Astute Energy Supervising using Machine Learning

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Abstract

In modish generation intellectual energy supervising concept has become the trend, as it paves the way for easy energy monitoring and prevention of energy thieving. A smart meter was developed to fetch readings from a remote area, but has nothing to do with those readings. Though the presently available models are capable of detecting faults like energy theft, energy over usage, they lag in accuracy, complexity and even difficulties in implementation. The proposed model Astute Energy Supervising system (AESS) using Machine Learning fulfils the necessary criteria and proved its worth in effective functioning. The purpose of the system is to monitor energy consumption by a household, prediction of energy consumption for the upcoming given period of time, theft detection, disconnection of power supply when the user failed to pay the debt or over consumed energy beyond the predicted limit. Those prime functions are performed by three modules of control as follows: Energy prediction, energy theft detection, auto cut-off. The final decision taken by the system regarding any issues is communicated with the user. On simulation, the results prove that the proposed system is 99.96% accurate and enhances the security of the IoT based smart home.

Keywords:- Energy theft, Internet of things, Machine learning techniques, Opto-coupler sensor, Raspberry Pi, Smart Energy Meter (SEM), Smart homes, Smart grid

I. INTRODUCTION

In this modern era automation has become the most convenient way of getting things done, which require much more manual effort and man-power. Also, time saving methods are preferred. Machine Learning (ML) is found to be the most suitable methods for almost all applications [8], [11]. One among them is energy supervising. Machine learning can be achieved through smart meters. But the changes to be made for installation of smart meters need great effort, money and more time. But the proposed model can be implemented by just making few adjustment and connections in the already available analog meter set-up. Though ML is an advanced technology, it has its so called advanced version that is Deep Learning. There are different algorithms available for deep learning. Among those available algorithms, two algorithms are found to be suitable for the proposed model functionality and hence Long Short-Term Memory (LSTM) and Neural Network (NN) algorithm provide the best results. LSTM notably has 6 classifications based on the sequence prediction process as follows, One-to-one, One-to-many, Many-to-one, Many-to-many. Also LSTM has various architectures as follows: vanilla, stacked, CNN, encoder-decoder, bidirectional, generative. In a prediction model, multiple inputs are fed and the model keeps on learning till it produces an accurate output/result by learning both forward and backwards. So, Bidirectional Many to one LSTM algorithm is chosen. While learning a system opts for repetitive data collection

and processing. Which is nothing but the initialization of the setup by taking the first certain number of input combinations as reference, before it becomes a predictive one. Considering all these facts, Neural Network algorithm is chosen. The advancements in these techniques paved a way for convenience in usage, installation, processing, remote transmission, cloud storage, etc. Using python as the programming language ML is achieved in software platforms. The proposed model uses Tensorflow platform with Scikit learn, pandas, NumPy, jupyter. These libraries possess functions which have splendid features that can be used for any given ML application. For energy supervising only few simple functions to fetch data, upload those data into cloud, process data, and finally to produce desired output, are used. To develop a ML system which is completely self-reliant, training the system is essential. The above mentioned attributes are put to use in order to achieve the successful creation of the needed ML system. The hardware requirements of the proposed model are very less compared to the other models available for this application. The board of electricity in India welcomes the technological changes in power lines and energy management. As an initiative towards such movement the so-called proposed model (AESS) is developed. As mentioned earlier, AESS solves the problem of energy theft and energy over-usage. These are collectively called as energy supervising [3], [5], [11]. Energy supervising involves energy usage prediction, energy theft detection and supply auto cut-off. These are done in 3 different stages. The above said actions May not be performed by existing model, as it is designed only for acquiring energy meter reading via smart meters, prediction is not possible.

II. Proposed Algorithm

First, the system learns about energy consumption of the house/zone for every 24 -hour, for a month by the RNN algorithm. Each load is monitored for its consumption of energy. On an average the limit/peak value is set for the zone to bring out the concern for users the data are uploaded to cloud and are accessed by the electricity board for further processing like bill amount calculation and cut off power supply. The graphical display of energy consumption is provided for the user's reference. If the consumption is about to exceed the predicted value, the user is indicated via SMS. So that the loads consuming energy unnecessarily will be switched off to keep it within limit. Then it predicts the average value of energy to be consumed for the next month. At the end of every month it is made sure whether energy theft has happened or not.

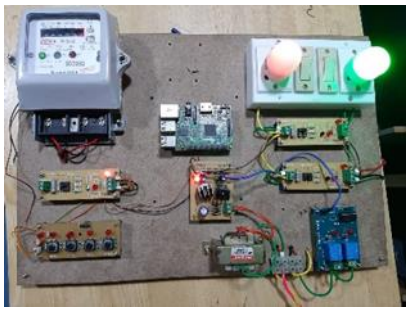

Fig.1 Prototype of the proposed model

In Fig. 1 shows the live demonstration of the proposed model and it is the basic representation of real time system. Also, it is clear that, the proposed model can be implemented by making few changes to the already made set-up in a given zone. The energy meter reading is taken into account. If the bill amount is high for low consumption, then it is

concluded that energy theft has happened. Then the source of theft is identified and necessary actions are taken by the electricity board.

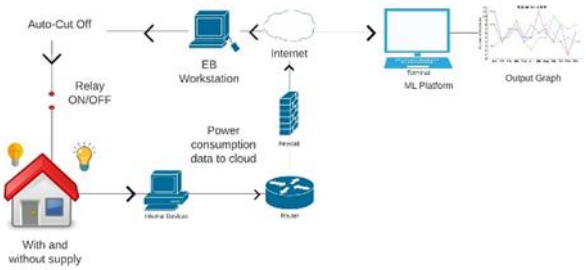

Fig. 2 Data acquisition

Fig. 2 clearly shows how the reading of energy meter in a given zone is fetched periodically and uploaded in cloud for further processing.

After intimation the user is conscious about paying the bill. If not paid, the power supply will be cut-off. Usually cut-off is done manually by the EB personnel but in the proposed model it is done automatically as follows. The relay to the supply is given an electrical signal controlled by the board of electricity. The signal disconnects the relay unit thus, the power supply cuts-off. After payment of bill, the power supply is restored by clicking the release button provided on the webpage by the EB personnel. The power supply restoration will be automated in our future scope.

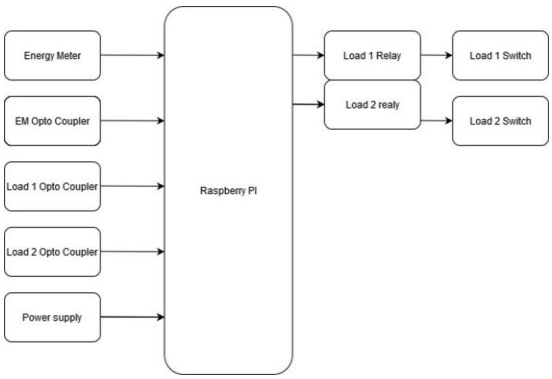

Fig. 3 Block diagram of proposed model

Fig. 3 shows the block diagram of the proposed model, from which the flow of functionality is clear.

III. EXPERIMENT AND RESULT

The mechanical set up of the model consists of analog energy meter, raspberry pi and opto-coupler sensor. The opto-coupler sensor is used for monitoring a particular load. Whether the power line is active or not is known by the sensor, which is helpful in switching off the loads when not in use. Also, the amount of energy consumed by that particular load is obtained. These values are updated to the cloud periodically. Raspberry pi is responsible for uploading the data to the cloud via the gateway.

Table I Actual Vs predicted value

datetime	actual	prediction
02/25/2020 0:00	60.12	51.18864
02/25/2020 14:00	54	47.15629
02/25/2020 15:00	58.77	50.17857
02/25/2020 16:00	79	62.98391
02/25/2020 17:00	90	69.93504
02/25/2020 18:00	76.97	61.60392
02/25/2020 19:00	53.8	46.92138
02/25/2020 20:00	51.8	45.64918
02/25/2020 21:00	47.32	42.8205
02/25/2020 22:00	40.81	38.687
02/25/2020 23:00	60	50.83392

In Table I the values in the first row are the initial input to the system which will be the reference for prediction. The values in the second row are the predicted value by the system based on which future actions like energy consumption reduction and energy theft detection, are performed. Fig. 3 shows the graphical representation of the actual energy consumption value and forecasted value. There is only a slight difference between them which proves the reliability and accuracy of the system.

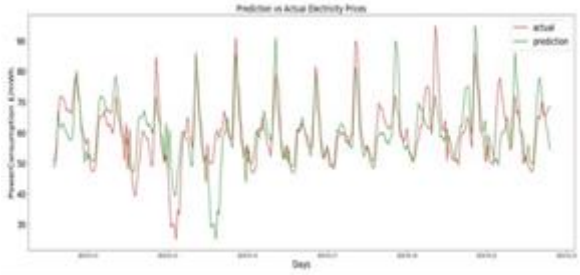

Fig. 3 Comparison between Actual and Predicted value

IV. CONCLUSION

Thus, main aim of the proposed model is to reduce manpower and to quickly attend to the problems regarding energy theft and connectivity issues. The proposed model is self-reliant, works with an accuracy of 99.9%. It is a predictive module which functions with inferential statistics and data visualization. The above said two features are the major advantages which make the system work as per the desired requirements for the given application. The graphical representation of power consumption and its comparison with the predicted value are shown on the webpage with the given time basis and is continuously monitored by the Electricity Board. Theft detection is proved to be accurate and is identified at the correct time. The verification of result proves that, it is a better solution for energy theft and ensures the security against it. The proposed model also proved its potential in various means.

It is very economical and a quick methodology for EB issues. It acts as an initiative towards digitalization of EB. Enables the relay cut-off without human intervention and theft intimation was done. It has a great impact on future technology and economical aspects.

V FUTURE SCOPE

The propose model is trained by feeding a set of data and making it to realize the impacts of them, to make it a predictive model. To train the model, experiments must be conducted and data are collected. A study is made on the impacts of these inputs on the controlled parameters. This requires human effort and takes more time to train the system. As the training is done manually, accuracy is affected. Apart from all these aspects, this model faces internet connectivity issues.

Though it is tolerable, it disturbs the functionality and loss of data during process. So, the future scopes of the proposed model are as follows. The improvised model will be free from connectivity issues. Accuracy will be promisingly excellent.

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