Contemporary Secure Mechanism Using Deep Belief Network (DBN) For Smart Environment in Wireless Sensor Networks

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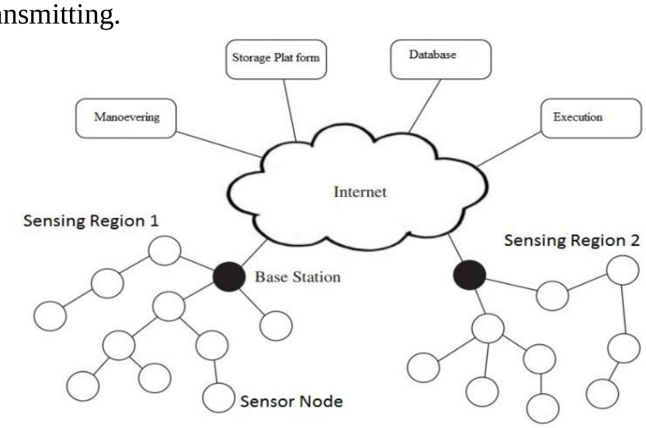
Abstract
In contemporary industry 5.0 demonstrates the impact of Robots and IOTs with sensor networks. It emphasis the humanoid machines, optimal balance in all aspects of Industry products and smartness of progress. IOTs are playing vital role for all kind industries, educational sectors, public domains and smart cities environments. Even though high usages of sensor devices in wireless mode or wired mode, security is the most crucial task for maneuvering the signals. In traditional systems are incorporating with securing algorithms for data or signal transmission. But those mechanisms are leading some less accuracy for high end process in wireless sensor network environments. Artificial Intelligence is one of the study of computer Science and train the systems in a rational way. Machine Learning algorithms are supporting for the automated process by learning parameters which are narrated with neuron vales. In such cases, ordinary ML is not adequate like non-linier functions or signals. So we go for deep learning for improving the efficiency in aspects with larger hidden layers for processing both structured and unstructured data. In this paper, we introduced Deep Belief Network for securing the signals in wireless sensor networks. We have to initiate with feature extraction and classifying with deep learning for secure our WSN signals while transmitting or processing.

Keywords: WSN, Deep Belief Network, feature extraction, DeepLearning 4j

I. INTRODUCTION

Wireless Sensor Systems is built with self-configure to able monitor the surroundings using the signals via various IOT devices. Major advantages for the WSN are Infrasturure less and dedicated sensors for the transmitting.



The above figure depicts how the networks are built with sensors and communication system. Protocol is having the set of rules were framed as software to monitor the physical devices over the network. A typical WSN is consists with senor node and architecture. Sensor node is comprising with power supply, process, communication and sensors. Network architecture is having user information, base station, and region of sensing area.

IOTs with WSN

In recent era, IoTs are embedding with the Wireless Sensor Networks because its emitting signals are to be analyzed by the WSN. Most of the real time example like hospital, research and automated electronic based industries are having the vital component i.e WSN. Many of the researchers are contributing the low latency for sensing device and security application, routing with efficient way.

Wireless Sensor Networks (WSN) is a popular research area among various classes of wireless communication networks like Adhoc networks, Cellular networks, and Mesh networks (Panigrahi et al 2013). Sensor Nodes are very small devices with limited battery source, processing power, and memory. WSN are popular in automation and control applications as they are scalable and easy to handle. Presently, there are many economical sensor nodes available capable of collecting environmental data with precise sensors and transmitting it to control station efficiently.

WSNs attracted is a popular research area due to huge theoretical and practical challenges and increasing practical civilian applications. “One deployment, multiple applications” is an emerging trend in WSN development. Such trends need sensor nodes to have various abilities to handle multiple applications (Chen et al 2007). Using mobile agents to dynamically use new WSN applications is an effective method to offset this challenge. It has been successfully used in Environmental monitoring, Habitat monitoring, Building management systems, Green house monitoring.

II Literature Review

YaraRizk et.al [1] had discussed about Cortical and Deep belief network and their research perspective said that DBN is the more powerful than CA. Restricted Boltzmann algorithm is modified with inter and intra layer connection for DBN. It shows the reduction of the training complexity with deep level. In DBN, Random initialization, unsupervised feed forwarding, supervised feedback learning are implemented are integrated together for non-linear data modules. They analyzed the above CA and DBN for different perspectives like classification style, accuracy and network connectivity. Cortical proves the higher classification for biological inspiration. But DBN is implemented with basic essence of Artificial Neural Network.

Xiaoai Dai, unying Cheng et.al [2] have addressed about the feature extraction with DBN models original data mapping with image processing. They depicted the data preprocessing and data sets in hyper spectral images. While this operation, image’s radiation correction and reflex inversion are to be connected in the Deep belief network. They have proven that Deep belief Network is not only reducing the dimensions of the data but extract the exact features also. They used 60-60-60-4 hidden layers with soft max regression classifier and achieved best optimum result. It concentrated on noise reduction or separation, factors analysis, component separation also.

Peter O'Connor had discussed about sensor fusion using DBN with 3 layer network and 2964 neurons were used. Inputs are gathered from 64 different channels. They used Jaer open source platform implementing this application. This architecture demonstrated about the distractions, noise, scaling and recognize using event based approach.

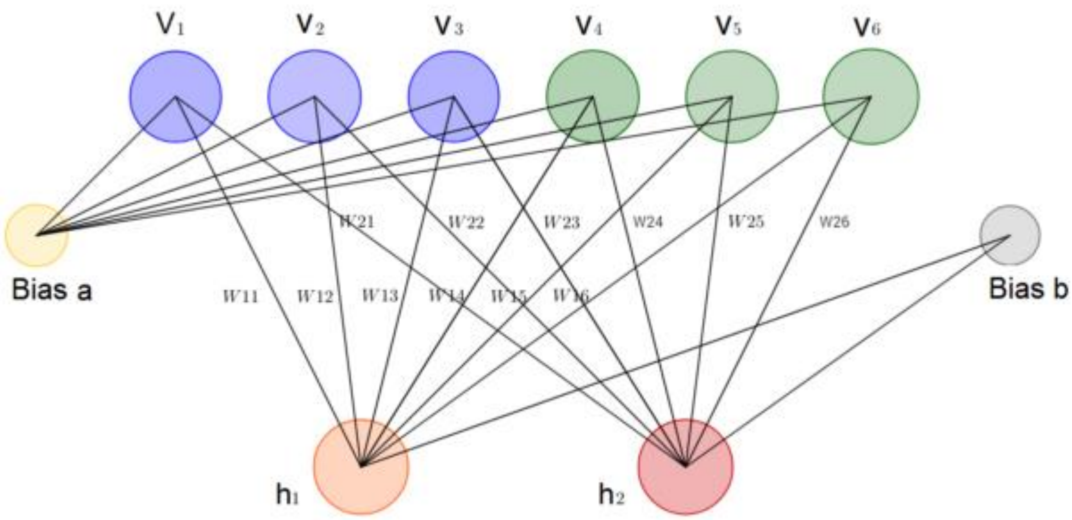


Fig. 2.1 Restricted Boltzmann Machines

In the RBN [4] is one of the simplest architecture of all Artificial Neural Networks (ANN). Figure 2.1 shows RBM consists out of one input/visible layer (v1,…,v6), one hidden layer (h1, h2) and corresponding biases vectors Bias *a* and Bias *b*. The absence of an output layer is apparent. But as it can be seen later an output layer won't be needed since the predictions are made differently as in regular feed forward neural networks. Besides they trained multi sensory fusion with tones and frequency and processed by two different sensory devices

Tone	A_4	B_4	C_5	D_5	E_5	F_5	G_5#	A_5	B_5	C_6
Freq.(Hz)	440.0	493.9	523.3	587.3	659.3	698.5	830.6	880.0	987.8	1046.5
Digit	0	1	2	3	4	5	6	7	8	9

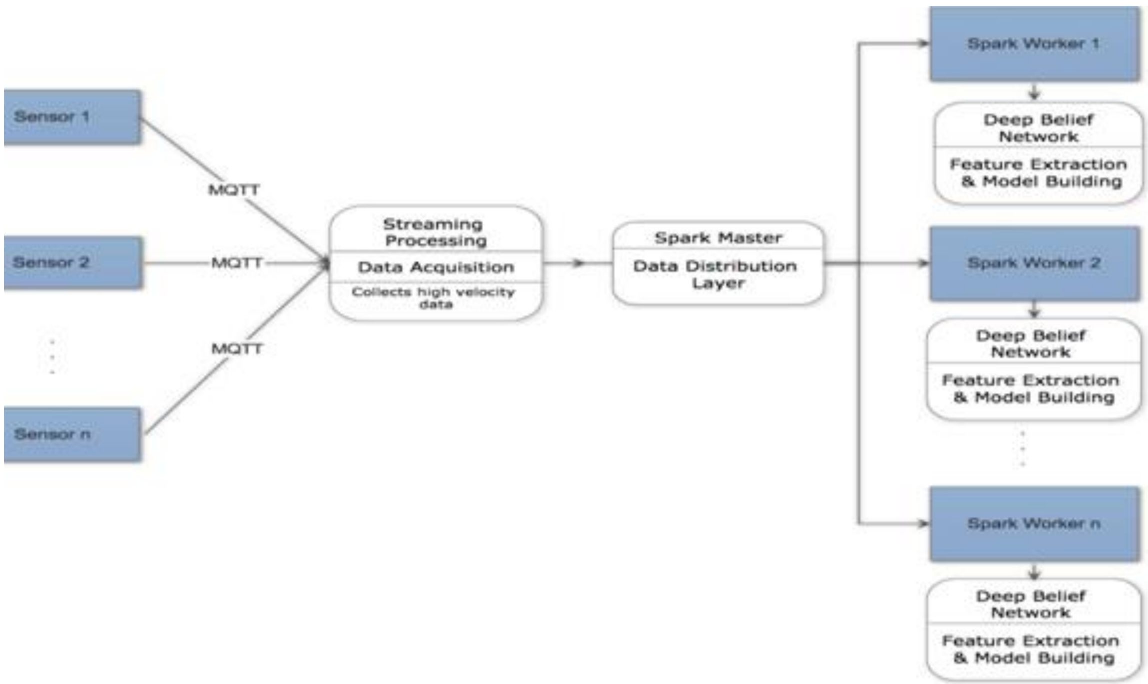
During training pure tones with given frequencies (upper rows) were paired with an associated digit (bottom row).

Table 2.1 Paired tones and images in fusion task.

Jaehoon Koo, Diego Klabjan had discussed about classification techniques with Deep Belief Networks. They had developed many supervised models with the base of DBN for improving two-phase strategy. Weight bounds and multi-programming were applied and functioned both supervised and unsupervised models [5]. Eventually in their article says that classification accuracy can be improved by regularizing the model parameters with the values trained for unsupervised and supervised purpose.

ChenmingLi ,Yongchang Wang et. al[6] have narrated the remote sensor data with optimum classic model using DBN. One layer comprises binary visible units, and the other comprises binary hidden units. An energy function was introduced to identify the state of the RBM, which was developed from the energy function of the Hopfield network in a nonlinear dynamic system. Therefore, the objective function of the system was transformed into an extreme value problem, and the RBM model could be easily analyzed. They concluded the deep learning method improves the accuracy of hyperspectral classification. According to their results, suggested that the DBN model be designed with 3–5 hidden layers, with each having no more than 100 hidden units

III IMPLEMENTATION



The above figure depicts the work flow of our research work. Authentication is playing major role for biometric enabled wireless network areas. Most of the countries are encouraging the smart city environments with secure mechanism. We are going to contribute the securing the signals using deep belief network Deep belief for restrict the security parameters for enforcing the network. In real time scenario, more than millions of signals are to be accumulated together; here preventing from the intruders or vulnerable signals are the major role for contemporary research. DBN is the form of Restricted Boltzmann machine with connectivity between the layers not as the units. Our proposed work says that we have to identify the neurons and weights are trained models.

The entire system architecture of this work has been depicted in Figure 4.3. This architecture contains the layers below:

1. The Data Acquisition Layer
2. The Data Distribution Layer
3. The Feature Extraction Layer and
4. The Model Building layer

In the initial stage, the data stream will flow from that of the Sensors are connected to this system. If in case these data points have been collected from the smart buildings, the data is given in this repository (Alhamoud et al., 2014). The data emitted will be forwarded to the layer of data distribution through the MQTT protocol which provides better data delivery, durability, reliability and its light-weight (Singh et al., 2015).

The modules below are like the Apache Spark MQTT streaming, the micro batching which is through the technique of Sliding window which is used in a D Stream and forms a Data Acquisition Layer. The data which is acquired is distributed to the nodes of Apache Spark Workers for performing the Extract Transform and Load (ETL) and the preprocessing of the time-series data. The Apache Spark makes use of the Directed Acyclic Graph (DAG) for managing jobs given to the Spark Cluster Master node. This will manage jobs having the status of execution, considerations of performance, data supply and failure. The work makes use of a stack containing a Restricted Boltzmann Machines (RBM) based algorithm used for the feature learning which is reached with the needed accuracy of the features that has been extracted from that of a Deep Belief Network (DBN).

The data that is used for the purpose of analytics has been extracted from the Spark Streaming on which feature extraction is duly applied. Finally, there is a training model built on the basis of the features which are extracted by using certain tools of Machine Learning

Sensors can emit the signals and in have been stored in the large medium via cloud storage. It supposed to be classified with proper rule based constrains. Those signals are to be stored as libsvm formats. The following example shows the dataset model of signals with numeric values.

```
14.23,1.71,2.43,15.6,127,2.8,3.06,.28,2.29,5.64,1.04,3.92,1065,1
13.2,1.78,2.14,11.2,100,2.65,2.76,.26,1.28,4.38,1.05,3.4,1050,1
13.16,2.36,2.67,18.6,101,2.8,3.24,.3,2.81,5.68,1.03,3.17,1185,1
14.37,1.95,2.5,16.8,113,3.85,3.49,.24,2.18,7.8,.86,3.45,1480,1
13.24,2.59,2.87,21,118,2.8,2.69,.39,1.82,4.32,1.04,2.93,735,1
14.2,1.76,2.45,15.2,112,3.27,3.39,.34,1.97,6.75,1.05,2.85,1450,1
14.39,1.87,2.45,14.6,96,2.5,2.52,.3,1.98,5.25,1.02,3.58,1290,1
14.06,2.15,2.61,17.6,121,2.6,2.51,.31,1.25,5.05,1.06,3.58,1295,1
14.83,1.64,2.17,14,97,2.8,2.98,.29,1.98,5.2,1.08,2.85,1045,1
13.86,1.35,2.27,16,98,2.98,3.15,.22,1.85,7.22,1.01,3.55,1045,1
14.1,2.16,2.3,18,105,2.95,3.32,.22,2.38,5.75,1.25,3.17,1510,1
14.12,1.48,2.32,16.8,95,2.2,2.43,.26,1.57,5,1.17,2.82,1280,1
13.75,1.73,2.41,16,89,2.6,2.76,.29,1.81,5.6,1.15,2.9,1320,1
14.75,1.73,2.39,11.4,91,3.1,3.69,.43,2.81,5.4,1.25,2.73,1150,1
14.38,1.87,2.38,12,102,3.3,3.64,.29,2.96,7.5,1.2,3,1547,1
13.63,1.81,2.7,17.2,112,2.85,2.91,.3,1.46,7.3,1.28,2.88,1310,1
14.3,1.92,2.72,20,120,2.8,3.14,.33,1.97,6.2,1.07,2.65,1280,1
13.83,1.57,2.62,20,115,2.95,3.4,.4,1.72,6.6,1.13,2.57,1130,1
14.19,1.59,2.48,16.5,108,3.3,3.93,.32,1.86,8.7,1.23,2.82,1680,1
13.64,3.1,2.56,15.2,116,2.7,3.03,.17,1.66,5.1,.96,3.36,845,1
14.06,1.63,2.28,16,126,3,3.17,.24,2.1,5.65,1.09,3.71,780,1
12.93,3.8,2.65,18.6,102,2.41,2.41,.25,1.98,4.5,1.03,3.52,770,1
13.71,1.86,2.36,16.6,101,2.61,2.88,.27,1.69,3.8,1.11,4,1035,1
12.85,1.6,2.52,17.8,95,2.48,2.37,.26,1.46,3.93,1.09,3.63,1015,1
13.5,1.81,2.61,20,96,2.53,2.61,.28,1.66,3.52,1.12,3.82,845,1
13.05,2.05,3.22,25,124,2.63,2.68,.47,1.92,3.58,1.13,3.2,830,1
13.39,1.77,2.62,16.1,93,2.85,2.94,.34,1.45,4.8,.92,3.22,1195,1
13.3,1.72,2.14,17,94,2.4,2.19,.27,1.35,3.95,1.02,2.77,1285,1
13.87,1.9,2.8,19.4,107,2.95,2.97,.37,1.76,4.5,1.25,3.4,915,1
14.02,1.68,2.21,16,96,2.65,2.33,.26,1.98,4.7,1.04,3.59,1035,1
13.73,1.5,2.7,22.5,101,3,3.25,.29,2.38,5.7,1.19,2.71,1285,1
13.58,1.66,2.36,19.1,106,2.86,3.19,.22,1.95,6.9,1.09,2.88,1515,1
13.68,1.83,2.36,17.2,104,2.42,2.69,.42,1.97,3.84,1.23,2.87,990,1
13.76,1.53,2.7,19.5,132,2.95,2.74,.5,1.35,5.4,1.25,3,1235,1
13.51,1.8,2.65,19,110,2.35,2.53,.29,1.54,4.2,1.1,2.87,1095,1
13.48,1.81,2.41,20.5,100,2.7,2.98,.26,1.86,5.1,1.04,3.47,920,1
13.28,1.64,2.84,15.5,110,2.6,2.68,.34,1.36,4.6,1.09,2.78,880,1
13.05,1.65,2.55,18,98,2.45,2.43,.29,1.44,4.25,1.12,2.51,1105,1
13.07,1.5,2.1,15.5,98,2.4,2.64,.28,1.37,3.7,1.18,2.69,1020,1
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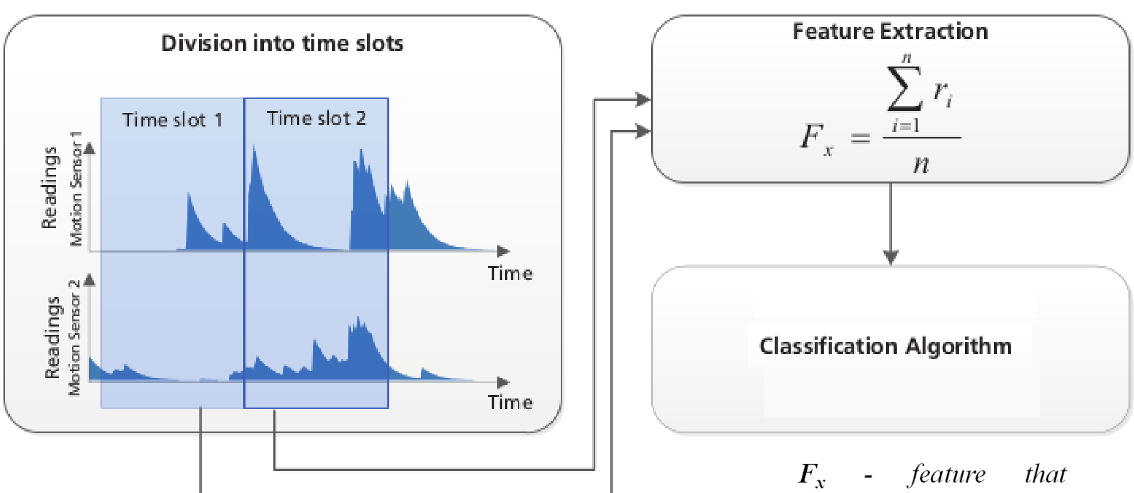
Fig 3.2 WSN dataset livsvm format

Feature extraction

Feature extraction is the way of reduction to more manageable cluster for processing the application.



F_x - feature that represents sensor x
n *- number of sensor readings during the time slot*
r_i *- sensor reading i*

Fig 3.3 Feature extraction
Steps:
- System is trained to map the activities and sensor value
- Input data is split into equal time slots
- Each data from the sensor is mapped and corresponding output time slot is recorded

Deep Belief Network
We used DeepLearning4j tool for implementing the DBN algorithm for improving the security operations. It offers the data science with JVM language using cala, Clojure and Kollin. The Deep learning has been escalated computationally and therefore on the vast datasets, speed is critical. The issue can be handled using speedier equipment (generally the GPUs) the streamlined code and certain other parallelisms. This working model is

1. Creating a TrainingMaster to appropriately cluster the nodes. (Here, we mentioned the signal and its rules extracted already)
2. Creating the SparkDl4jMultiLayer or SparkComputationGraph case utilizing the network setup and TrainingMaster objects
3. Selecting from the variety of distinctive techniques for stacking information considering the corresponding tradeoffs
4. Calling the suitable fit technique on the SparkDl4jMultiLayer or SparkComputationGraph occasion
5. Saving or utilizing the prepared network i.e. the prepared MultiLayerNetwork or ComputationGraph occasion

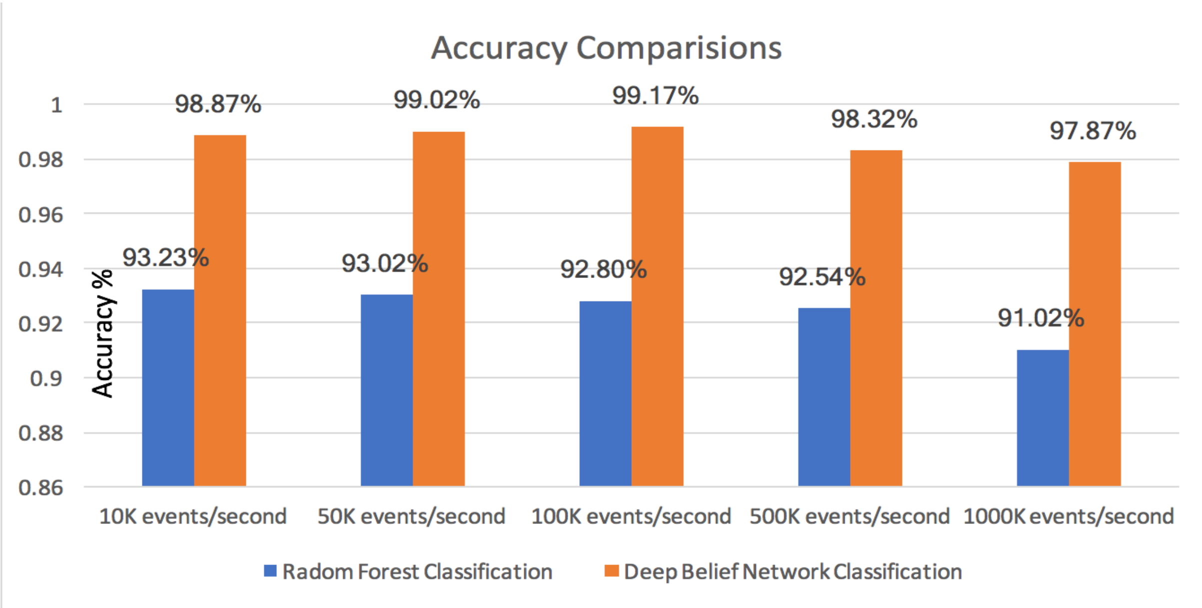
IV Result and Discussion
The time taken for training the hidden layer and accuracy for the proposed approach as shown in tables 4.1 & 4.2 and figures 4.4 & 4.5

Table 4.1 Time Taken for Training the Hidden Layers

Hidden Layers #	Parallel Computation on 4 node	Single PC with NVIDIA GPU
100 nodes	2.63	3.78
250 nodes	2.65	4.33
500 nodes	2.78	8.29
750 nodes	2.93	15.23
1000 nodes	3.02	18.43

Table 4.2 Accuracy of the Proposed Approach

	Apache Spark With MLlib	Apache Spark With Deep Learning 4j
IoT Streams	Radom Forest Classification	Deep Belief Network Classification
10K events/second	93.23%	98.87%
50K events/second	93.02%	99.02%
100K events/second	92.80%	99.17%
500K events/second	92.54%	98.32%
1000K events/second	91.02%	97.87%



CONCLUSION

WSN are a very crucial component in the IOT which has been making use of servers effectively by communicating with various digital devices effectively. Deep learning has been making many attempts in artificial intelligence and the approach and its performance have been analysed for increasing the hidden layers which are constructed. The Deep Learning has enabled a training model along with the feature extraction which may be chosen from data of a large scale and this has constructed a new model on its own. The DBN has also achieved a maximum accuracy compared to the method of random forest classification.

FUTURE WORK

In future, to improve the computational complexity, to implement various other meta-heuristic algorithms and to implement various other big data applications. Future plan is to implement on real time applications. The *cyber security* threats and attacks against *smart building* devices can be solved. Energy-intelligent homes based on user action are to distinguish an occupiermovement and building framework and to approve buildings for saving energy.

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