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Prediction Of Street Lights In Metro Cities Using Time Series Analysis In Machine Learning Algorithm

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Abstract: In the current scenario, the substitution of man power becomes liable in the urban area where more sustainable projects have been developed to implement the smart city environment. In this venture, the smart lighting in the streets are getting popular to maintain the operations of the street lights. There are different other constraints in which the smart lighting can be addressed in monitoring the usage of the resources of the particular LED bulbs and replacement time period of the LED Bulbs placed in the different location. A device designed to monitor the LED bulbs intensity and usage time of the LED bulbs in the particular location will be sent through the Message Queuing Telemetry Transport –SN (MQTT-SN) protocol to the IOT web environment. The information is maintained in the real time database where time based autoregressive integrated algorithm with moving average is used to predict the usage of the particular bulb and alerts the replacement of the particular bulb before the bulb gets worn out. The analysis is performed with respect to the life time of the bulb and their usage in the particular environmental factors such as temperature and humidity at the location.

Keywords: LED Bulbs, Intensity, Life time prediction of the bulbs, MQTT-SN and Autoregressive Integrated Moving Average.

1. INTRODUCTION

In the current era, we all come across many different technologies in different areas. So that every person is looking for an intelligent system which keeps them updated[1]. Among many technologies, “Internet Of Things” becomes a backbone of our daily life. Iot is a system which interconnects many devices as a whole. Using Iot, we are able to read, write, store and receive information to and frorespectively[2].

Street lights are more essential in both urban and rural areas. In rural areas, we have minimal amount of street lights (i.e.,They will have only one street light in one street) so they will face many difficulties when compared to the urban areas. In urbanareas, they will have a large number of street lights and it also consumes more energy[3]. Sometimes, the street lights suddenly wear out due to some environmental factors. The maintenance of street lights also matters these days[4]. To overcome these disadvantages, we are replacing it in an intelligent manner so that we can give alerts through the MQTT protocol to the nearby electricity board for the replacement of the bulb[5]. We are also using the time based autoregressive integrated algorithm with moving average to predict the usage ofbulbs.

2. LITERATURE SURVEY

Aziera Abdullah et al., presented a paper in which the Street Light with different light intensities will be be switched on at night based on the number of users on the road.The LDR sensor helps to modify the intensity of light based on light conditions [7].The light will be at ON state if the light intensity is lesser than 80%. They used two infrared sensors for measuring the speed of an object[8]. When sensor 1 detects an object, sensor 2 will start the time to get calculated.This will make the sensor 1 to reach sensor
2. Arduino UNO is used along with IR for object detection to make the lights ON and to calculate the speed intensities of an object.
Hajra Ahmad et al., represents that the main purpose behind executing programmed street lights is that lights will switch ON with full force just when there are vehicles or walkers out and stay off something else[9]. The road lights can be controlled by the electrical energy produced through the weight applied by strides and vehicles.The programmed road light framework includes DC lights, lux meter, PIR sensors, piezoelectric sensors, LDR and ultrasonic sensor.In this system the street lights become bright when a car comes closer and become dim when there's a distance between the car and lightweight.It can be implemented on roads,bus stations and other publicplaces.
Rakesh Roshan et al., developed a smart solar street light for saving the Electrical power consumption[11]. They use Arduino , IR sensors, Solar panels are used along with Wifi model for sending and receiving communication from the server room for managing the status of light accordingly.Conditions of Street lights can be operated by server room using Wifi model.Here they used mainly Wifi to track the light conditions.So that the energy can be consumed and used very low[6].Thus the solar panel helps in consuming large amount of energy and when the IR detects the motion the light will be ON and it sends the message to the control room.If the lifetime of battery is overed, it will also informs the message to the control room.
Jessin Mathew et al., established an IoT based street light monitoring and control using LoRA network. In condition 1, If on premise/one directional choose wireless communication configure Node MCU and sensor at device end to connect master.In condition 2 it will choose LoRAWAN and configure LoRa gateway and sensor at device end to connect master.If both conditions were met, it will configure IOT cloud server to connect Raspberry master.Connect Mobile application web application to cloud server and PI.It wil monitor and control the devices from the application whether the street light is in working condition.It has a Transmitter and Receiver to detect the vehicle and sends data to Arduino to check the working of light condition.
Nabil Ouerhani et al., describes about a dynamic street light control and management which is open and flexible in IoT Architecture[10].Considerable commitment is brought at the interoperability level utilizing novel gadget association idea dependent on model-driven specialist to accelerate the combination of sensors and actuators to the Internet of Things stages.It mainly describes about a closed-loop system using wireless sensor that

will automatically and dynamically control the intensity of street lamps in tunnels. In this process, a dynamic light control solution permits an energy saving of about 56% compared to classical static, time-based street light control.

Sakthi Priya et al., established a Automatic street Light control system using WSN based on vehicle movement and Atmospheric condition[12].The Raspberry pi is a microcontroller which is connected to power supply and passive infrared sensor for detecting the movement and IOT for connecting the devices with the hardware.LDR sensor is used to fetch the conditions of light even in sunlight and also in darkness.we use IoT mainly for any time and anywhere connection to check or track the street light when the vehicle comes in contact or any other movable objects.It works in atmospheric conditions.

Dipak et al., established a wireless control system for maintaining street lights, which provides high efficiency for street light system.This System consists of various Sensors for collecting the data & the mixture of ZigBee & GSM module is used for transmission of knowledge from one place to a different place.The Zigbee wireless device is used for efficiency purposes.The information is transferred to Zigbee device and it gets transmitted to base station through GSM module for monitoring the functions performed in street lights.One base station keep track of functions performed by street lights.Then it finally displays on the PC or Terminal window.

3. PROPOSED METHODOLOGY

The 3 steps in the proposed model of monitoring and alerting Street LED bulb monitoring system which is shown in fig 1 ,

1. Reading the sensor data from the LED Bulbs integrated with Temperature, Humidity , LDR sensor with esp8266module.

2. The module communicate the information to the Raspberry pi as an access point through which information is forwarded to thecloud

3. Dashboard has been set in the cloud to monitor the usage of the LED bulb and to provide alert to replace the Bulb prior to the wear out condition using time series based on autoregressive integrated moving averageanalysis.

Fig.1. Model of the Proposed System Setting up the sensor device module

The sensor module consists of a DHT 22 temperature and humidity sensor to monitor and send the data to the node MCU module connected with the sensor. The LDR sensor connects to the analog pin of the Node MCU module to measure the intensity of the environment surrounding the LED bulb. The circuitis designed to integrate the sensors together and send the information to the raspberry pi module placed on the reachability of the WiFi module ESP 8266. The raspberry pi acts as a hotspot or fog server to correlate the information received from the node MCU and manipulates the information according to the requirement for the analysis. The weighted average of the temperature and humidity sensors are calculated in the raspberry pi module and the result is sent to the cloud using MQTT-SN Message Queuing Telemetry Transport –Sensor Networks. The Module also keeps notes with time and date parameters while exchanging information to thecloud.

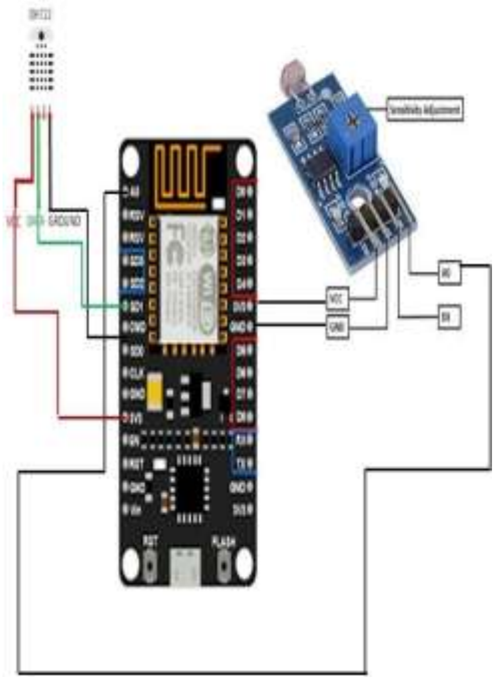

Fig.2. Proposed Sensor Module Diagram

The sensor nodes use MQTT-SN protocol to communicate T- Temperature, H- Humidity, I - Light Intensity information to the raspberry module. The sensor nodes are defined as MQTT-Client and Raspberry as MQTT Gateway and the web server is considered as MQTT-Broker is shown in fig 2

Algorithm
Step 1: The Node MCU module Reads (T, H, I) from their corresponding sensors in a periodic interval.
Step 2: The sensor module discovers the gateway and where the raspberry pi sends Advertisement Message its information such as raspberry pi_id, raspberry pi_name, and advertisementduration.

Length	Msg_Typ	Raspberry_id	Duration

Fig.3. Advertise Message Format

Length	Msg_Typ	Radius

Fig.4. Search Message Format

Step 3: The Sensor node broadcasts the search message (Srch_msg) in the specified format where the radius is fixed to 1 hop distance to the raspberry pi gateway as shown in fig3.
Step 4: The aggregate gateway is used to connect each sensor module to a raspberry pi intern it will communicate to the web server installed with the MQTT broker as shown in fig4.
Step 5: The response from the raspberry pi broadcasts a GW_info message to the searched client with respect to the radius indicated in the Srch_msg as given by the format below in fig 5

Length	Msg_Typ	Gw_id

Fig.5. Response Message

Step 6: Thus the client is registered with the raspberry pi using MQTT-SN protocol shown in fig 6.The connection can be established as follows in fig 7.

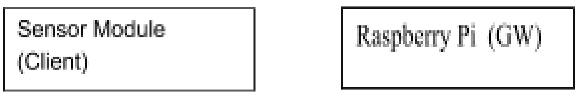

Fig.6. Client Connection Establishment

Fig.7. Connection Process

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Step 7: Client starts to publish the message using the topic id registered with the gateway (raspberry pi) as given below in fig 8.

Lenght	Msg_Type	Flags	Topic_id	Msg_id	Data

Fig.8.Message Publish Gateway

Step 8: The raspberry pi sends the acknowledgement by sending the Publish back message

Length	Msg_Type	Topic_id	Msg_id	Return code

as specified in the format as shown in fig 9.

Fig.9. Acknowledgement Message

Step 9: Message gets received by the gateway it sends to the web server through which it acts as a broker in the MQTT-SNprotocol.
Step 10: Information is maintained in a real time database for the concurrent updation of Information in the webserver.

A. Dashboard and Monitoring LEDBulbs.

The prediction of the LED lifetime is performed through the time series analysis algorithm autoregressive integrated moving average model (ARIMA model). The information is sent from the sensor module to the firebase Real time database and upgraded to the excel file through the app scripting process. The following information is stored in the database with respect to the date and time values. There are nine attributes to predict the lifetime of the particular LED_Bulb as shown in fig 10.

Date	LED_ID	GW_Id	Temparature	Humidity	Intensity	Location	Duration	Replacment date

Fig.10. Dashboard

ARIMA model to predict the life time of the LED_BULB present in the dataset collected from the sensor module.

B. Auto RegressionModel

In this we consider three parameters y1 = Temperature, y2 = Humidity, y3 = Intensity which support in defining the autocorrelation function ACF by standard deviation of the intensity with respect to time constraints.
In auto regression the past values ACF are considered to have an AR model in which the order is defined as the number of days incorporated in the form.

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \beta_3 y_{t-3} + \cdots + \beta_p y_{t-p}$$

C. Moving averagemodel

In moving average model the error rate is considered with respect to the previous days of all the parameters considered to define the formula

$$y_t = \varepsilon_t + \alpha_1 \varepsilon_{t-1} + \alpha_2 \varepsilon_{t-2} + \cdots + \alpha_q \varepsilon_{t-q}$$

$$X_t = \mu + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q}$$

In our proposed system we have combined both the process in to the single model known as ARIMA model which can defined as below

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \beta_3 y_{t-3} + \cdots + \beta_p y_{t-p} + \varepsilon_t + \alpha_1 \varepsilon_{t-1} + \alpha_2 \varepsilon_{t-2} + \cdots + \alpha_q \varepsilon_{t-q}$$

The ARIMA model is defined as in differencing subtracts the current value from the previous and can be used to transform a time series into one that's stationary.

The three integers are used in ARIMA model

1. p- order in which the AR model is defined (3days)
2. d- non seasonal difference order(day and night /2)
3. q- current day with previous day order (2 noises)

Each Smart LED is uniquely identified with the combination SLED_Buld _id and GW_Id (raspberry pi_id) to locate a specific bulb in the particular location in the ward. This model predicts the replacement of the number of bulbs with respect to the time duration.

4. RESULT AND ANALYSIS

In the result and analysis phase, the calculation is done to predict how much the intensity of street light takes during the ON phase. We have collected the information about the street lights like ward name, zone name, length of the street pole and the replacement of the bulb status.

The graph 11 describes the relationship between the date and the intensity of light. In this, it will show how much light intensity is produced in a daily manner.

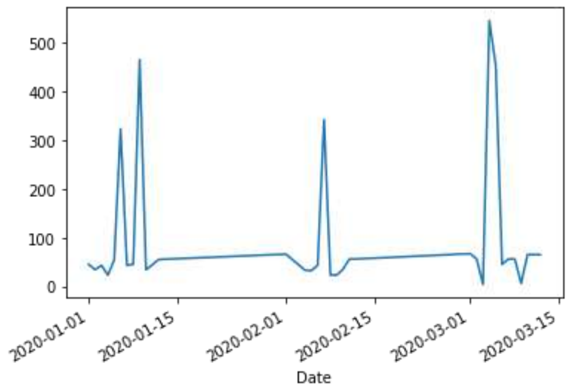

Fig.11. Street light Intensity Dataset Plot.

The graph 12 shows that what we showed before was not stationary, so next we are calculating the correlation to make them stationary. In this, we will take spike value as a lags and we are taking difference order as1.

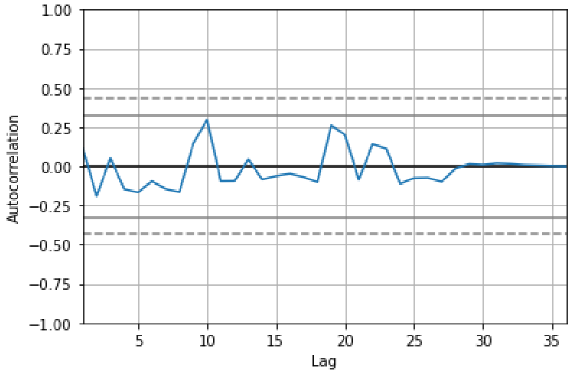

Fig.12. Autocorrelation Plot.

The below graph 13 is produced by using the ARIMA Model. We fit a model by taking lag as 5, difference order of 1and moving average of0

ARIMA(5,1,0)

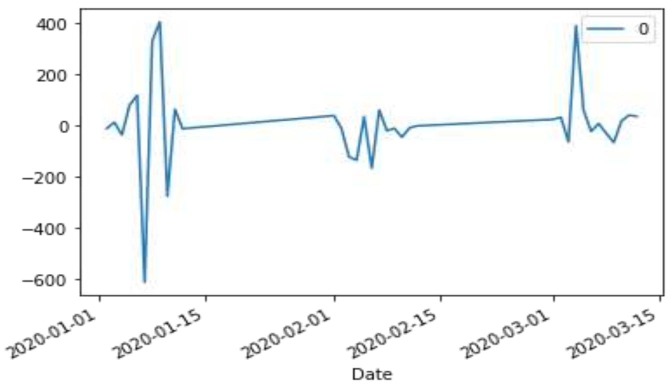

Fig.13. ARIMA Model Plot

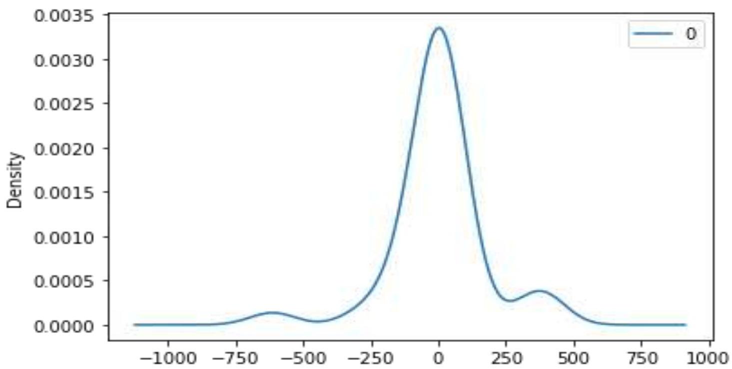

Fig.14.ARIMA Residual Density Plot

In graph 14 we have calculated the predicted and expected values for every iteration during the runtime. From the below graph 15, we have plotted the expected values in blue color and predictedvalues in red color. Finally, we also calculated the total mean square error of amodel.

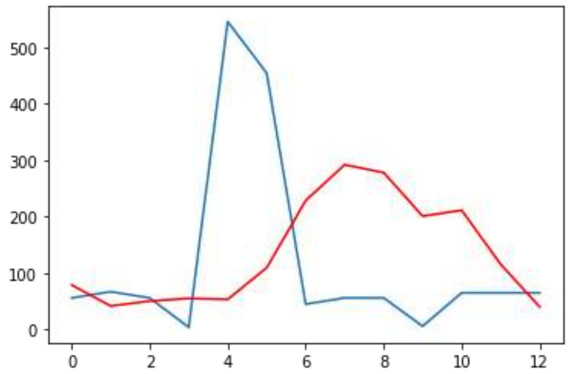

Fig.15. ARIMA Forecast Plot Predicted: 78.862220 Expected:56.000000

Predicted: 78.862220 **Expected:**56.000000

Predicted: 78.862220 **Expected:**56.000000

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Predicted: 78.862220 **Expected:**56.000000

TEST MSE: 43457.109

5. CONCLUSION AND FUTURE WORK

This project deals with the Smart Street light monitoring which reads the data from the LED bulbs with the help of ESP8266 Module.This hardware communicates with the RaspberryPi and forwards the information to the cloud.It works on Autoregressive integrated moving average model which helps to predict the future values based on the past events.The temperature and humidity values are being calculated using Raspberry Module and the data is sent to the cloud by Message Queuing Telemetry transport - Sensor

Networks.Therefore,the information is stored in a realtime database for the updation of information in the Web server.

The Future scope of the paper is defined as the prediction with other dependent variables such as temperature and humidity which influence the usability of the LED bulbs and their life. The complexity may increase if we consider the failure of the LED bulbs due to natural calamities like rain and lighting which will reduce the lifetime of the LED Bulb. Other time series algorithms can also be substituted to predict the life time of the LED bulb and monitor the depreciation of the LED bulbs.

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