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Research Article

Analysing Electricity Utilization Using Internet Of Things

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Abstract

We are able to promptly complete our tasks with the technology's innate ability and thereby enhancing human's quality of life. The capability of computers is letting everyone to retrieve higher volume of information everywhere, every time. Besides this, it provided us the potential to control, communicate and manage our time. Our work is about designing an energy economizing system. It activates appliances prior to presence of a living body using Node MCU microcontroller (MC). Whenever an IR sensor notices an object, relays are excited by MC which then switches ON the light and fan depending on the strength of light and warmth of the room. Simultaneously, it also records the amount of power consumed by each and every device and is sent to get stored in cloud which could be downloaded as an excel file. The collected data is then analyzed to foresee the power utilization of next 7 days using a method called ARIMA and also forecasts the tradeoff linking the power utilization before and after using this system

Keywords: Microcontroller, ARIMA, Future electricity prediction, RMSE, Things board cloud.

1. Introduction

A framework that interconnects people, computing devices, animals, objects, digital machines or mechanical machines using internet is called Internet of Things. A unique identifier is assigned to each and every object over network to identify them and supports data transfer automatically instead of human-human or computer interaction. It's a trending technical field which converts all electronics into clever one. This innovative technology also furnishes various other features like automation, real-time analytics, analyze the data by providing a platform, cloud data storage, trigger an action from remote location, remote notifications etc. Automation schedules events for devices that are connected locally over network through stimulus related or time triggered programs.

Now-a-days the challenge caused by increased current consumption and the biggest problems is raising power costs. In current time, the amount is exponentially increasing. It is ultimately draining the limitedly available conventional fuel

resources. To provide these sources available to further generation we need to preserve the energy. Not less than 50% of the electricity consumption is saved by utilizing the potential of new technologies that are a part of IoT. Most often we ourselves are responsible for wasting lots of energy by leaving the room without switching off appliances.

In this paper, we have developed an IoT sanctioned system for saving energy that uses NodeMCU ESP8266 microcontroller with some sensors. It is programmed to switch ON the fans and lights whenever the system detects the presence of living object in the room. Microcontroller collects the data and sends it to the ThingsBoard cloud. To predict future electricity consumption, the collected data is trained using ARIMA model and the trade-off's (power consumption) between with and without using this system has been assessed employing the matplotlib library.

The below set of lines describes the structure of the remaining paper. Some existent systems are explained in Section II, implemented methodology in III, examination of experiment results in IV and is concluded in V.

2. Related Work

In [1] Jayavardhana says that, Harvesting the information from the environment (sensing) and interacting with the physical world, providing services for communications, information transfer, analytics and applications are served by internet, that includes network of interconnected objects.

Reference [2], develops and implements a system that uses embedded ARM Cortex-M3 microcontroller as its core with a reset circuit, external crystal oscillator and CAN bus as the communication interface. The non-automatic and automatic control of housekeeping light is possible. Hence, it needs the manual support too.

Now-a-days to diminish the use of lamps in day as well as cut down the electricity expenses, almost all buildings are constructed in a way that allows sun light to easily pierce into the rooms. Thus, in [3] a reliable system was implemented that involve 3 relay modules, a LDR, an infrared control panel, Arduino Uno microcontroller, LED bulb and displays its output on LCD. It computes the room's brightness and tunes the bulb.

The world of technology is motivating towards the automation for governing the devices present in the room according to the needs i.e., the lights and fans are enabled only when someone's presence is sensed in the room and otherwise, if it is empty. This purpose is fulfilled by the system that was aimed to be developed in [4]. It includes Arduino microcontroller in addition to temperature sensor and relay. Based on the temperature the rotating speed of the fan is regulated. The system calls the functions that controls fan, light only when it detects objects.

The modern electrical power management system, electricity load forecasting has gained substantial importance. To study the energy consumption patterns, author uses ANN (Artificial neural network) along with MLP (Multilayer perceptron). He used Mean Absolute value of Relative Percentage Error (MAPRE) as the performance evaluation metric for developed model to get the desired estimation.

3. Methodology

The block diagram of the proposed system is shown in Fig.1. Our system contains 2 modules. Namely, IoT module and analysis module and are explained below.

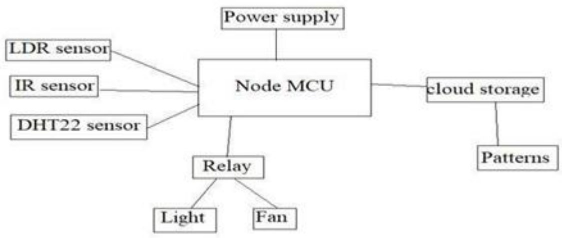

Fig. 1. Proposed system's Block diagram

3.1 IoT module:

Designing and implementing a system that turns on the light and fan based on following conditions is the crucial objective of this module:

- In the company of ample of natural light and human, switch ON the light
- In the existence of human, turn ON the fan if the temperature is above 30℃ in the room.
- Both the appliances are switched OFF in the human's absence.

Fig. 1 presents the hardware components required to implement the system. With the help of GPIO pins all components are coupled to MC. Initially, MC senses the presence of object through IR sensor module associated with it. It contains a transmitter that emits radiation that is reflected by the object on touching it. The reflected radiations are sensed by the IR Receiver. The digital data from the entire components is gathered by MC that further inquiries for the intensity of the light for which sensor (LED) is employed. When high energy light hits the device, conduction band is excited by huge number of electrons which induces the current to progress against the device. If MC receives 1 from both IR and LDR sensors, it activates the relay which in turn triggers the bulb connected to it else the bulb remains turned off. Concurrently, if MC acquires digital 1 from IR sensor further it checks for the temperature sensed through DHT22 sensor module. If temperature sensed is greater than 30℃ then the relay triggers the fan that is associated with its second input pin else fan remains turned off. The entire data received by MC is directed to the thingsboard cloud using its ESP8266 WiFi module. All the system's functional requirements are programmed using Arduino IDE and the MC stores this program in the flash memory available in ESP-12E module soon after loading MC with software program. The collected data is analyzed as explained in following section.

3.2 Analysis module:

The date and a measure of electricity consumption are features of the data stored in cloud that has been acquired into an excel file. As the data is a series with day interval i.e., equally spaced points in time and therefore forms time series. Extracting characteristics and meaningful statistics can be done with a statistical technique that analyzes time series popularly known as Time Series Analysis. Using a model to estimate future values based on previously observed values is called Time Series Forecasting. It is performed by a very popular technique termed as ARIMA that stands for Auto-Regressive Integrated Moving Average. ARIMA model works on following assumptions-

- Stationarity of data, the mean and variance should remain constant with time. Log transformations or differencing the series are the techniques used to make series stationary.

- Since, ARIMA uses the previous values to predict the forthcoming values, the input data must be a univariate series.

It has 3 components: AR term that specifies the past values used for forecasting the next value, differencing term and MA term that serves the future values with the past forecast errors and are represented by 'p', 'd' and 'q' by arrangement. The general steps involved in implementing an ARIMA model are:

- Load the data: Loading the dataset is the initial step performed during model building process using p and is done using pandas library in python.

- Preprocessing: This includes creating timestamps, converting the datatype of date-column etc.

- Make series stationary: This would include checking whether the series are stationary or not and performing required transformations.

- Determine d value: This value will be the number of times difference operation is performed.

- Create ACF and PACF plots: To identify the values of input parameters for model these plots are used.

- Resolve p and q values: The previous step helps you to identify them.

- Fit ARIMA model: Using the processed data and the calculated parameter values from the previous step, train the ARIMA model.

Predict = const + Lags of Combination that is linear + lagged forecast errors in

Linear combination.

- Calculate RMSE: The performance of the model can be evaluated using a metric as such of RMSE. It uses the predictions and trained values on the validation set.

Root Mean Squared Error = sqrt (∑predict -train) 2 /n)

4. Experiment And Results

The system is experimented for 2 rooms with one Node MCU MC, one DHT22, one LDR and two IR-sensors i.e., one for each room. It is working well for the pair of rooms. For instance, the system's conduct with human only in one room is captured in Fig.2.

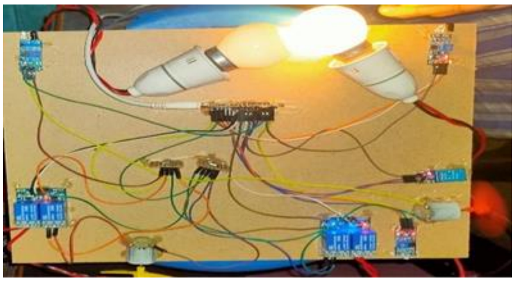

Fig. 2. Human detected in room1.

The examination results of analysis module are presented here. It has been conducted on 91 days energy consumption data. The data is preprocessed that includes converting date string to datetime type of python and adding index. Log transformation is performed to study the stationarity of data whose initial values are shown in Table 1 and Augmented Dickey-Fuller test is conducted in which p value should be as little as possible whose result is conveyed in Fig.3.

Table 1. Dataset Values

Date	PC (without system)	PC(with System)	Logarithmic values
2020/1/1	500	300	0.041020
2020/1/2	450.23	290.2	-0.190105
2020/1/3	482.56	190.45	-0.058611
2020/1/4	456.12	192.26	-0.061754
2020/1/5	390.42	156.7	0.036914

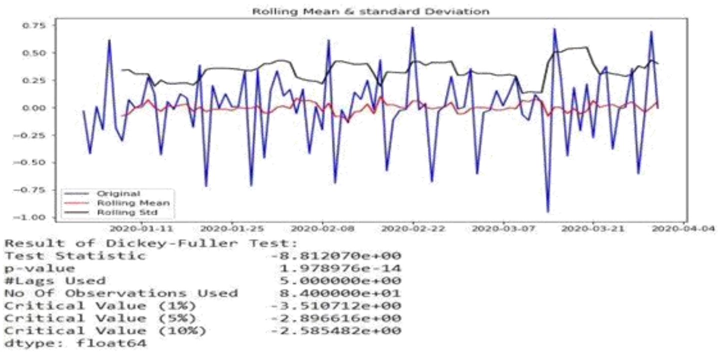

Fig. 3. Dickey – Fuller Test Result

The above graph clearly states that mean is almost not varying i.e., it is constant. Fig.4 displays the ACF, PACF plots of our data. From ACF graph, it is clear that the line touches Y-axis at x=1, 3, 7, 10 which is considered as p value and in the PACF graph, line touches Y-axis at x=1, 7 which indicate q value. The best parameters for the data are (7, 0, 3) assessed using RMSE measure according to the above values and are portrayed in Table 2 and least error value is 52.923.

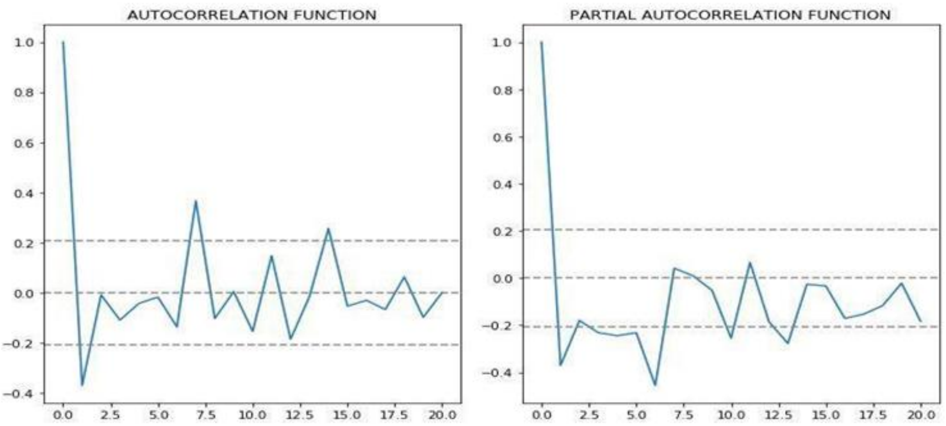

Fig. 4 . ACF and PACF plots

The model (ARIMA) is fitted and next 7 days values are predicted and displayed on UI created using tkinter library in python. The estimated values are forecasted as shown in the fig.5. The first plot i.e. difference plot shows the difference in power consumption (of the room) with and without using this system.

Table 2. RMSE Values

(p, d, q) value	RMSE value
(0, 0, 1)	55.370
(0, 0, 2)	54.782
(0, 2, 0)	111.026
(1, 0, 0)	68.302
(1, 0, 1)	55.182
(1, 1, 0)	95.056
(1, 2, 0)	142.097
(2, 0, 0)	66.738
(3, 0, 0)	65.647
(3, 0, 1)	54.859
(4, 0, 0)	64.732
(4, 1, 0)	82.240
(5, 0, 4)	55.678
(5, 2, 0)	103.570
(6, 0, 0)	53.744
(6, 0, 1)	57.324
(7, 0, 0)	56.077
(7, 0, 3)	52.923

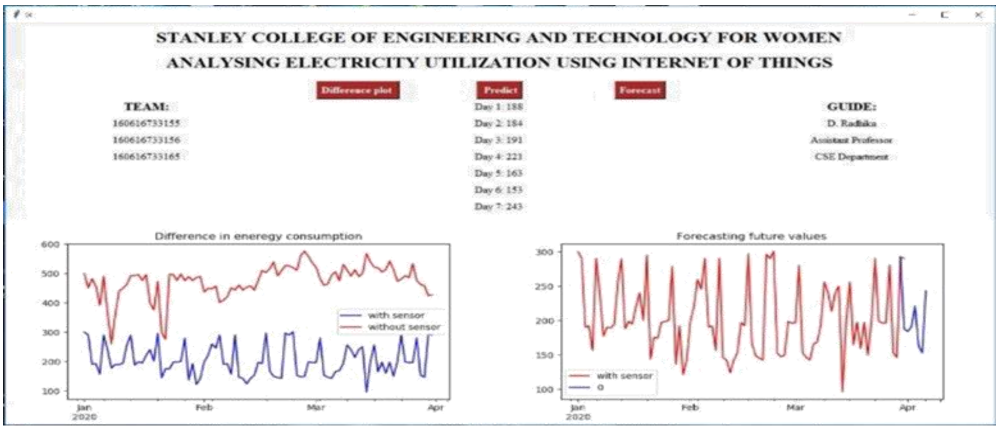

Fig. 5. User Interface with forecast results

5. Conclusion

Our work can be ended up saying that an efficient, fast and reliable automatic switching model has originated replacing a manual and unreliable system. This automation will save time, power consumption and thereupon money spent on electricity bills, lower the mediation of humans in switching on and off appliances. Also an approximation of future electricity consumption will be provided to the customer..

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