Adaptive Self-learning Lightning for Smart Cities

An Approach using Machine Learning and Data Mining on IoT Sensor Data

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***Abstract*—In this paper, authors have proposed a model for Smart cities based on Internet of Things and approach for data analysis over the various data collected by the deployed sensors. Smart city is a generalized superset further consisting of different sub-modules like Smart Lightning. The modules are tested by cost-effective ESP8266 IoT chip with Lua/Arduino compilers on board. Specifically, the Smart Lightning module deploys features like adaptive lightning control that senses the light intensity around the sensors and control the light toggle accordingly. Moreover, the data collected through the phototransistor along with other data points like time, area and master control are then fed to a Fuzzy Inference System (FIS) that could be used to generate self-learned and modified threshold levels for light toggles. Since street lights in a city-wide area can be numerous, approaches for Data Mining and Big Data options are also explored. Security lapses regarding the current research work and their proposed solutions are also discussed.**

Keywords— IoT; Smart City; ESP8266; Lua; Arduino; Data Mining; Machine Learning;

I. INTRODUCTION

Light and energy saving is one of the most important step to be taken for present scenario. Automatic systems including IoT (internet of things) plays a crucial role for achieving the solution of problem. ESP8266, a Wi-Fi processor, is used in the project that is reliable and economical. It connects with the LUA interface easily and is best for embedded system designing. LDR and related sensors are used to detect the lights. The thing that needs to be taken care of is the electrical components that are required to make a reliable circuit and the design of the circuit through Eagle tool, the correct amount of voltage supplied to the circuit, correct soldering of components and proper connections to be done. Authorized users communicate through the android application SmartStreet to control the light patterns of the poles situated on different locations in the university. Thus, the proposed system is easy, reliable, economical and efficient to implement and hence saving light.

Internet of Things (IoT) is presently a hot technology worldwide. Government, academia, and industry are involved in different aspects of research implementations, and business with IoT. IoT cuts across different application domains including agriculture, space, healthcare, manufacturing, construction, water and mining, which are presently transitioning their legacy infrastructure to support IoT. Today it is possible to envision pervasive connectivity, storage, and computation, which, in turn, gives rise to building different IoT solutions. IoT-based applications such as innovative shopping system, infrastructure management in both urban and rural areas, remote health monitoring and emergency notification systems, and transportation systems, are gradually relying on IoT based systems.

Section II describes the current research work done on similar approaches. Section III explains the project implementation in phase-wise model. It also explains the usage of dataset, master control and LDR implementation of machine learning algorithms over the dataset. The Section IV mentions about the generated results and their implication with the project. Section V presents the conclusion of our current research work.

II. BACKGROUND STUDY

A lot of research work in the field of solutions for smart cities and smart home has been done. Authors in [1] have proposed a similar IoT based smart and adaptive lightning system though they don't talk about any scope of data mining on the sensor data collected. In the paper, authors proposed a system used for smart and weather adaptive lighting in street lights. Nowadays, major expenses in the transportation and municipal management involves that due to the street lights. If revamped to proposed Smart Street Light model, it is estimated to reduce the consumption by 50-60%. The phototransistor in the model whenever detects the sunlight or any form of high intensity light, the connected street light is turned off automatically to save energy and money. Additionally, the system analysts and administrators can see the street light status on their connected control machines through the local network or also the internet via remote access. Street light controller is setup on the poles of street light along with the microcontroller, and some censors, sensors used to detect the lights and send information to microcontroller to take appropriate action to it. In Controller, camera is also installed to capture the footages in real time and stored it in a server database and also an emergency button is present on pole during the emergency situation like theft, attack, accidents etc. and on pressing the button, current video footage

with an alert is send to nearest police station. Author proposed a problem in current existing street light system, like manual system is used to ON/OFF the lights, more energy consumption and also more manpower for the periodic check. The proposed solution implements Automated Street control system that should be used to reduce energy consumption, reduce light pollution and man power is completely eliminated. In this project, MSP430 mixed microcontroller is used, which is designed for low cost and consume less power. LDR (Light Detection Resistor) device is used whose resistivity factor is dependent on the electromagnetic radiation which makes them similar to human eyes, LDR works on photo conductivity phenomenon in which its conductivity is reduced by absorbing the lights. Some more components like panic Button during emergency situations and IP65 CCTV Camera used for video footage. Working of this project involves the initial condition of sunlight falling over it that led to its resistance decreasing which results in lights to switch off and during sun set, sensor detects less than threshold light intensity, so resistance decreases the street lights are again turned one. Authors concluded that their main aim to tackle the problems like wastage of energy and crime on streets, and authors ensures that their project provides security to people, especially to women and other threats also.

In [2], Author focused on the Advancement of Security which is one the most important concerns for the society. Authors also get us aware with the disadvantages of the Security cameras as well as propose the ways how to overcome these issues. They have developed a project for Security Alarm System using Internet of things, in which they sense when door is opened, it should send the signal to user. Sensor used in the project is attached to the door which are connected through a microcontroller Hence, on the event of door opened, sensor will sense it and sends the data to cloud storage through Wi-Fi module using communication protocol named MQTT (Message Queuing Telemetry Transport). In storage, there will be data analysis and concluded information is sent to the user through a SMS. Objective of project is to make society life more secure and concern free.

Authors in [3] aim to collaborate the IoT with the Video Surveillance to improve its accuracy and fulfilment of future needs of surveillance. Video Surveillance is basically a system to collect video data and information with the help of cameras and some sensors and then transmit data to the network. Authors explores the usefulness of mobile devices when people are travelling or on some other places from their own which will further help them in monitoring. A topology proposed by the author to improve the video Surveillance is hybrid of Ring and Star topologies. Using the proposed topology, they can develop a dependent network for error detection and able to scale up the network to increase flexibility and effectiveness. In the process of data transmission, data collected by cameras are send to cloud server then local server and then we have all data in storage system of server. Another major issue discussed by authors is event detection problem in the noisy environment. Some surveillance type like Cameras and RFID devices are much affected by the IoT whereas Biometric Surveillance is less affected by the IoT technology. Authors show a comparison between six previous topologies proposed and its own proposed on the basis of characteristics like Quality of Communication and Security. And On comparing, Authors claim that their topology provides more security and privacy. The proposed topology could be applied in huge buildings. Authors concluded that their proposed topology would provide a better use of IoT technology in Video Surveillance and suggested that Video Surveillance could be more improved with the help of IoT and Cloud Computing Technology.

As described in [4], authors propose a system which detects visitors with the help of Internet of Things tools. Nowadays, various technologies are being developed for the home security like CCTV monitoring system. However, in these monitoring systems, the prototype generally consists of fixed cameras resulting in some blind spots. Authors propose a system to minimize the blind spots and to check all remote location. The implementation uses Raspberry Pi 2 as controller, IR sensor for visitor detection, two ultrasonic sensors for visitor position and in camera module, servo motor is used to move camera's direction towards visitors. The IR senses the presence of visitors followed by the two ultrasonic sensors which are actively spotting the visitor location and then camera records the video and stores in database. The saved data in database then can be easily seen from any location through the Internet from any connected electronic device. For testing, they developed an actual experimental setup and tested all their components, sensors and devices. Python language is used for the algorithm implementation for Raspberry Pi 1. Authors suggests further work over this by extending their project with the use of more than two ultrasonic sensor and an infrared camera to locate the visitor more precisely during dark.

Alzubaidi, et.al, states to design automatic system with energy efficiency feature. The paper focusses on the objectives and considerations: night-time safety of the community members and the road users, the reduction of crime and fear of crime, minimizing its effect on the environment whilst enhancing the night-time ambience, provide public lighting that is cost effective, taking into account energy conservation and sustainability. Also continues to explore the use of smart wireless sensors networked LED lighting. Experimental results show that the proposed smart LED lighting system with an energy saving mechanism incorporated is able to achieve similar lighting performance as the conventional lighting condition, while at the same time, able to attain about 44% energy saving as compared to the original fluorescent system [5].

Iromini, N.A, et.al, work focused on design and implementation of an automatic light controller used in offices in order to conserve electricity as well as reduce electricity bill. The major component used is light dependent resistor (LDR) that works on the principle of changes in resistance of LDR according to

light falling on it and will hence reduce the electricity bill and is used for sensing light intensity. Manual application of controlling bulbs is eliminated by using this system. This automated system is not only applicable to offices but also applicable in, rooms, hostels, street lights, garden lights, hotels etc. [6].

Bhavik Pandya, et.al, shows the design and features of a smart home automation system. It is Bluetooth based, hence wireless and can be flexible in terms of cost. It has a special feature for smart speech sense, which would decode user's sentences into appropriate commands. It requires authentication details as a medium of security, thus preventing the use of application by unauthorized users. The system also connects with sensors, thus helping in detecting LPG leakage, intrusion detection or fire breakout [7].

Author in [8] concerned about the security lapses regarding the IoT technologies, therefore, proposed a user friendly mutual authentication protocol based on QR code [9] for the smart home scenario. In a recent case about the security issue, attacker only needed Vehicle Identification Number, with the help of which attacker can easily fetch private data and can take control over it. A major challenge is that known authentication protocols and key exchange protocols on Internet are not applicable due to the limitation of hardware resources. Authors setup the smart home in use case model. They used three types of devices namely base station (master), sensor control devices (slaves) and user devices (smartphones). Data transmission is assumed to be secured with the use of QR code scanner device having physical access to the QR code display without the interference of third party. Author basically encoded the data in QR code instead of typing information which increases its usability and avoids certain errors. In this implementation, authors developed two versions of protocol, active and passive authentication. In active authentication, new devices (smart phones) scan the proposed QR codes while in passive, new devices actually generate a QR code. Authors also introduce an attacker model to test security of the proposed protocol. They assume that attacker will not modify or drop messages and is also not able to break the cryptography at any cost. In this protocol, QR code contains Tokens (an array byte randomly generated used to authenticate devices that scans QR code), Address of the device and Fingerprint (hash of public key of device). During active authentication, firstly a device must request the QR code from master. In response, master has to generate QR code and displays on screen and wait for new devices to scan it. Authors concludes by claiming that this protocol can be applicable in any network and for the utilization of the protocol, smart home scenario can be implemented at other platforms also. Public keys exchange [10] can be used to encrypt the data in future communication.

In [11], author proposed a concept of weather station, it can provide us with details about surrounding temperature, barometric, pressure, humidity, etc. It can also analyse the light intensity and predict probability of rain. Author uses various types of sensors which can fetch the value of temperature and humidity of a particular place. And with the help of above factors we can determine some other parameters also like dew point. The main idea to implement this is by using ESP8266 based Wi-Fi module NodeMCU. Whenever the values of these parameters exceed its threshold values, corresponding this an instant SMS, E-mail and Tweet is sent to the owner of the appliance to take necessary action required. Nowadays, Internet of Things (IoT) is become an important factor to do the unexpected things smartly. And the major factor to use IoT is availability, easy to implement and reduction in cost. IoT concept is basically to connect electronic devices and sensors through the network to fetch the data from these devices (sensors) and stores in databases and later analyse these data to gather some useful information. Earlier days, peoples around the world present anywhere have no idea of whether parameters, so these devices become helpful for them in today's life. With the use of LDR which measures the intensity of light, will able to greet us with morning and evening. Module used by author is ESP8266 based NodeMCU WiFi module. It supports C programming written in Arduino IDE or Lua script. After code uploads to ESP8266 and connected to WiFi and device starts working properly. Components used to setup the module are Barometric Pressure sensor, Temperature and Humidity sensor, LDR (Light Dependent Resistor) and Raindrop module. For Raindrop module and LDR, analog pin (A0) of NodeMCU board is multiplexed using two diodes to get the output. Different pins of NodeMCU are connected to different sensors to provide required output.

In this, one pin is high and another one is at low, to work for only one sensor at one time makes other one shut. After the all measurements made by sensors, data is uploaded to the cloud storage, IBM Bluemix, then values are analyzed and then an email, an SMS is send to the user by checking the threshold values. In Future perspective, we can use OLED display to display all measured parameters and also, we can add GPS module to find the exact location, will also be mailed to the users. In this, we can modify in such a way that all the environmental parameters of device along with its location will be sent by the sender's phone.

Coming to the scope home automation, authors in [12] implemented use of IoT tools efficiently for the control and monitoring of the home appliances through internet. In home automation, user needs to use portable device to communicate with network through the protocols like Zigbee [13], Wi-Fi etc. Basic objective of the project is to control the home appliances like light, fans and doors using smartphone connected through internet or local network and control the appliances from a website or web UI using Raspberry Pi as server system. This predictive system contained flexibility, since it is using wireless reliable network to interconnect various modules of automation system. Among the major challenges of IoT system nowadays includes interoperability [14]. The implementation uses LAN (Local Area Network) for the connection among various components and modules. Infrared sensor senses the light and

sends a signal to Raspberry Pi board and by using IoT concept we are able to control the light. In case of fire, sensor detect fire and immediately sends an alert message along with image to the mobile phone and make an automatic call to the nearest fire station. Author implemented this project, starting with Raspbian [15] as the operating system and configured it accordingly while Python language is used for interfacing among different sensors. Raspberry Pi resulting the output on computer, a website or a portal is created to control over the devices and same can be done using android smart phones. After accessing the system, various areas of home are visible with various devices and selection could be made accordingly to take control over them. The proposed system can be implemented at many places like hospitals, banks, labs etc. which could reduce the chances of drastic hazards. They can be employed in industries and management through the internet resulting in improvement of security.

The main objective as described in [16] is to discuss a general reference framework for the design of an urban IoT. The main interest of this paper is the application of the IoT paradigm to the urban context as it will ultimately respond to the strong push of many national government to adopt ICT solutions in the management of public affairs. The paper describes about the specific characteristics of an urban IoT, and the services that may drive the adoption of urban IoT by the local government. The paper then discusses about the web-based approach for the design of IoT services, and the related protocols and technologies with their suitability for the smart city environment. The paper aims at the better use of the public resources, increasing their quality of the services offered to the citizens, while reducing the operational cost of the public administration, paper also focuses on the discussion about *the "Padova Smart City"* project, which is a proof-of-concept deployment of an IoT island in the city of Padova and interconnected with data network of city municipality. Paper starts with discussion about the services that are commonly associated to the smart city vision and that can be enabled by the structural deployment of the urban IoT. It states that the proper maintenance of the historical buildings of a city can be deployed with the help of IoT by continuous monitoring of the condition of the building and identifying the areas that are most probable to be affected by external agent. A distributed database of buildings structural integrity measurements will be provided by IoT most preferably collected by suitable sensors mainly vibration and deformation sensor to monitor building stress, atmospheric agent sensors to monitor pollution levels and temperature and humidity sensors to keep record of environmental conditions. After that paper discusses about one more service which is waste management which is a primary issue for modern cities. Both because of cost of service and problem of waste storage. Use of intelligent waste containers, which will detect the load and will according on the basis of optimization will take necessary steps can improve the quality of recycling. One more brilliant service mentioned in research paper is about the emission of greenhouse gases. According to European Union officials there should be 20% reduction in amount of greenhouse gases till 2020. IoT can play a key role in achieving this goal by monitoring the quality of the air in the crowded area, parks or fitness trials. Also with the help of smart devices facilities could be provided to users to find out the areas with minimum greenhouse emissions for their healthy activities. Then paper continues with one more approach which could be used in noise cancellation and traffic congestion. Sensors could be used to monitor the areas with maximum pollution and thus effective steps could be taken to overcome those cases. After that in the next section paper discusses about the Urban IoT Architecture in which starts with the discussion of Web Service approach for IoT which being flexible and interoperable system could be extended to IoT nodes by adopting the Representational State Transfer (ReST) services designed closed to ReST have strong similarity with traditional web architecture and thus facilities great use by both the server and the end users. After that paper continues with various layer of this web based approach starting with data layer in which the use of XML language is most commonly defined along with two types of encoding one being schema-less and other schema-informed. After that comes the discussion of the second layer mainly application and transport layer which starts as on why HTTP can't be used in case of IoT devices and providing an alternate to it in the form of CoAP which is binary format transported over UDP and also support ReST. Then the solution is provided in the form of HTTP-CoAP intermediary known as cross proxy which can transport request between the two protocols and inherit the advantages of both the protocols in single unit. Then the paper precedes to network layer which starts with as of why we can't use IPV4 addressing because of its limited devices constraint and also about the overheads included in large domain of IPv6 addressing. After that paper discusses about the 6LoWPAN which is compression format of IPv6 and UDP over low powered constrained networks. Then paper continues to traditional Network Address and Port Translation(NAPT) service to translate between the IPv4 and IPv6 address along with one more IPv4/IPv6 domain name conversion. Then at last comes the final part of the paper which is about the practical implementation of IoT in Padova smart city with main applications including collecting the environment data and monitoring the public street lightning by means of wireless nodes mainly with the help of different kind of sensors placed on street light and poles connected to the internet through the gateway unit. Sensors mainly perform the task of monitoring air temperature and humidity, vibrations, noise and so on while at the same time providing mechanism to check the correct operation of public lightning by measuring the lightning in the surrounding areas. Main implementation is done in lightning lamp which isolated can be considered to be a unique IoT device which not only monitors the intensity of lightning in the area but also provides data about the CO2 and benzene level in the area with the help of attached sensors thus providing the effective way to monitor the surrounding in sparse areas. These IoT devices could be connected to mobile devices through which they can be configured and monitored remotely and with no efforts required to perform the task. At the final part comes data being collected from the city which

mainly consists of the final analysis that more densely populated areas have more emission of Greenhouse gases than sparsely populated areas.

Sayali Arkade et al. proposed an economical automatic system for street light monitoring. The proposed system increases the efficiency and accuracy of industry by automatic control of switching of street lights. GSM modem, circuitry and electrical devices were used to make the control system. Main aim of the research depicted here is to save energy; base server was used to control the street lights of the city by sending text message through GSM.
Interface between user and system has been provided by Raspberry-Pi, which is connected to wireless network and relay circuit that helps in passing the operational admin's message to the system. The system can handle commands like ON lights, OFF lights, alter ON and alter OFF. Two admins had been used in the project, one called as system admin that handles log message and operational admin. System admin can add, delete, modify and view operational admin. Local sensors have been used for lighting of the lamps. Thus, it is concluded from the paper, that the automatic street lighting system hence provides efficient system by saving money and light without any use of mechanical system. [17]

From the above discussion, it is stated that light and energy saving is one of the most important step to be taken for present scenario. Automatic systems including IOT (internet of things) plays a crucial role for achieving the solution of problem. ESP8266, a Wi-Fi processor is used in the project that is reliable and economical. It connects with the LUA interface easily and is best for embedded system designing. LDR and temperature sensors are used to detect the lights. The thing that needs to be taken care of is the electrical components that are required to make a reliable circuit and the design of the circuit through Eagle tool, the correct amount of voltage supplied to the circuit, correct soldering of components and proper connections to be done. Authorized users communicate through the android application SMART STREET to control the light patterns of the poles situated on different locations in the university. Thus, the proposed system is easy, reliable, economical and efficient to implement and hence saving light. The main topic of discussion in today's world is on how to reduce the energy consumption and greenhouse gases emission on day to day basis. According to a report of 2014 there are globally 280 million street lights which are operating in world whole around. Each street light consumes around 300 to 1000 kWh of energy per year. But as there is no monitoring of these street lights they sometime operate even when they are not required to operate like in daylights or even when light is sufficient to be seen by individuals this extra consumption of energy leads to $25 to $125 wastage of money on each street light annually along the globe. More serious problems occur when they are not working properly at a given time. As there are thousands of them finding the faulty one is next to impossible task. Even when ample amount of light is available then also lights remain just because of human error. Also because of absence of a centralized control system it becomes unsafe in many practical situations which ultimately leads to road accident as on an average it takes about 20 hours to find and repair a faulty light in ideal case which using this system will reduce to an average of 30 min as it will be already known as of which and where the fault has occurred. Also, still the data obtained from these system is not considered to be applied for data mining and machine learning which when considered would ultimately lead to a boom in the use of such technology.

Embedded systems with the server hardware and programmable LUA interface plays a pivotal role in developing automatic appliances and controlling them by providing ease to the complexity of human life. Controlled energy and light consumption is very crucial to save the depleting natural resources so that future generations could make use of the facilities. IOT is an emerging trend nowadays and most of the systems are based on it. Devices and systems can be remotely accessed with the help of Wi-Fi. IOT based energy meter reading, IOT based light system are examples of this approach and are an innovative application of real time embedded systems. LDR sensors and GSM are used that sends an interrupt signals to the microcontroller for each flash of LED [18]. Automatic light system is used in determining when to activate street lights at different times of the year. The household appliances like AC, TV, lights, etc. could be controlled by using this application remotely. The system has an application in consumer electronics that are applied everywhere as it has become necessity of survival. Younger generation is mostly attached to electronic devices and uses in daily routine more often. Consumer electronics includes mobile phones, videogames, printers, Blu-ray discs, home entertainment systems, televisions, digital camera and music players. Household appliances provide comfort to the home makers or working professionals to perform multitasking within scheduled time and manage home properly. Washing machines, microwave ovens, refrigerators, dishwashers, air conditioners, kitchen appliances like juicer, mixers are few such examples that provide ease to the people.
In medical equipment too IOT is playing a major role. As the technology is growing at faster speed and these advancements are also shown in medical field. CT scanners, electrocardiogram (ECG), MRI scanners, blood pressure monitors and heart beat monitors are the equipment used to examine the patient effortlessly. Embedded systems also play a major role in providing electronic fuel injection systems, anti-lock braking systems, in- vehicle entertainment systems, air-conditioner controls and inbuilt GPS systems in automobiles. In industry assembly lines, multiple parameter monitoring systems, feedback systems and data collection systems are used while in aerospace, navigation systems, guidance systems, global positioning systems (GPS) modernizes the surroundings. The automatic system is also helpful for security purposes or in emergency at home, offices, and organizations by activating the appropriate sensor, programming and alerting respective authorized users [19], [20].

The competitive world in which we are surviving requires paying most of the attention to the natural resources like coal, water, natural gas and light energy. Careless attitude can bring harm to the society, thus leaving future generation as sufferers or devoid of basic amenities. Saving power and money is important and therefore switching OFF the lights when not required is crucial. In order to reduce manual involvement and to provide flexibility and convenience to the humans, automatic system is developed. It helps to turn ON or OFF the lights based on the parameters like intensity, area, chronological time i.e. day, night, and distance between the poles of light. The main aim of the project is to design interfaces using LUA programming environment and to establish communication of server with sensory ports and other sub-units. Each controller will have sensors like LDR, current, voltage, temperature, real time clock to detect the suitable light pattern and take action as desired by the device that time. Small, simple and low-cost microcontrollers are used that provides greater capability, efficiency and accuracy in dealing with the system. Thus, the main objective of the proposed research is to design embedded system with hardware and software application to generate automatic light system that in turn can save light and power in any university, institution, organization or large establishments effectively and efficiently.

The focus of this research is to design an embedded system for automatic controlling the light system. Hardware circuit and programmable interface is important for the realization of the system. Low cost, economical and efficient system has to be used so that it can be applied in any organization thus, saving power. Various input sensors have to be properly utilized that can convert the analog signals to digital ones. All the information is passed to microcontroller that can save the information in memory and produce analog output that users can see in LCD displays or in form of audio accessible through speakers. The illumination system developed is reliable, efficient and economical.

III. Our Project

A. Architecture

Proposed system architecture describes the overall description of the major components used in the project for remote communication of RISC server based processor with sensory ports and other sub-units through LUA interface, controlled by PDA device. Various segments are incorporated together so that the communication amongst the peripherals may be achieved. The major components used in the system are RISC Processor, Wi-Fi Modem, Hardware module, LUA Interface and Web Server, along with the components, graphical user interface is created so that end users can modify or view the currently going pattern. The output i.e. smart light system is generated that provides the different light patterns on the basis of time, area, distance between the poles of light for university thus saving light and human energy [21]-[24]. Basic block diagram of the system is depicted in Fig. 1.

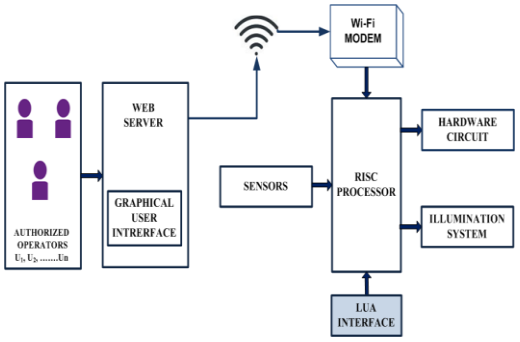

Fig. 1: Block Diagram of the System

Hardware platform is developed that allows the components to fit into the system architecture and provide communication between the ports like Bluetooth, MIC, sensors, devices, processors and programmable interface. Sensors like LDR, current, voltage, temperature and real-time clock are used that fed input to the processor. LDR works on the principle of photo conductivity which means that when there is light available then LDR will be in OFF state and when it becomes dark outside, LDR will be in ON state. When light falls on LDR, it sends commands to the microcontroller, depicting that LDR should be in OFF state. All commands are received by micro controller, based on which the device operates. Microcontroller is a small computer on single integrated circuit, a system on chip model that contains one or more processors with memory and programmable input or output peripherals.

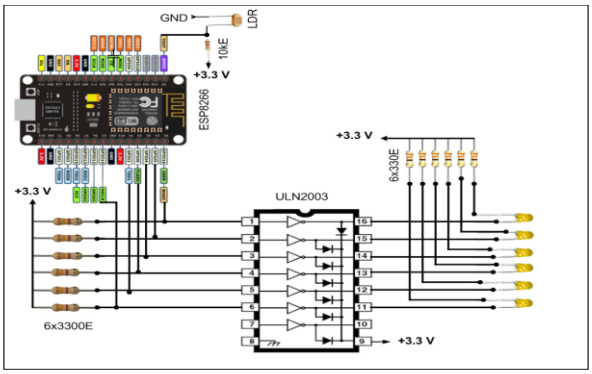

Fig. 2: Hardware Circuit for Adaptive Lightning

B. Web Server

Web server that is the main server carries all the important and updated information about the university's lights, poles, distance between the poles, area of illumination covered by the light, intensity of lamps, etc. A microprocessor ESP8266 is used that has a direct Wi-Fi (P2P support) and has direct communication with the LUA interface. It also consists of 16-bit RISC and 32 bit micro controller unit tensillica. With the Wi-Fi supportability it can connect to the internet from any place and provides a medium to smart phones to interact with

the system. Android application SMART STREET is developed by using android studio with microcontroller that are responsible for receiving the input data and then follow the programming instructions embedded in it to produce light patterns [30]-[32].

C. Master Control

The main objective of the project was to eliminate the manual efforts to control the lighting system automatically and remotely. First and foremost, step for the fabrication of hardware circuit was to create the list of electronic components and to identify input and output of the system to control the lights. Output is in the form of three lights that are ESP8266 inbuilt LED, outer LED and pole bulb that switches ON or OFF as per the user's instruction. The design is tested on the prototype model and works accurately. The system can be implemented in real life scenarios. The circuit can be positioned on the pole so that it is controlled remotely using Wi-Fi centralized network, Ethernet or Bluetooth by the authorized operators. The circuit system can be copied and multiple circuits can be designed to be placed on the poles where the light has to be operated automatically in some particular area. All the systems designed can be differentiated from one another by the unique IP address to which their microprocessors are connected to. The system through microcontroller can be further modified to detect sensors from temperature, humidity, moisture, and water as per the requirement of the system. It can also display the time on real time basis on LCD (liquid crystal display) and can take audio-video input-output. The system can be used for security purposes or emergency. Two circuits are designed to simultaneously control the lights on different poles through the same microcontroller used in the both circuits. Modifications in the circuits designed can be done as per the requirement. After circuit is designed, NodeMCU LUA interface is developed and saved to ESP8266 processor. All the lights are assigned to the specific pin numbers of the processor with whom they are connected and are set to output mode. Wi-Fi connection is established by giving the suitable IP details. Buttons format, font and style are programmed in HTML in LUA code itself. Various conditions are set to control the three light systems. This code can be further enhanced by increasing the number of lights and conditions associated to increase the security. Fig. 4 represents two hardware modules flashing lights as per the program interface. It displays all the lights of both the circuits ON. Mobile application is developed in android studio with login and street map activity. Functions like onCreate, onESP, onLogin, onOffline, validateEmail, Firebase authentication, etc. are created to work in modules and develop different patterns. When users open the SMART STREET application on their mobiles, firstly authorized users have to login. A map of university will open up and will display the poles at the location where the circuit is placed, on clicking on one of the lamp, IP address will be displayed and then five options will be displayed as Lights On, Lights Off, ESP LED, LED and Bulb. User can click on any one option and can see the expected result. Firebase authentication provides security to the authorized users and generates real time data. All the modules together perform as an automatic light system that controls illumination of lights using proposed android based Wi-Fi enabled ESP8266 model from remote PDA device using Firebase database. Any android phone can be used to access and control the system remotely, only if the application is installed in the phones of authorized operators.

D. Self-Learning

The crux of the project lies in the self-learning algorithm developed for adaptive lightning control. Once the adaptive lightning and master controls are working fine, the sensors data are collected in the administrator's system database. The log of master control commands and crisp threshold levels are the part of this database along with the parameters like temperature, area, time, weather, season of the year as well as other devices logs in the same cluster. This can now be used to fed into a Fuzzy Inference System that uses different approaches like Mamdani or Takagi Sugeno to develop fuzzy ranges for lightning control. Since, the decision output would be in Fuzzy Sets, same can be used to control the intensity accordingly. Using deep-learning algorithms, we can train the cluster to make decisions more precisely using the pre-defined attributes discussed above.

IV. Results

This section describes and interprets the result generated through the implemented techniques. Results are sub-divided corresponding to the different machine learning techniques used.

V. Conclusion

This project elaborates the design of server hardware circuit based on Wi-Fi based RISC processor and implementation of the LUA interface with mobile application that automatically controls the lighting system remotely. Hardware circuit works in a proper manner, with ESP8266 as the main processor component and LDR sensor to detect the presence or absence of light. SMART STREET mobile android application works well as expected. Authorized users are able to control the lights easily and efficiently. The system has reduced the manual efforts and has automatized the control, thus saving energy. This automatic control system is useful in many applications for home, offices, institutions or large establishments.

The above project can be developed using solar street light system with automatic street light controller. The system gets power by harvesting the solar energy through a solar cell during day time through battery and provides an effective way for the operation of hardware circuit and controlling the light system. Automatic light system can be used for emergency, fault detections and for security purposes at home, offices or institutions as per requirement. This system can be used to automatically control home appliances, security burglar alarms, etc. It can be used to measure traffic density and can control traffic of the road.

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