected data (dataset–1 and dataset–2) has been mined using WEKA open source software (Witten, *et al.*, 2016). WEKA provides a large collection of machine learning algorithms and thus is widely used in EDM research.

Considering that a classifier has to classify items into one of two classes: i) Positive (P) and ii) Negative (N), there are four possible outcomes that the classifier can predict: True Positives (TP) – items that have been correctly classified in to class P, True Negatives (TN) – items that have correctly been classified into class N, False Positives (FP) – items that should have been classified into class N but have been incorrectly classified into class P and False Negatives (FN) – items that should have been classified into class P but have been incorrectly classified into class N. The 10–fold cross validation approach has been used to validate the outcome of the considered classifiers. Table 2 presents a performance measure of classifiers in terms of how successfully they could classify data items.

Table 2. Performance of Classifiers.

Classifier	Classifiers applied on Dataset–1			Classifiers applied on Dataset–2		
	Correctly Classified Instances (TP)	Incorrectly Classified Instances (FP)	Time to Build Model (secs)	Correctly Classified Instances (TP)	Incorrectly Classified Instances (FP)	Time to Build Model (secs)
OneR	146	30	0	169	52	0
PART	143	33	0.09	182	39	0
J48	148	28	0	186	35	0
RF	144	32	0.05	195	26	0.06
REPTree	147	29	0	188	33	0.01
BNet	143	33	0	186	35	0
NB	139	37	0	182	39	0

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Classifier	Classifiers applied on Dataset–1			Classifiers applied on Dataset–2		
	Correctly Classified Instances (TP)	Incorrectly Classified Instances (FP)	Time to Build Model (secs)	Correctly Classified Instances (TP)	Incorrectly Classified Instances (FP)	Time to Build Model (secs)
IBK	139	37	0	188	33	0

Experimenting on the original dataset, it has been observed that the J48 classifier attained the highest number of correctly classified items, closely followed by the OneR, REPTree and Random Forest classifiers respectively. Experimenting on the balanced dataset, the Random Forest outperformed the remaining classifiers by classifying 195 items correctly and misclassifying only 26 items. The REPTree and IBK also exhibited better results.

The classifiers used in this paper have been evaluated using the evaluation metrics of Accuracy and Kappa Statistic. For results of performance evaluation of the considered classifiers, see Table 3.

Table 3. Comparison based on Evaluation Measures.

Category	Classifier	TP Rate	FP Rate	Precision	Recall	Kappa	Accuracy (%)
Results of Classifiers applied on Dataset–1							
Rule	OneR	0.83	0.423	0.826	0.83	0.4757	82.95%
	PART	0.813	0.342	0.807	0.813	0.4887	81.25%
Decision Tree	J48	0.841	0.39	0.838	0.841	0.5188	84.09%
	RF	0.818	0.34	0.812	0.818	0.5004	81.82%
	REPTree	0.835	0.348	0.827	0.835	0.5293	83.52%
Probabilistic	BNet	0.813	0.196	0.84	0.813	0.5560	81.25%
	NB	0.79	0.204	0.828	0.79	0.5149	78.98%
Instance	IBK	0.79	0.306	0.798	0.79	0.4713	78.98%
Results of Classifiers applied on Dataset–2							
Category	Classifier	TP Rate	FP Rate	Precision	Recall	Kappa	Accuracy (%)
Rule	OneR	0.765	0.252	0.765	0.765	0.51	76.47%
	PART	0.824	0.191	0.823	0.824	0.63	82.35%
Decision Tree	J48	0.842	0.154	0.846	0.842	0.67	84.16%
	RF	0.882	0.130	0.882	0.882	0.75	88.23%
	REPTree	0.851	0.172	0.850	0.851	0.68	85.06%

Category	Classifier	TP Rate	FP Rate	Precision	Recall	Kappa	Accuracy (%)
Probabilistic	BNet	0.842	0.140	0.854	0.842	0.68	84.16%
	NB	0.824	0.153	0.841	0.824	0.64	82.35%
Instance	IBK	0.851	0.137	0.859	0.851	0.69	85.06%

Considering the original dataset, the J48 classifier has the best accuracy value closely followed by the REPTree classifier. The Random Forest classifier exhibited an accuracy of 88.23% after the application of SMOTE followed by the REPTree and IBK classifiers, both exhibiting an accuracy of 85.06%.

It can thus be evidently stated that the accuracy of classifiers greatly improves when they are trained on balanced data. Examining the results of dataset–1, although Bayes based classifiers did not perform that well in terms of accuracy, the BayesNet classifier has better kappa static score followed by OneR and RepTree classifiers respectively. Similar experiments applied on dataset–2 resulted in a significant improvement in kappa score, with the Random Forest achieving a kappa score of 0.75 making it highly significant.

5. CONCLUSION

Academicians are always interested in discovering means through which students may learn in better ways. The abundance of student data and innovative technological breakthroughs has allowed discovering useful patterns. Behavioral features such as note taking, attention, assignment submission, and seating position, extracted from real student data, have been used in this paper for predicting students' performance. Several classifiers exhibited good performance in terms of accuracy and kappa scores. Balancing data with SMOTE greatly improved the performance of the classifiers evident through improved accuracy and kappa scores. The model generated by the Random Forest classifier exhibited significantly better results with an accuracy of 88.23% and a kappa score of 0.75. This research demonstrated that behavioral tendencies depicted by the students in class could be used to predict their semester outcomes allowing the creation of early warning systems. Interventions can be planned to ensure proper

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guidance is provided to students at the risk of failure. Future line of classifications can explore behavioral factors such as talkative tendency, social interaction, punctuality, participation in extracurricular activities, etc., and combine these with descriptive, behavioral, attitudinal and interactional features.

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CONTROLLING THE ALTITUDE DYNAMICS OF QUADCOPTER USING ROBUST OUTPUT FEEDBACK CONTROLLER

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ABSTRACT

This paper deals with observer based controlling and stabilization of the nonlinear dynamics of the quadcopter and in order to explore the complex dynamics of the quadcopter, the only altitude of the quadcopter is considered. A nonlinear model of the altitude is extracted from the six DOF model of the quadcopter and the same is linearized. A robust controller is implemented in the design to cater to the nonlinear nature of the quadcopter at hover by using both Sliding mode control and model predictive controller. The soft instrument, observer, is designed here for the state estimation purpose to bring the simulated system more closely to realistic values. Effectiveness of the designed system is ensured by trajectory tracking of the quadcopter. Simulation results presented show that output feedback based controller designed having optimum performance in estimating the states of the targeted system with almost negligible error. Also, the nonlinear controller designed having superior performance as compared to a controller designed with the linearized system.

KEYWORDS

Observer, Output feedback controller, Altitude, SMC, MPC.

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1. INTRODUCTION

The current technological and automated era has proved the quadcopter, a class of UAVs as an important contribution towards civilian usages due to their significant properties such as vertical take–off and landing capabilities. Navabi and Mirzaei (2017) proposed that the four–rotor flying vehicles i.e. Quad–rotors provide a much easier approach and mechanism to benefit from different helicopter features in different scenarios being either rescue operations, navigation and surveillance or even military missions in harmful and threatening conditions, and so on. Even though, quadcopter being a major invention, a serious challenge is posed when dealing with highly non–linear, under actuated and coupled dynamics of the system. Historical background of Research includes different control algorithms and techniques for improving quadcopter performance and controlling different DOFs (degrees of Freedom). A research study García, López, Lozano and Pégard (2013) analyzed that out of six degrees of freedom of quadcopter, the altitude control is the most demanding problem since altitude parameter appears to be connected with the quadcopter mass and along with attitude angles as well. Different factors, in addition, may lead to disturbances in altitude. The most important causes being rotational dynamics, change in mass, thrust and wind gusts, etc.

In a literature review, different kinds of controllers for controlling different characteristics including linear and non–linear techniques along with simulation works are available. In a paper about Automation and Robotics (Fatan, Sefidgari & Barenji, 2013), an adaptive neuro PID controller involving genetic algorithm was proposed. Wang, Ma, Xia, Weng and Ye (2013) presented the experimental scenarios for altitude control. It adopted a linear Gaussian–based controller and intended to maintain a constant altitude and for estimating the altitude velocity a Kalman filter was designed. Meanwhile, in a paper about Automata presented by Paiva, Soto, Salinas and Ipanaqué (2016), a modified PID controller was designed for regulating the altitude i.e. z–axis of the quad rotor by varying the rotational angles in the presence of disturbances. Adaptive pole placement based self–tuned PID controller was designed by Yang, Cai, Lin and Wang (2013) for controlling the heading and attitude of the quadcopter. Since dealing with disturbances and state estimation is the important characteristic in quadcopter model. Observer design usually forms the basis for output control realization where the controller aims to make the error of estimation negligible or zero. For this contribution, time domain disturbance observer controller is introduced in Aboudonia, Rashad and Badawy (2015). The disturbances were estimated using observer and then integral control was used to compensate for these disturbances. Meanwhile, a high gain state observer was designed by Yayla, Kaya and Kutay (2017) that estimated the system states. The controller used this model to control the attitude and altitude of quadcopter. State feedback controller is used in the design. The designed observer was not implemented in the trajectory tracking of a quadcopter. A linear quadratic optimal controller with linear kalman filter state observer is used for the altitude and attitude controller of the Quadrotor in Kurak and Hodzic (2018). The results obtained depicts the system reaching to reference trajectory with a delay which may be improved. Furthermore, for estimating different variables of UAVs, many types of observers have been used. An, Li, Wang, Wang and Ma (2013) worked to carry out a second order geometric sliding mode observer for altitude parameter but it didn't include any perturbation estimation. While Benallegue, Mokhtari and Fridman (2008) worked on a higher order sliding mode observer estimator considering external disturbances like wind and noise of sensors.

The paper layout is structured as: section 2 involves the basics of quadcopter system model followed by two sub sections that include modeling of the parameter under consideration i.e. altitude modeling and then linearization of the altitude model. Section 3 involves controller design by two important and most widely preferred techniques, sliding mode controller design (SMC) and Model predictive controller (MPC). While section 4 includes the high gain observer HGO design with sliding mode controller since SMC appears to be robust as compared to MPC. HGO is included in this research work to estimate the unmeasured states of the system. Section 5 covers the simulation results for above mentioned different designs. Finally, section 6 sums up the work by presenting the concluding remarks as well as future work statements.

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2. SYSTEM MODEL

Quadcopter, as the name, suggests consists of four rotors that are usually arranged at the corners of the body. Figure 1 depicts the basic structure of a quadrotor system composed of four motor–driven propellers. Entire system model has quad i.e. four inputs and six outputs hence considered as six DOF and second

order under the actuated system, exhibiting highly non–linear characteristics when being flown at high speed and the system usually gets affected by all kinds of disturbances and parameter changes during flight operation (Alexis, Nikolakopoulos & Tzes, 2011). To come up with proper controlling techniques and state estimation and for simplifications, this research work is confined to only altitude parameter consideration.

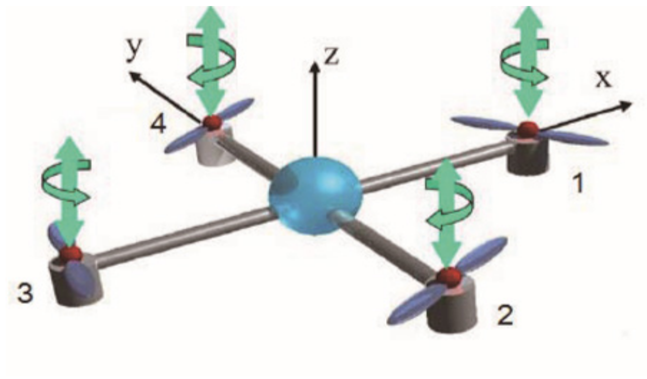

Figure 1. Basic structure of the quadcopter (Hou, *et al.*, 2010).

2.1. QUADCOPTER ALTITUDE MODELING

Quadcopter altitude modeling requires the altitude parameter to be decoupled from the system model for stabilizing at hovering point. Foe decoupling, it requires first to have a complete state space vector of the system that mentions all the linear and angular velocities and quadcopter's position in space as well. After the detailed computations carried out in Bushra, Memon, Nighat and Chowdhry (2018), Ganga and Dharmana (2017), Khuwaja, *et al.* (2018), the state vector of the system in general form and the state space representation of quadcopter system is mentioned in (1) and (2) respectively.

$$X_{(q)} = \begin{pmatrix} \phi_{(q)} & \dot{\phi}_{(q)} & \theta_{(q)} & \dot{\theta}_{(q)} & \psi_{(q)} & \dot{\psi}_{(q)} & z_{(q)} & \dot{z}_{(q)} & x_{(q)} & \dot{x}_{(q)} & y_{(q)} & \dot{y}_{(q)} \end{pmatrix}^T \quad (1)$$

Focusing the parameter under consideration, the above formulated mathematical model is de–coupled for hovering as mentioned earlier. This point demands a researcher to assume a few assumptions in order to have a stable hover. The aerodynamic moments and forces are considered negligible since there seems to be no any aero– dynamical lifting surfaces (Bushra, *et al.*, 2018; Ganga & Dharmana, 2017; Khuwaja, *et al.*, 2018).

Keeping in view the same assumptions shown below mathematically, the complicated system of quadcopter mentioned in (11) in (Bushra, *et al.*, 2018) gets reduced as given in (3).

$$f_{(q)}(X_{(q)}, U_{(q)}) = \begin{pmatrix} \chi_{(2q)} \\ b_{1\_r} \cup_{(2q)} - a_{2\_r}\chi_{(4q)}\Omega_r + a_{1\_r}\chi_{(4q)}\chi_{(6q)} \\ \chi_{(4q)} \\ b_{2\_r} \cup_{(3q)} + a_{4\_r}\chi_{(2q)}\Omega_r + a_{3\_r}\chi_{(2q)}\chi_{(6q)} \\ \chi_{(6q)} \\ b_{3\_r} \cup_{(4q)} + a_{5\_r}\chi_{(2q)}\chi_{(4q)} \\ \chi_{(8q)} \\ g - \dfrac{\cup_{(1q)}}{m}(c\chi_{(1q)}c\chi_{(3q)}) \\ \chi_{(10q)} \\ -\dfrac{\cup_{(1q)}}{m}(s\chi_{(1q)}s\chi_{(5q)} + c\chi_{(1q)}c\chi_{(5q)}s\chi_{(3q)}) \\ \cup_{(12q)} \\ -\dfrac{\cup_{(1q)}}{m}(c\chi_{(1q)}s\chi_{(5q)}s\chi_{(3q)} - c\chi_{(5q)}s\chi_{(1q)}) \end{pmatrix} \quad (2)$$

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$$\dot{\phi}_{(q)} = \dot{\theta}_{(q)} = \dot{\psi}_{(q)} = 0$$
$$\phi_{(q)} = \theta_{(q)} = \psi_{(q)} = 0$$
$$c\phi_{(q)} = c\theta_{(q)} = c\psi_{(q)} = 1$$
$$s\phi_{(q)} = s\theta_{(q)} = s\psi_{(q)} = 0$$

$$m_{(q)} \begin{pmatrix} \ddot{\chi}_q \\ \ddot{y}_q \\ \ddot{z}_q \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ m_{(q)} g \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ -\cup_{(1q)} c\phi_{(q)} c\theta_{(q)} \end{pmatrix} \qquad (3)$$

The above equation helps in designing the controllers in a bit easier way. It also adds in analyzing the robustness of the system.

2.2. LINEARIZATION

Since the scope of this research is restricted to altitude model of the quadcopter and this model is taken as a single input single output system with a control input $\cup_{(1q)}$. Input/Output relation in such type of system can be expressed as:

$$y_q = f(\cup_{(1q)}) \qquad (4)$$

Taylor series expansion is normally utilized for such nonlinear systems for a small region of operation and research for quadcopter controller design is limited to this small region for flight operation (Selfridge & Tao, 2014). This nonlinear system is made linearized so that makes it compatible to be used in designing the linear controllers for quadcopter and here in this research the linear model predictive controller. This altitude system can be represented as a linearizable SISO system given as:

$$\begin{aligned} \dot{x}_q &= Q_A x + Q_B \cup_{(1q)} \\ y_q &= Q_C x + Q_D x \cup_{(1q)} \end{aligned} \qquad (5)$$

An arbitrary value of all states are used in the linearized system given in (5) where the states in Q_A system matrix are the partial derivative with respect to state variable while in the Q_B input matrix, the entries are the partial derivative with respect to input and these are given as:

$$Q_A = \begin{pmatrix} \frac{\partial f_1}{\partial xq_1} & \cdots & \frac{\partial f_1}{\partial xq_n} \\ \vdots & \ddots & \vdots \\ \frac{\partial f_n}{\partial xq_1} & \cdots & \frac{\partial f_n}{\partial xq_n} \end{pmatrix}_{(x_0, \mathrm{U}_{(1q)0})} \quad \text{and } Q_B = \begin{pmatrix} \frac{\partial f_1}{\partial \mathrm{U}_{(1q)1}} & \cdots & \frac{\partial f_1}{\partial \mathrm{U}_{(1q)m}} \\ \vdots & \ddots & \vdots \\ \frac{\partial f_n}{\partial \mathrm{U}_{(1q)1}} & \cdots & \frac{\partial f_n}{\partial \mathrm{U}_{(1q)m}} \end{pmatrix}_{(x_0, \mathrm{U}_{(1q)0})}$$

3. CONTROLLER DESIGN

The two important approaches, Sliding mode controller (SMC) and Model predictive controller approach (MPC) are to be incorporated in this research work in order to have a stabilized altitude controller for the system under consideration. Leading to the results of both approaches, the one showing the robustness would be further processed for observer design to estimate states of the quadcopter model.

3.1. SLIDING MODE CONTROLLER DESIGN

SMC approach makes the basis in developing and controlling the non–linear dynamics of different systems. For stabilizing the system, SMC is applied here for heading feature of the quadcopter. SMC usually comprises of two phases for its implementation. The first phase also called the "reaching phase" involves the selection of a hypersurface or a manifold that is also considered as the sliding surface. When system trajectory is confined to this surface, it exhibits the desired behavior. In the second phase, multiple discontinuous feedback gains are found such that the system trajectory intersects and stays stable on the manifold.

Since SMC aims the system to track desired reference trajectories, the error state vector error for altitude parameter may be represented as given in (6), where z_{dq} is the desired altitude of the quadcopter.

$$e_q = z_q - z_{dq} \qquad (6)$$

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The sliding surface for the system may be described as in (7), where e_q is the error term that denotes the difference of quadcopter altitude to its desired altitude.

$$s_q = \dot{e}_q + ce_q \qquad (7)$$

Since the design of SMC requires a sliding surface or manifold to be described as mentioned earlier hence the sliding surface can be described as given in (8).

$$\delta = S_q^T X_{states} \qquad (8)$$

(8) can be further elaborated as expressed in (9).

$$\delta = \begin{pmatrix} s_{1q} & s_{2q} \end{pmatrix} \begin{pmatrix} z_q - z_{dq} \\ \dot{z}_q - \dot{z}_{dq} \end{pmatrix} \qquad (9)$$

SMC design requires the sliding coefficients of surface vector to be chosen in such a way that $\underset{to\to\infty}{lt}\ \dot{\delta} \to 0 \;=>\; \underset{to\to\infty}{lt}\ \delta \to 0$ ensures all the state vector tending to zero, i.e. $\underset{to\to\infty}{lt}\ e_q \to 0 \;=>\; \underset{to\to\infty}{lt}\ (z_q - z_{dq}) \to 0$. (10) denotes the energy Lyapunov function for the SMC controller as considered in (Adeely, Zaidiz & Memon, 2015).

$$V(\delta) = \frac{1}{2}(\delta)^2 \qquad (10)$$

To ensure system stability, conditions need to be determined. Following the derivative of (10) yields (11).

$$\dot{V}(\delta) = \delta\dot{\delta} \leq -\lambda_{smc}^2 \left|\delta\right|^2 \qquad (11)$$

Where the design parameter factor λ needs to be positive. (11) ensures that the system trajectories are converged towards sliding manifold in a finite time period. By referring Tripathi, Behera and Verma (2015), the overall output generated by the SMC controller after being implemented for the quadcopter altitude can be expressed as given in (12).

$$u_{(smc)q} = \frac{m_q}{c\phi_q c\theta_q}(k_b s + k_a \,\mathrm{sgn}(s) + c(\dot{z}_q - \dot{z}_{dq}) + g - \ddot{z}_{dq}) \qquad (12)$$

3.2. MODEL PREDICTIVE CONTROL DESIGN

The model predictive controller is usually designed to forecast the control input so that the system under consideration may be effectively and optimally controlled (Qin & Badgwell, 2003). Linear MPC is designed and implemented here for the linearized model of quadcopter altitude. Designed controller's objective is to solve the optimization problem for quadcopter altitude under operation at some desired value which may be given as (Memon, Chowdhry & Aamir, 2016):

$$J_{qa} = \sum_{np=1}^{Nqp} x_q(k_j + np \mid k_j)^T S_q x_q(k_j + np \mid k_j) + \zeta^T \mathrm{A}_q \zeta \qquad (13)$$

where $S_q \geq 0$ is weighting matrix and defined as $S_q = C^T C$. The dimensions of S_q matrix are equivalent to the number of state variables and A_q is diagonal matrix and used here as the tuning parameter in order to improve the closed loop response. The state vector used in the optimization is given as:

$$x_q(k_j + np \mid k_j) = \left[\Delta x_q(k_j + np \mid k_j)^T \; Z_q^i(k + np \mid k_j) - Z_{dq_i}(k + np) \right]^T$$

4. OUTPUT FEEDBACK CONTROL

This portion incorporates the use of high gain observer (HGO) for estimating and controlling the unmeasured states of quadcopter model. An observer takes the input and output under consideration and produces the estimated states of the system. Therefore observability of the system under consideration needs to be tested. Since this paper focuses only on altitude parameters, the linearized altitude system is already depicted in (5). It requires the system to be observable. The generalized formula for finding observability rank is evaluated as under.

$$\hat{O}(W_A, C) = \begin{bmatrix} C & CWA & \cdots & CWA^{n-1} \end{bmatrix}^T$$

Evaluating according to the above details, the system is found to be observable with rank=2= n. High gain observer design adds to make the observer robust to uncertainties in modeling the non–linear systems. It also ensures that the state feedback control performance is recovered when the observer gain is sufficiently

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high. High gain observer Structure for external states is expressed in (14).

$$\begin{Bmatrix} \tilde{\chi}_1 = \tilde{\chi}_2 + l_1(y - \tilde{\chi}_1) \\ \tilde{\chi}_2 = l_2(y - \tilde{\chi}_1) + \upsilon \end{Bmatrix} \qquad (14)$$

The gains are obtained as:

$$\begin{bmatrix} l1 \\ l2 \end{bmatrix} = \begin{bmatrix} 2/\gamma \\ 1/\gamma^2 \end{bmatrix}$$

Where γ is the design parameter chosen a very small value, such that it reduces the estimation error in states as it tends to zero.

The proposed high gain sliding mode observer based output feedback control is suggested as in (15).

$$\left(u_{smc-o} = k_{1o}S_o + k_{2o}sign(S_o) + C_o(\dot{z}_o - \dot{z}_{do}) + g - \ddot{z}_{do}\right) \qquad (15)$$

5. SIMULATIONS

Nonlinear dynamics of quad copter for altitude parameter are simulated. Open loop response of the said system is highly unstable as analyzed from the literature available as well as from simulating the said system. The system under consideration is simulated using both Model Predictive controller and sliding mode controller with parameters given in Table 1. Performance of the system for both of these controllers is presented in Figure 2 and Figure 3.

Table 1. Controller parameters.

MPC Controller		SMC Controller		HGO Parameters	
Nqc	3	Ka	18	γ	0.9
Nqp	40	Kb	14		
Rq	0.9	c	4		

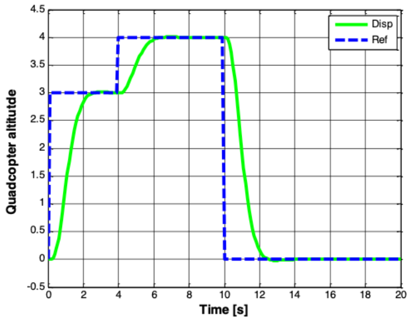

Figure 2. System response with MPC.

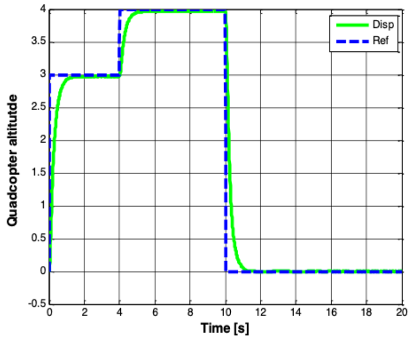

Figure 3. System response with SMC.

Since both of these controllers are able to follow the reference trajectories without any distortion which ensures the controlling and stabilization of altitude parameter of quad copter under flight operation. Furthermore, the response generated by the SMC controller is much better in terms of speed, overshoots and delay as well as in minimizing the error as it is explained in Figure 3. It can also be depicted that SMC controller given in (12) is more robust and able to stabilize the quadcopter altitude more quickly as compared to the MPC controller.

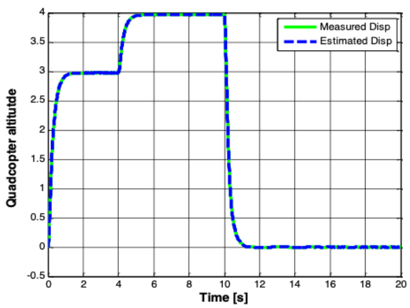

Figure 4. Measured and estimated states using HGO for some arbitrary trajectory.

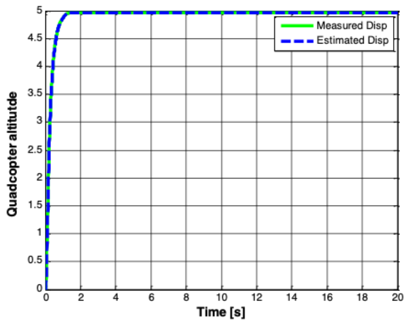

Figure 5. Measured and estimated states using HGO for fixed altitude value.

In order to realize the system towards reality, the high gain observer is utilized so as to incorporate the unmeasured states of the system. Altitude control designed in (15) comprises of SMC controller and high gain observer controller applied to the nonlinear altitude model. Simulations for measured and estimated states using observer are presented in Figure 4 and Figure 5 for some arbitrary trajectory and

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fixed value of altitude of 5m. Since observer based design is implemented with the SMC controller only due to its much better performance.

It is clearly observed from the response that designed observer based system is estimating the system states efficiently with almost negligible error. States estimation is effective and efficient not only for some fixed value of altitude but also with any arbitrary trajectory given as concluded from Figure 5 and Figure 4 respectively.

6. CONCLUSION AND FUTURE WORK

Altitude parameter of the quadcopter is analyzed by decoupling it from the six DOF nonlinear model. The same is linearized in order to design and implement the control design using Model predictive controller. The same nonlinear model is then used with the sliding mode controller design. Performance of both these controllers is analyzed for the altitude parameter stabilization and controlling revealed that performance of SMC is much better as compared to MPC in terms of robustness, reaching the final value quickly and exhibiting negligible overshoots. The model under consideration is then controlled using High gain observer with the controller having better performance in order to estimate the unmeasured states of the system. Simulation results depicted that system states are measured effectively with negligible error. Future work may also be carried out in terms of improving the performance with observer using the MPC controller and the system shall be analyzed by introducing different disturbances model in the presence of an observer.

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ANALYZING STUDENTS' ACADEMIC PERFORMANCE THROUGH EDUCATIONAL DATA MINING

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ABSTRACT

Predicting students' performance is a very important task in any educational system. Therefore, to predict the learner's behavior towards studies many data mining techniques are used like clustering, classification, regression. In this paper, new student's performance prediction model and new features are introduced that have a great influence on student's academic achievement i.e. student absence days in class and parents' involvement in the learning process. In this paper, considerable attention is on the punctuality of students and the effect of participation of parents in the learning process. This category of features is concerned with the learner's interaction with the e–learning management system. Three different classifiers such as Naive Bayes, Decision Tree, and Artificial Neural Network are used to examine the effect of these features on students' educational performance. The accuracy of the proposed model achieved up to 10% to 15% and is much improved as compared to the results when such features are removed.

KEYWORDS

Educational data mining, Students' performance prediction model, Artificial neural network.

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1. INTRODUCTION

In the discipline of data mining and its well–known application Knowledge Discovery in Databases (KDD) , one of the new evolving fields now–a–days is Education Data Mining (EDM) that emphasizes on discovering the useful knowledge and mining the useful patterns from educational information systems such as, course management system (Moodle, Blackboard etc.) , online learning management system , registration systems , admissions systems, and so on which help out students at each stage of their studies like from primary to higher education. Romero and Ventura (2007) proposed that the data can be obtained through manual traditional surveys. The further investigation on education data mining (Romero, Ventura & Garcia, 2008) concluded that data can be gathered from many sources such as databases of academic institutes, online learning management system. In this field, a major focus of concern is to analyze and discover meaningful rules and patterns to either encourage students to manage their education and deliverables in a better way and enhances their performance or to give educational institutes direction to maintain the policies for the betterment of students. Abu Tair and El–Halees (2012) analyzed student's data by creating the decision trees, making an association or sequential mining rules and classifying students for enhancing their performance and taking fruitful decisions in the fascinating research area. Romero and Ventura (2010) concluded that many data mining techniques used to generate specific patterns, rules, classification and prediction to help students in the future. In this paper student performance model is introduced which focus on important features i.e parents' participation in the learning process and student absence days. The dataset is obtained from Kalboard 360 e–learning system. The performance model applies different classifiers such as decision tree, naive bayes, and artificial network to examine the effect of such features on students' academic performance. For building the student's performance model source of data is obtained from http://www.kaggle.com, this is an educational dataset of e–learning website, the dataset contains 500 records and having 17 different features. Then, we applied three of the data mining algorithms. Finally, the results are evaluated by using different measures.

2. LITERATURE REVIEW

Educational data mining is used to find potential knowledge that helps in the utilization of active learning in technological aspects. E–learning is becoming one of the most important areas of research in developing countries. So many well–developed countries switched their educational system into fully or partially automated which not only helps students but teachers as well to provide ease of learning. A survey is made where many data mining application is applied to the course management system. It was a tutorial and case study related to the Moodle system to improve the students' learning experience and their courses. Quadri and Kalyankar (2010) shows C4.5 decision tree algorithm to arrange a set of attributes in hierarchical form, this technique is used by many researchers due to its simplicity through which set of classification rules can be formed. Some of the well–known Decision Tree algorithms are J48, C4.5 and CART. Murugananthan and Shiva (2016) proposed a new approach in deriving association rules for optimal learning sequence of tutors and students using a K–means clustering algorithm. An Artificial neural network is one of the most used practices in mining educational data. This is very intelligent algorithm which works based on a neuron that relate to each other and work together to produce the output. Arsad and Buniyamin (2013) used artificial neural network for predicting academic progress of bachelor's degree student. Hien and Haddawy (2007) used Naïve Byes algorithm to predict final Cumulative Grade Point Average (CGPA) at the time of admission which was based on their academic background. The study about students' educational behavior (Amrieh, Hamtini & Aljarah, 2015) proposed framework having a category of a feature called "Behavioral feature" is introduced where they focus on student's behavioral features and their relationship with student's academic success. The authors (Amrieh, Hamtini & Aljarah, 2016) used the same framework to examine student's progress by using ensemble techniques which enhance the overall accuracy of results. So, numerous researches have been conducted so far to predict the students' performance using data mining. But few of them highlighted the important features that affect students' educational performance. In this research, we are going to use the most

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important category of the features that affect the grades of a student and their overall performance.

3. DATASET AND DATA PREPROCESSING

The dataset for building the proposed student's performance model to anticipate the students' academic performance is acquired from https://www.kaggle.com/aljarah/xAPI–EDu–Data. It is an instructive dataset collected from e–learning system called Kalboard 360. The dataset consists of 500 student records. It has 17 different features.

3.1. E–LEARNING MANAGEMENT SYSTEM

It is an e–learning system that engages learners, track progress and delivers targeted outcomes. Learning is significant, innovative and interactive. Student engagement was defined by ("Kalboard 360 e–learning system", 2000) as "People ENGAGE and INTERACT with it for better understanding and effective learning. That's why the only focus of this system is on custom–made solutions. Core competency lies in their decade of experience, expertise, and creativity of the solutions". The emphasis is on delivering an inspiring and engrossing experience for students. The aim of this system is to build a world where e–learning and development matters. Their main objective is to tackle recent technologies to develop online learning methods for students and educational institutes. Where they can offer several customized courses options related to students demands. As compared to conventional methods like books, PDFs, PowerPoint's, training manuals they have shifted to fully interactive activities based on e–learning procedures. Course designer prepares a fully interactive course layout where audio voice can be included so that student can get desired content in any format.

Table 1. Features of student dataset and their categories.

Feature	Description of features	Category of features
Gender	The student gender i.e masculine or feminine	Demographical Features
Country	A Country student belongs to.	
Birthplace	Born place of student	
Parent Responsible	Parent of the student (dad or mom)	
Levels of Education	Different educational stages of students like high, medium and low level	Academic Background Features
Student Grade	Grade level of student (GL–1, GL–2, GL–3, GL–4, GL–5, GL–6, GL–7, GL–8, GL–8, GL–9, GL–10, GL–11, GL–12)	
ID of Section	Class section A, B or C student belongs to.	
Student semester	Student semester (1st or 2nd)	
Course	Offered courses such as (IT, Math, English, Arabic, Science, Quran)	
Punctuality of student in the class	No. of student available days in class (Below–07 or Above–07)	
Parent involvement	Survey forms provided by tutors is answered by parents or not	Participation of parents on the whole learning process
Satisfaction of Parent	This feature is concerned with the intensity of satisfaction of the parent (Positive or Negative)	
Group Discussions	These all features are concerned with student behavior while interacting with Kalboard 360 e–learning website.	Behavioral Feature
Resources visited by a student		
Raising hands		
Assignments viewed by a student		

After a dataset is collected the most important task is to pre–process data by applying pre–processing techniques. As real data is not complete (inadequate attributes, missing values of interest, having summarized data). So to eliminate noise and outlier data pre–processing is applied which includes cleaning data, transforming data and selection and analysis of appropriate features.

3.2. PRE–PROCESSING DATA

The techniques are applied to convert unstructured data into some conventional format so that it can be easily accepted and used by data mining algorithm.

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3.2.1. DATA CLEANING

Data cleaning is one of the major tasks in preprocessing. Data cleaning is used to remove noisy and inconsistent data and to deal with incomplete values. In this work, we used a dataset of 500 records out of which 20 records contain some missing values from different categories so after cleaning the final dataset becomes 480 records.

3.2.2. DATA TRANSFORMATION

Data transformation is applied to transform the numerical values into nominal values for classification to represent class labels. In Table 2 we distribute the dataset into below–mentioned class intervals lowest level, medium level and highest level based on student's grade or marks.

Table 2. Classes based on their numerical values.

Classes	
Interval Value	Class Label
0–69	Lowest Level
70–89	Medium Level
90–100	Highest Level

3.2.3. FEATURES SELECTION AND ANALYSIS

A research study (Karegowda, Manjunath & Jayaram, 2010) analyzed feature selection as most important task in data preprocessing. The objective of this step is to choose some important and appropriate subset of features from dataset to transform or reduce the number of attributes that can appear in the algorithm, therefore reducing the proportion of feature area so that the repeatable and inappropriate data is removed. In this way, feature selection helps in enhancing the performance of the learning algorithm by improving the data quality. Feature selection methods are divided into two main categories (1) Wrapper Based methods (2) Filter Based methods. Filter method is applied to identify relevant subset of features while avoids the remaining. These methods rank the features by using variable ranking techniques so that highly ranked features can be selected and applied to the learning algorithm. Acharya and Sinha (2014) investigate many feature ranking techniques such as information gain and gain ratio that is used for feature evaluation. In our work, we applied selection algorithms based on the gain ratio which is filter based approach to examine different feature scores so that the most important features for building students' performance model can be identified. Figure 1 shows the highly ranked features after filter based evaluation.

As shown in Figure 1 student absence days got the highest rank followed by category related to parent's involvement like their answering survey, satisfaction from school and so on. In Figure 1 we have observed that an important subset of features is selected while others are eliminated. In this way, the features we are considering in this research got the highest rank which means that student punctuality and their parents' participation during whole education practice have a great effect on their academic performance.

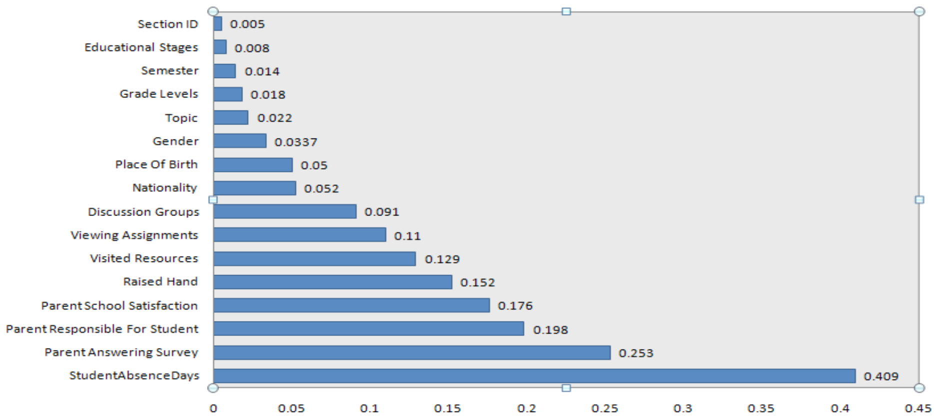

Figure 1. Highly Ranked features after applying filter based evaluation using gain ratio.

4. METHODOLOGY

In this paper, we present students' performance framework using three different classifiers, to assess the subset of features having an effect on students' academic achievement. Figure 2 demonstrates the primary steps in the given framework. This framework begins by gathering information from Kalboard 360 online learning management system referenced in section 3.

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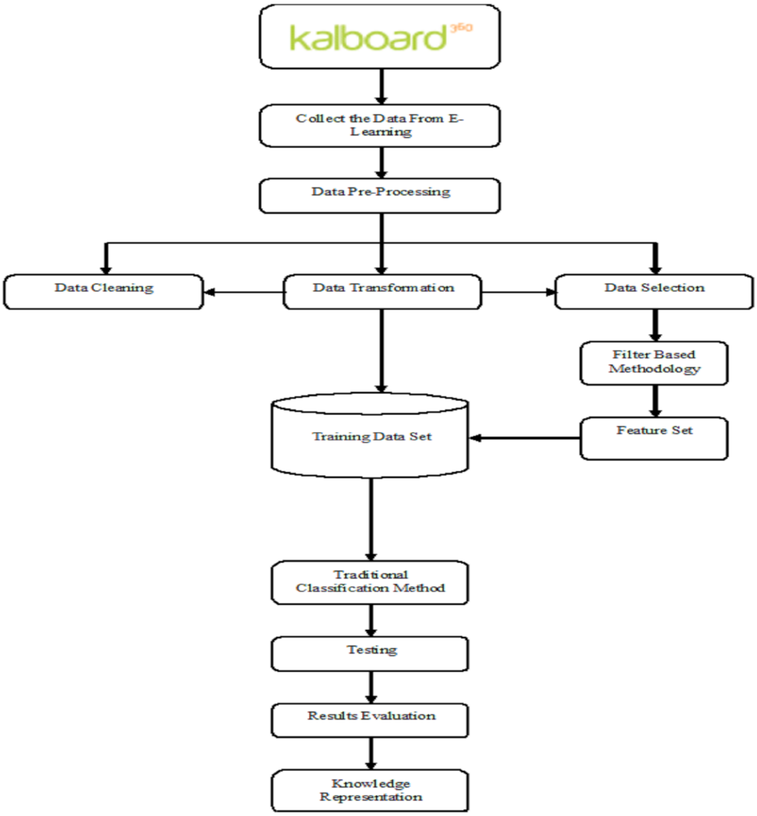

Figure 2. Steps of students' performance prediction model.

This step is trailed by the next step which is pre–processing data related to changing the gathered data into some convenient format. So in this step, first of all, we applied data cleaning technique to remove the irrelevant and redundant data from the dataset. After that, the numerical values are transformed into nominal values for classification to represent class labels. To achieve the task, we distribute the dataset into three class labels (highest level, medium level, and lowest level) based on student's total grade At this step, dataset has a ratio of 199 students at the lowest level, at the middle level there are 248 students and at the highest level there are 33 students. A step onward, feature selection and analysis are used to pick the optimum list of features with highest scores. As appeared in Figure 1, we applied selection algorithms based on the gain ratio which is filter based approach to examine different feature scores. At last, we proposed a framework for having three classifiers. The classification algorithms are used to get to know about features that may affect students academic achievements. The three different classifiers that are applied to assess the student's performance are Decision Tree (DT), Naïve Bayes (NB) and Artificial Neural Network (ANN).

4.1. NAÏVE BAYES CLASSIFIER

This classifier work on a strategy to evaluate the probabilities of different attributes from training data set for any class after that utilizes these probabilities to characterize new elements. Each level has associated probabilities. With a middle level, it is 0.3, 0.27 with low level and, 0.44 with high level.

4.2. DECISION TREE CLASSIFIER

DT is used to discover rules that characterize the data based on a lot of braches and helps in the decision. For nominal attributes, it gives the best results. Figure 3 demonstrates a J48 pruned tree having 31 number of leaves. Size of the tree is 48.

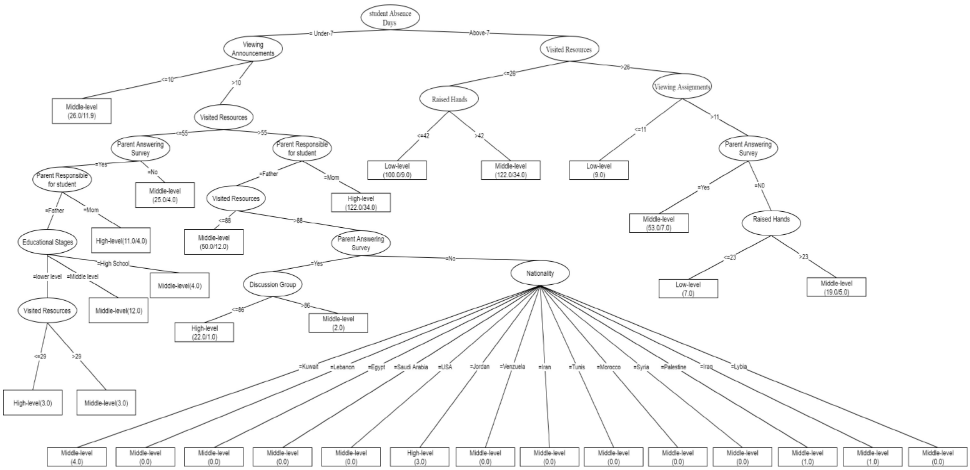

Figure 3. Decision Tree having 31 nodes.

4.3. ARTIFICIAL NEURAL NETWORK CLASSIFIER

In research study (Naser, Zaqout, Ghosh, Atallah & Alajrami, 2015) used ANN which is an approach of neural network prepares data for achieving good accuracy. ANN framework is used to generate patterns and to solve complex

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prediction problems. It comprises an input layer, the output layer, and a hidden layer. The input is taken by input layer from the user and output to the user is sent by the output layer. Middle layer is between input layer and output layer. The neurons of middle layer are just associated with different neurons and do not straightforwardly interface with the main user application. For knowledge representation patterns and results are assessed.

5. EXPERIMENTS AND EVALUATION OF RESULTS

5.1. SETTING ENVIRONMENT

The experiment is performed on PC having RAM of 8GB, 5 intel core (2.50 GHz). Weka tool in classification algorithms (Arora, 2012) analyzed good accuracy and prediction results. We used Weka tool in our work to evaluate our proposed models, comparisons and results. Training set, cross–validation, supplied test set, and percentage split are few options available for test purpose. The dataset is distributed into a training set and test set using 10 folds cross–validation because this option is widely used one, especially if we have a limited amount of dataset. The dataset is randomly divided into ten subsets. Weka tool uses set 1 for test purpose and remaining 9 sets for training purpose for first training and uses set 2 for testing and rest of 9 sets for training and repeat that in total ten times by interchanging the set each time with next one. In the end, the average success rate is calculated.

5.2. EVALUATION MEASURES

For evaluating the quality of different classification techniques applied on students' academic performance model we use four different measures accuracy, precision, recall, and f–measure. Table 3 demonstrates different calculated measures, it shows confusion matrix comprises of 1,2,3 and 4 equation.

Table 3. Two class confusion matrix

		Predicted	
		Yes	**No**
Actual	**Yes**	TP	FN
	No	FP	TN

Yes is for positive values and *No* is for negative values whereas TP is for true positive values and FP is for false positive values similarly FN is for false negative and TN is for true negative. Accuracy is calculated as correct classifications divided by a total number of classifications. The Recall is the proportion of rightly classified to total unclassified and rightly classified cases. Precision is the proportion of rightly classified to total misclassified and rightly classified cases. F–measure is also included which is a combination of precision and recall and it is considered the best indicator of the relationship between them.

$$\text{Accuracy} = \frac{\text{TruePositive}+\text{TrueNegative}}{\text{TruePositive}+\text{FalseNegative}+\text{FalsePositive}+\text{TrueNegative}} \tag{1}$$

$$\text{Recall} = \frac{\text{TruePositive}}{\text{TruePositive}+\text{FalseNegative}} \tag{2}$$

$$\text{Precision} = \frac{\text{TruePostive}}{\text{TruePositive}+\text{FalsePositive}} \tag{3}$$

$$\text{F–measure} = 2\,\frac{\text{Precision}*\text{Recall}}{\text{Precision}+\text{Recall}} \tag{4}$$

In our case, there are three classes. Table 4 shows the classification confusion matrix based on A, B, and C class.

Table 4. Confusion matrix for more than two classes.

		Predicted		
		A	**B**	**C**
Actual	**A**	TPa	Qab	Qac
	B	Qba	TPb	Qbc
	C	Qca	Qcb	TPc

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For any class total false negative values is the addition of all values in respective row except true positive and for any class false positive values is the addition of all values in the respective column except true positive values while total true negative values for any class is the addition of all columns and rows except the row and column of that class.

Recall A= $TP_a / (TP_a + Q_{ab} + Q_{ac})$

Recall B= $TP_b / (TP_b + Q_{ba} + Q_{bc})$

Recall C= $TP_c / (TP_c + Q_{ca} + Q_{cb})$

Precision for considered class can be calculated as:

Precision A=$TP_a / (TP_a + Q_{ba} + Q_{ca})$

Precision B=$TP_b / (TP_b + Q_{ab} + Q_{cb})$

Precision C=$TP_c / (TP_c + Q_{ac} + Q_{bc})$

5.3. RESULTS

Different results are examined based on three different classification techniques which are applied to student dataset to predict students' academic performance. Table 5,6,7 shows confusion matrix for three different classifiers i.e DT, NB, and ANN based on which above measures are calculated for A, B, and C class while Accuracy of the overall algorithm is calculated.

Table 5. Confusion matrix for decision tree classifier.

		Predicted		
		A	B	C
Actual	A	143	21	47
	B	27	100	0
	C	29	2	111

$$\text{Accuracy}= \frac{143+100+111}{143+21+47+27+100+0+29+2+111} \text{x}100\%$$

$$= \frac{354}{480} \text{x}100\%$$

$$= 71.1\%$$

Recall for Class A, B and C:

Recall A=143/143+21+47=67.7, Recall B=100/100+27+0=78.7

Recall C=111/111+29+2=78.12

Precision for Class A, B and C:

Precision A=143/143+27+29=71.8, Precision B=100/100+21+2=81.3

Precision C=111/111+47+0=70.3

F–measure for Class A, B and C:

$$\text{F–measure A} = \frac{2 \text{ Precision x Recall}}{\text{Precision+Recall}}$$

$$= \frac{2(71.8 \text{ x } 67.7)}{71.8+67.7}$$

$$= 69.0$$

F–measure B = 80.0

F–measure C = 74.0

Following the above procedure, the results for accuracy, recall, precision, and F–measure is calculated for naïve bayes and artificial neural network by acquainting the data from given respective tables.

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Table 6. Confusion matrix for naïve bayes classifier.

		Predicted		
		A	B	C
Actual	A	112	40	59
	B	16	111	0
	C	39	2	101

Accuracy = 67.5%

Recall for Class A is 53.1, Recall B is 87.1 and Recall C is 71.1

Precision for Class A is 67.1, Precision B is 72.5and Precision C is 63.1.

F–measure for Class A is 59.3, F–measure B is 79.3 and F–measure C is 66.

Table 7. Confusion matrix for artificial neural network.

		Predicted		
		A	B	C
Actual	A	156	21	34
	B	20	106	1
	C	29	0	113

Accuracy = 78.1%

Recall for Class A is 73.9, Recall B is 83.4 and Recall C is 79.5

Precision for Class A is 76.1, Precision B is 83.5 and Precision C is 76.3

F–measure for Class A is 75.0, F–measure B is 83.5 and F–measure C is 77.9

Table 8 shows results using three data mining algorithms (ANN, NB, DT). Two different classifications results are achieved by each algorithm (1) classification results with highly ranked features (RF) i.e. student absence days and parent's participation (2) classification results without those highly ranked features (WRF). Details of results with a highly ranked feature are given above. The results without those features can be achieved in a similar way. In Table 8, we can see good classification results with highly ranked features as compared with the results without those features this proves there is a great impact of student punctuality in class and their parents' involvement in learning process to students' academic success and achievements.

Table 8. Algorithm results with highly ranked features (RF) and without highly ranked features (WRF).

Evaluation Measures	Decision Tree		Naïve Bayes		Artificial Neural Network	
	RF	WRF	RF	WRF	RF	WRF
Accuracy	71.1	61.4	67.6	58.3	78.1	59.1

Observing the results in Table 8 we notice that ANN outperform other classification algorithms. Artificial Neural Network provides 78.1 accuracies with highly ranked features and 59.1 without ranked features. 78.1 means 375 out of 480 students are correctly classified to correct class label i.e. High Medium and Low and 105 students are incorrectly classified.

6. CONCLUSION

Academic performance of students is a pillar for their successful future and becoming a big area of interest for all academic institutions over the world. Nowadays the use of e–learning management system is increasing rapidly, and many developed countries have shifted their educational system to fully or partially automated systems because this system generates a huge amount of data that contains hidden knowledge and patterns that can be used to generate meaningful knowledge to help students to improve their academic grades and achievements. In this research, we introduce a students' performance model with new categories of features related to student's punctuality in classes and their parents' participation in the learning process. The overall performance of students' academic prediction framework is examined by three different classification algorithms decision tree, naïve bayes, and artificial neural network. The results show that these features have a strong impact on the academic success of a student. The model provides very good accuracy while using these categories of features and is achieved 10 to 15% increased as compared with results when removing such features.

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LOAD STATUS EVALUATION FOR LOAD BALANCING IN DISTRIBUTED DATABASE SERVERS

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ABSTRACT

Distributed database servers are very popular as they provide data availability, reliability, replication, and partition for both homogeneous as well as heterogeneous software and hardware. In this paper, we analyze the previous works on load balancing of database servers. Further we also propose an algorithm for controlling job distribution at the database servers in different node partitions. We also formulate a methodology for load status evaluation of database servers to balance their loads for effective load status management. The load status of the database servers depends on three important parameters namely processor, RAM, and bandwidth. On the basis of load status, the clients'/users' requests can then be directed to another database in a distributed environment in order to balance the load effectively to meet user demands in an unobtrusive manner.

KEYWORDS

Load balancer, DBalancer, Balance controller, M/M/c: ∞/ ∞ model, M/M/c: N/ ∞ model, Bully algorithm, Dlb.

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1. INTRODUCTION

Current web network traffic must simultaneously handle a million or billion clients' requests. It is naturally expected that the servers uninterruptedly handle all such requests and provides the required data that may be audio, video, image or text form, etc. To serve this large number of user requests for an unimaginably large amount of data, multiple servers are expected to work together. Any single point of failure in this situation can result in loss of important data due to hardware, software, network or configuration failures. A load balancer (Xu, Pang, & Fu, 2013) can help save important client data in case of failure because if one server is not able to reply to the request, another backend server will be available to service the user requests (Wu, 2011). It may also be noted that such distributed databases may be situated in different geographical locations. These different partitions can be categorized into 3 different states namely (1) idle (2) normal and (3) overloaded (Xu, *et al.*, 2013). For balancing the load, two different load balancing strategies are generally applied, namely static load balancing and dynamic load balancing (Xu, *et al.*, 2013). In static load balancing (Chen, Chen, & Kuo, 2017), once the jobs are assigned there is no change at runtime. While in dynamic load balancing the job is reassigned as per the situation. Hence, if the status of the server is overloaded then the job is sent to the idle server or normal server. The rest of this manuscript is arranged as follows. Section II discusses the significant works that have been taken as the basis for this work. Section III outlines the basic model of the proposed system. Section IV elaborates the balance controller component of the proposed system. Section V explains how jobs are assigned to the distributed partitions. Section VI details how the incoming jobs are assigned to the varied nodes in a Distributed Database System. Section VII lays down the strategy for load status evaluation. Section VIII concludes the work.

2. RELATED WORK

Xu, *et al.*, (2013) introduced a load balancing model. They used each node from the lowest to highest load degree. Whenever the load is assigned the complete table is simultaneously refreshed. They also defined the architecture of one controller with multiple servers. This controller worked as a load balancer and round–robin algorithm was applied for load balancing (Xu, *et al.*, 2013).

Chen, Li, Ma and Shang (2014) discussed a dynamic load balancing method for cluster–based server on Open Flow technology in a virtual environment. They solved the load balancing problem through network virtualization in the data center. Their experiments showed that it is plausible to construct a powerful, flexible load balancer in a cost–effective manner. OpenFlow technology is suitable for load balancing in varied environments as it provides the flexibility for varied load balancing strategies in a convenient form (Chen, *et al.*, 2014).

Chen, *et al.*, (2017) presents a novel load balancing architecture named "CLB". This architecture can be applied to both physical as well as virtual web servers with ease (Chen, *et al.*, 2017).

3. BASIC MODEL OF PROPOSED SYSTEM

Distributed databases may consist of homogeneous as well as heterogeneous Breitbart, Olson, and Thompson (1986); Sadowsky and Szpankowski's (2009) databases. Communication between each of such databases is realized with the help of the network. In distributed databases, there is centralized software to control or manage incoming data operations, such as update, delete, retrieve, and create (Silberschatz, Korth & Sudarshan, 2013). Our proposed system is based on the distributed ideology where the database servers are distributed at different geographical locations. The partitioning schema of the proposed model is depicted in Figure 1 below.

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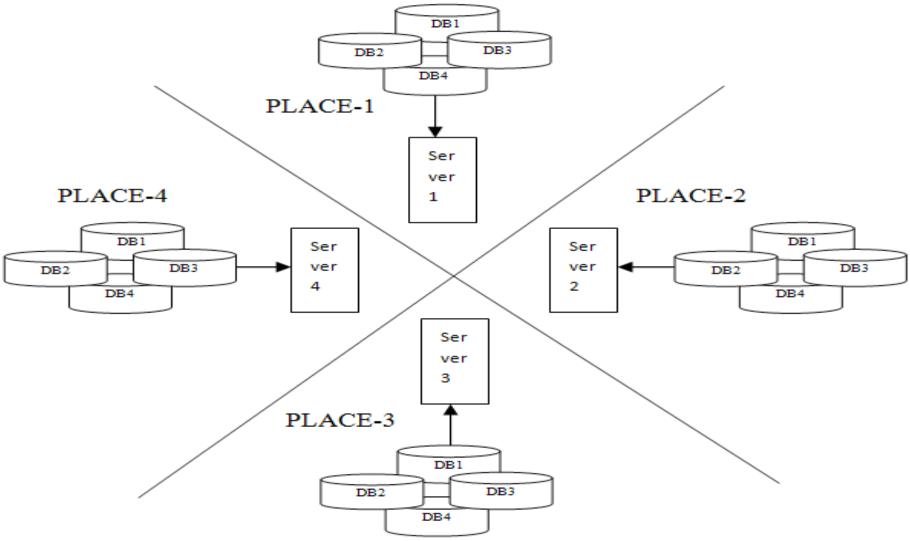

Figure 1. Partition of Distributed Database.

The proposed load balancing strategy is based on the distributed concept defined in Tanenbaum and Steen (2007). When the request arrives at the server the load balancing system activates. The load balancer, which is in server compares this job value (how much bandwidth, processor and RAM are required) (Chen, *et al.*, 2017) to the server status. If server load status is normal, then the job will be assigned, otherwise, the request will be redirected to another server.

4. BALANCE CONTROLLER OF THE PROPOSED SYSTEM

The solution to the load balancing problem is done by the balance controller component of the server. When the request arrives at any database server of any geographical location, the job request is assigned and new status to the database server is generated. This information is forwarded to the balance controller of the server. After receiving this information, the balance controller updates its table of database status.

5. ASSIGNING JOBS TO THE DISTRIBUTED PARTITIONS

When the job arrives at the server, it chooses the optimal part of the database distribution. The status of distributed databases can be classified into three main states, namely (1) idle (2) normal and (3) overloaded. These states can be explained as below:

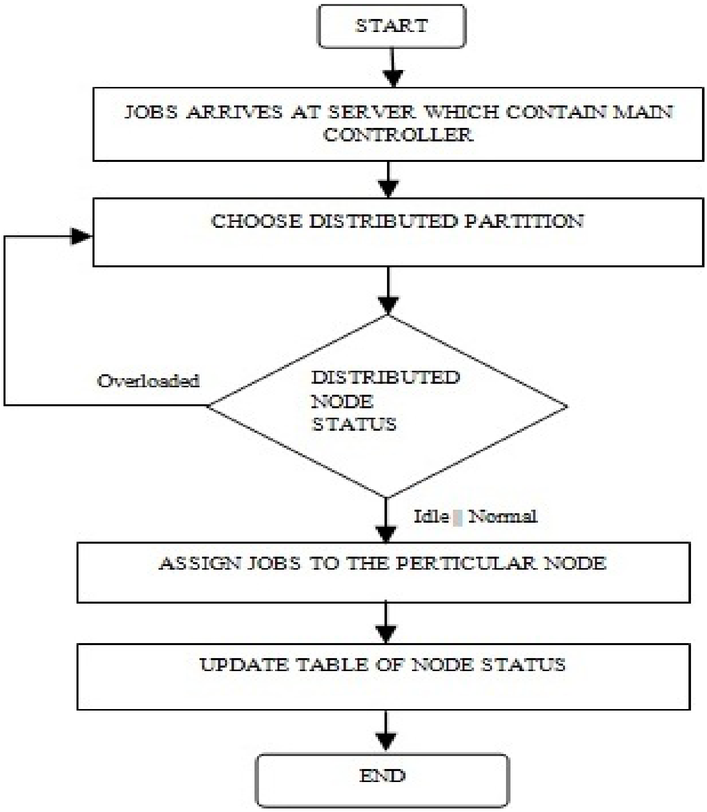

Figure 2. Choosing Partition for Job Assignment.

- Idle: – There is no work going on the database partition.
- Normal: – The database is accepting and responding to the user request.
- Overloaded: – The database does not have enough capacity to accept and respond to the user request.

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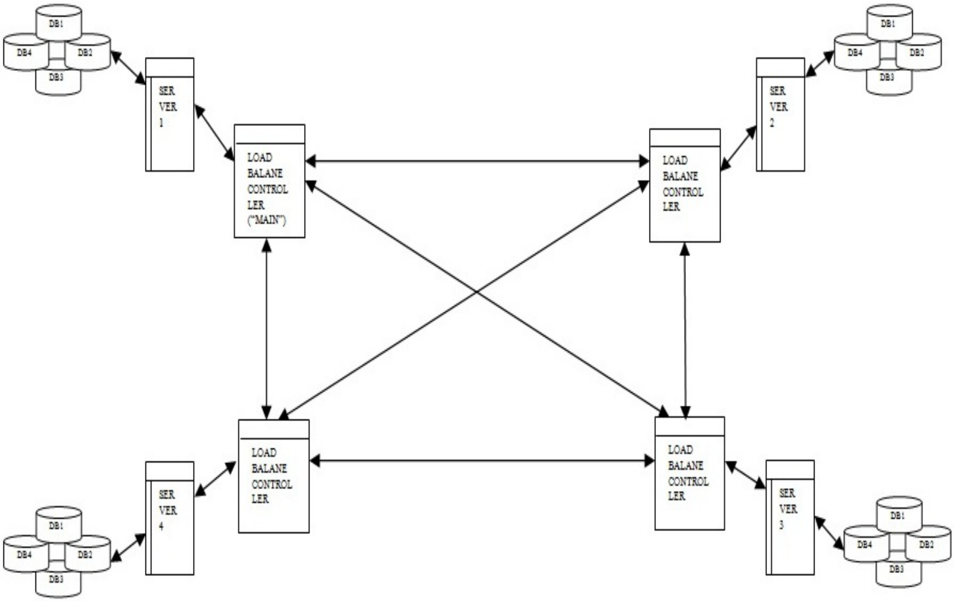

Figure 3. Distributed Partitions.

6. ASSIGNING JOBS TO THE NODE IN DISTRIBUTED DATABASE SYSTEM (XU, PANG & FU, 2013)

We now list how jobs should be assigned to varied nodes in a distributed database system. Algorithm 1 below step–by–step lays down the complete process of job assignment to a specific node in a distributed system.

Step–1:– Load Value

$(Lv)=\sum_{(i=1)}^{n}(aiRi)$

Step–2:– I: – Load_value(Lv)=Lvmin

II: –Load value(Lv)min<Load value(Lv)

<=Load_value(Lv)high

III: – Load value(Lv)high<=Load value(Lv)

Algorithm: Choosing a partition for job assignment

Begin

While (job) do

Search Node (job)

If Node Status==idle||normal then

Assign job

Else

Search Node+1

Update table of node status in the main controller

Endif

End while

End

Algorithm 1: Job Assignment to Node in a Distributed Database System

From algorithm 1, it is clear that a job will not be assigned to any node until the node will come under idle or normal status. To balance nodes on the basis of their status, how do we calculate the status of any node attached with many devices? The solution to this problem is that three parameters play the deciding parameters in this decision namely: processor, RAM and bandwidth. If we are able to calculate the threshold value of these parameters, then we can easily generate the status of any node.

7. STRATEGY FOR LOAD STATUS EVALUATION

In this section we now consider load balancing between nodes as per their status. However, the node status calculation is a challenging task as each node is attached to many devices. Here we again suggest that three main parameters, namely

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processor, RAM and bandwidth can serve as the deciding factors. If we are able to calculate the threshold value of these things, then we can easily generate the status of any node.

7.1. STRATEGY FOR MAIN MEMORY STATUS EVALUATION

Each and every node in the distributed database have their own memory for accepting the request and retrieving the requested data, but the memory has limited capacity to store data. Based on memory capacity we can calculate the high threshold (Özsu & Valduriez, 2011) value for evaluation of the node status. When a client sends any request to the database to retrieve the data, the memory will be consumed based on the size of the requested data. Here, we have two different parameters, namely memory size and the size of the requested data. From the size of the memory and size of requested data, we can calculate the memory state whether it is in overloaded or in the idle or normal state. For this calculation, we assume the parameters described below:

$$Cs=Max(R) \qquad (1)$$

$$Cs=Cs-Ps \qquad (2)$$

$$M=Cs-Min(s)/Max(s)-Min(s) \qquad (3)$$

$$N=Ps-Min\ (Ps)/Max(s)-Min(s) \qquad (4)$$

If N<=M then the request will be accepted otherwise overloaded message will be generated.

Here Cs denotes current status; Max(R) is the maximum capacity of the main memory; Ps is processed request size; In equation (3) Min(s) is the minimum capacity of current size and Max(s) is the maximum capacity of the current size of the main memory; In equation (4) Min (Ps) is the minimum capacity of process size and Max (Ps) is the maximum capacity of process size of process request.

7.2. STRATEGY FOR PROCESSOR STATUS EVALUATION

We first explain how the processor works. The processor, first of all fetches the instruction from memory with the help of control unit and executes it. These instructions may arrive at the processor in many states such ready, waiting, and execution state (Silberschatz, Korth, & Sudarshan, 2013). Departure from one state to another state is called process scheduling (Tanenbaum & Bos, 2015). There are mainly two types of scheduling algorithms, namely pre–emptive and non–preemptive scheduling (Tanenbaum & Bos, 2015). When a program enters into the system the processor executes it in the form of instructions. But if a large size program is sent to the processor to execute, this type of program generates a job queue because at a time only one instruction will be executed (multiple core processor can execute multiple instructions at a time) (Hennessy, 2019). These instructions or processes wait in the ready state before the execution.When a processor finishes its job, the processor scheduler schedules the next instruction from the ready state to an execution state. If the processor is busy in execution due to some processes in memory, then the process of ready state goes to the waiting state and waits for processor until it is free. These waiting queues serve as a buffer (a type of memory) having some capacity to store the instructions. But the question arises about how much instructions can be stored in a waiting queue or what is the size of the waiting queue. Here our main aim is to generate the high threshold value of a processor. To know this, we apply the queuing model mechanism in which there may be (1) single server model or (2) Multiple server models. Both single and multiple server models are based on two queuing models, namely (1) Finite Queue Length and (2) Infinite Queue Length (Shortle, Thompson, Gross & Harris, 2018; Bhat, 2008). Here, we are considering only a single server model in which we can calculate how the server accepts the requests from the queue.

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7.2.1. M/M/C : ∞/∞ MODEL

$$\rho=\lambda/c\mu<1 \text{ or } \rho/c= \lambda/c\mu<1 \qquad (5)$$

Here λ= request arrival time per unit of time, μ= service rate per unit of time and c= number of servers. Assume that μn =nμ where n<c and μn =cμ

So, pn = ρn p0 = λn/μn p0
pn = λn /μ, 2μ, 3μ, 4μ, …….nμ
pn = (λ /μ)n (1/n! * p0) where n<c
pn = (λn /μ 2μ 3μ 4μ 4μ 4μ) (1/n! * p0)
If we consider that there are 4 servers are available.

So pn = (λn /c! μncn−c)* (p0) where n ≥ c

p0+p1+p3+ ………..pn= 1

$$\sum_{n=1}^{C-1}\left(\rho^{n} \Big/ n!\left(p_0\right) + \rho^{n} \Big/ c!c^{n-1}\left(p_0\right)\right)=1 \qquad (6)$$

The above equation is both for n <c or n ≥ c and

$$L_q = \sum_{n=c}^{\infty}\left(n-c\right)p_n \qquad (7)$$

Here n=c (server) that is one. If more than one server then n=c+1, n=c+2, n=c+3 and more.

So exact server number è

n−c = c+1−c= 1,
n−c = c+2−c= 2,
n−c = c+3−c= 3 etc

$$L_q = \left(\left(\rho^{c+1}\right)\left(p_0\right)\right) \Big/ \left(\left(c-1\right)!\left(c-p\right)^{2}\right) \qquad (8)$$

where j=1, 2, 3, 4, …, ∞ request

Example: − Find the values of Ls, Lq, Ws&Wq if the c=2, λ=10/hour, μ=6/hour. We know that ρ=λ/cμ<1

$$\begin{aligned}
\boldsymbol{p}_0 &= \left[\sum_{0}^{c-1}\left(\rho^{n}/\boldsymbol{n}!\right)+\left(\rho^{c}/\boldsymbol{c}!\right)\frac{1}{1-\left(\rho/\boldsymbol{c}\right)}\right]^{-1} \\
&= \left[1+\frac{10}{6}+\left(\frac{10}{6}\right)^{2}*\left(\frac{1}{2}\right)*\left(\frac{1}{1-\left(\frac{5}{6}\right)}\right)\right]^{-1} \\
&= \left[1+\frac{10}{6}+\left(\frac{100*6}{36*2}\right)\right]^{-1} \\
&= 0.0909
\end{aligned} \tag{9}$$

$$\boldsymbol{L}_q = \left(\left(\rho^{c+1}\right)\left(\boldsymbol{p}_0\right)\right) \Big/ \left(\left(\boldsymbol{c}-1\right)!\left(\boldsymbol{c}-\rho\right)^{2}\right) = 3.7878$$

Ls= Lq+ρ = 3.7878+1.666 = 5.4544

Wq = Lq/λ =3.7878/10 = 0.378 hour\

Table 1. Server Status by giving Arrival Rate and Service Rate in M/M/c: ∞/∞ Model.

Parameter Type	**Parameter Value**
Arrival Rate/ Second	10
Service Rate/ Second	6
Average Number of Customer in System (L)	5.4545
Average Number of Customer Waiting in the Queue (Lq)	3.7879
Average Time spent in System	0.5455
Average Waiting Time in Queue (Wq)	0.3788
Processor Utilization (%)	0.83
Number of Servers	2

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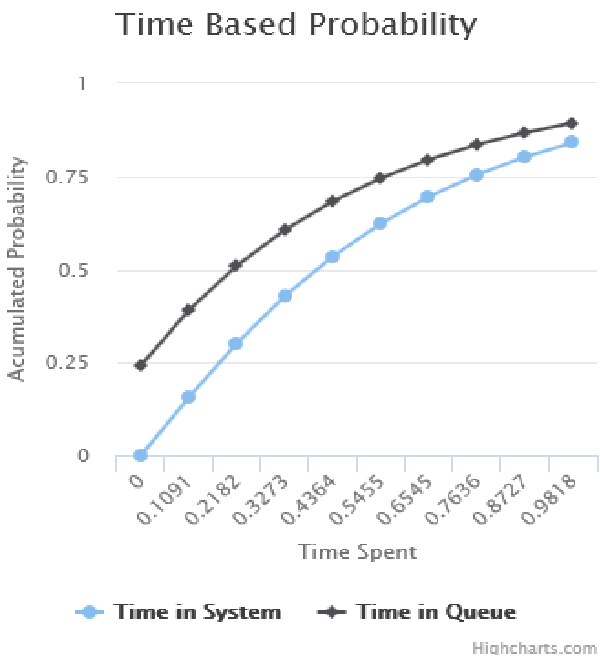

Figure 4. Queuing Theory Models Calculator.

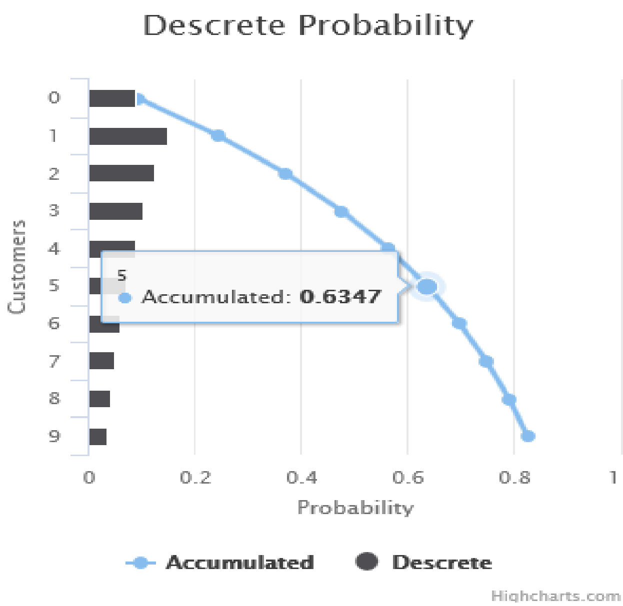

Figure 5. Queuing theory models calculator.

7.2.2. M/M/C: N/∞ MODEL

A system will not accept any other request if it will contain an N number of requests in the system.

Here p0, p1, p2, p3, …,pn
& p0+ p1+ p2+ p3 +…+ pn = 1

$$\sum_{n=0}^{c-1}\frac{\rho^n p_0}{n!} + \sum_{n=c}^{c-1}\frac{\rho^n p_0}{(c!)c^{n-c}} = \mathbf{1} \qquad (10)$$

If n>c then this part will be used

If n≤c then this part will be used
We are assuming that n>c then

$$p_n = \frac{\rho^n p_0}{(c!)*(c^{n-c})} \qquad (11)$$

This is the probability that N person in the system. So:

$$L_q = \sum_{n=c}^{N}(n-c)p_n$$

forn≥c after expanding it.

$$L_q = \frac{\rho^{c+1}}{(c-1)!}\left[\frac{1-\left(\rho/c\right)^{(n-c+1)} - (n-c+1)\left(1-\rho/c\right)\left(\rho/c\right)^{N-c}}{(c-\rho)^2}\right] \qquad (12)$$

Example: – Find the values of Ls, Lq, Ws and Wq where N=7, λ=10, μ=6 and c=2?

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We know that:

$$L_q = \left[1 + \rho = \frac{(\rho)^2 \left(1 - \frac{\rho}{\mathbf{c}}\right)^6}{2!\left(1 - \frac{\rho}{\mathbf{c}}\right)} \right]^{-1} \qquad (13)$$

= (1+5/3+5.5425)

= 0.1218

When 2 servers are available then:

p0 +p1 = p0 + ρ p0 =0.3248

p0 +p1 + p2 =0.3248 + ρ2 /2 (p0) = 0.4939

So, Lq = 125/27 (0.1218) {1–(5/6) – 6*1/6 (5/6)5} = 1.335

pn = p7 = 0.68 = (λ/6*(12)6)p0

λeff = λ(1–pn) = 9.32

So, Ls = 2.89 (expected number of the people in the system)

Ws = Ls/ λeff = 0.31 hours

Table 2. Server Status by giving Arrival Rate and Service Rate in M/M/c: N/∞ Model.

Parameter Type	Parameter Value
Queue Capacity	7
Arrival Rate/ Hour	10
Service Rate/ Hour	6
Average Number of Customer in the System (Ls)	3.133
Average Number of Customer waiting in the Queue (Lq)	1.336
Average Time Spent in the System	0.3362
Average Waiting Time in Queue	0.1695
Processor Utilization (%)	0.83
Number of Servers	2

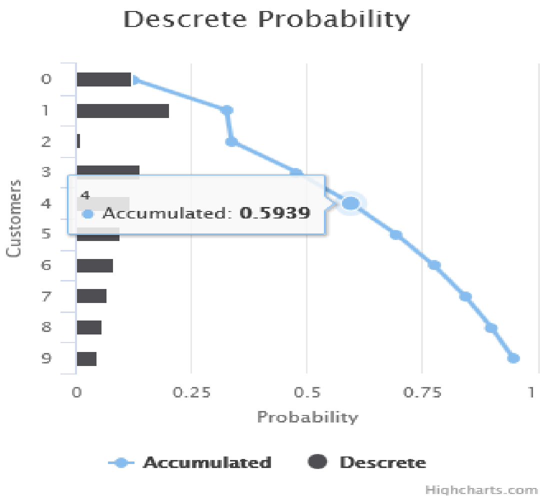

Figure 6. Queuing Theory Models Calculator.

NOTE: – from these, we can understand that if $\lambda/\mu<=1$ then the processor performance will decrease and at least it will generate a high threshold value.

7.3. STRATEGY FOR LOAD BALANCING BY SELECTING NEXT CONTROLLER IF THE MAIN CONTROLLER FAILS

Suppose there is only one main controller for a group of servers and it fails due to hardware, software or network failure then the whole system will fall down. To avoid these problems if we attach one controller with every server then if any server falls down the next controller, which attached with another server will wake up and work as the main controller.

The coordinator selection problem is to opt a controller from among a group of the controller in a distributed system and it acts as the central coordinator. A Bully algorithm is used to solve the coordinator selection problem (Dhamdhere, 2012).

- P2P communication: All controllers can send messages to all other controllers.
- Assume that all controllers have unique IDs, i.e. one is highest.
- Assume that the priority of the controller's Ci is i.

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7.3.1. BULLY ALGORITHM

Any controller Ci sends a message to the present coordinator; if no response in T time units, then Ci tries to select itself as a coordinator. Details are as follows (Silberschatz, *et al.*, 2013):

An algorithm for controller Ci which detects the drawbacks of coordinator

- Controller Ci sends a "Selection" message to every controller with higher priority.
- If no other controller responds, controller Ci starts the coordinator code execution and sends a message to all controllers with lower priorities saying "Selected Ci"
- Else, Ci waits for T' time units to hear from the new coordinator, and if there is no response then start from step (1) again.

Algorithm for other controllers (also called Ci).

- If Ci is not the coordinator, then Ci may receive either of these messages from Cj
- If Pi sends "Selected Cj"; (message received, if i< j)
- Ci updates its records to state that Cj is the coordinator.
- Else if Cj sends "Selection" message (i> j)
- Ci sends a response to Cj state that it is alive
- Ci starts a selection.

Suppose, there are a total of seven servers and each server contains one controller and these servers are connected to each other. Due to some kind of failures such as hardware or software then another controller who is idle then it will be active. In the below figure, the 7th number is a coordinator because it has the highest priority.

Figure 7. Total Number of Nodes.

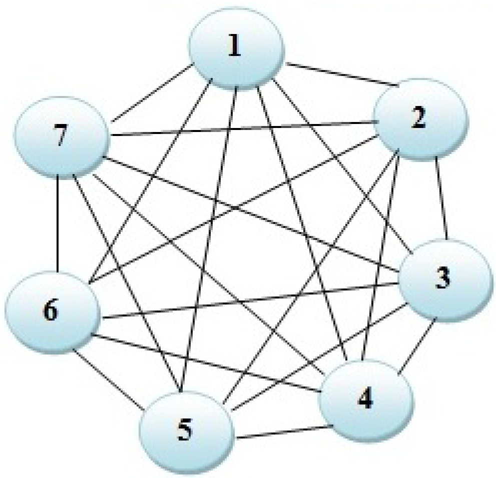

Figure 8. Connection of Server Nodes.

In the Figure 8, it shows that each and every server with a controller connected with each other.

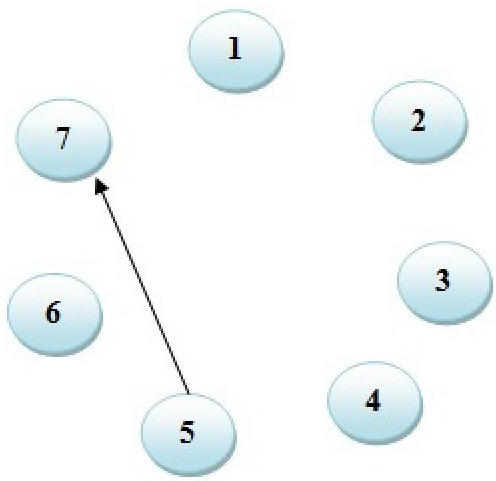

Figure 9. Response of Coordinator.

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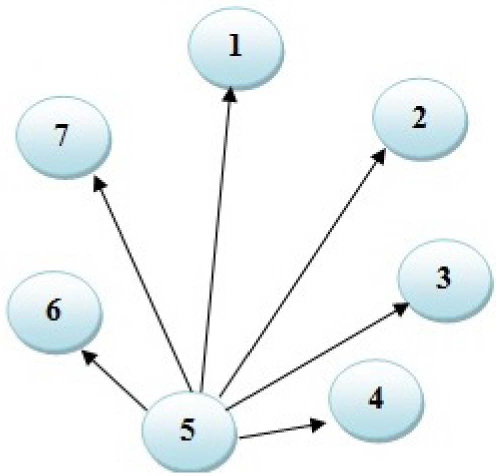

Figure 10. Message Broadcast by a Node.

Then it sends the message to another controller and starts the election to choose the next coordinator. Including itself, it started an election that who has greater priority.

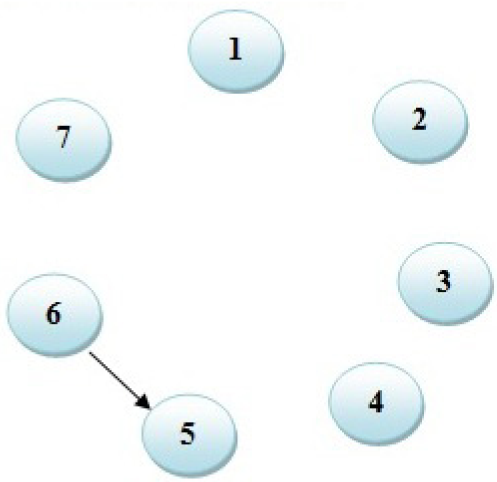

Figure 11. Reply by higher priority node.

Then controller 6 replies the response that it has greater priority, including a controller (5).

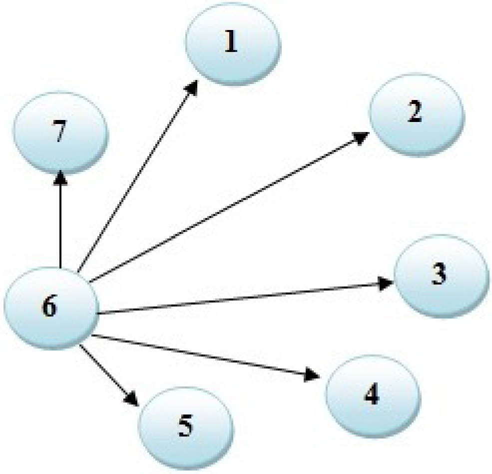

Figure 12. Message broadcast for new Coordinator.

At the last controller (6) will become the next coordinator.

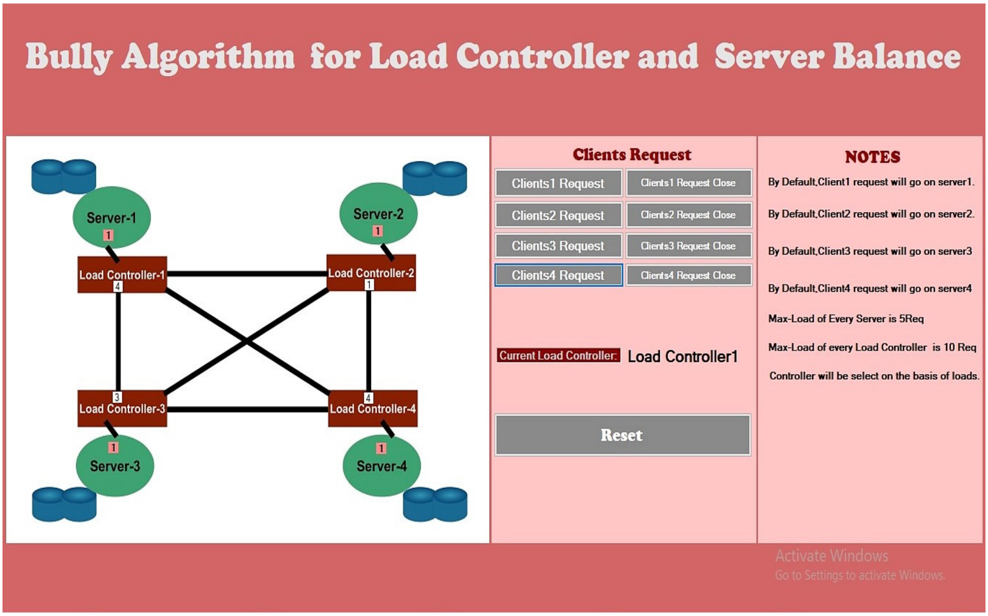

Figure 13. Output–1.

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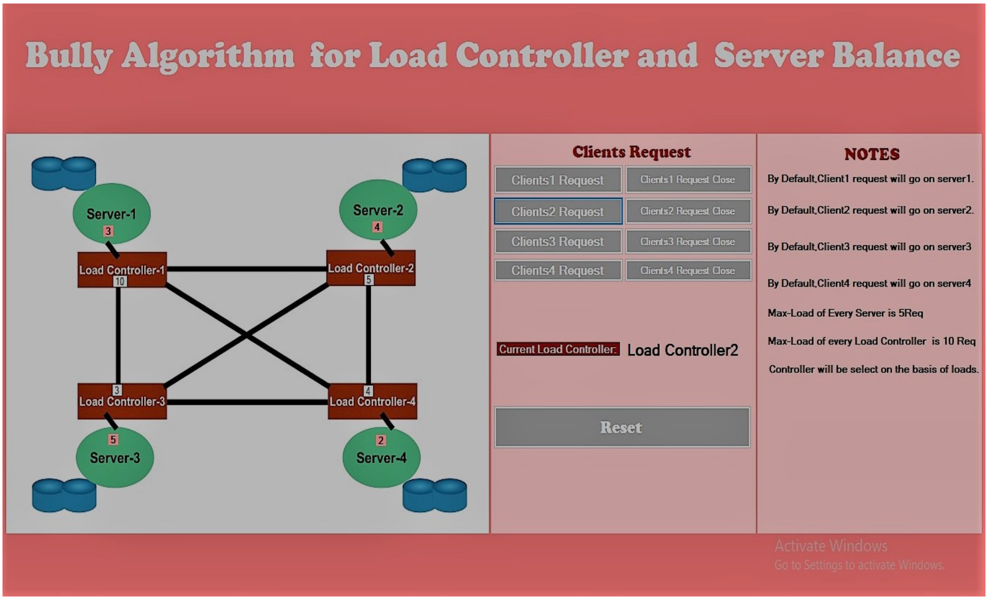

Figure 14. Output–2.

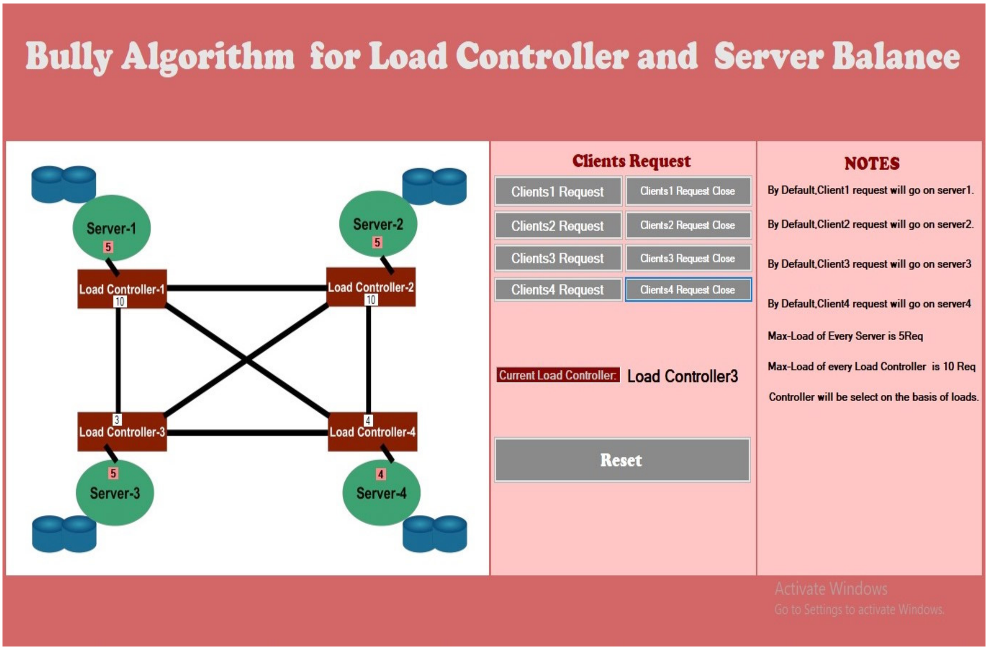

Figure 15. Output–3.

Pseudo Code of Load Controller:

```
int LoadController1=0;
int LoadController1=1;
int LoadController1=2;
int LoadController1=3;
void Controller Selection()
  {
 If (LoadController1 < LoadController2 && LoadController1 < LoadController3
&& LoadController1 < LoadController4 || LoadController1 < 10)
  {
 LoadController1++;
LCSelect.Text = "Load Controller1";
  }
else
  {
if ( LoadController2 < LoadController3 && LoadController2 <
LoadController3 && LoadController2 < LoadController4 || LoadController2
<10)
  {
LoadController2++;
LCSelect.Text = "Load Controller2";
  }
else
  {
if ( LoadController3 < LoadController4 || LoadController3 < 10)
  {
LoadController3++;
LCSelect.Text = "Load Controller3
  }
else
  {
```

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```
if ( Lo4dController2 < LoadController3 || LoadController4 < 10)
 {
LoadController4++;
LCSelect.Text = “Load Controller4”;
 }
else
 {
Message(“Sorry..All Load Controllers are failed..”)
 }
  }
   }
    }
     }
```

8. CONCLUSION AND FUTURE WORK

In this research paper, we discussed how the databases are distributed in different places. The existing research papers show that only one load balancer is available to balance the load. If it fails, the entire system may shut down. To remove this problem every database server has its own balance controller. If one of them fails the others will be activated and it will work as it was working previously. Load balancing technology is necessary today in environments where big data are working. To handle the big data, it is necessary that database servers should be balanced to work properly. To balance the load, the best algorithm is required which takes minimum time complexity.

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NOVEL FRAMEWORK FOR HANDWRITTEN DIGIT RECOGNITION THROUGH NEURAL NETWORKS

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ABSTRACT

The biggest challenge for natural language processing systems is to accurately identify and classify the hand–written characters. Accurate Handwritten Character recognition is a challenging task for humans too as the style, size and other handwriting parameters may vary from human to human. Though a relatively straightforward machine vision task but improved accuracy as compared to the existing implementations is still desirable. This manuscript aims to propose a novel neural network based framework for handwritten character recognition.

The proposed neural network based framework, transforms the raw data set to a NumPy array to achieve image flattening and feeds the same into a pixel vector before feeding it into the network. In the neural network, the activation function is applied to transfer the resultant value to the hidden layer where it is further minimized through the use of minimized mean square and back propagation algorithms before applying a stochastic gradient on the resultant mini–batches.

After a detailed study, the optimal algorithm for effective handwritten character recognition was proposed. Initially, the framework has been simulated only on digits through 50,000 training data samples, 10,000 validation data set and 10,000 test data set, the accuracy of 96.08.

This manuscript aims to give the reader an insight into how the proposed neural network based framework has been applied for handwritten digit recognition. It highlights the successful applications of the same while laying down the directions for the enhancements possible.

KEYWORDS

Natural Language Processing, Handwritten Character Recognition, Neural Networks, Machine Vision; Digit Recognition.

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1. INTRODUCTION

Many literate humans effortlessly recognize the decimal digit set (0–9). A sample of the same is depicted in Figure 1 below. This natural attribute of mankind is actually due to the seemingly simple human brain. The human brain is a supercomputer in itself as each of its hemispheres has a visual cortex containing 140 million neurons with approximately tens of billions of connections between them (LeCun, *et al.*, 1990). So this supercomputer tuned by evolution over hundreds of millions of years on this earth is superbly adapted to understand this complex, colourful visual world.

This masterpiece–human brain can solve a tough problem like recognizing any entity in this world in moments of seconds. The difficulty bubbles up when we attempt to automate the same task by writing a computer program and applying computer vision for character/digit recognition (Bottou, *et al.*, 1994) (Nielsen, 2018). Recognizing digits, in particular, is a simple task as the input is simple black and white pixels with only 10 well–defined outputs. However, the accurate recognition of the handwritten shapes in different styles, fonts etc is a complex task in itself. A simple 6 has a loop on bottom and vertical or curved stroke on top which can be written in varied styles and is difficult to express algorithmically to a machine which is none other than a newborn baby born after every turn off (Bottou, *et al.*, 1994; Nielsen, 2018; Hegen, Demuth, & Beale, 1996). Neural networks solve the above problem in a much simpler way (LeCun, *et al.*, 1990; Bottou, *et al.*, 1994; Nielsen, 2018; Hegen, *et al.*, 1996; Widrow, Rumelhart, & Lehr, 1994; Mishra & Singh, 2016). The strategy is to take huge data set of black and white handwritten digits from real life people and build a neural network to train from those data sets and learn to recognize those digits (Shamim, Miah, Sarker, Rana, & Jobair, 2018; Patel, Patel, & Patel, 2011; Ganea, Brezovan, & Ganea, 2005).

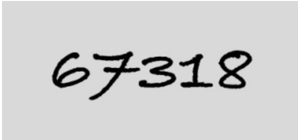

Figure 1. Sample of Handwritten Digits figure.

In Neural Networks, each node performs some simple computation on the input and conveys a signal to next node through a connection having a weight and a bias associated with it which amplifies or diminishes a signal (Nielsen, 2018; Shamim, Miah, Sarker, Rana, & Jobair, 2018). Different choices for weights and bias results in different functions evaluated by networks. An appropriate learning algorithm must be used to determine the optimal values of weights and bias (Widrow, *et al.*, 1994; Knerr, Personnaz, & Dreyfus, 1992).

All neural networks have these following common following attributes (Widrow, *et al.*, 1994; Alwzwazy, Albe–Hadili, Alwan & Islam, 2016; Matan, *et al.*, 1990).

- A set of processing units
- A set of connections
- A computing procedure
- A training procedure

The Processing Units

The processing units in a Neural Network are the smallest units just like neurons in a brain. These nodes work in a similar fashion and operate simultaneously. There is no master procedure to coordinate them all (Cardoso & Wichert, 2013). These units compute a scalar function of its input and broadcast the results to units connected to it as output. The result is called the activation value and the scalar function is called activation function (Widrow, *et al.*, 1994).

There are three types of inputs:

- Input unit, which receives data from the environment as input.
- The hidden unit, which transforms internal data of network and broadcast to the next set of units.

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- Output unit, which represents a decision as the output of all system (Widrow, *et al.*, 1994).

The Connections

The connections are essential to determine the topology of a neural network. There are three types of topologies (Gattal, Djeddi, Chibani & Siddiqi, 2016):

- Unstructured networks for pattern completion.
- Layered networks for pattern association.
- Modular networks for building complex systems.

The topology used in this paper for the proposed system is layered networks (Widrow, *et al.*, 1994).

A Computing Procedure

Computations feed input vectors to processing units from the input layer (Sakshica & Gupta, 2015). Then the activation value of remaining units is computed synchronously or asynchronously. In a layered network, this is done by feedforward propagation method. The activation functions used are mathematical functions. The most common function is a sigmoidal function (Mishra & Singh, 2016).

A Training Procedure

Training a network implies adapting its connections according to the input environment so the network can exhibit optimized computational behaviour for all input patterns (Arel, Rose & Karnowski, 2010). The process used in this paper is modifying weights and biases with respect to the desired output. The cost of error is calculated using a mean square error method (Mishra & Singh, 2016).

2. DATA COLLECTION

Handwritten digit data set is vague in nature because they may not always be sharp straight lines of pixels (LeCun, *et al.*, 1990). The main goal in digit recognition of feature extraction is to remove the ambiguity from data (Bottou, *et al.*, 1994; Cireşan, Meier, Gambardella & Schmidhuber, 2010). It deals with extracting essential information from normalized images of isolated digits that serve as raw data in the form of vectors (Cireşan, *et al.*, 2010). The numbers in the images can be of different sizes, styles and orientation (Patel, *et al.*, 2011).In this study, a subset of MNIST dataset is used which contains ten thousands of scanned images of handwritten digits from 250 people. This data is divided into three parts, the first part contains 50,000 images to be used as training data. The second part is 10,000 images to be used as testing data. The third part contains 10,000 images for validation data. There are 28X28 pixels in size gray scale images. The training set, validation set and testing set are kept distinct to help neural network to learn from training set , validate the results from validation test and generate output from test set (LeCun, *et al.*, 1990; Liu, Nakashima, Sako & Fujisawa, 2003; LeCun, *et al.*, 1995). These are an example of digits of MNIST dataset collected in different hand writings. For example – a digit 2 can be represented in a different orientation with or without a loop at the bottom or straight line or curved line at the bottom.

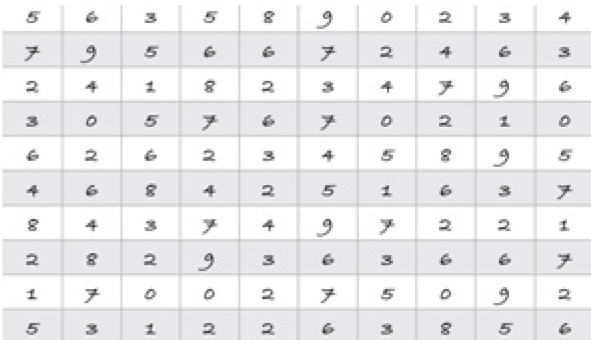

Figure 2. A sample set of MNIST dataset.

These are the 100 examples out of 60,000 used in the input of neural network in this paper.

3. PROPOSED DETECTION ALGORITHM

We now discuss this feed–forward neural network that was applied in this work to achieve highest possible accuracy in handwritten digit recognition (LeCun, *et al.*, 1989; Knerr, *et al.*, 1992).

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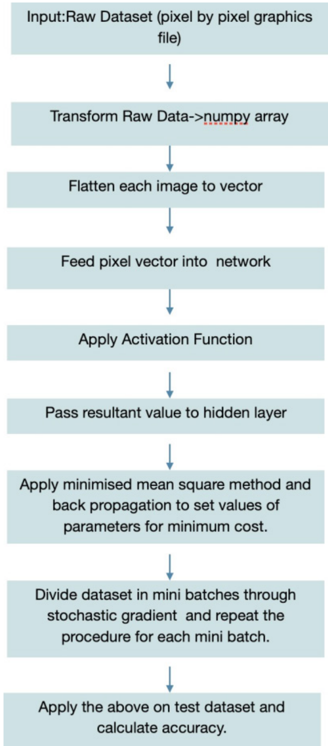

Figure 3. Proposed Algorithm.

Above elaborates the steps of the proposed framework used in this study. The next section details this simulation.

4. PROPOSED METHODOLOGY

A. Neural Network

Figure 3 describes the architecture of the proposed neural network. It consists of an input layer, a hidden layer and an output layer. Each layer contains a number of neurons represented by a sigmoid function. So, the output of each neuron lies in the range of [0,1]. Every neurons output is determined by a weighted sum. jwjxj w is the weight of jthneurone having x input. The sum of the weighted sum and bias value determines the output value. The input layer consists of 784 neurons with each neuron representing each pixel value. Since each digit should be between 0and 9. So, the output layer consists of 10 neurons represented by the matrix (LeCun, *et al.*, 1990; Lauer, Suen & Bloch, 2007).

$$g(x) = \frac{1}{1+e^{-x}} \qquad (1)$$

Equation 1: Sigmoid Function.

Equation 1 defined shows the sigmoid function used. Here, g(x) represents the sigmoid function and the net value of the weighted sum is x. So, x is areal number. If the value of x is a very large positive number then the value of g(x) will be 1. And if the value of x is a very negative number then the value of g(x) is 0. Hence the graph shown by sigmoid function is

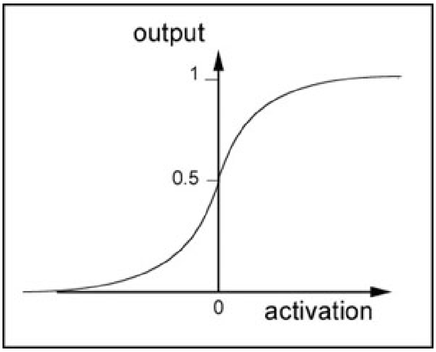

Figure 4. Graph of Sigmoid function.

But the problem with sigmoid function is that the for negative values the speed of neural networks become slow. That is in the second quadrant of the graph.

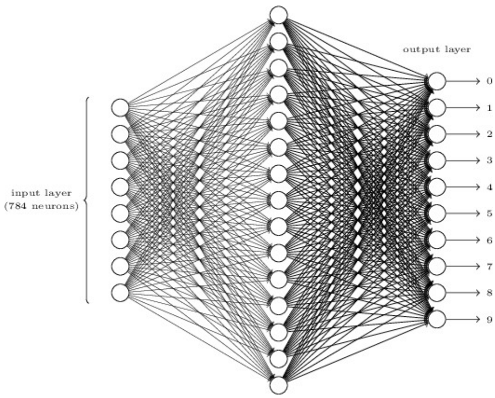

Figure 5. Neural Network Layer Architecture.

Figure 4 represents the whole multiple layered structures used in the neural network. The input layer contains 784 neurons that are each neuron for every

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pixel. The intensity of each pixel is the input to the neurons of the first layer. The activation function is performed on that input and the reuniting activation value is passed on to every neuron in the next layer. This same procedure is performed on the next layer. The output layer having 10 neurons So, the neuron with the highest activation value is the result. Figure 5 represents the output matrix where each row and column represents the output of the node in the output layer.

$$\begin{array}{c}\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \\ y_k^{(1)}\; y_k^{(2)}\; y_k^{(3)}\; y_k^{(4)}\; y_k^{(5)}\; y_k^{(6)}\; y_k^{(7)}\; y_k^{(8)}\; y_k^{(9)}\; y_k^{(10)} \end{array}$$

Figure 6. Output Matrix for output Layer.

B. Gradient descent back propagation algorithm **(LeCun, *et al.*, 1990)**

This algorithm helps in finding weights and biases so that output from network approximates the ideal output for all training input x. This is done by the cost function. The cost function is a measure of how wrong the model is in terms of its ability to estimate the relationship between weights and biases (Widrow, *et al.*, 1994; Patel, *et al.*, 2011; Ganea, *et al.*, 2005; Lee, 1991). ((LeCun, *et al.*, 1990), equation 2) is also called mean squared error for the cost function.

$$C(w,b) = \frac{1}{2n}\sum_x \left\| y(x) - a \right\|^2 \qquad (2)$$

Equation 2: Cost Function.

C(w,b) is non–negative since the sum of squared terms is always positive. If C(w,b) is approximately equal to 0 the ideal output is equal to obtained output. So, our algorithm is doing a good job. So, this algorithm minimizes the cost function which is represented by a graph (Shamim, Miah, Sarker, Rana & Jobair, 2018; Knerr et., 1992; LeCun, *et al.*, 1989).

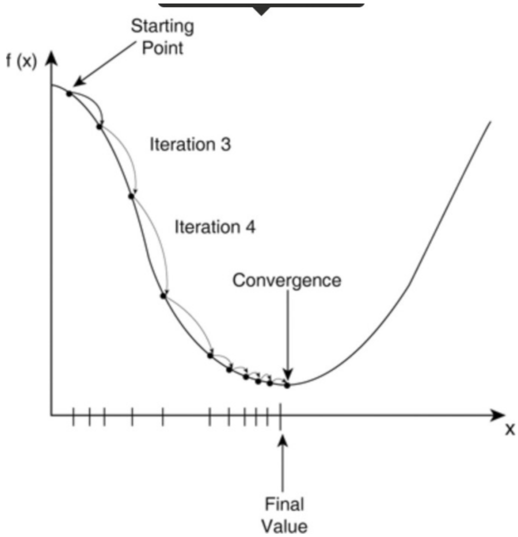

Figure 7. Curve Representing the Cost Function.

Figure 7 shows the 2D curve representing the linear equation depending on the two variables x and y same as weights and biases. Consider this curve as a valley in the mountains to reach the minimum height we have to reach the bottom of the valley. Similarly, if we roll down a ball from the above of the valley the ball will roll down and reach to the lower point in the valley. Neglecting the friction by air and ground and further physics laws of momentum.The minimum cost is the point of the lowest point in the valley. Hence the below two equations gives the minimum cost by partial differentiating the cost with respect to weight and bias. Solving this equation through this algorithm gives two ((Bottou, *et al.*, 1994), equations 3) for weight and bias as:

$$w_k \rightarrow w'_k = w_k - \eta \frac{\delta C}{\delta w_k} \quad (3)$$

$$b_l \rightarrow b'_l = b_l - \eta \frac{\delta C}{\delta w_k} \quad (4)$$

Equation 3, 4: Cost with respect to weights and biases.

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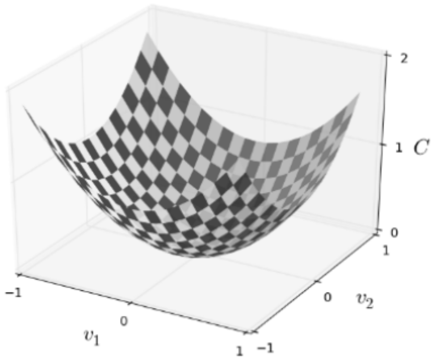

Figure 8. 2D Curve Representing the Cost Function.

C. Stochastic Gradient Descent

Stochastic Gradient Descent helps in speed up the gradient descent algorithm by dividing the training input into mini batches of each size m.

Step 1: Initialize the parameters

The cost function of this algorithm is dependent on two parameters that are weight and bias. So, random values are initialized to weight and bias vector for each input of neuron of each layer. The values of weights and biases are not initialized to 0 because that will be equivalent to the deletion of connections between the nodes.

Step 2: Feed–forward Algorithm

In this algorithm, the output from one layer is input to the next layer. That is there are no loops and information is fed forward not backward. This is achieved by the ((LeCun, *et al.*, 1990), equation 5).

$$a' = \sigma\left(wa + b\right) \qquad (5)$$

Equation 5: Feed forward equation

Here, a is the vector of activations of the second layer of neurons. To obtain a, a is multiplied by weight matrix w and vector b of biases is added. And then the function is applied element–wise to vector w.a+b. This is how inputs are fed forward. This equation gives the following results

Equation 6: Output Equation

Step 3: Calculate the gradient

The gradient for output and hidden layers are obtained by updating the weights and biases. This is done by shuffling the training data and then dividing into mini batches and then updating weights and biases for each mini batch.

Step 4: Update the weights

In the beginning, weights and biases are initialized some random values. Now, this model gives the output using those values which is far different from the ideal output. This gives a huge error. So, to reduce the error we will minimize the cost function and get the desired values of weight and biases. This is how back propagation works. ((LeCun, *et al.*, 1990), equation 7) is used.

$$w_k \to w'_k = w_k - \frac{\eta}{m}\sum_j \frac{\delta C_{X_j}}{\delta w_k} \quad (7)$$

$$b_l \to b'_l = b_l - \frac{\eta}{m}\sum_j \frac{\delta C_{X_j}}{\delta b_l} \quad (8)$$

Equation 7,8: Update weights and biases.

5. EXPERIMENTAL RESULTS

The number of neurons in hidden rate and learning rate are called hyper parameters of neural network (Gattal, *et al.*, 2016). So, changing the number of neurons and training the network again and again until the highest accuracy is achieved.

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Table 1. Hidden Neurons Vs Accuracy.

Hidden Neurons	Accuracy(%)
10	91.46
30	95.07
50	95.86
60	95.16
65	96.30
70	87.56
80	87.33
100	78.37

Table 1 shows the analysis of data when the network is trained with a different number of neurons in the hidden layer and the accuracy they achieved. Figure 6 shows the graph of accuracy vs a number of hidden neurons. With 65 hidden neurons, mini–batch size of 10 and learning rate of 3 the highest accuracy achieved is at 96.30 Learning rate describes how quickly or slowly the network learns. Low learning rate slows down the learning process but converges smoothly. Larger learning rate speeds up the learning but may to converge. So, the desired learning rate is decaying learning rate. Table 2 shows the analysis data with different learning rate with their accuracy.Learning Rate should not be too low or too high. If it is too low then the neural network will take time to train and if it is too high the neural network will quickly forget the previous training and adapts new training faster. Both of which are of no use.

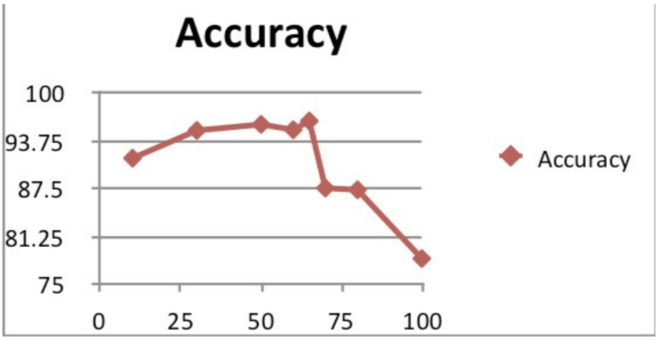

Figure 9. Accuracy Vs Hidden Neurons Graph.

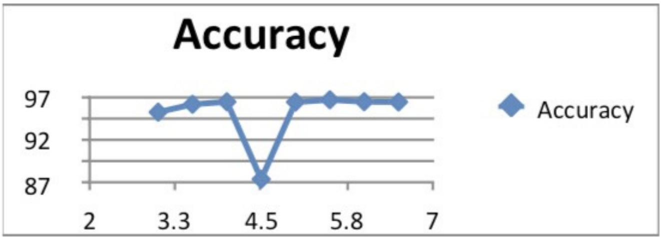

Figure 10. Accuracy Vs Learning Rate Graph.

Table 2. Learning Rate Vs Accuracy.

Learning Rate	Accuracy (%)
3	95.16
3.5	96.06
4	96.35
4.5	87.45
5	96.32
5.5	96.58
6	96.36
6.5	96.33

6. CONCLUSION

Performance of a neural network depends upon factors like the number of hidden neurons, learning rate, number of layers etc which are called hyper parameters of a network (Sakshica & Gupta, 2015; Lee, 1991). This research paper creates experiential support to showcase the effectiveness and efficiency of the neural networks to recognize handwritten digits. The main objective of this paper is to show the highest possible accuracy achieved for recognition of handwritten digit using the technique of feed forward and back propagation in neural networks. Although research is still going on in this field in many forms of LeNetarchitecture like LeNet–1, LeNet–4, Boosted LeNet–4.The main aim of the paper is to implement one of the methods of various methods. This branch of artificial intelligence is to develop a better network for all kinds of data sets with better performance.

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7. FUTURE WORK

Neural networks have been applied to many applications like character recognition, signature recognition, and leaf decoding. The more training samples give more accuracy of the networks. By changing the model of the network from feed–forward to convolutional network the process can be faster and accuracy can be improved although it must be tried for different activation functions. Dropout technique which is turning off part of networks layers randomly to increase the regularization and decrease over fitting. In this case, accuracy for training data is much higher than testing data. It can be improvised for colored digits and can be used for code on post cards for sorting of letters. The proposed framework in this manuscript can also be further applied to some well–defined digit sets to accurately validate them. For example, the proposed framework in this manuscript can be applied on zip code digits, university enrollment numbers or mobile numbers of a given set in a given setting to automate their machine recognition or identification.

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SPATIAL ANALYSIS OF ANNUAL AND SEASONAL SUNLIGHT VARIATION THROUGH GIS KRIGING TECHNIQUE

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ABSTRACT

Today the developing countries are facing multiple types of crises especially in the term of energy crises. Also Energy has great worth because it is very essential for the development of any society as well as for the adequate standard of living, every country requires the energy i.e. Electricity, as to carry out the basic activities, however as the population is increasing rapidly so the demand for energy (electricity) is also increasing and if the required demand for energy is not supplied then it creates the energy shortage, therefore we require the alternative resources (solar energy), to control the energy crises. Sunlight has a lot of importance because it is a renewable resource and is the best alternative to control the energy crises.

Pakistan is a country which is facing energy crises. These crises take the serious shape of torment in the summer season, especially in Sindh province. However, due to its geographical location, the province receives a sufficient quantity of sunlight in the whole year.

In this research, our focus is to spot the most appropriate locations for the efficient utilization of solar energy in different seasons, based on pointed data, derived from different meteorological observatories over the last thirty years. And with the help of Geographic information system, the annual average sunlight of the province has been observed which is 8.5 hrs /day and the central part of the province is spotted, which is more suitable for solar plants because the temperature remains high in this part.

KEYWORDS

Sunlight, Spatial Variation, Pointed Data, GIS, Kriging Interpolation.

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1. INTRODUCTION

Pakistan is a developing country having a high growth rate of population, which has created multiple types of problems in–spite of these troubles, God has bestowed with many blessings among them, its geographical location is one and more important, and due to its location it is the richest country in the world in terms of solar energy, which receives the yearly global irradiance of 1900–2200 kW hr/m2 (Asif, 2009; Bakhtiar & Ahmed, 2017). Most area of country, mainly Baluchistan, Sindh, and southern Punjab get plentiful solar irradiation approximately 2 MW hr/m2 and 3000 hrs of sunlight per year, which is the great average amount of solar radiation in the world (Ahmed, Zafran, Khan, Waqar & Hasan, 2017; Tahir & Asim, 2018). Pakistan has predictable solar energy more than 100,000 MW (Basir, Aziz, Ahmad & Wahid, 2013). Sunlight carries radiant energy to the surface of the earth. The sunrise to sunset is the duration of sunlight of any place and its amount is badly influenced by various factors including clouds, humidity, air pollution, latitudinal and altitudinal location, physical relief, annual march of the sun, and length of the day. Just like other climatic components, sunlight is also valuable for human beings and other ecosystems. Various crops need short days (winter), while other need lengthy days (summer) and it is very essential for the photosynthesis process and flowering, thus, reasonable sunlight is necessary for the growth of plants as well as for human activities. The best alternate source of renewable energy is the sun. The solar energy is required for heating, lighting houses and other buildings as well as for the generation of electricity, and for different commercial and industrial activities.

The Solar Energy has the great potential for providing clean, safe, and reliable power; however it reaches on the surface of earth greater than 200 times the total annual commercial energy is being utilized by humans (Kabir, Kumar, Kumar, Adelodun & Kim, 2018; Venkataraman & Elango, 1998). Most of the rural areas where people are suffering from the energy crisis, solar energy can bring them a solution as it has some benefits as free energy source, free from pollution, used in remote areas and it can be stored in the battery. The people living in rural areas are approximately Ninety–seven million, which contains 7 million houses. As said by the International Energy Agency approximately 38 per cent population in Pakistan remain to deprive of electricity. While at present about 54% of rural population have not the availability of electricity, which causes to live sub–standard life of poverty and social inequity. Therefore the development of the country is being suffered as these areas possess an abundance of resources and workforce that is currently disengaged from the mainstream.

2. STUDY AREA

The study area is shown in (Figure 1). The Sindh province lies in the southeast of the country. Sindh is the 3rd largest province of Pakistan by area wise, which is further divided into 29 districts. The total area is approximately 140,915 km^2 (Ahmed, *et al.*, 2009). The latitude and longitude of the Sindh province are 25.8943° N and 68.5247° E. The approximately yearly rainfall in the province is 150 mm. The climate of a region is majorly influenced by rainfall and temperature.

The climate of the province varies from tremendously hot in the north to moderate in lower Sindh districts. In lower Sindh during the summer seasons in the months of May and June, the temperature reaches above 40 degree Celsius, and in winter seasons it remains 17 to 19 degree Celsius (Qasim, Luqman & Khan, 2016).

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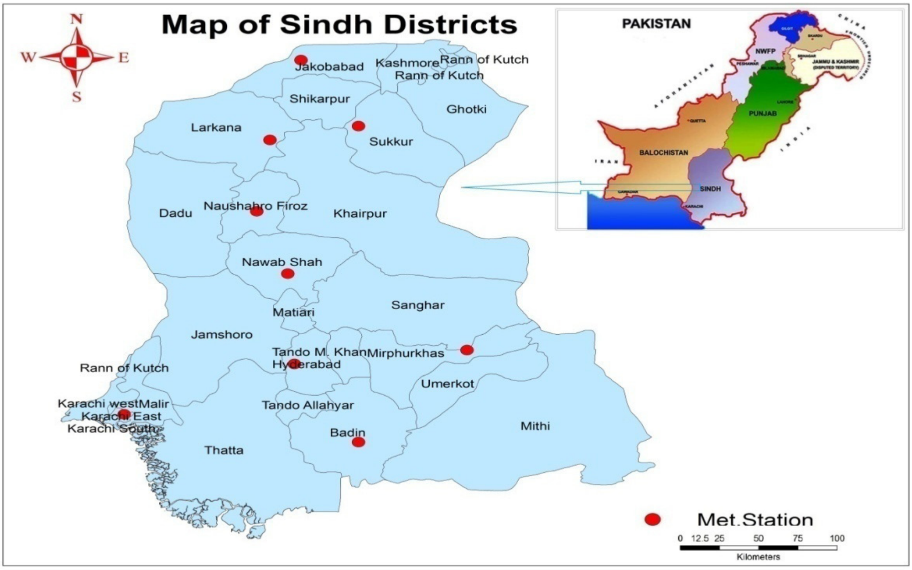

Figure 1. Map of the study area.

3. METHODOLOGY

This research work explains the annual and seasonal variation of sunlight in Sindh province and identifies area having the highest and lowest amount of sunlight in a year. The research is based on the meteorological weather observatories data which were collected from the Pakistan Meteorological Department. For the analysis of sunlight duration, the year has been divided into two major seasons such as summer and winter. The yearly and seasonal variation of sunlight duration of Sindh has been studied taking into account highest sunlight regions (higher than 9 hrs /day), moderate sunlight regions (between 8 hrs/day to 9 hrs / day), and the lowest amount of sunlight regions (less than 8 hrs /day).

The Kriging interpolation technique has been employed to generate a sunlight duration surface of the Sindh province. Kriging is generally used as a type of interpolation techniques, which estimates the outputs in the form of a linear combination of measured values, whose weights depend on the spatial correlation between them. Addition of weights is equal to 1. While the previous postulation of this technique is that the spatial procedure should be postulated as inherent stationary, which means the raw data will not alter with space or time. Kriging assumes the distance or direction between sample points reflects a spatial relationship which can be used to describe a variation on the surface. The Kriging tool fits a mathematical function to a particular number of points, or all points within a particular radius, to determine the output value for each location.

The mathematical form of Kriging is shown in Eq.1:

$$\hat{Z}(S_O) = \sum_{i=1}^{n} \lambda_i Z(S_i) \qquad \text{Eq.1}$$

Where: Z (s_i) = the measured value at the i^{th} location

λi = an unknown weight for the measured value at the i^{th} location

s_0 = the prediction location

N = the number of measured values

4. RESULTS AND DISCUSSION

Annual daily sunlight duration

Figure 2 (a) depicts a spatial distributional pattern of mean annual daily sunlight duration and (b) depicts the mean daily annual maximum temperature (°c) of Sindh province.

i. Maximum sunlight duration areas: The Sanghar, Umerkot and Mithi are the areas which have the highest sunlight duration. The maximum rate of reflection of solar energy in these areas is due to cloudless skies which may be the causes of maximum sunlight.

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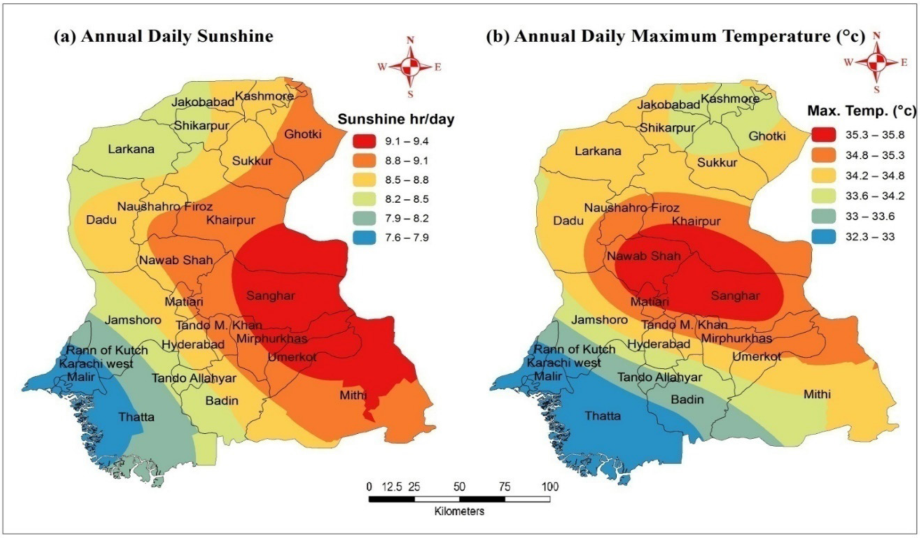

Figure 2. (a, b) spatial distribution of mean annual Sunlight hrs/day and max, air temperature (°c).

ii. Moderate sunlight duration areas: The central and upper regions of Sindh are of moderate sunlight duration areas. The mean daily maximum temperature is high in central regions of the province. The duration of bright sunlight decreases towards the southwest.

iii. Minimum sunlight duration areas: The coastal areas of the province are of low sunlight areas because of cloudiness in the summer season. The minimum sunlight duration is at Karachi 7.6 hrs /day.

Seasonal variation in sunlight duration

Winter sunlight duration

Figure 3 (a) depicts the spatial distributional pattern of mean winter daily sunlight duration and (b) depicts the mean daily winter maximum temperature (°c) of the Sindh province. The highest winter sunlight duration of Sindh province is 9.4 hrs /day, observed at Chhor, and the lowest is 7.5 hrs /day at Larkana. The winter sunlight duration of Sindh Province categorized into the following regions.

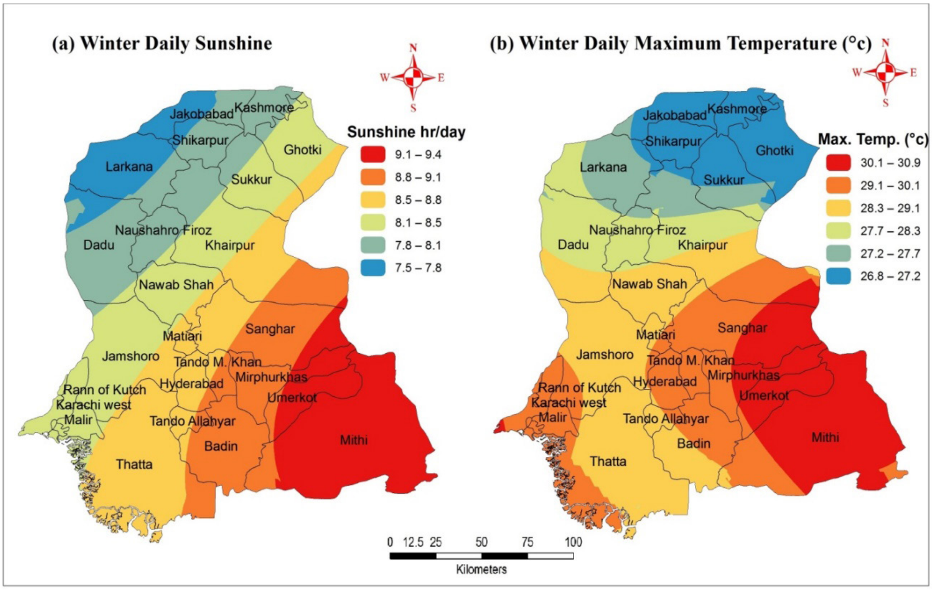

Figure 3. (a, b) Spatial distribution of mean winter Sunlight hrs /day and max. Air temperature (°c).

i. Maximum sunlight duration areas: The region includes the Mithi and Umerkot are receiving the maximum sunlight duration in winter. The maximum winter sunlight duration of the region is due to its tropical location and clear skies. The mean daily maximum temperature remains also high in this region. The region has sunlight duration above 9.1hrs /day.

ii. Moderate sunlight duration areas: In winter most of the central part of the study area receives moderate sunlight duration with an average of 8 hrs / day to 9 hrs /day throughout the season. While in Karachi the highest sunlight duration is 8.8 hrs /day, therefore these regions are commonly appropriate for human activities and vegetation growth.

iii. Minimum sunlight duration areas: some areas of upper Sindh fall in this region. The minimum and maximum Sunlight duration have been observed in this region which is below 7.8 hrs /day. The mean daily maximum temperature is also comparatively low in this region, however the sunlight duration increases in winter towards the southeast of the province.

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Summer sunlight duration: The Figure 4 (a) depicts a spatial distributional pattern of mean summer daily sunlight duration and (b) depicts the mean daily summer maximum temperature in (°c) of the Sindh province. The maximum sunlight duration in summer has been observed which is 9.1hrs /day at Padidan, while the minimum sunlight duration is 6.8 hrs /day at Karachi. Meanwhile, we have categorized the summer sunlight duration of Sindh Province into the following zones.

i. Maximum sunlight duration areas: Most of the central and southeastern part of province constitutes a region of maximum sunlight duration. The mean daily maximum temperature also remains high in the central part. It has been characterized by sunlight duration over 9 hrs /day throughout the season, while the sunlight duration decreases from central part towards North West and coastal areas of the province.

ii. Moderate sunlight duration areas: Larkana, Hyderabad, Sanghar and Jamshoro have been observed as moderate sunlight duration, having (above 8.7 hrs /day) highest sunlight duration in the upper part of study area while it decreases to 6.8 hrs /day towards Karachi in the south.

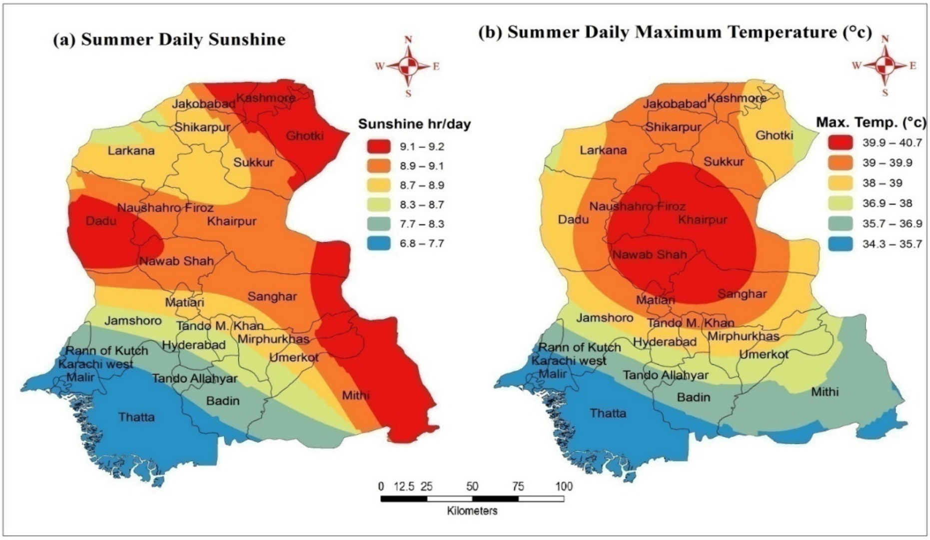

Figure 4. (a, b) spatial distribution of mean summer Sunlight hrs /day and max. air temperature (°c).

iii. Minimum sunlight duration areas: It has been observed that the coastal region of the province having the areas of minimum sunlight duration which is below 7 hrs /day in summer, because of high humidity, clouds and sea fogs.

Relationship between sunlight duration and air temperature

The annual and seasonal mean sunlight duration and mean daily maximum air temperature of nine meteorological stations are attributed in Table 1. The relationship between sunlight duration and the air temperature was also quantified for each annual and seasonal variation. The linear regression analysis was carried out with sunlight duration as the independent variable and maximum air temperature (Tmax°C) is the dependent variables for each annual and seasonal variation. For further observation and find the relationship between sunlight and air temperature, a scatter plot has been created which shows a strong positive correlation between sunlight duration and air temperature as shown in Figures (5–7). It is because the sunlight duration and air temperature are in directly proportional.

Table 1. Mean Sunlight duration and mean daily maximum air temperature (°c).

Station	Annual		Winter		Summer	
	Temperature (Tmax°c)	Sunlight hrs /day	Temperature (Tmax°c)	Sunlight hrs /day	Temperature (Tmax°c)	Sunlight hrs /day
Chhor	35.2	9.4	30.9	9.4	38.4	9
Hyderabad	34.3	8.6	29	8.6	38	8.4
Jacobabad	34.3	8.4	26.9	7.8	39.6	8.9
Karachi	32.3	7.6	29.6	8.4	34.3	6.8
Nawabshah	35.8	8.8	29	8.3	40.7	8.9
Badin	33.2	8.4	29.1	8.8	36.1	7.9
Padidan	35	9	27.7	8.3	40.2	9.2
Rohri	34.2	8.6	26.8	8.1	39.6	8.9
Larkana	34.5	8.2	27.4	7.5	39.6	8.6

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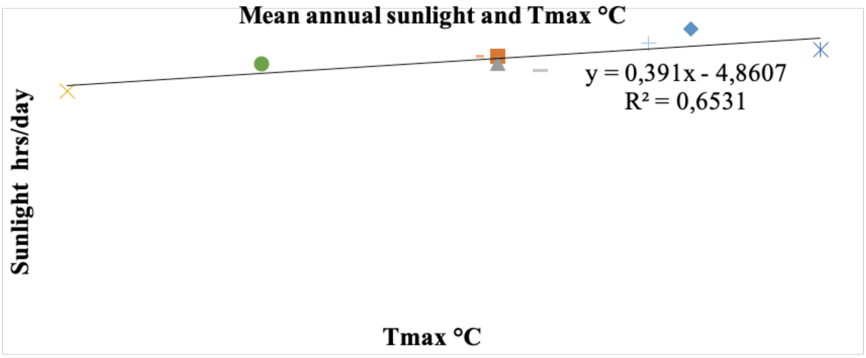

Figure 5. Scatter plot with a fitted line of mean annual air temperature versus sunlight duration.

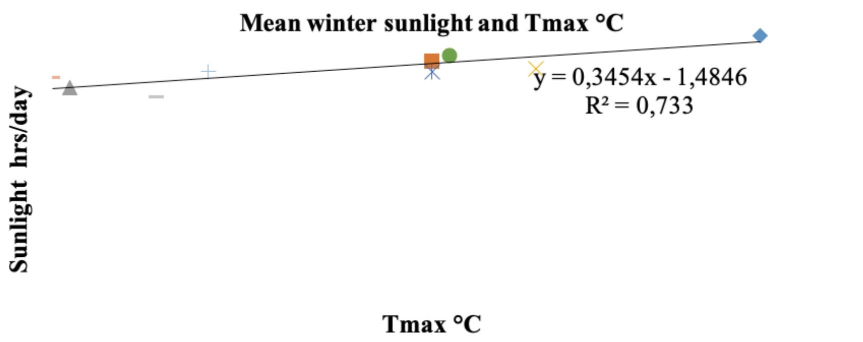

Figure 6. Scatter plot with the fitted line of mean winter air temperature versus sunlight duration.

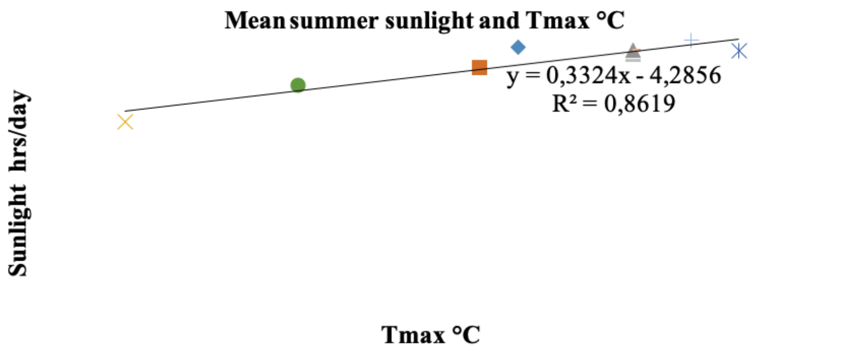

Figure 7. Scatter plot with the fitted line of mean summer air temperature versus sunlight duration.

5. CONCLUSION

With the help of Geographical Information System (GIS) tools the spatial variation of the mean duration of sunlight analyzed for the last thirty years through the Kriging interpolation technique. It was observed the Sindh province receives a substantial quantity of sunlight in the year and has a chance to control the energy deficiency by using alternative energy resources i.e. solar energy. The mean irradiation falling on a horizontal surface is about 3000 plus sunlight hours in a year. These conditions are ideal for photovoltaic (PV) applications and other solar applications. The mean duration of sunlight and maximum air temperature are positively correlated. The duration of sunlight in the southeastern part of the study area is longer as compared to the rest of the part, but the mean air temperature remains high in the central part of the study area. Therefore, the most appropriate site for solar power plants is the central part of the province.

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WSN BASED SMART ADVERTISEMENT IN INTELLIGENT TRANSPORTATION SYSTEM USING RASPBERRY PI

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ABSTRACT

In this current era of technology, Intelligent Transportation Systems (ITS) are helping different cities around the globe to becoming smart cities, while advertisements always played a vital role in any product's sale ratio. Besides security, transportation data, and traffic management, the field of advertisement through (ITS) still needs attention for researchers. According to current literature, a huge amount of budget has been invested in the field of advertisement as well as numerous deaths are caused due to roadside billboards. In this paper, we have developed a system which helps to advertise content digitally on LEDs installed on vehicles by incorporating Raspberry Pi. In results, an advertisement can be remotely controlled from the client's mobile phone and Raspberry Pi will act as a server which collects, manage and displays ads digitally. This system is a good addition towards low cost, efficient and user–friendly solutions.

KEYWORDS

Intelligent Transportation System, Smart Cities, WSN, Client–Server Architecture, Raspberry Pi, GPRS.

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1. INTRODUCTION

In this era of technology, the development of new internet–based business models provides too much importance to the Web in the market economy. The most successful and profitable among those is the online advertisement. The online advertisement which is also known as Internet Advertisement (IA), it provides the end user promotional contents through the internet. The ratio of revenue coming from IA only in the United States in the year of 2013, surpassed the cable television and broadcast television was nearly exceeded (Aksu, Babun, Conti, Tolomei & Uluagac, 2018). Plus, in 2016, almost 200 billion dollars revenue was generated through internet advertisement world widely (eMarketer, 2017) and it can reach 335 billion dollars by the end of the year 2020 (eMarketer, 2016). More Generally, IA business will ultimately broaden to pervasive and ubiquitous smart devices which are interconnected with each other, they are collectively known as the Internet of Things (IoT). Various related work and applications are discussed in (Sharma & Tiwari, 2016), one of those is in Dogo, Akogbe, Folorunso, Maliki and Akindele (2014), where researchers presented the development and design of their electronic strolling message display board which was a microcontroller based application, which displays the information and messages in real–time via SMS. The implementation and utilization of this application were presented in public utility places, educational institutes and in advertisements. A novel approach is used in Reddy (2013) for intimating messages to the peoples using GSM technology which is synchronized with the wireless electronic display board. This approach omits the old traditional way of message pasting on the board by just sending a message immediately without any delay. This approach can also be used in big buildings, hotels and shopping malls to enhance the security systems by providing awareness of emergency situations which may avoid many dangers. The concept of ITS is discussed in Bhosale and Khan (2016), where researchers tried to understand the IoT and its feasibility in the bus transportation system of Singapore. Technically, Singapore is very advanced but still needs improvement in its transportation system's advancement. By the usage of IoT, they made a system for the user which evaluates and understands effectively various bus options.

In the IoT world, enabling computational advertising is an under–investigated area for researchers; however, many interesting challenges and opportunities can be found in it. Indeed, the traditional internet advertisement can be enhanced through IoT advertisement by the help of three key features of IoT (Chen, Cox, Uluagac & Copeland, 2016): high connectivity, high diversity, and scalability. As we know that, due to the high amount of new smart devices are connecting and leaving IoT network constantly, IoT high connectivity and accurate scalability play a vital role to perform an advertisement in a really dynamic environment. Furthermore, complex advertising strategies which consider context awareness as their fundamental component is handled by IoT device high diversity. For example, customized advertisements from roadside digital billboards can be provided to the car driver based on his interests or habits (e.g. preferred hotels, restaurants, and nearby shopping locations). Finally, the difference can be seen between traditional web–browser based ads, where during whole day very limited and rare user interaction occurs, and IoT ads in which users are interacting with IoT environment almost 24 hours a day.

The rest of the paper is organized as follows: In section 2, the proposed methodology for current research is discussed. While results are shown in section 3 and in last, section 4 concludes the research study.

2. PROPOSED METHODOLOGY

In recent years, automakers putting their efforts to adorn the vehicles with a set of computational devices and sensors, and in the IoT industry, smart connected vehicles are considered as one of the most dominant trends. Millions of smart vehicles are possibly carrying multiple passengers around us. We cannot consider further an automobile just a mechanical machine which people always use to travel from point Y to point Z. When comparatively they are mobile, complex nodes, and interconnected establishing distributed and dynamic computing systems. These elements open up new chances for researchers and developers to create novel services and applications. Advertisers can find easily their interesting

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"targets" during passengers are travelling on board through those smart vehicles. Hence, in this paper, we focused to utilize IA by integrating it with the mobile phones to generate and publish ads. Hence, proposed methodology has been divided into 4 stages as shown in Figure 1, 1) Uploading Customized Ads, 2) Ads Verification and Legalization through Admin Panel, 3) Incorporating with Raspberry Pi, 4) Publishing Ads.

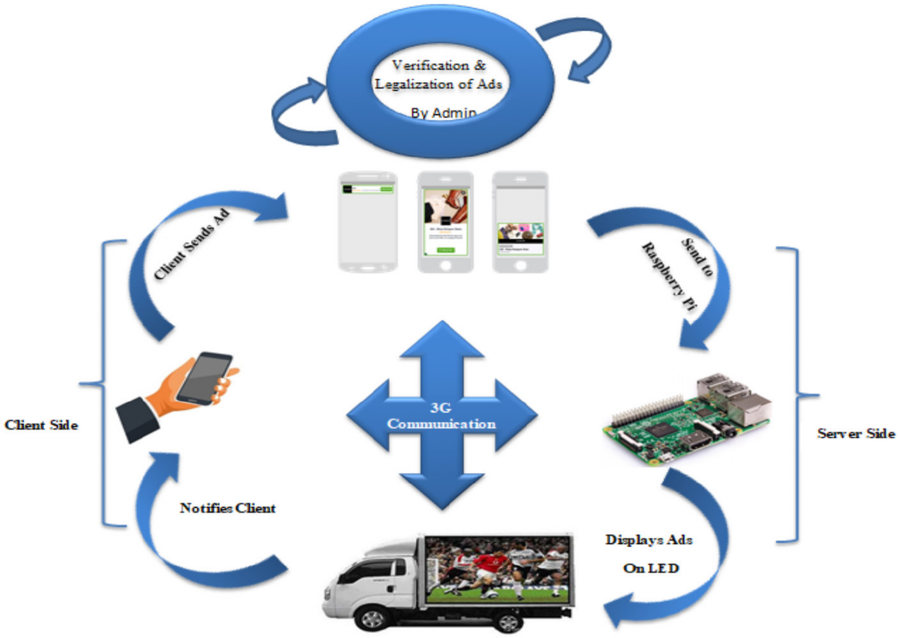

Figure 1. Proposed System Flow Diagram.

2.1. UPLOADING CUSTOMIZED ADS

The first phase is dedicated to client–side; in this section, the user/client will upload his/her own customize ads in the form of images or videos through the android application. Only the following images formats are supported to be uploaded: *jpeg, png, gif, tiff,* while for videos our designed application only supports *.mp4* format (University of Michigan Library, 2019).

2.2. ADS VERIFICATION LEGALIZATION THROUGH ADMIN PANEL

This phase of research cycle deeply focuses to avoid any irrelevant, anti–state, anti–religious, and sexual content to be published on L.E.D according to the electronic media code of conduct–2015. For this purpose, an admin is assigned to verify and validate the ads properly through the application and only after the approval of admin ad/ads can be forward to the server side processing. This process can be repeated for any particular client due to any amendments in the content.

2.3. INCORPORATING WITH RASPBERRY PI

After the verification and legalization process, integration between designed android application with Raspberry Pi will occur. During this process, the medium of communication which is used is 3G services.

2.4. PROPOSED METHODOLOGY

In the end, Advertisements will be published on the L.E.D installed on the smart vehicle. The reason for choosing smart vehicles is to avoid old approaches like billboards, walls, static poster etc. Furthermore, a moving vehicle can deliver ads more efficiently across the city, or city to city. This process will improve the promotion rate of content as well as the satisfaction of the client.

3. EXPERIMENTAL RESULTS AND DISCUSSIONS

Firstly, users have to login him/her self after opening the application as shown in Figure 2, if a user doesn't have an account then he may create first through signup functionality. After logging, the user can upload his desired ad as shown in Figure 3. Each Ad will be uploaded and will be saved separately into the database with a unique Ad_ID.

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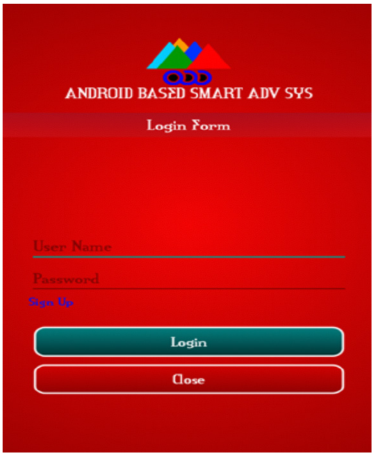

Figure 2. User Login and SignUp Panel Screen.

Figure 3. Advertisement Uploading Screen.

After uploading process, the admin will make sure each ad and its contents. If an ad is improper, the admin will disapprove it as shown in Figure 4. In results, a notification will be generated for modification in that particular ad to the client/ user.

Figure 4. Varification and Legalization Screen.

Moreover, in case of approval by the admin, it will be forward to the Raspberry Pi and be displayed on L.E.D screen as shown in Figure 5.

Figure 5. Smart Vehicle Advertisement on L.E.D Screen.

4. CONCLUSION

Internet Advertisement worths billions of dollars and growing rapidly in the current era, while the integration of IA with ITS needs further attention from researchers. In this research, we focused to introduce a novel architecture of an IoT advertisement which improves the implementation of ITS in smart cities.

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We expect that this work can impact researchers on this topic, as well as on the new product's development on the industrial scale. For future work, we will try to make proposed application hybrid; for e.g will develop for IOS users as well to remove platform barrier. Furthermore, in our future research, we will target different mediums of vehicles like (motorbikes, heavy trucks and cars) which could help us to increase the usability of this framework to be adopted.

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MASSIVE MIMO, MM WAVE AND 5G TECHNOLOGY INSIGHTS AND CHALLENGES

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ABSTRACT

The global broadband cellular demand is increasing exponentially resulting in a worldwide shortage of available bandwidths allocated for wireless transmission, leading to in–depth research being carried out in the underutilized Millimeter Wave (mmWave) bands which occupy the frequencies above 3GHz in the frequency spectrum. The 5G technology is evolving rapidly from the current 3G and 4G networks deployed worldwide, and the mmWave technology plays a vital role in the future 5G networks. Massive MIMO will be unprecedented during the design considerations when utilizing mmWave data streams with not only less complexity but will also enhance the spectral efficiency of the wireless system economically. This paper looks at the 5G revolution, its advantage over 4G, the incorporation between 5G and mmWave technologies, and MIMO antenna design considerations. It will also highlight the challenges facing the above technologies, and some new technologies such as Ultra Dense Networks (UDN), smart cities and Li–Fi which will incorporate mmWave, MIMO and 5G technology.

KEYWORDS

3GHz, Millimeter Wave, 3G, 4G, 5G, MIMO, UDN, Smart cities, Li–Fi.

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1. INTRODUCTION

The expeditious increase in the worldwide demand for high speed, secure, bi–directional and fully networked wireless communications has led forward vast research towards alternate frequencies in the spectrums. The limited bandwidth resources which are currently available are being exhausted due to the high Compound Annual Growth Rate (CAGR) of wireless traffic, and this has prompted research into the previously untapped high–frequency bands of 3GHz to 300GHz in the frequency spectrum as shown in Sharma (2013), also known as Millimeter Wave (mmWave) spectrum. This spectrum shares similar propagation characteristics and can be incorporated relatively easily with the wireless technologies currently deployed worldwide (Pi & Khan, 2012).

1.1. MMWAVE FREQUENCY ALLOCATION

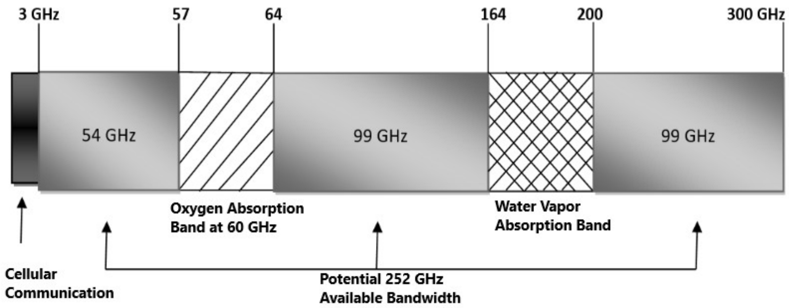

Figure 1. The frequency range of the mmWave (Pi & Khan, 2012).

The mmWave range within the frequency spectrum is between 3GHz to 300GHz, as illustrated in Figure 1. It is shown that the 57–64GHz band is limited to oxygen absorption and the 164–200GHz band is not suitable for propagation due to severe water vapor attenuation, with maximum losses at 180GHz. Therefore, only around 252GHz of the spectrum is available for mobile broadband communication (Federal Communications Commission, 1997). If it is assumed that only 40% of the mmWave spectrum is available for mobile broadband communication, it still provides more than 100 GHz of unused frequencies, which are about 200 times more than the current 4GHz frequency bands deployed worldwide (Pi & Khan, 2012).

1.2. (5G) DEPLOYMENT WORLDWIDE

Table 1. Frequency Allocations for Cellular Usage within different generations.

1G	
	800MHz
2G	
D AMPS	800MHz–1.9GHz
GSM	800MHz–1.9GHz
AS95 A/B	800MHz–1.9GHz
3G	
UMTS	2GHz
WCDMA	2GHz
CDMA2000	2GHz
4G	
LTE	1.8–2.5GHz
5G	
LTE	600 MHz–6 GHz
mmWave	24–86 GHz

As seen in Table 1, the current mobile networks which utilize their allotted radio frequencies to provide cellular services don't exceed 780MHz, and each provider has about 200MHz of spectrum available to them (Rappaport, *et al.*, 2013). This bandwidth is proving to be insufficient for the explosive traffic volumes, even for the most advanced 4G technologies.

To meet these unprecedented magnitudes in demands, 5G networks, which are still under research, are proving to be a promising solution and are expected to hit initial phases of commercialization by 2020, with global adoption by 2025 (Sharma, 2013). To reach the 5G design target, there are three paramount approaches: Ultra–dense Networks (UDN), large spectrum efficiency and increase bandwidth allocation. This is harnessed by mmWave incorporated with a large number of antennae, also referred to as mmWave massive Multiple Input Multiple Output (MIMO) antennae, to provide a wireless network with high speeds and smaller cell sizes to support not only the cellular demands, but also backhaul and Wi–Fi services (Rappaport, *et al.*, 2013).

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2. 5G EVOLUTION

Each new cellular generation, when compared to the previous generation, is an enhancement the system electronics, security, speed, frequency, data capacity and latency. This journey began with 1G, followed by 2G, 3G, the currently deployed 4G and the newly emerging 5G technologies. A new generation has appeared every ten years since 1981 and has followed its own evolutionary path towards achieving higher speeds and better performance, as the global market of mobile and wireless communication has increased exponentially.

The first generation (1G) used the analog transmission to fulfill basic mobile voice transmission. The 2G systems used digitally enhanced multiple access technologies such as TDMA (Time Division Multiple Access) and CDMA (Code Division Multiple Access) leading towards early data services and enhanced spectral efficiency, under the Enhanced Data for Global Evolution (EDGE) standard. However, the standards were found to differ globally, and a network was developed where the design standards would not differ and be independent of the technology platform. And hence 3G was implemented (Sharma, 2013; Swindlehurst, Ayanoglu, Heydari & Capolino, 2014).

In 3G, technologies such as Wideband Code Division Multiple Access (W–CDMA) and High–Speed Packet Access (HSPA) resulted in enhanced improvements within video and audio streaming capabilities (Rappaport, *et al.*, 2013) by supporting information transfer rate of at least 2Mbps.

3G was a family of standards working together to meet the IMT–2000 technical standards (Bangerter, Talwar, Arefi, & Stewart, 2014). Universal Terrestrial Mobile System (UMTS) was adopted in Europe, while the American 3G technology is named as cdma2000 (Hossain, 2013) and both were developed by the Third Generation Partnership Project (3GPP).

3GPP also developed the Long–Term Evolution (LTE) to offer a complete 4G capable mobile broadband and an upgrade to the existing 3G network. LTE uses Orthogonal Frequency–Division Multiplexing (OFDM) to support a transmission bandwidth of 20 MHz, while also supporting MIMO antenna arrays. These combined with dynamic channel allocation and channel–dependent scheduling allows for the utilization of propagation via multiple paths, in order to improve signal performance, spectral efficiency and diversity (Bangerter, Talwar, Arefi & Stewart, 2014).

The predicted increase in mobile broadband demands is up to a thousand fold by the year 2020, which has led to the motivation behind research in alternate spectrums beyond the 4G standard.

5G is the latest generation to be developing in the wireless revolution. It promises speeds of up to 10 Gbps, 100 times faster than 4G. It has low latency of 1 ms or less, and mobility with larger coverage areas. The higher data rates will allow services beyond cell phones, and base stations will provide the necessary bandwidth for office and home usage, which was not possible in previous generations (Rappaport, *et al.*, 2013).

3. 5G AND MMWAVE INCORPORATION

Currently, the 700 MHz to 2.6 GHz radio spectrum is highly saturated for all wireless applications, and the 5G mmWave technological advances will support the imminent congestion by providing at least 100GHz of bandwidth which is substantially greater and would allow 4G service providers to expand their channel bandwidths significantly.

The incorporation of 5G with the mmWave spectrum will also allow antennae with highly directional beam–forming at the base stations and mobile phones, lower infrastructure costs due to smaller base stations, longer battery life and provisions of uniform, uninterrupted and consistent connectivity.

This will be achieved with the usage of steerable antenna arrays as the mmWave spectrum will simultaneously support mobile communications as well as backhaul, and possibly allow for the convergence of both cellular and Wi–Fi services (Swindlehurst, *et al.*, 2014). The smaller wavelengths allow for physically smaller antenna arrays, which is discussed in detail in the following section.

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Recent developments into CMOS technology operating within the mmWave spectrum, as well as antennas that are steerable both at the base station as well as the mobile phone has further enhanced the operation of 5G within this spectrum (Gutierrez, Agarwall, Parrish & Rappaport, 2009). The smaller component sizes, about 40nm, allows them to be applicable in numerous areas such as radar transceiver and in chipsets employed in automotive and industrial applications.

The higher frequencies and bandwidth allocations in the mmWave spectrum allow for a significant increase in data transfers. This, in turn, reduces latency, which is invaluable for digital internet–based applications and access requiring minimal latency.

The mmWave spectral band results in smaller cell sizes as RF path loss increases with frequency. This increase can be overcome by the large beamforming gains obtained through massive antenna arrays, and simultaneously increase the coverage areas (Swindlehurst, *et al.*, 2014). Operating in smaller cells reduce the channel coherence time and allow higher channel coherence bandwidth and lower mobility. All these factors, as well as the smaller wavelengths and higher frequencies, resulting in a reduction in the antenna sizes and electronics, which are appealing for massive MIMO transceiver design (Swindlehurst, *et al.*, 2014).

As compared to the 4G networks in populous areas, mmWaves offer such a high jump in bandwidth that links between station–to–device, as well as backhaul, can be established wirelessly and would be capable to handle the larger traffic. Using smart, steerable antennas would allow the base station cost to be reduced as their numbers would increase in urban environments, thus increasing wireless backhaul even more achievable and necessary (Rappaport, *et al.*, 2013).

4. MASSIVE MIMO AND 5G

Millimeter–wave (mmWave) (30–300 GHz) Multiple–Input Multiple–Output (MIMO) with large antenna array, incorporating 5G technology, has been considered as a promising solution to meet the one thousand times increase in data traffic predicted in the near future (Marzetta, 2010). Besides providing larger bandwidth compared to the current 4G wireless communications, antenna arrays can now be packed into a smaller physical size due to the shorter wavelengths associated with mmWave frequencies. This means that the spectral efficiency can be improved considerably as MIMO with a large antenna array effectively compensate for the high path loss induced by high frequencies (Hossain, 2013).

To increase the diversity or the number of degrees of freedom in the wireless communication system, the usage of multiple antennas is essential. Compared to the conventional single antenna channels, a system with multiple transmits and receive antennas (MIMO) has higher spectral efficiency and higher bandwidth, as each pair of transmitting and receiving antennas will provide separate signal paths from the transmitter to receiver.

Reception reliability is therefore increased as signals carrying the same information are transmitted on different paths, and multiple independently faded replicas of the data symbols are received at the receiver (Zheng & Tse, 2003). Therefore, the probability that all signal symbols fade simultaneously reduces as the receiver receives multiple independently faded replicas of the same information symbol.

At higher frequencies, rain, foliage and atmospheric absorption are a serious impediment to mmWave mobile communication. The attenuation caused by rain and oxygen absorption is around 10–20 dB/km. These issues can be overcome when we consider that the cell sizes have been reduced to about 50–200m, especially at 28 GHz and 38 GHz, equating to about 1.4 dB over 200m (Rappaport, *et al.*, 2013; Gao, Dai, Mi, Wang, Imran & Shakir, 2015).

The primary imposing factor on the cell size in mmWave massive MIMO would be free space path loss. In smaller cells, this loss can limit intercell interference, and allow for greater frequency reuse.

In a wireless communication downlink system, the relationship between Transmitted Power (P_t), Received Power (P_r), Transmitted Gain (G_t) of entire transmit array and Received Gain (G_r) is given by

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$$P_r = \frac{P_t G_t G_r}{(4\pi r)^2 \lambda^2} \quad (1)$$

In reference to Eq. (1), the path loss is given by $(4\pi r)^2\lambda^2$, and is directly proportional to wavelength, λ, where r is the range (Zheng & Tse, 2003). A larger path loss value can be compensated by increasing the transmitted power, receiver sensitivity, antenna array gain and reducing channel noise. Hence, equipping massive antennas at macro and small–cell base–stations (BSs) can not only compensate for severe path loss whilst achieving larger coverage distances, but also improve signal directivity. Deploying antenna arrays with a large number of antennas will increase the antenna gain (Gao, *et al.*, 2018).

To achieve dramatic gains, MIMO envisions BSs with antennas numbering 100 or more, and this concept leads to massive MIMO. BSs with a very large number of antennas N_t, serve a group of single antenna co–channel users. It can be concluded that as N_t approaches infinity, where throughput and quantity of terminals are independent of cell size, the effects of uncorrelated noise and fast fading vanish and the spectral efficiency is independent of bandwidth, with the required transmitted energy per bit vanishes (Swindlehurst, *et al.*, 2014; Marzetta, 2010).

A larger N_t enables a substantial increase in capacity, but in reality causes interference problems which can be alleviated by using beamforming antennas as opposed to the conventional ones (Ali, Ismail, Nordin & Abdulah, 2017).

In MIMO, beamforming is a signal processing procedure where the radiated beam patterns of the antenna are produced by formulating the processed signal in the direction of the desired terminals while cancelling interfering signals. This enhances the energy efficiency, spectral efficiency while increasing system security (Jungnickel, *et al.*, 2014).

As the value of N_t increases, more orthogonal pilots are required for channel estimation, which is exhausting for the radio resources (Lu, Li, Swindlehurst, Ashikhmin & Zhang, 2014). As the number of independent pilot sequences is limited, they are reused between different cells and can cause conflicts in antenna arrays known as pilot contamination (Jungnickel, *et al.*, 2014). Pilot contamination in massive MIMO systems limits the spectral efficiency and increases with an increase in N_t.

It is assumed that as N_t increases, the user channels remain spatially uncorrelated and remain orthogonal with their respective pairs given proper propagation conditions. However, increasing the number of antennas cannot provide orthogonality in the highly correlated channels and user scheduling can render a problem and signal processing of higher complexity is needed to separate spatially correlated users (Ali, *et al.*, 2017).

5. APPLICATIONS OF 5G

As wireless access techniques are being deployed extensively due to the rapid convergence of computational technologies and information communication, 5G can no longer be constricted to conventional technical characteristics. 5G is a cloud of multiple technologies, a diverse system of air interfaces, frequency bands, protocols, network types and access node classes which are integrated to provide smart and customized services, ranging from medicine to smart cities and the more obvious cellular technologies. 5G should not be viewed as a solution to replacing the current 4G LTE systems, but the seamless and efficient utilization of advanced technologies and spectrum–usage schemes.

5.1. ULTRA–DENSE RADIO ACCESS NETWORKS

Ultra–Dense Radio Access Networks (UDRANETS) is seen as a promising system architecture to enable high traffic capacity over extremely reliable short–range links (Chávez–Santiago, *et al.*, 2015).

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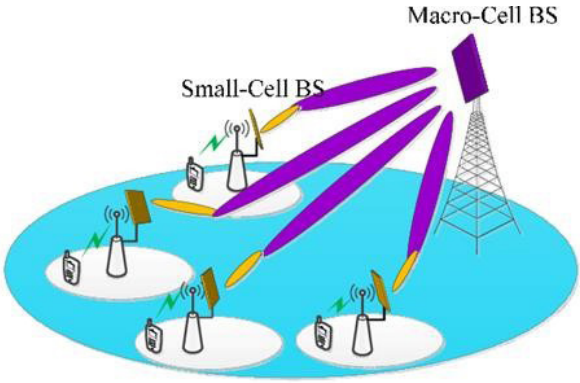

Figure 2. MmWave massive MIMMO based 5G UDN (Skouby & Lynggaard, 2014).

A macro–cell base station with large coverage areas is responsible for the user scheduling and resource allocation of high mobility users, while the various ultra–dense smaller BSs provide a very high data rate for low mobility users (Gao, *et al.*, 2015), as illustrated in Figure 2. The UDRANETS allow for better frequency reuse and improving energy efficiency and reduction in path loss. There is a possibility of completely wireless backhaul based on the mmWave massive MIMO in the future (Sulyman, *et al.*, 2014).

These cells do pose several problems, such as frequent handovers due to small cell sizes, higher energy consumption and backhaul, which will increase interference and mobility (Hao, Yan, Yu–Ngok & Yuan, 2016).

5.2. SMART CITIES AND 5G

The deployment of new ecosystems utilizing 5G technologies for the combination of smart cities and homes has huge potential, with a focus on compatibility with existing infrastructures to create sustainable and cost–efficient urban environments. This will provide multiple options in a smart city in areas of health care, green ecosystems and intelligent community services such as e–businesses, security surveillance, social networks, intelligent transportation, telemedicine, logistical management, Internet of things (IoT) and Cloud of Things (CoT), Artificial Intelligence (AI) just to name a few (Lynggaard & Skouby, 2015).

Smart homes are targeted towards enriching the living environment and improving the quality of life of its inhabitants. This targets the home automation area, where embedded devices such as light, heating, entertainment systems security are controlled remotely (Skouby & Lynggaard, 2014).

The wireless technologies such as Bluetooth, Radio Frequency Identification (RFID), ZigBee, Wireless Local Area Networks (WLANs), sensor networks along with fiber communication and cable networks form the basis of smart city infrastructures (Han, Ge, Wang, Kwak, Han & Liu, 2017). All these together with IoT produces a huge amount of information that needs to be securely stored for processing. Hence, the incorporation of CoT with rest of these technologies is crucial as it provides resources and calculation capabilities which are accessible via the internet and can store the IoT data efficiently.

There are various challenges that face the development of such ambitious technologies. The complexity of the movement of various mobile terminals increases and becomes more varied. The data transmission can be of a pedestrian with a cellular phone, a laptop device on a high–speed train or even a navigational device on a moving car. There are also various obstacles in a dense urban environment, especially in the mmWave spectrum.

The security and privacy of networks users pose a serious threat to the development of 5G technologies. Sensitive and personal information such as banking information would have to be shared on a cloud platform and could pose a threat of being disclosed to the wrong persons. This would require highly complex data security management with strong encryption and cryptographic tools to maintain network system confidentiality and also to identify vulnerabilities in networks that could serve as weak points for various attacks (Gao, *et al.*, 2015; Mehmood, *et al.*, 2017).

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5.3. LI–FI AND 5G

High–speed wireless data communication using infrared and visible light spectrum is being deployed and is predominantly known as Li–Fi. The concept of Visible Light Communication (VLC) is used to achieve bi–directional high–speed, secure and fully networked wireless communication.

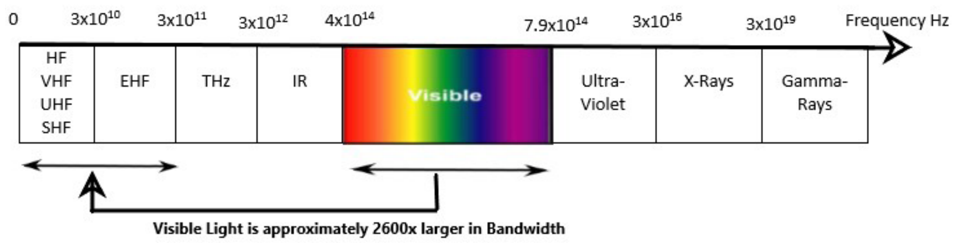

Figure 3. Comparison of the Radio Frequency (RF) Spectrum and the Visible Light Spectrum (Haas, 2018).

As illustrated in Figure 3, the bandwidth occupied by VLC is approximately 2600 times greater than the currently employed radio frequencies for wireless communication. The conventional VLC system was being conceived as a single point–to–point wireless communication between a LED source and a receiver that is equipped with a photodetection device. The data rates required to depend on digital modulation and lighting technology.

Adoption of wireless networks based on light as opposed to pointing to point links pose several challenges. As each cell can have several users, multiple access schemes are required. Uplink provisions can be the difference from downlink ones, as the portable device requires lower energy consumption, and the user is not likely to be distracted by the visible light source (Swindlehurst, *et al.*, 2014), and therefore infrared spectrum is the most desirable for uplink (Bangerter, *et al.*, 2014).

The high–speed uplink requires its modulation to be both power and spectrum efficient simultaneously. Handovers will be complicated as connectivity needs to be maintained as a user leaves a certain premise for an area without any Li–Fi coverage (Ayyash, *et al.*, 2016).

However, the incorporation between Wi–Fi and Li–Fi proves promising and it is a possibility for the two of them to co–exist. It will allow for off–loading opportunities for the Wi–Fi network as immobile users would be utilizing the Li–Fi technology. With this collaboration, the total number of users can more than triple, and throughput can increase exponentially, by enhancing indoor coverage and providing high data rates.

6. CONCLUSION

To achieve dramatic demands that wireless technologies will need in terms of capacity and spectral efficiency, 5G systems embracing mmWave spectrum from 3300GHz is promising. It promises high speed, low latency amongst other advantages, and would meet the predicted demands that 4G networks will meet by 2020. It will result in smaller cell sizes, and wireless backhauls to be implemented. Higher spectrums allow for utilization of highly directional antennas to be packed into larger arrays with smaller physical sizes. This is appealing for the massive MIMO transceiver design. To reduce the path loss mmWaves experience, increasing the number of antennas can lead to high capacity, but also high interference. Signal analysis complexity increases, and results in pilot contamination.

The Ultra–Dense Radio Access Networks (UDRANETS) is a system architecture to meet high traffic and handle large capacity. 5G technologies are being deployed in smart cities, embracing IoT and CoT technologies. This would meet some challenges such as data security, privacy and an increase in overall signal analysis complexity.

Li–Fi would be a promising solution as it would be able to integrate with Wi–Fi and increase the capacity, while also enhancing indoor and outdoor coverage.

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NOVEL DESIGN AND MODELING OF SHUTTER VALVES FOR CAMLESS ENGINES

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ABSTRACT

For the intake of air fuel mixture and exhaust of gases camshaft operated valves are mounted on the cylinder head. In this paper, we have proposed a novel physical model of a shutter valve to replace the traditional camshaft operated valve resulting in a camless four–stroke engine. The lift control for the opening and closing of the intake and exhaust valves are monitored traditionally by a camshaft which is a mechanical component having a fixed shape. A camless engine replaces the camshaft by allowing the control of valves through the Electronic Control Unit (ECU). The already developed valves have limitations in terms of lift, life expectancy or higher costs. This research work proposes a novel shutter valve design instead of a poppet valve for intake and exhaust of four–stroke engines. These valves are then operated directly by an ECU and controlled through pulse width modulation. The proposed variation in shutter valve design optimally adjusts and controls the fuel intake amount and the flow of exhaust gases in and out of the cylinder respectively. The opening of the valve can be set to maximum or at the desired angle so that the engine can run according to the driver's requirement. The novel design of the shutter valve will reduce the engine cost and will improve the fuel economy. At the same time, providing complete control to the driver's performance preferences.

KEYWORDS

Camless engine, Camshaft engine, Four–stroke engine, Shutter valve, Poppet valve.

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1. INTRODUCTION

The basic concept of an engine is to convert one form of energy into mechanical energy and use that energy to do work. There are different types of engines available but in this work, the focus will be given to four–stroke engines and their performance factors. Since the invention of engines, society has upgraded a lot of its norms. These engines are used in various types of transport models like aircraft, ships, trains and road vehicles. For each of these types, the engine is modified accordingly. Different vehicles are suitable for different ranges of torque to be produced. The engine is built according to the environment where it is to be used. Either a large load is to be carried along which requires heavy torque based engines or quick mode of transportation is the key focus. In the latter case, high speed producing engines are required such as in racecars. There are cases where engines with both power and speed play a vital role. The vehicles have become the most important part of our socio–economical activities which either run on petrol, diesel or other forms of non–renewable fuels. The increasing number of vehicles on road is stressing the non–renewable fuel resources as there hasn't been any major discovery since last two decades and reserves are depleting quickly. On the other side, burning the fuels produce pollutants which are destroying the environment. To overcome these issues, the researchers are working on different alternatives to power up the engines by making internal and external design changes for economical purposes and reducing carbon emission at the same time.

The already developed valves have limitations in terms of lift, life expectancy or higher costs. This research work proposes a novel shutter valve design instead of a poppet valve for intake and exhaust of four–stroke engines. These valves are then operated directly by an ECU and controlled through pulse width modulation. In this paper, we are proposing the design variations in shutter valve to optimally adjust and control the fuel intake amount and the flow of exhaust gases in and out of the cylinder respectively. The opening of the valve can be set to maximum or at the desired angle so that the engine can run according to the driver's requirement.

The valid scope of this research is to replace the traditionally used camshaft based poppet valves with a suitable model of a shutter valve which eliminates the requirement of a cam. The intention of the model designed is to increase the overall economy of the engines and to reduce the rate of production of exhaust gases by controlling the amount of fuel to be burnt.

The remainder of the paper is organized as under; in Section 2 a technical comparison between the cam and camless engine is made. The working of IC engine is discussed thoroughly. In response to existing poppet valve, the novel prospect of shutter valve is discussed in Section 3. In Section 4, a novel model of shutter valve for camless engines is proposed, designed and modelled. Section 5 concludes the paper and highlights future research potential.

2. CAM VS CAMLESS ENGINES

According to Heywood (1988), the working of an internal combustion engine requires a proper balance of air and fuel intake and with that, proper timings are required to allow the mixture to flow in the engine and the waste gases to flow out of the engine. The general structure of the IC engine is shown in Figure 1. According to Roan (1959), in this era, most of the vehicles are equipped with a mechanical overhead camshaft. According to Siewert (1971), the idea of varying the valve timing in a spark ignition engine for improved performance, better fuel economy, improved power, improved turbocharging, efficient emission control and other performance factors are under consideration since last century. The most basic type of internal combustion (IC) engines is four stroke engines. The piston covers four stages called strokes to cover a complete cycle. The movement of the piston from TDC (top dead center) to BDC (bottom dead center) or vice versa is called a stroke. These stokes are named as intake, compression, power and exhaust respectively.

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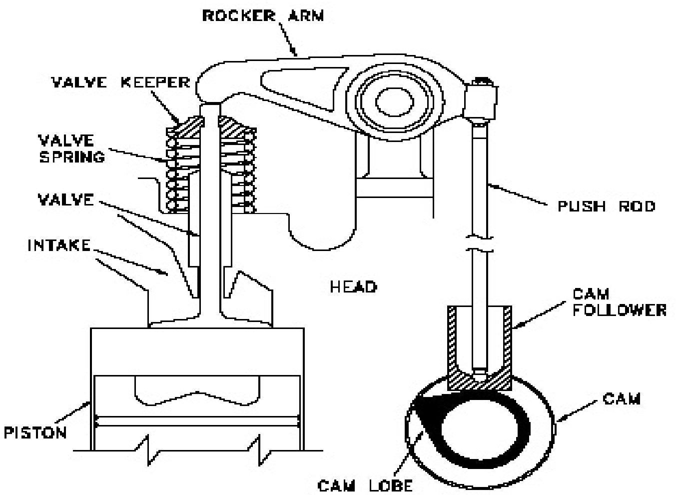

Figure 1. General structure of the IC engine.

In this paper, we have concentrated on the intake and exhaust stroke. In an IC engine, the intake of the fuel mixture and the exhaust of the different gases from the cylinder are controlled by the intake and exhaust valves respectively. The cylinder head has an intake opening and an exhaust opening so that the flow of the fluids can enter or leave the cylinder that is before and after the combustion process for a required cycle. In a particular cycle, both valves operate only once. As the cycle begins, the intake valve opens up that is in the first stroke and at the end of the cycle, at the last stoke, the exhaust valve opens up in order to release the exhaust gases.

Traditionally, the types of valves used are the poppet valves. These valves are operated by a camshaft which is a mechanical component having a fixed shape of lobes. The cam operates the pushrod or lifter which operates the rocker arm in order to control the opening and the closing of the valves as shown in Figure 2. One of the drawbacks of a cam is that the timing of the valves remains fixed for a predetermined driving functionality. The duration of the opening and the closing of the intake and exhaust valves are constant and depend on the shape of the camshaft lobe. At increased revolutions per minute (RPM), the engine requires a higher amount of air–fuel mixture to pass through the intake valve. Due to the fixed period of time for the opening of the intake valves, the air–fuel mixture can blow out of the cylinder and return to the intake manifold thus creating a state of blowback.

Though a mechanism known as variable valve timing does change the timing according to the ignition requirements in an Engine Control Unit (ECU) based engines that is again for limited performance ranges. In a camless engine, the cam, pushrod/lifter and rocker arm are removed. These alterations not only reduce the size and the weight of the engine but also offer flexible synchronization of valve operation at particular RPM. The valves in a camless engine are directly controlled by the ECU which eliminates the need for a timing belt to synchronize the opening and the closing of the valves with the strokes of the pistons.

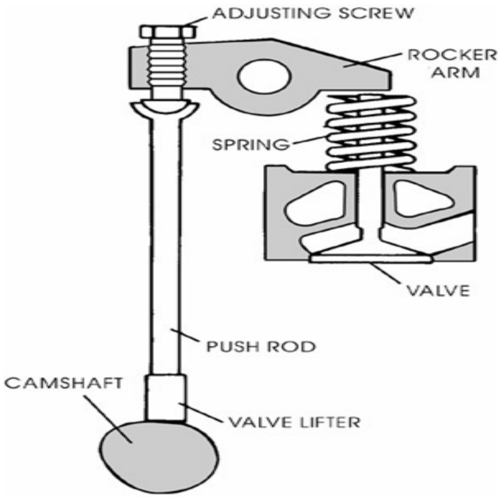

Figure 2. Operation of a Poppet value through a cam.

The concept of the camless engine valvetrain system has been revolving since over the last decade. Though the potential has not yet met the high–performance criteria. According to Postrioti, Battistoni, Foschini and Flora (2009) as compared to conventional RPM ranges, the range was limited to much lower RPM values. The valves in a camless engine are controlled electronically through the signals from the ECU and a required control circuit according to the valve's design. These values can be remapped by mapping the ECU or by altering the programming of the control circuit. A camless engine thus becomes more suitable and efficient as compared to the camshaft based engine. It also becomes more economical due

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to the reduction in the size and weight of the engine. With the reduction in size, as the engine bay is reduced in height, the overall dynamics of the vehicle can be improved which results in faster accelerations. Other than this, the added cost of the mechanical components is reduced which improves the manufacturing cost.

3. SHUTTER VALVES VS POPPET VALVES

Current research in the field of camless engines is focused upon poppet valves. They have controlled either through electro–hydraulic (Nam, Cho, Park, & Choi, 2017), electro–pneumatic or electro–magnetic circuits (Chen, Chang & Fan, 2019). The authors Tai, Stubbs and Tsao (2001) have developed electromagnetic valves by using grey box approach through which system identification and mathematical modelling was performed. The study states experimental results for the quiet seating issue of the valves. They further recorded the error and timing of the valves through feedback. As an extension of Tai, *et al.*, (2001), the authors Gillella and Sun (2011) have developed an improved version of a camless–valve actuation system which included an internal feedback system to monitor the working and the timings of the valves.

Current work has been carried out on camless engines using solenoid valves (Liu & Chang, 2011) but still, there is a dire need to further work on the lifting and the proper closing of the valves (Anderson, Tsao & Levin 1998). The other replacement of the mechanical camshaft available in the literature is the electro–hydraulic valve system (Sun & Kuo, 2010). This system has limits in terms of practical implementation at low RPM. According to Haas (2010), an electro–hydraulic valve system (EHVS) based control system was developed which utilizes the fixed volume of oil for the lift of the valves which limits the maximum valve lift as compared to the cam profile. The intended research controls the valves through electromagnetic circuit. The poppet valves have their limitations in terms of use. They have limited lift which matters especially at higher RPMs. The lift is an essential factor while considering the efficiency and the power output of an engine. Due to limited lift, at higher RPMs, the required fuel mixture does not reach the cylinder thus resulting in low engine performance. In the designed shutter valve, the lift factor isn't involved. Instead of the lift factor, the shutter valves open radially which can be adjusted using a different number of blades in a shutter valve. Another factor such as the heavy springs used in the poppet valves in order to keep the valves properly closed at high pressures, produce a delay in the lift's response time and also results in a higher resistance when it comes to operating them at the precise moment. This process is detailed in Figure 3.

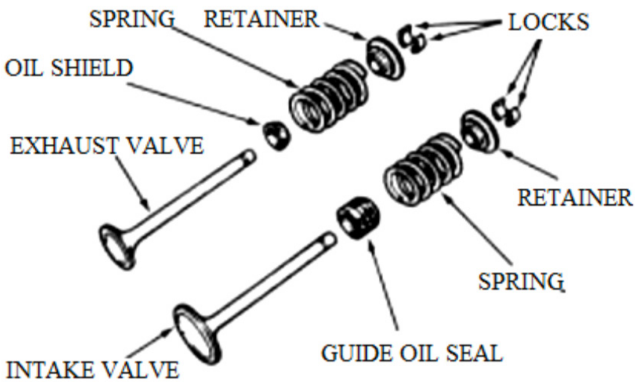

Figure 3. Components of Poppet valves.

Poppet valves in a cam based engine can easily be operated as the driving force is a heavy mechanical component but when it comes to an electronically controlled engine, these can only be when provided with a high–power supply. The shutter valves operate on a simple mechanism which eliminates the use of heavy springs thus clearing the error of a delay factor and the loss of power from the crankshaft which results in an efficient system of control. When using the poppet valves, the pistons are affected by cavities which form over time as the engine is used. The cavity thus results in a dimpled interior within the combustion chamber. Due to these cavities, uneven flame propagation takes place. As the cavities increase in depth, some air–fuel mixture is left unburnt leaving the car run rich and results in uneconomic fuel combustion. This also results in the loss of energy which results in the lower performance of the engine.

In the proposed shutter valve, cavities will not be formed due to the mode of operation and the shape of the shutter valve. This will eliminate the drawbacks

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of loss of energy, engine running rich and out of order. Other than these factors, poppet valves take up more space in an engine bay and increase the weight of the engine as compared to shutter valves. Both of these factors reduce the efficiency of the engine. By further reducing the size of the engine, the vehicle's aerodynamics can be enhanced which results in an increase in the performance of the vehicle. The efficiency is also increased by the reduction in weight due to the poppet valves and the required components to operate them. This will slightly reduce the production cost of the engine. The electromagnetic valves based camless engines were modelled but were limited in terms of lifting and the proper closing of the valves (Lino, *et al.*, 2016). Though improvements have been made since the introduction of this method still there is a lot of work required to reach the optimum results. An engine based on electro–pneumatic valves was designed and nowadays it is in use for testing purpose. As per observations of various researchers, the valves are expensive and there are lots of chances of fluid leakage at higher RPM but these observations need proper verification and experimental setups to validate.

The purpose of this research is to propose a novel approach towards the camless engines. For this purpose, the diaphragm shutters are used as shutter valves. These shutter valves will reduce the loses carried out by the previous systems, by reducing the use of noisy components and the risk of wear and expensive maintenance. The implemented model of shutter valves will allow the separate monitoring and easy tuning which eliminates the hectic process of altering the camshaft of an engine.

4. THE PROPOSED NOVEL DESIGN OF SHUTTER VALVE

Figure 4 is the novel proposed design of shutter valve's front view. The valve consists of two circular disks, 6 blades in between which interlock with each other, and a slider to operate the blades.

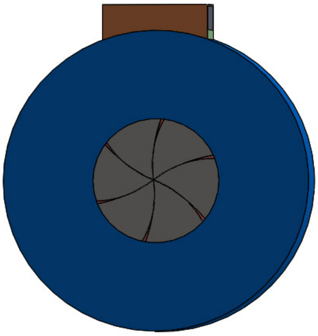

Figure 4. The proposed novel design of shutter valve.

The interlocking mechanism is present so that the blades may not get bent out of shape when affected by heavy pressures. At the instance of combustion, the pressure in the cylinder rises. In the shutter valve, as compared to the poppet valve, the spring is not required for the linear operation of the valve. The pressure developed during the power stroke, it is necessary for the intake valves to remain closed as well as during the compression and the exhaust stroke. On the other hand, the exhaust valves sustain high pressures during the compression and the power stoke. So, this shape of the shutter valves keeps the blades in fixed shape and remains tightly closed. This is shown in Figure 5.

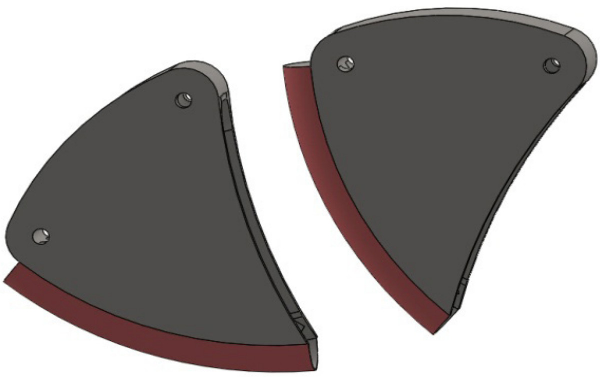

Figure 5. Interlocking blades of shutter valve.

In a normal state, when the engine is powered off, the valves remain closed. The bar on the shutter valve assists the opening and closing of the valve. The ECU monitors the position of each of the pistons separately by using the crankcase

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sensor which regulates the voltage signal and is transmitted to the control circuit. When the control circuit signal is activated due to defined pulse timing, the magnetic contact becomes energized and attracts the rod towards itself as shown in Figure 6.

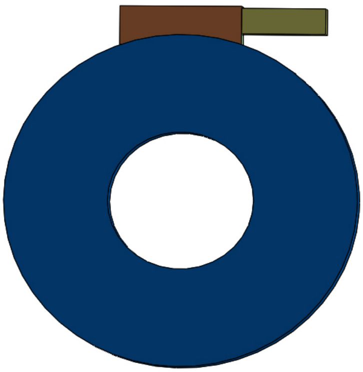

Figure 6. Opening of shutter valve during the high state of the control circuit.

When the contact is closed, the operating bar rotates the slider. As the slider rotates, the blades rotate allowing them to open up or close. This operation is carried out separately for allowing either the air–fuel mixture to enter the cylinder or the exhaust gases to leave the cylinder. For both the intake and the exhaust operations, different configuration of the control circuit is required in order to adjust the operating cycle of the shutter valves. The shutter valves are enclosed within the casing structure through which the blades cooling mechanism is achieved. At high temperatures, the blades will get deformed and to avoid that both the material and the cooling of the blades is essential.

Another feature of these shutter valves is that the performance output is adjustable. Depending on the drive requirements, the opening and closing diameter of the shutter valves can be adjusted. There are different levels upon which the operating contact of the control circuit is tuned. Potentially there can be different positions of operating contact ranging from nearest to farthest. Fixing the contact at the farthest end will result in the complete opening of the valve and adjusting it to the nearest operating end will result in a narrow opening of the intake shutter valve. The unburnt fuel will return in the tank to be utilized in the next cycle. Through the change in the opening, the working of the engine will either produce an economic run or a power drive. On the operating bar of the shutter valves, a spring is mounted as shown in Figure 7.

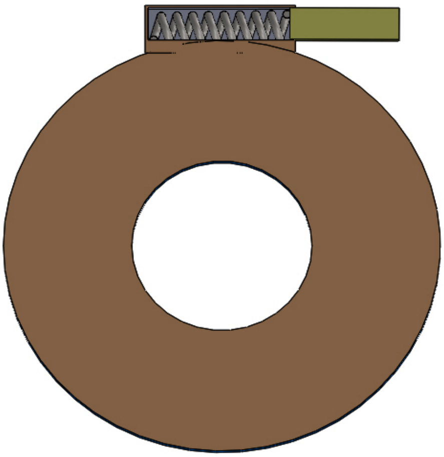

Figure 7. Cross–sectional view of shutter valve during blades opening.

The functionality of the spring is to keep the valves closed at all times and assist in the closing of the valve once the control circuit switches from on state to an off state. Normally when a magnetic circuit switches to the off state, there is a delay time due to the demagnetizing factor of the attracting metals. The purpose of this spring is to reduce the delay time and allow fast and easy switching of the shutter valves. This proposed design alteration of shutter valves will save the vehicles fuel consumption, resulting in a more economical model. This economy lends a hand in reducing the nitrogen oxide emissions (NOx).

5. CONCLUSION

Camless engines are emerging research area and its true potential is yet to be explored in the field of automobiles. In this paper, the existing camless engines are thoroughly studied. On the detailed study, a novel model of shutter valve for camless engines is proposed, designed and modeled for fuel efficiency, light weight, cost efficiency, variable valve control, aerodynamics and environmental friendly by reducing NOx emission. The proposed shutter valve is easy and maintainable and allows the industries to adapt without any hectic processes or heavy upgrades.

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The modeled design of shutter valve based camless engines will revolutionize the automobile industry by opening the gates of the novel concept of hybrid economical sports cars. This can be a new venture for automobile industries to explore, invest and produce a high grossing production line of futuristic vehicles.

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RESIDENTIAL COMMUNITY MICRO GRID LOAD SCHEDULING AND MANAGEMENT SYSTEM USING COOPERATIVE GAME THEORY

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ABSTRACT

This paper proposes a residential community based microgrid using cooperative game theory to share excessive energy within a community's neighbor homes for optimal load scheduling and management. The proposed model is a grid connected residential community where smart homes are connected through central energy management system (EMS) to share the benefits of excessive distributed energy resources (DERs) from solar PV or wind turbine by selling to other community residents at a price lower than the utility gird but higher than the feed–in tariff. The community smart homes are categorized as Externally Importing Homes, Internally Exporting Homes and Externally Exporting Homes which are further classified as passive consumers, active prosumers and proactive prosumers based on the facilities they possess in form of DERs and battery storage (BS). With the cooperative energy transaction mechanism, the smart community homes after fulfilling their own load requirements can place the excessive energy on community poll using decentralized or centralized approach through peer to peer trading or smart community manager (SCM) respectively. The excessive energy can be sold or purchased to and from other community homes as per some defined preferences and priorities. This will benefit the entire community in terms of cost compared to the utility grid's Time of Use (ToU) pricing. Proposed system will not only share, schedule and manage the community load optimally but will reduce the overall energy cost, system operational stress, improves system operational efficiency and reduces carbon emission.

KEYWORDS

Residential Microgrid, Distributed Energy Resources, Cooperative Game Theory, Load Scheduling, Energy Management System.

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1. INTRODUCTION

Considering the scarcity of conventional energy sources, increasing environmental carbon emission and requirement of improved operational efficiency needs diverse, and smarter solutions for meeting energy efficiency and conservations at the same time (Halepoto, Uqaili, & Chowdhry, 2014). Residential sector contributes almost one third share of energy consumption (Sahito, *et al.*, 2015) and unfortunately this sector mostly relies on conventional energy sources. There is a strong need to shift the residential load by utilizing small DERs to minimize the concerns about polluted carbon emission and to meet the ever–growing energy requirements and operational stability (Basu, Chowdhury, Chowdhury & Paul, 2011). Recently, the electric power industry has seen the acceleration in DERs installation and utilization. Microgrids are the most complex and dynamic form of DERs. A microgrid is setup by integrating the interconnected electric loads and DERs acting as a single controllable entity with respect to the grid (Planas, Gil–de–Muro, Andreu, Kortabarria & de Alegría, 2013). In recent years, microgrids have evolved from a growing concept to a significant source of opportunity however it is still in the developing phase as there isn't one–size–fits–in all microgrid development system. In the microgrid industry, the immense focus has been given to the institutional campus, commercial or industrial segments, but now there is a growing trend to expand these applications to serve broader needs. Residential communities can serve this purpose as it is broadly accepted that the electric utility future is only sustainable and reliable with resilient communities to supplement the existing energy infrastructure with microgrids.

Since DERs are internment in nature and their availability is subject to natural concerns and climatically variations, these resources must be operated in a coordinated manner. For the interactive operation of DER in a coordinated approach, the introduction of multi–agent system (MAS) can provide hierarchical control architecture for the optimization of resources and to avoid any operational uncertainty (Halepoto, Sahito, Uqaili, Chowdhry & Riaz, 2015). This can framework an efficient load sharing, load scheduling and EMS especially for residential sector by developing a community based residential microgrid where each resident is cooperative with each other in game theory concept. In a game theory, instead of each user utilizing the DERs individually for its own load usage and management, a better approach can be to use DERs as cooperative load management scheme (Parisio, Wiezorek, Kyntäjä, Elo, Strunz & Johansson, 2017). The community microgrid can potentially serve the needs of both community residents and utility grids by selling or purchasing the excess amount of energy optimally, as every residential community home consumer can be a prosumer (producer and consumer) at the same time.

The reminder of paper is organized as follows. In section 2 a residential smart home system model is proposed and discussed being the mandatory requirement of community microgrid. A residential smart home community based microgrid developed in Section 3 which categorizes three types of community homes on base of facilities they possess. In Section 4 a cooperative game theory based energy management system for community microgrid is proposed using EMS. A prosumer–centric residential community microgrid system using decentralized and centralized design is proposed and analyzed in Section 5. Section 6 concludes the work and point to the future work directions.

2. RESIDENTIAL SMART HOME SYSTEM MODEL

The residential community microgrid is strongly dependent on residential smart home system (RSH) as proposed in Figure 1. The smart homes are utility grid connected and are equipped with RESs (PV solar system, and wind turbine), solar charge controller, wind charge controller; advance metering infrastructure (AMI) based smart meter, energy scheduling unit (ESU), energy management controller (EMC), DC/AC inverters, battery storage (BS) and home appliances. Through smart meter, not only the bi–directional communication between utility grid and consumers can be established but the consumer can get real time information about load demand, energy consumption data and electricity prices especially ToU pricing. The solar PV system generates the electricity in DC form which is then converted into AC form via DC/AC converter. The BS is utilized for both

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source and sink purpose to store DERs produced energy. The ESU is responsible to generate and schedule the appliance energy consumption data and send the scheduling patterns to the EMC. According to the generated schedules by ESU, the EMC controls the BS and appliance's operation.

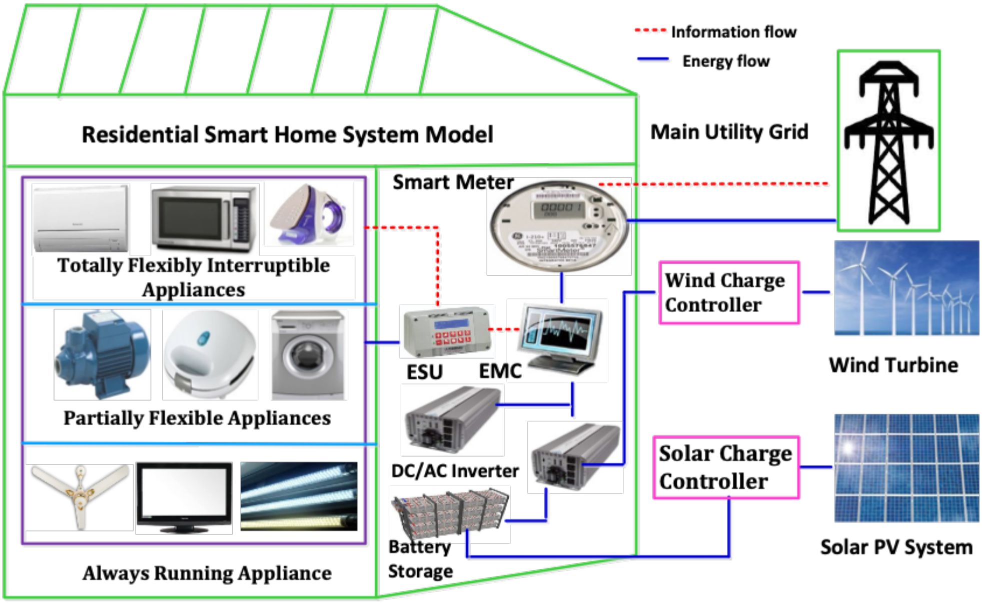
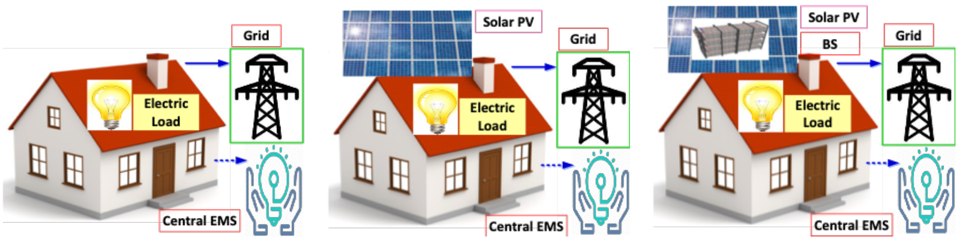


Figure 1. Residential Smart Home System Model.

The home appliances are categorized into three types by end consumers according to schedulability, flexibility and interruptibility; (i) Partially Flexible Appliances (PFA), (ii) Totally Flexibly Interruptible Appliances (TFA), (iii) Always Running Appliances (ARA). With PFA, the consumers are partially flexible to shift or schedule the appliances load to another time slots. The starting and finishing time slots are defined already with mostly one hour time interval. Once any appliance is started, it will complete the one hour operating time slot; after that, the consumer will follow the utility request to schedule or curtail the load for next time slot. With TFA, as per defined agreement between the utility and consumers, the end consumer must cutoff, curtail or schedule the electric load as per utility request at any time. The ARA is most inflexible type as the consumer's home appliances are not non–interruptible, non–deferrable and non–shiftable. These types of appliance are always run type of appliances.

3. RESIDENTIAL COMMUNITY HOMES BASED MICROGRID

This paper aims to model a residential community based microgrid to generate, utilize and serve multiple residential home prosumers in cooperate way to share or sell excessive DERs energy to the other community residents or even to main grid at a price lower than the utility gird's price but higher than the feed–in tariff. The community homes are grid connected and are classified into three types; Externally Importing Homes, Internally Exporting Homes and Externally Exporting Homes . The considered model homes and their parameters are shown in Figure 2.



(a) **Externally Importing Home** (b) **Internally Exporting Home** (c) **Externally Exporting Home**

Figure 2. The different types of homes in a community microgrid.

Externally Importing Homes: The residents of does not possess any DERs (either cannot afford DERs or not willing to install) and are totally dependent to utility grid supply and on community homes which one offers low electricity prices. Such residents are a greedy and passive consumer whose only focus is low electricity prices, even not on the energy availability.

Internally Exporting Homes: The residents of are active prosumers. They have DERs installed to meet their energy demands but they do not possess any battery storage. After meeting their energy demands, the owners become part of residential community through a SCM to sell excessive energy to their neighbor homes especially to external importing homes on priority. In case, the neighboring homes do not require energy at that time since these homes do not have any backup battery system, they try to sell energy to the grid rather than wasting it.

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Externally Exporting Homes: The residents of are proactive prosumers. These are ideal community homes possessing both the DERs and BS. Such homes after filling their own energy requirements store the additionally available energy through BS. After that, they try to share or sell the excessive energy to the neighbors especially to through the smart community manager.

As externally importing homes are without DERs so they always need energy either to be purchased from the utility grid or from other community homes, depending which one is offering lowest prices. The offered price from utility will base on ToU price, so for case of high peak price periods, they can purchase energy form community homes through SCM using cooperative game theory. Being the part of community microgrid, they may get the energy at a price lower than the utility gird price but still higher than the feed–in tariff. On the other hand, the internally exporting homes will put their excessive energy into community poll for sell through the SCM at a very low feed–in tariff during the day. Since such homes do not have BS, so during nights they may also need to purchase the energy either from externally exporting homes or from the utility grids depending on the ToU pricing periods. As a special case, since externally exporting homes have both DERs and BS, so they can easily store the energy which can be utilized during nights. Even with storage, if they sell out the stored energy to community homes at some earlier time of the day, they may also face power shortage during night's occasionally.

4. COOPERATIVE GAME THEORY BASED ENERGY MANAGEMENT SYSTEM

Game theory is a multi–agent based concept where different autonomous rational players interact with each other for mutual benefits (Nguyen, Kling & Ribeiro, 2013). This game theory concept can be very effective to energy related applications especially in community based micro grids for optimizing the energy resources (Mei, Chen, Wang & Kirtley, 2019). The game theory is classified into cooperative and non–cooperative game theory (Stevanoni, Grève, Vallée &

Deblecker, 2019). In non–cooperative game theory, different players which are the part of the system, partially interact with each other to achieve their own individual objective(s) which can be contradictory to overall system objectives. On the other hand, cooperative game theory is based on a coalitional game theory, where all the set of players are always ready to cooperate, coordinate and communicate with each other without any conflict of interests to achieve one common goal. Figure 3 illustrate the community based microgrid configuration connectivity of different homes using EMS.

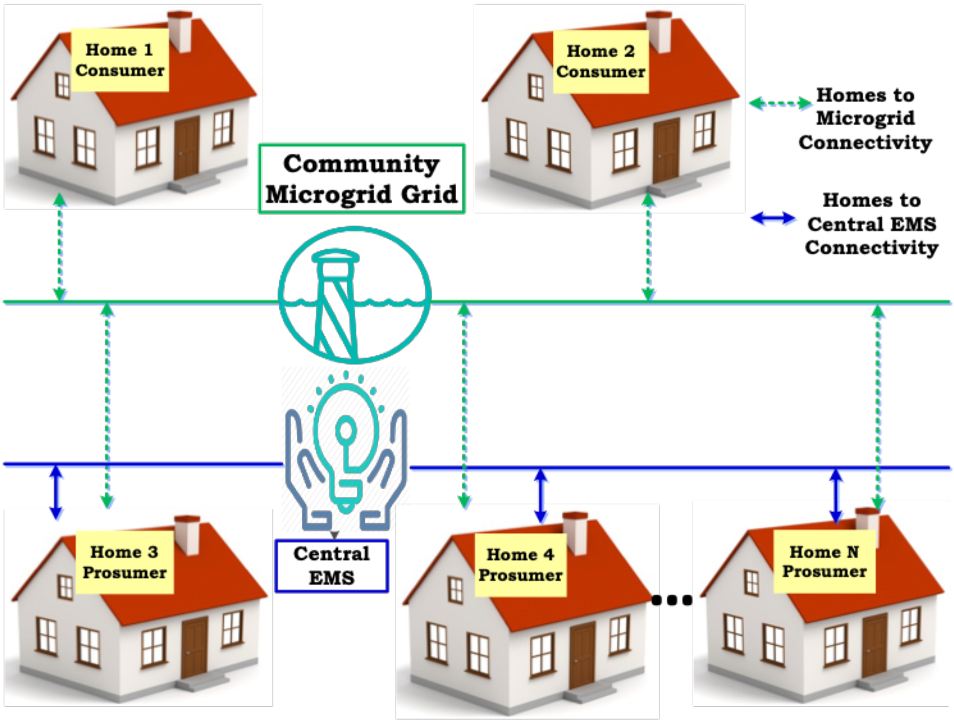

Figure 3. Residential Community Microgrid Connectivity Configuration using central EMS.

The prime objective of cooperative game in a community microgrid is to schedule and optimize the electricity load requirements within the community smart homes. Being the prosumer, the locally generated electricity from DERs is used by homes to fill their load demands and after meeting the requirements the excess energy is either sold back to the community resident or to utility grid. Although this is an attractive solution for both utility and community prosumers, this can be more effective if managed optimally through community microgrid

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manager using MAS to develop the communication at different layers. Figure 4 shows the MAS configuration for a central EMS which comprises of three communication levels; primary, secondary, and tertiary EMS.

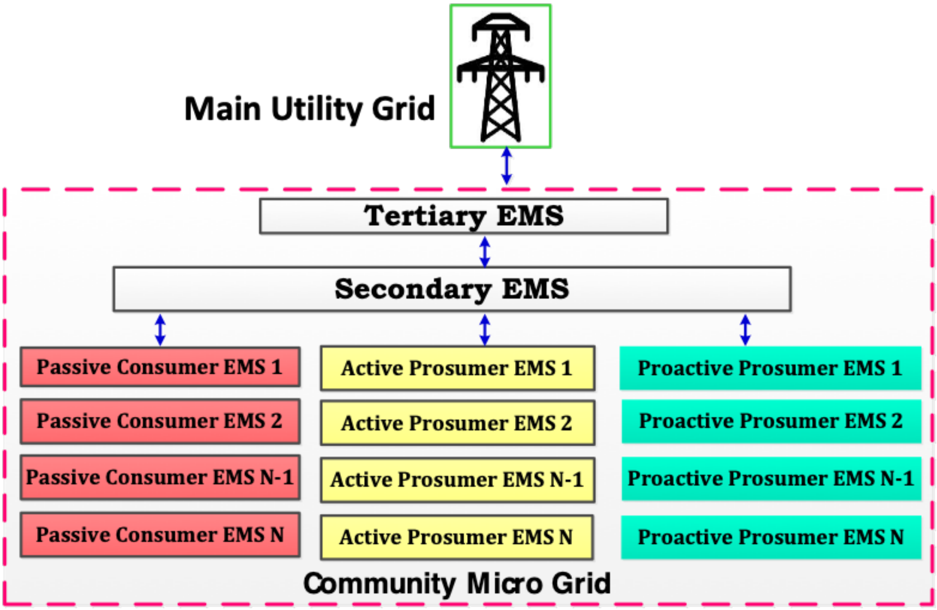

Figure 4. MAS Configuration for a central EMS in Community Microgrid.

The community smart homes are considered as the primary EMSs. At the primary level, every smart community home having its own EMS, communicates its ongoing energy status with the secondary EMS, which on receiving the information shares the energy status and places an excess amount of energy on community poll for other community homes less than the utility grid's prices according to priorities defined by community homes for sell or purchase. Finally, the tertiary EMS being the overall decision maker, based on secondary EMS information, accumulates the overall energy status and decide(s) for buying or selling energy to and from the utility grid.

5. PROPOSED PROSUMER–CENTRIC RESIDENTIAL COMMUNITY MICROGRID

In this paper, we have proposed two stage prosumer–centric residential cooperative community microgrid; decentralized cooperative community microgrid design and centralized cooperative community microgrid design. We have molded six community homes, two from each category being passive consumer, active prosumer and proactive prosumers.

Decentralized Cooperative Community Microgrid Design: This is a decentralized or distributed agent based design approach where the community homes' residents can directly negotiate with each other in form of grouping or peer to peer (P2P) to make energy transactions (selling or purchasing) without involving any centralized supervisory mechanism like smart community manager, as shown in Figure 5.

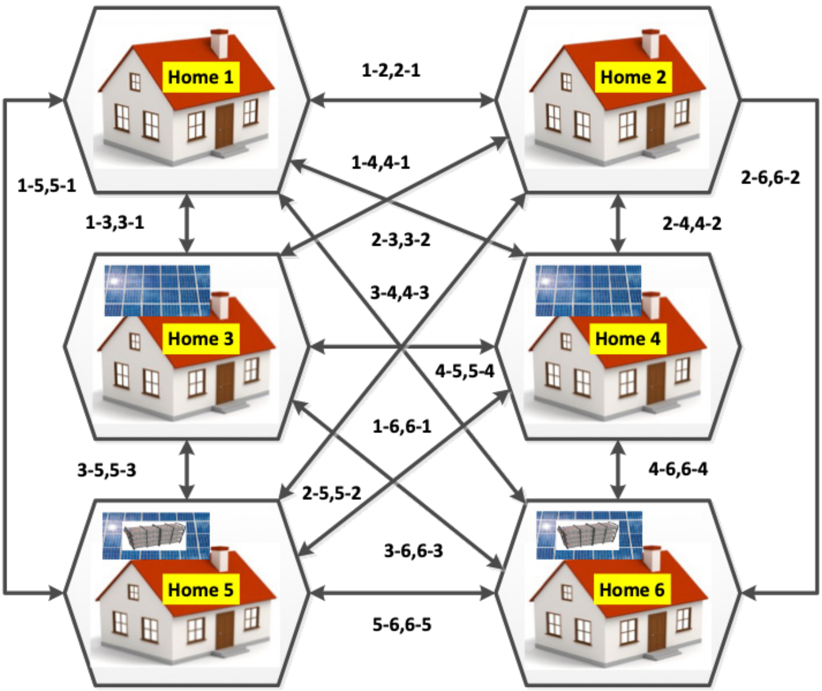

Figure 5. Decentralized Cooperative Community Microgrid Design.

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Figure 5 illustrates all the possible combination of P2P trading patterns between all community homes. The trading patterns are shown vice versa form where everyone can trade (sell or purchase) with other one. The information is only shared to those community homes that are willing to trade the energy (sell or purchase) in P2P form. The price of energy transaction is kept in secrecy. Figure 6 illustrates the model example microgrid consisting of 6 community homes trading in P2P. The peers 1 and 2 are passive consumers; peers 3 and 4 are active prosumers while peers 5 and 6 are proactive prosumers. For the illustration purpose we have chosen prosumer 3 is one community home which has some excessive amount of energy. Since it equipped only with DERs but does not possess ant battery back, so he desperately wants to sell the excessive energy. Since this is a decentralized approach so community home by itself tries to find out the target homes. This example illustration of prosumer 3 is shown in Figure 6. Consumers have prosumers as energy transaction trading partners and while prosumers have both consumers and producers as trading partners. Considering the negotiation process, the pricing priorities for bilateral trade can be defined and may vary accordingly for trade between the peers. Considering the prosumer 3 case scenario, the bilateral trading between four prosumers can be made by using reciprocity property as shown in Figure 6.

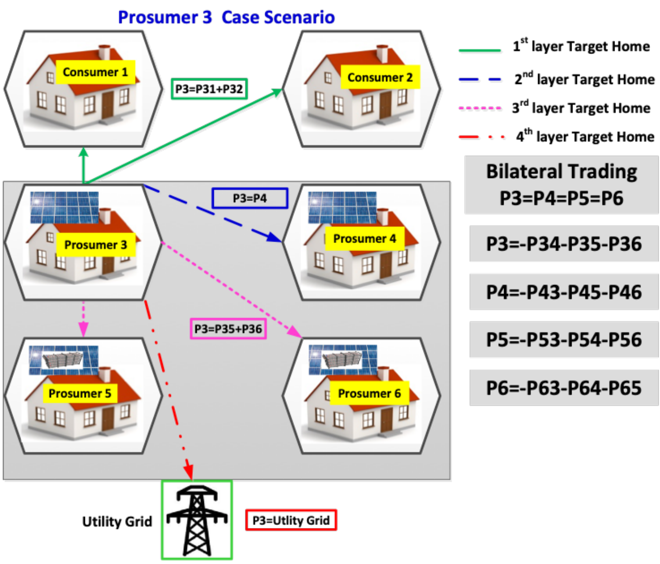

Figure 6. Decentralized Cooperative Community Microgrid Design Trading in Peer to Peer.

This confirms that all four prosumers have equal opportunities of balance trade during bilateral trading but with opposite sign. This design is truly a consumers' preference centric where the owner has total freedom to whom energy transaction is to be made. At the same time the negotiation process (price, time horizon) scalability and limitations are the main issues. The negotiation process can become more complex for the scenarios where a greater number of community homes are involved, as both the seller and the buyer are unaware about the requirements and priorities of each other.

Centralized Cooperative Community Microgrid Design:

This is centralized poll based design approach where all community homes put their excessive energy on the community energy poll and is managed, decided and shared through a CSM which acts as an intermediator between all the community homes. This system design is shown in Figure 7. Based on three community homes categories; a centralized cooperation through SCM can be made based on different priorities or preferences mainly on electricity prices and available time horizon defined by community homes owners. Based on defined priorities, the SCM is responsible to decide to whom the excess energy is to be sold to or purchased from on the bases of auction schemes where the energy seller's and buyer's demands are met. It is not necessary for the seller and the buyer to know each other as energy transactions are handled through the SCM. This design is more structured and optimized where most of the community members can not only be in a social relationship by helping other community residents but can also earn good revenues as energy can also be sold to utility grid at higher prices when the utility grid is under system stress through smart community manager. This scenario can be more realistic if through SCM an aggregated energy is sold to the utility grid and total collected revenue is shared (e.g., in a logical proportional way) midst all community members. At the same time, SCM has the strong responsibility of being fair and unbiased so that every community home gets equal opportunities of energy transaction.

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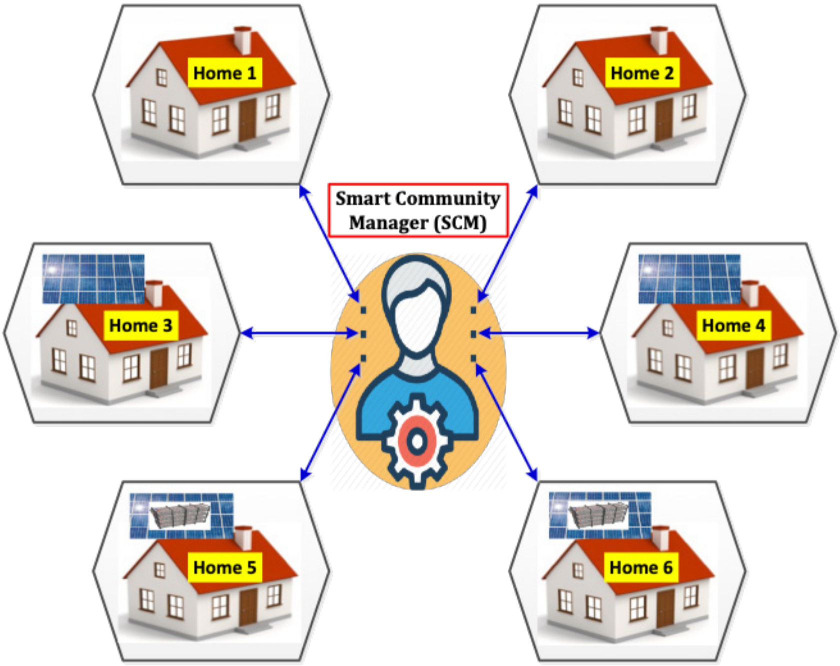

Figure 7. Centralized Cooperative Community Microgrid Design through Smart Community Manager.

6. CONCLUSION

In this paper, a grid connected residential community based microgrid is proposed using cooperative game theory to share, manage and schedule the excessive amount of energy generated through DERs with the community neighboring homes. In this work, three types of community home residents' passive consumers, active prosumers and proactive prosumers are used as the main agents which makes the energy trading and transaction to other community residents after fulfilling their own load requirements. This energy trading and transaction is based on two stage prosumer–centric residential cooperative approach in centralized or decentralized way to sell or purchase the energy from community neighboring homes at a price lower than the utility gird but higher than the feed–in tariff. With decentralized approach community residents can directly negotiate with each other in form of grouping P2P to make energy transactions; whereas in centralized approach all community homes put their excessive energy on the community energy poll and is managed, decided and shared through a smart community manager which acts as an intermediator between all the community homes. It is concluded that the proposed system will not only share, schedule and manage the community load optimally but reduces the overall energy cost, system operational stress, improves the system operational efficiency and reduces the carbon emission. This work can be extended further to develop the rural electrification using community microgrid especially in energy deficit countries like Pakistan to avoid grid system stress.

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