ADAPTIVE AND SELF-LEARNING SMART STREET LIGHTING AUTOMATION

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SUMMARY

Adaptive Smart Street Lightning is a module to automate existing street lights infrastructure using deployment of cost-efficient ESP8266 WiFi chipsets. The module optimizes group's net intensity (thereby energy costs) using self-learning over attributes like area light intensity (using LDR), weather conditions (like cloudiness, temperature, visibility), geolocation (using Google Maps API), time of the day and Master Control. A group of Street Lights (belonging to a colony or area) is a (sub)network and thus bears an IP address that can be controlled by the administrators using local internet/Wi-Fi (the android interface that allows this is the Master Control). Moreover, the street network is not hard-coded into the app but is managed via cloud server (Firebase) allowing real-time management. The module will thus help connect a network of street lights arrive at a collective optimized intensity to further reduce net energy consumptions as well as collect environmental parameters that could be used to generate datasets for statistical analysis and predictions using Fuzzy Inference System and/or Machine Learning Algorithms. The approach can be extended to whole city or state department and can additionally help rectify local errors such as a non-working street light or those depicted by the collected data. While administrators would have advanced tools to control and manage the network through mobile or web authorized interfaces, citizens would be able to view their local and global street lights cluster and can have further access to corresponding open data.

IDEA

1.1 What is the problem you are trying to solve?

The focus of this research is to design an embedded system for automatic controlling the light system, optimizing energy usage and learning light patterns over areal and weather patterns. 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. The illumination system developed is reliable, efficient and economical. The primary theme of discussion in this day and age is on the most proficient method to decrease the energy utilization and greenhouse gases emission on everyday premise. As per a report of 2014 there are 280 million street lights globally. Each street light on an average expends around 300 to 1000 kWh of energy every year. But since 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 and this extra consumption of energy leads to around ₹1700 to ₹8400 ($25 to $125) wastage of money on each street light annually along the globe. Also, each street is responsible to produce about 300 to 1500 Kg of CO_2 each year which ultimately is released to our atmosphere. More major issues happen when they are not working legitimately at a given time. As there are a great many of them, finding the flawed one is time-consuming and detecting the faulty one as soon as the fault occurs is next to impossible. 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, the data obtained from systems like the proposed can be considered to be applied for data mining and machine learning which would ultimately lead to a boom in the use of such technology. Also, street lights currently do not employ the weather conditions to take decision about the lightning of street lights which is one of the major factor as time at which daylight vanishes depends on the weather condition as well as the timezone There needs to be a centralized system connected to internet or local network through which authorities can control lightning of the whole area remotely as well as with the assistance of which users could monitor them anywhere and anytime.

1.2 Do you have any supporting statistics from reliable sources?

A plenty of surveys have been done for street lighting data and energy usage. The author in [4] also estimated the energy savings by using LDR for light automation. It was assumed that for a minimum of 2 hours a day, the lights were kept on uselessly. The lights were of Sodium Vapour which are 400W each. By automating only 50 street lights, author estimated a saving of 40 kWh per day and 14,400 kWh per year. The EESL Toolkit for Street Light Energy Efficiency [10] has projected the energy consumption in Indian public lighting sector for 2021-22 given the available data for previous years as per the 18th Electric Power Survey of CEA.

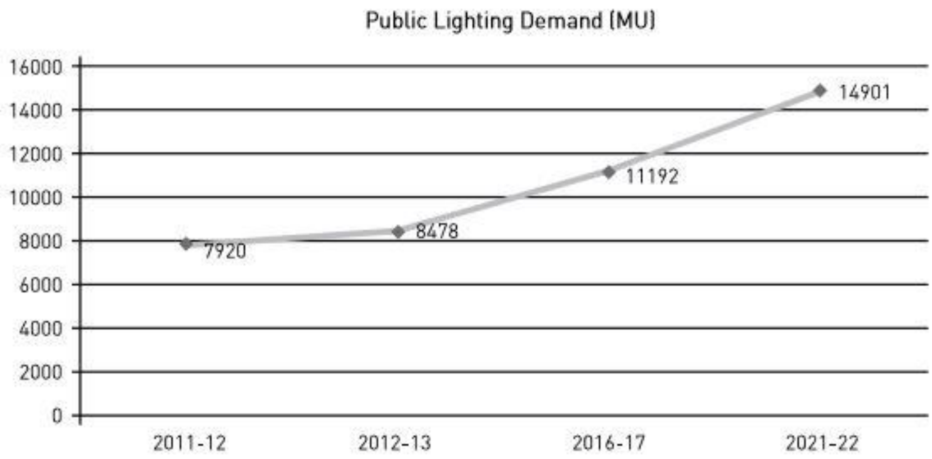


Fig. 1.1: Public Lighting Demand

The toolkit has also compiled state-wise data for no. of lights and related information which can be used for urban and rural implementation according to the area-wise data. The data is summarized in Table 1.1.

Energy Savings Potential for Street Lighting in India [11] estimates that the average growth rate per year in energy consumption over last 10 years is around 7.0%. This is summarized in Table 1.2 whereas the energy usage for 2010 and 2020 by technology type is provided in Table 1.3.

The discussed report by EESL [9] estimates that there are more than 3 million street lights in India. Even using the basic implementation of LDR as depicted in [4] gives an annual savings of around 900 GWh which attributes 10% more savings as per the DELP project. On world level, it is worth more than 80 TWh of energy savings.

Table 1.1: State-wise street lighting data

Name & No. of MC	Energy Con-sump-tion – MU	Energy Savings MU	Monetary Savings - in Cr	Invest-ment - in Cr	Simple Pay-back – yrs.	Tariff - Rs./ kWh	No. of lights
Andhra Pradesh (9); Anantapur, Guntur, Hyderabad, Khammam, Kurnool, Mehaboob-nagar, Nalgonda, Tirupati, Vishaka-pattnam	186.03	93.39	59.49	359.97	6.05	6.37	356162
Assam (6); Dehikiajuli, Dibrugarh, Jorhat, Rangapara, Rangia, Tinsukiya	1.04	0.47	0.22	1.90	8.63	4.70	4372
Bihar (6); Bhaglapur, Danapur, Ka-tihar, Munger, Muzaffarpur, Purnia	5.67	2.68	0.67	12.36	18.48	2.50	11129
Chattisgarh (4); Bhilai, Bilaspur, Durg, Raipur	22.28	12.40	3.53	32.43	9.18	2.85	54811
Haryana (9); Ambala, Bhiwani, Faridabad, Fatehabad, Gurgaon, Narnaul, Rohtak, Thanesar, Yamuna Nagar	26.26	13.86	6.86	45.87	6.68	4.95	54151
Himachal Pradesh (4); Dalhousie, Ghumarwin, Kangra, Shimla	1.35	0.72	0.29	2.01	7.00	4.00	5913
Kerala (9); Allappey, Ambalapu-zha, Cochin, Kasaragod, Kottayam, Malappuram, Palakkad, Trichur, Trivanduram	64.51	34.17	10.25	99.30	9.69	3.00	144515
Maharashtra (10); Jalgaon, Kalyan, Nagpur, Nanded, Nasik, Pimpri, Chincwad, Pune, Sangli, Solapur	209.26	102.75	34.94	428.25	12.26	5.00	401303
Madhya Pradesh (13); Bhopal, Burahanpur, Dewas, Gwalior, Jabal-pur, Katni, Khandwa, Ratlam, Rewa, Sagar, Satna, Singroli, Ujjain	72.34	38.94	14.80	120.62	8.15	3.80	401303
Punjab (6); Amritsar, Bhatinda, Gurudaspur, Hoshiyarpur, Ka-purthala, Patiala	3.99	1.88	1.05	8.28	7.91	5.56	116291
Rajasthan (6); Bikaner, Gan-ganagar, Hanumangarh, Jaipur, Jaisalmer, Nathdwara	58.50	29.10	14.26	105.85	7.42	4.90	182117
Uttar Pradesh (11); Aligarh, Alla-habad, Barabanki, Ghaziabad, Jhansi, Kanpur, Luc-know, Meerut, Mirzapur, Sitapur, Varanasi	182.32	98.80	55.33	296.49	5.36	5.60	348332
Uttarakhand (1); Dehradun	9.01	4.01	1.58	21.16	13.36	3.95	23367
West Bengal (17); Aliduarpur, Asansol, Bhatpara, Cooch Behar, Darjeeling, Durgapur, Haldia, Hoo-gly Chinsurah, Howrah, Jalpaiguri, Kamarhati, Kharagpur, Kolkata, Maheshtala, Panihati, Rajpur Sonar-pur, Siliguri	183.96	97.97	52.61	294.40	5.60	5.37	399457
Gujarat - (159);	353.42	180.24	89.22	637.93	7.15	4.95	862000
Total (269)	1,379.94	711.37	345.09	2,466.8	7.15		3,365,223

Source: EESL Toolkit for Street Light Energy Efficiency

Table 1.2: Recent Public lighting energy use and growth rates

Year	Year	Public Lighting (GWh)	Annual Growth Rate	CAGR
0	2000-01	3,422	NA	NA
1	2001-02	3,587	4.8%	4.8%
2	2002-03	3,975	10.8%	7.8%
3	2003-04	4,426	11.4%	9.0%
4	2004-05	4,968	12.2%	9.8%
5	2005-06	5,177	4.2%	8.6%
6	2006-07	5,825	12.5%	9.3%
7	2007-08	6,131	5.3%	8.7%
8	2008-09	6,141	0.2%	7.6%
9	2009-10	No Data	No Data	No Data
10	2010-11	6,731	No Data	7.0%

Source: Energy Savings Potential for Street Lighting in India

Table 1.3: Public Lighting Base case scenario for 2020 by technology type

Luminaire Type	Estimated Energy use 2010	Energy 2020 in Base Case	% GWh
Incandescent	169	332	3%
Tungsten halogen	1,096	2,156	16%
Compact fluorescent	118	232	2%
Light emitting diode	74	146	1%
Mercury Vapor	916	1,802	14%
High Pressure Sodium	965	1,898	14%
Metal Halide	1,145	2,253	17%
Linear fluorescent	2,147	4,224	32%
Efficient linear fluorescent	101	198	1%
Total	6,731	13,241	100%

Source: Energy Savings Potential for Street Lighting in India

1.3 How does your idea address the problem?

The module at its very basic assists to toggle the lights or control its intensity based on various parameters like intensity, area/timezone, time, and orientation of the cluster of poles of light. The principle 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 major objective of the proposed research work 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. For the initial phase, the phototransistor senses the amount of light over it and adjusts the intensity of the street light or a cluster of street lights. In second phase, the master control implements supervised learning and analyzes the error between actual output and expected output. For example, LDR is simply a sensor that it like all other electronic devices error-prone. Suppose a case where the time is 9:00 PM but headlight of a car imposed on the sensor (maybe accidentally) can make the sensor not to trigger light ON. Similarly, a bird sitting on the sensor even in a condition of ample sunlight can cause the sensor to trigger light ON. Machine learning can make the module learn about parameters like sensor reading, time, temperature, weather and other devices outputs in the same cluster (group of lights like in a colony). The third phase consists of the learned dataset that would now control lightning according to these parameters. The module will then continue learning from its experience and feedback.

1.4 Who are the target customers?

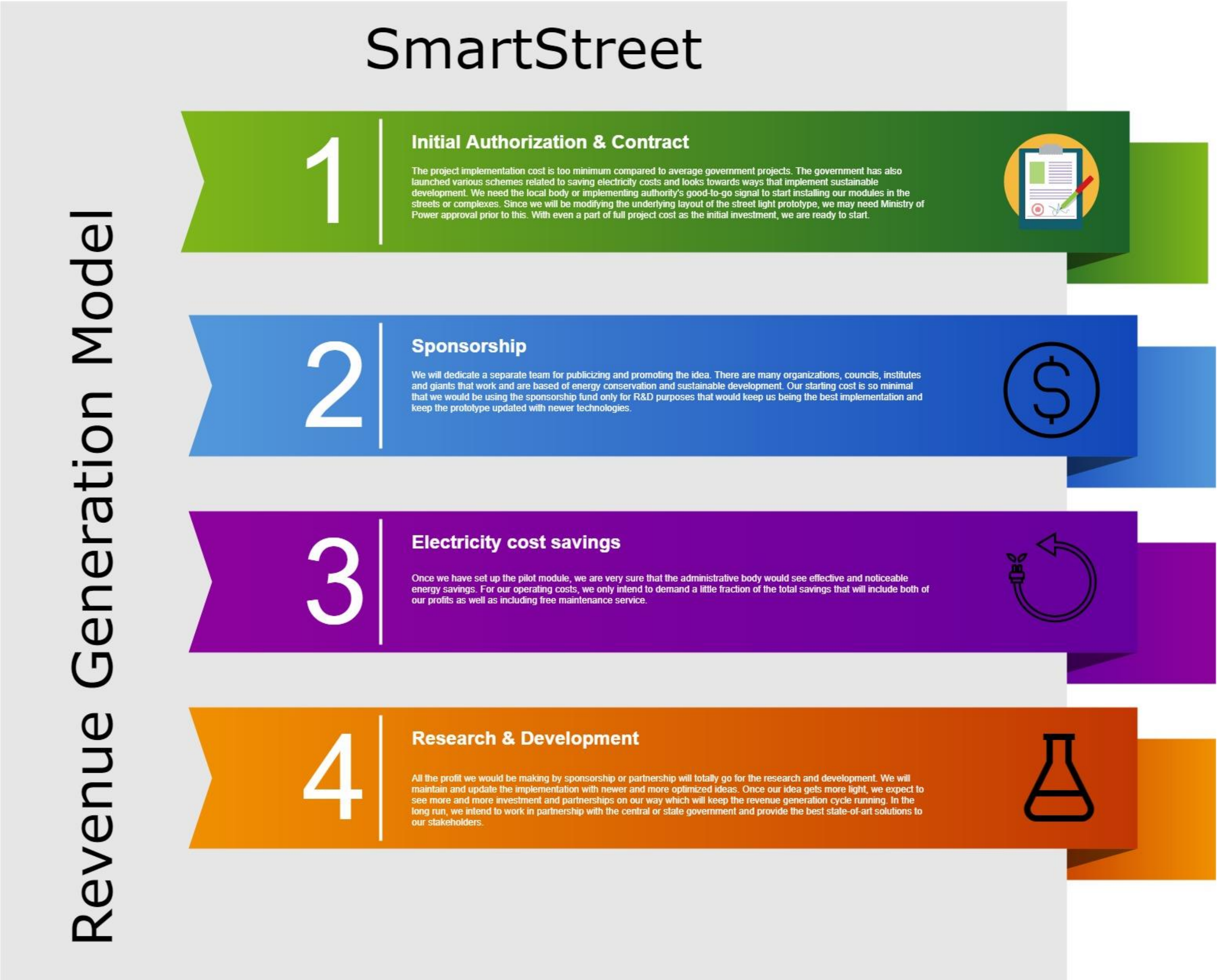
Since this a nation-wide idea and appeal to the government, all the citizens are our target customers. On commercial point of view, we want local governmental bodies or residential societies to invest and implement this on pilot basis. Our statistical generation tools will then help them to analyze the cost and electricity they save for a customized period and condition.

1.5 What makes your idea unique?

Table 1.4: Comparison of other existing approaches

Reference	Our Approach	Existing Approach
[2]	LDR used to measure intensity; MSP430 microcontroller is used. Output is binary i.e. ON or OFF.	In addition to LDR, weather data is also fetched. ESP8266 enables Wi-Fi connectivity. Output is intensity percentage for the cluster.
[3]	Discussed how energy can be saved using IoT based approaches.	Implemented the light intensity and time based automatic street lighting control system and estimated the energy saved.
[4]	LDR is used to measure intensity and then energy saved is calculated.	In addition to LDR, cloud database, weather API, Master Control and learning module is also implemented.
[14]	LDR is used to detect resistance while the output is binary.	The output is a continuous value depicting required counter intensity that is function of the learning algorithm.
[17]	ESP8266 is used to collect LDR values as well as parameters like temperature and humidity.	In addition to fetching related parameters, this data is also sent to Cloud Database. Data mining could be used over this data set then.
[33]	Raspberry Pi is used as the interface to connect LDR to the cluster. GSM is used for remote communication.	ESP8266 is used as automatic controller with the help of Lua programming interface. It is more cost efficient. Wi-Fi is used for remote connectivity.

1.6 Share your revenue generation model?



1.7 What are the geographies, do you think the idea would be suitable for?

Because of the minimal setup costs, the idea can be implemented anywhere where street bulbs are installed though we think urban and semi-urban areas would benefit most of out of this. Excluding critical areas, like highways, where appropriate lighting is preferred over cost savings, areas with clusters of street lights like colonies, parks, residential complexes and low population density ones would see a considerable decline in energy usage.

1.8 What are the risks associated with your idea and how can you mitigate it?

Risk Analysis Table

Risk ID	Description of Risk	Probability (P)	Impact (I)	RE (P*I)	Risk selected for Mitigation (Y/N)	Mitigation plan, if any
1.	Schedule risk	0.2	5	1.0	Y	
2.	Budget risk	0.05	1	0.05	N	Very less chances of budget problem.
3.	Operational risk	0.3	5	1.5	Y	If data set is large, then the throughput and response time decrease significantly. Scheduling can be done.
4.	Technical risk	0.4	8	3.2	Y	Proper feature Selection is key of better accuracy.
5.	Programmatic risk	0.2	4	0.8	N	Packages, Interpreter and Developing Environment should be install properly.

Mitigation Table

Mitigation Approaches

- For Interpreter Problem, re-install/re-open it or check for Lua/Esplorer/Python.
- For unwanted output, check the proper working of sensors, range of variables or functions.
- Copy the Source code and dataset for backup.
- Check environment variables for better performances.

Testing Plan

Type of Test	Will Test Be Performed?	Comments/Explanations	Software Component
Requirements Testing	Yes	Needed to check if LEDs have correct outputs	LDR module, Weather API
Unit Testing	Yes	Every unit needs to checked for correct output	LDR module, Weather API, Master Control, Cloud store and fetch, Login, Maps API, Self-learning
Integration Testing	Yes	All modules need to work as expected to produce the combined output	LDR module and ESP8266 output; Master trigger and ESP8266 output; Master trigger and Weather API; Master trigger and Firebase store; Login and Firebase fetch; Login and Maps API
Performance	Yes	To determine energy savings and automation status	LDR intensity check; ESP8266 output
Stress	Yes	Test for extreme conditions like high voltage and temperature, data transfer.	LDR module; Wi-Fi module; LED module;
Compliance	Yes	Wireless communication should be done using standard modules	Wi-Fi module
Security	Yes	Intranet and internet communication should follow security standards	Wi-Fi module; Firebase store and fetch
Load/Volume	Yes	Test conditions for high intensity and high bandwidth consumption	LDR module; circuit module; Wi-Fi module

1.9 Who are the stakeholders involved in order to take bring this idea/product to the market?

- Local bodies that control the street light implementation in the area: Society admin in case of private complexes, Municipal corporation in case of city and metro residential colonies, NHAI for highways, state government for streets and central for pan-India expansion.

- Sponsers in case of large investments that can drive more sophisticated tools to be built.

- Ministry of Power for authorization and discussions for large scale implementation.

- Organizations & Schemes working on energy saving and sustainable development for support.

However, for starting the project on pilot basis, even a good-to-go signal from a small society is enough for us to demonstrate the capability of this model.

INTELLECTUAL PROPERTY ASSESSMENT

2.1 Is your idea patentable or patented? Is your idea built existing work? If so how is it different?

We have already discussed how our idea stands in front of existing work done in this field in Table 1.4. Pandova had already implemented the similar technology to control street lights but our idea does a dozens of stuff in addition to optimizing the current one – namely machine learning over the collected sets, data mining with the large set of weather and related data, remote access, cloud control and easier addition of street bulbs over the map, mobile application for admins and users and using sophisticated sensor to teach patterns and analyze areal data. We have not found any other implementation other than ours that does anything more than just using sunlight intensity to control intensity of the bulbs. This is prone to many machine-based errors, false triggers and no adaption based on weather patterns for a particular area.

We have done a lot of background literature study over the existing similar approaches. Authors in [2] have proposed an IoT based smart and adaptive lightning system which is used for weather/surroundings adaptive lighting in street lights. Extra feature includes administrative control of street light using smart phones and an emergency button on pole for emergency situations. In [25], Author focused on the Advancement of Security. Authors have developed a project for Security Alarm System using IoT, in which they sense when door is opened and it should send the signal to user in a suspected situation. Authors in [34] aim to collaborate the IoT with the Video Surveillance. 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. 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 [19], authors propose a system which detects visitors with the assistance of IoT tools. In monitoring systems, 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 by tracking the moving object using sensors. In [3], author propose to design automatic system with energy efficiency feature. The paper suggests cost effective and environmental friendly way of reducing crimes at night time. Author also explores the use of smart wireless sensors network LED lighting. Experimental results demonstrate that the proposed smart LED lighting system can achieve around 44% energy saving when contrasted with the original fluorescent system [3]. In the paper [19] work is focused on outline and implementation of an automatic lighting controller used in workplaces or offices in order to conserve electricity as well as reduce electricity bill using light dependent resistor (LDR). Paper [23] proposes smart home automation system. It is Bluetooth based, has a special feature for smart speech sense, which would decode user's sentences into appropriate commands and also connects with sensors which help in detecting LPG leakage, intrusion detection or fire breakout. Author in [21] concerned about the security lapses regarding the IoT technologies, therefore, proposed a user friendly mutual authentication protocol based on QR code for the smart home. In [17], author proposed a concept of weather station, it can provide us with details about surrounding temperature, barometric, pressure, humidity, etc. It can also analyze the light intensity and predict probability of rain. The main idea to implement this is by using ESP8266 based Wi-Fi module NodeMCU. This system also notifies user in certain conditions. In [37] implemented use of IoT tools efficiently for the control and monitoring of the home appliances through internet is done. Basic objective of the project is to control the home appliances like light, fans and doors using smartphone connected through internet. The main objective as described in [1] is to discuss a general reference framework for the design of an urban IoT.

The paper describes about the specific features of an urban IoT, and the services that may encourage the adoption of urban IoT by the 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. Paper [33] 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. The system can handle commands like ON, OFF, alter ON and alter OFF. The smart street light system is economic as well and can be used in almost every environment, urban or rural. The survey on Indian Streets [4] depicts how much wastage of energy can be attributed to even a group of street lights on an ordinary highway. A simple inclusion of economical LDR sensors can reduce the amount of energy used to a considerable level. The surveys and statistics by EESL and various survey groups [9,26,33] gives idea of the state of street lighting in the country. If the estimated 35 million conventional street light across India uses even the basic implementation of automatic lighting framework, the country can save thousand of crores of rupees each year. As per the literature studied and empirical study done, an estimated saving of 900 GWh each year for the country gives even the basic implementation of the project a go signal while the inclusion of Master Control, Data Mining, Cloud Database, Wi-Fi connectivity, Self-Learning algorithms and Web interface makes it unique and trending at the same time.

CHAPTER 3: PROOF OF CONCEPT

3.1 What is the nature of the prototype/ proof of concept, you would be able to submit?

Since this is a IoT based project, we have built a GitHub repo to share the source code we use in our LUA board, the documentation, maps images, phots and video of the demo, user manual and the related stuff one would need to build the project from scratch.

- **GitHub repo:** https://github.com/paras-lehana/digifest-bikaner
- **Article on GeeksforGeeks:** https://www.geeksforgeeks.org/project-idea-smartstreet/
- **Project Video:** https://drive.google.com/file/d/1-Tx-8BmVL0baxRuUhpweKQSohKL8aNnq/view

3.2 Have you completed pilot tests for your prototype?

Yes, provided in Testing Plan in 1.8. Here are some more tables:

Table 5.2: Component decomposition

S.No.	List of Various Components (module) that require testing	Type of Testing Required	Technique for writing cases
1.	LDR module	Requirement, Integration, Stress, Unit, Load/Volume	White Box – statement testing, decision testing
2.	Wi-Fi module	Stress, Compliance, Security	Black Box
3.	LED module	Stress	Black Box – cause effect, robustness
4.	ESP8266 output	Integration, Performance	Black Box – cause effect
5.	Master trigger	Integration, Unit	White box – path testing
6.	Login	Unit	White box – path testing
7.	Weather/Maps API	Integration	Black box – cause effect
8.	Firebase	Unit, Integration	White box – path testing, statement testing

Table 5.3: Error and Exception Handling

Test Case ID	Test case	Debugging Technique
LDR/03	Intensity variation with temperature	Print debugging
CLOUD/03	Lamp data not stored	Print debugging
MASTER/03	Auto Mode ON doesn't trigger LDR on again	Backtracking

Table 5.4: Test Cases

Test Case ID	Input	Expected Output	Status
LDR/01	High intensity	Low value (near 0)	Pass
LDR/02	Low intensity	High value (near 100)	Pass
LDR/03	High/low intensity with high temperature	Expected Low/high value	Fail
LED/01	High intensity	Turn off	Pass
LED/02	Low intensity	Turn on	Pass
LED/03	High input on each	Turn on	Pass
ESP/04	High input on A0	High value	Pass
ESP/05	Unconditional high	Turn all LED on	Pass
WIFI/01	Connect to AP with (SSID, password)	Connected	Pass
WIFI/02	Use Static IP	Connected	Pass
CLOUD/01	New lamp location	Store lamp	Pass
CLOUD/02	Login fetch with internet	Fetch lamps	Pass
CLOUD/03	Login fetch without internet	Remember lamps	Fail
MASTER/01	Click on lamp	IP fetch	Pass
MASTER/02	Auto Mode OFF	LDR off	Pass
MASTER/03	Auto Mode ON	LDR on	Fail
MASTER/04	Lamp controls	Toggle lamp, call weather API, send parameters to cloud	Pass
ML/01	Collected Data	Learning	Pass

3.3 What is the approximate cost of developing the prototype?

We have spent around 1000 INR for 2 ESP8266 modules, 3000 for circuit setup and 500 for electrical kit. TelosB costs around 25,000 but it was borrowed as it was only needed to analyze weather patterns at great precision and rate our findings. The similar setup can simply be installed with the larger street lamps and would just need an additional transformer. In society locations, this module can be install as it is in the control room that can control around 1000 street lamps with single ESP8266 module and the basic setup would cost only 5000-10,000 rupees at max. This is less than 5-10 rupees per street lamp.

3.4 Design Documentation

3.5.1 Basic Architecture

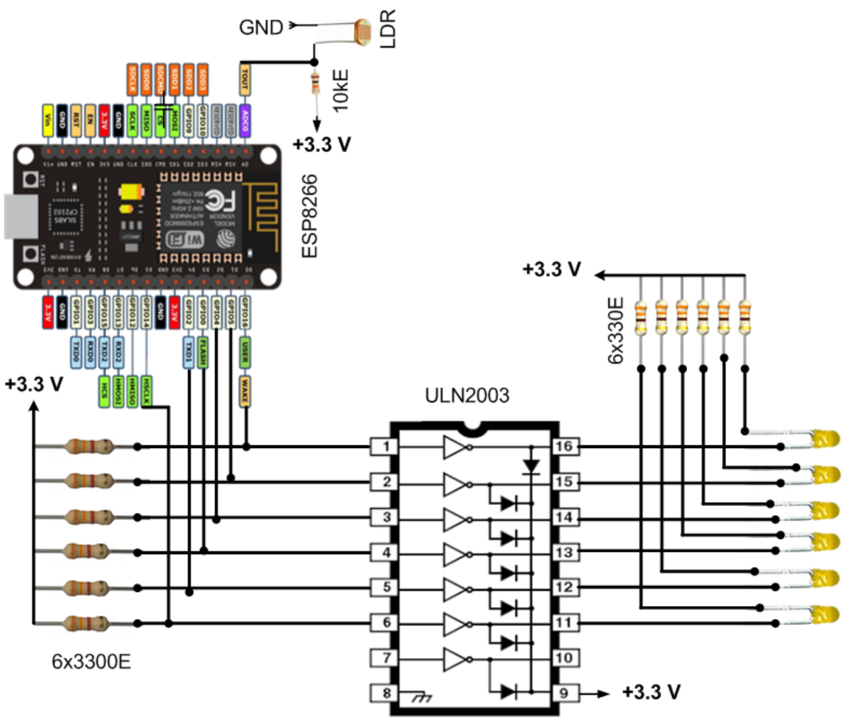
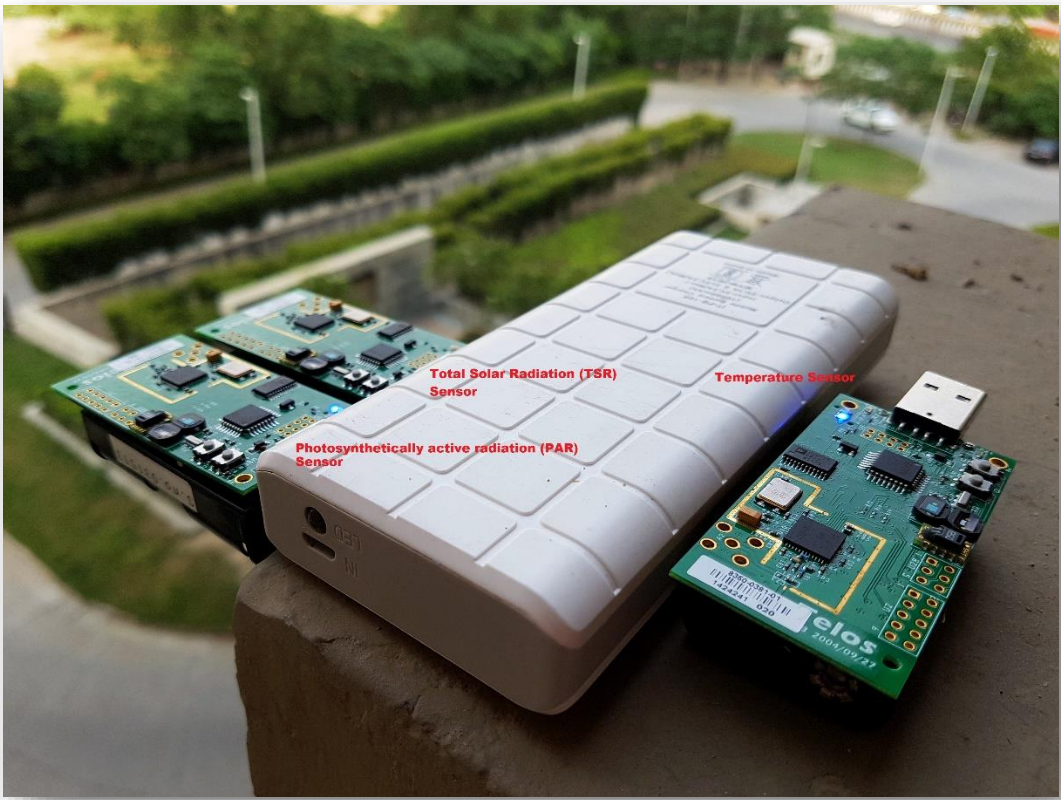
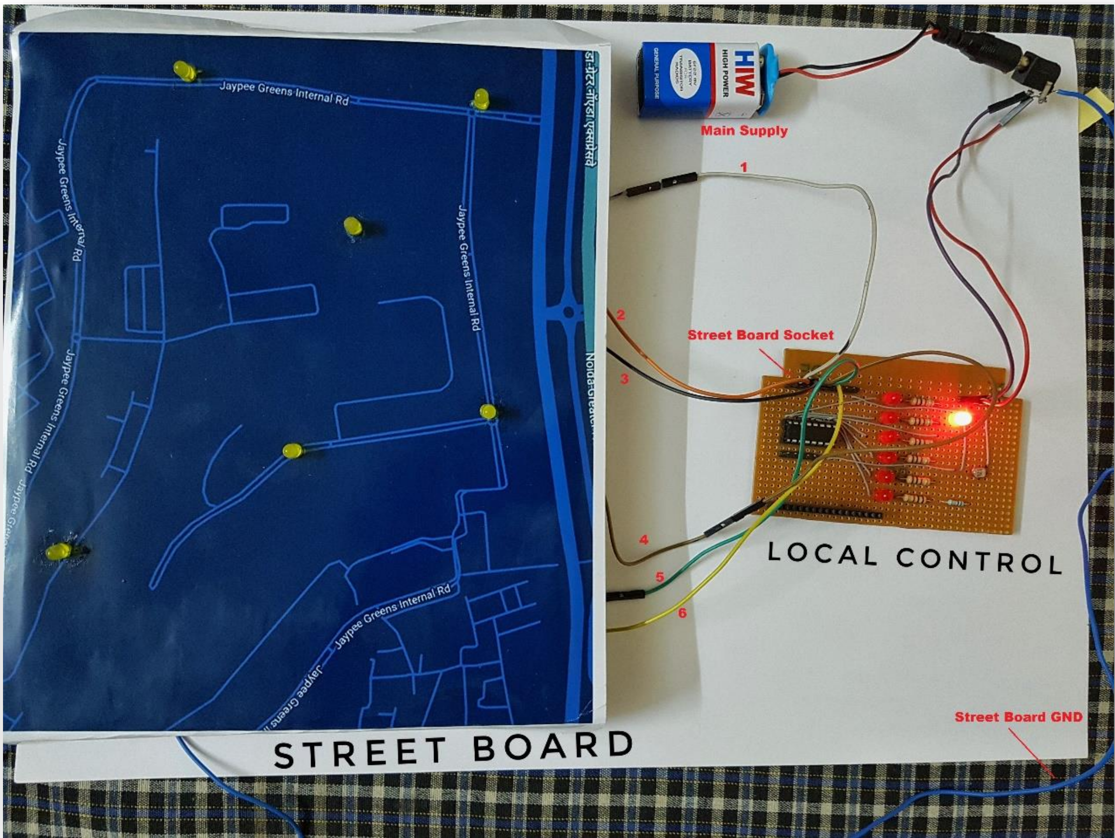
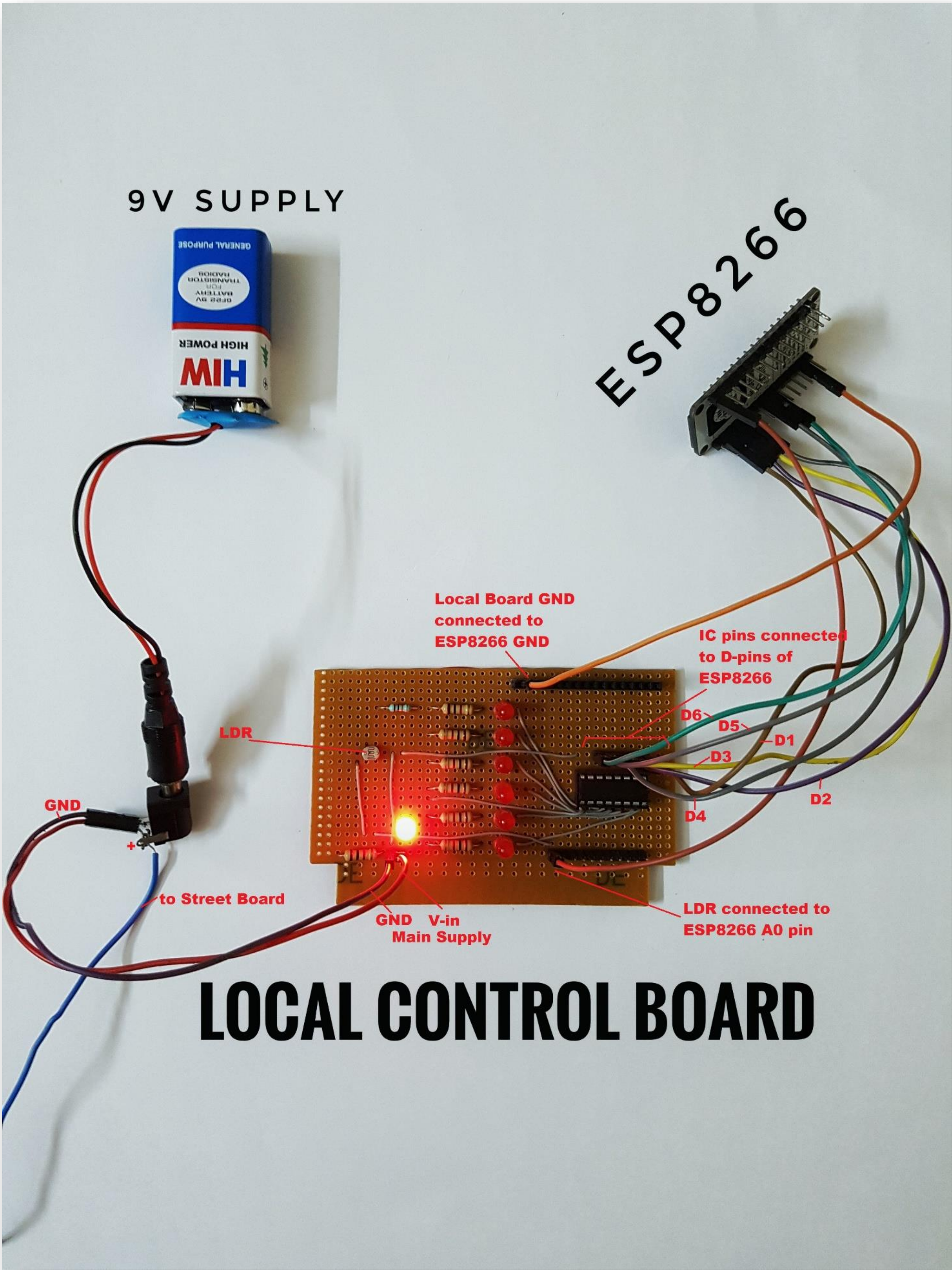


Fig. 3.1: Circuit Diagram of Light Sensing Module


Total Solar Radiation (TSR) Sensor
Temperature Sensor
Photosynthetically active radiation (PAR) Sensor


Main Supply
1
2
3
Street Board Socket
4
5
6
LOCAL CONTROL
STREET BOARD
Street Board GND
Jaypee Greens Internal Rd


9V SUPPLY
ESP8266
Local Board GND
connected to
ESP8266 GND
IC pins connected
to D-pins of
ESP8266
LDR
D6
D5
D1
D3
D2
D4
GND
+
to Street Board
GND
V-in
Main Supply
LDR connected to
ESP8266 A0 pin
LOCAL CONTROL BOARD

3.5.2 Use Case

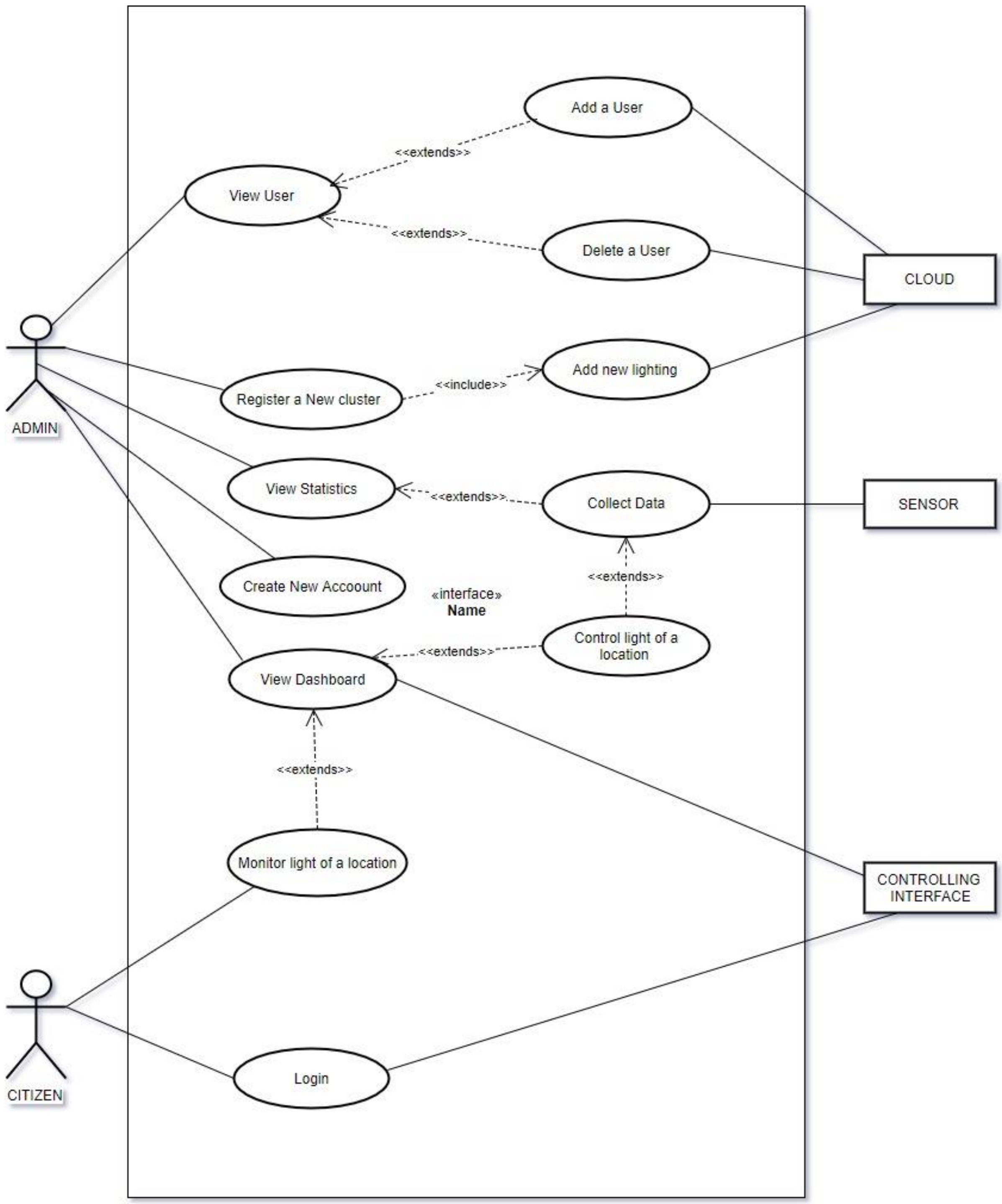


Fig. 3.3: Use Case Diagram

3.5.3 Flow Diagram

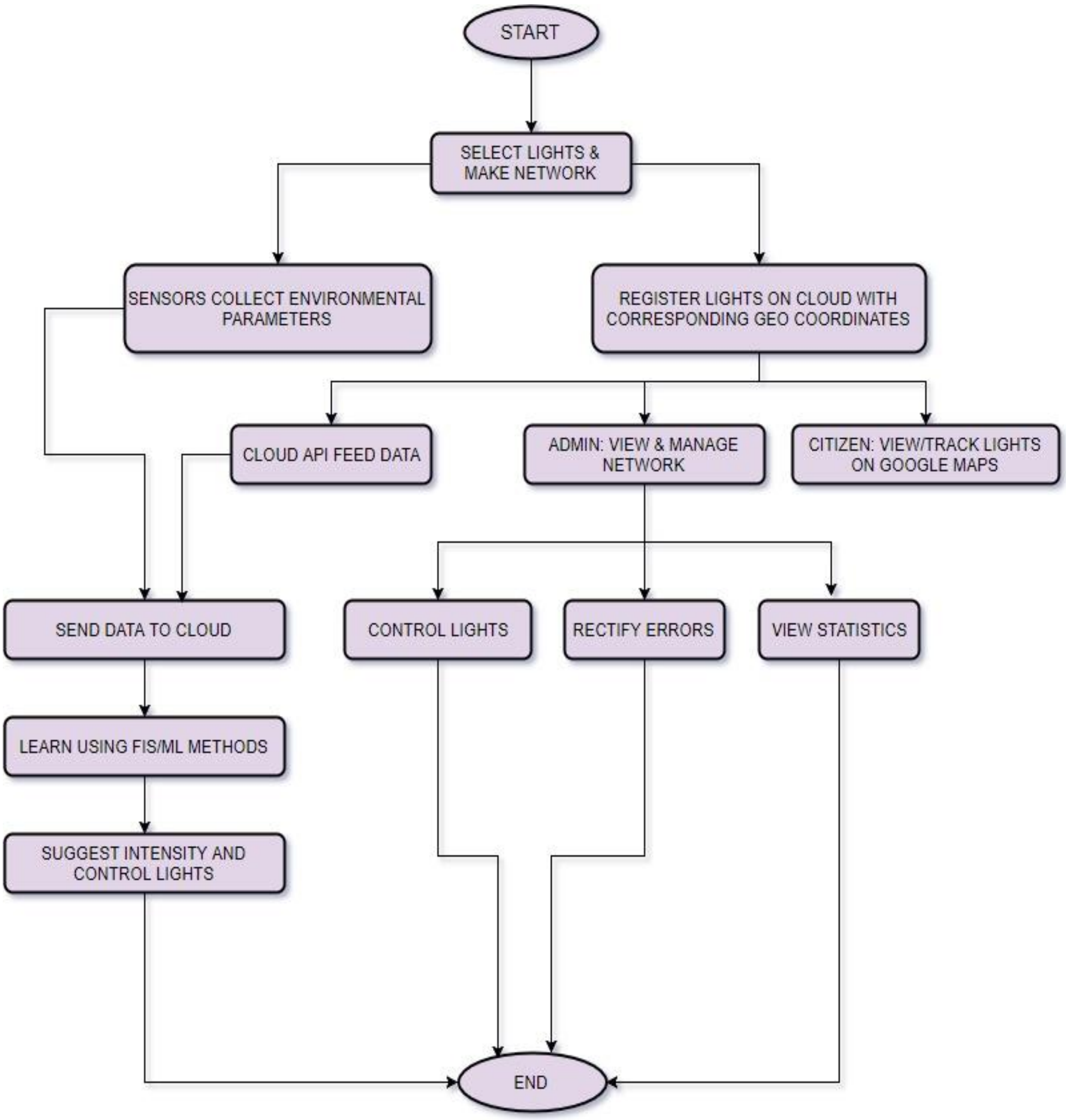


Fig. 3.4: Flow Diagram

3.5.4 Class Diagram

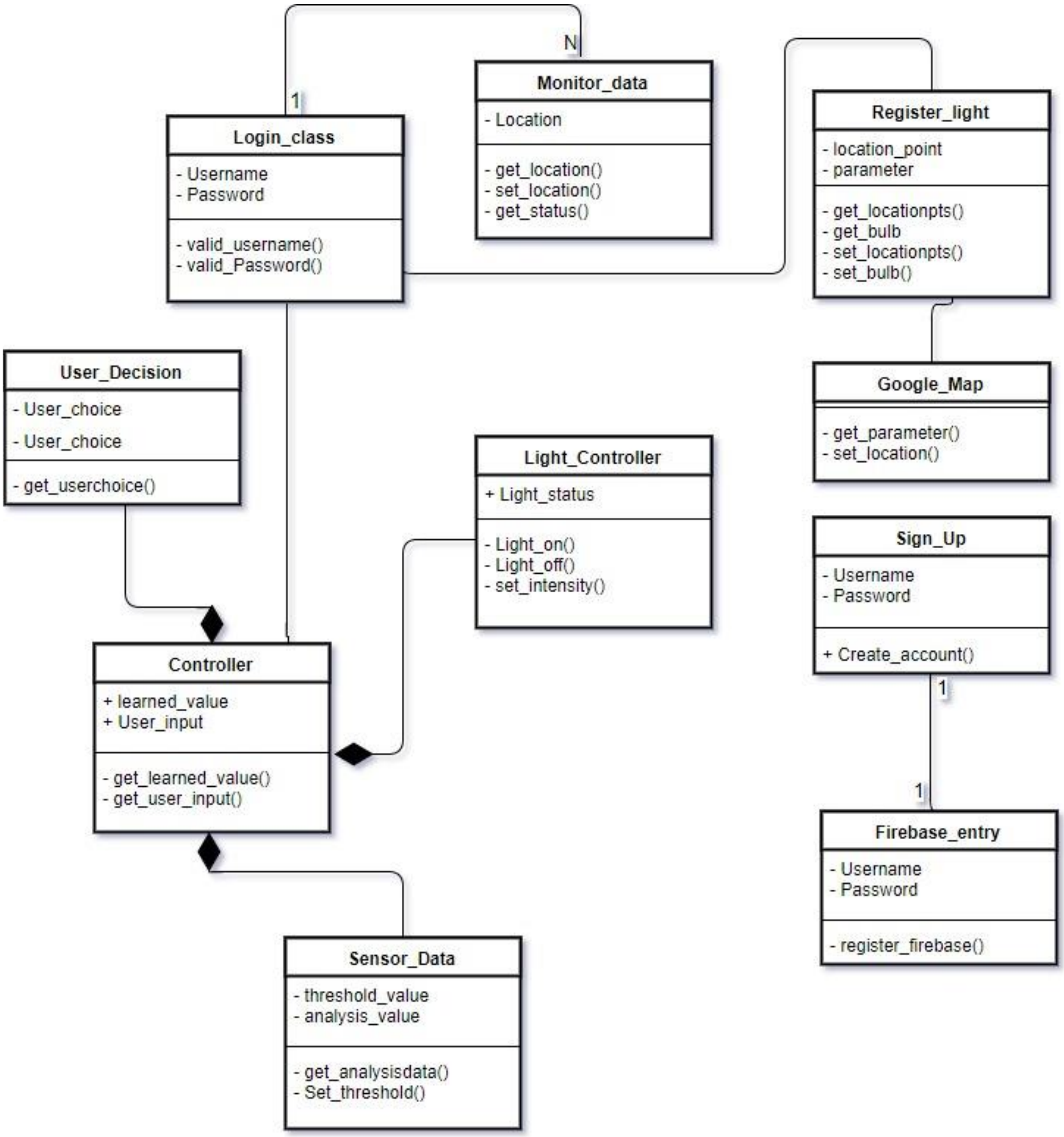


Fig. 3.5: Class Diagram

3.5.5 Activity Diagram

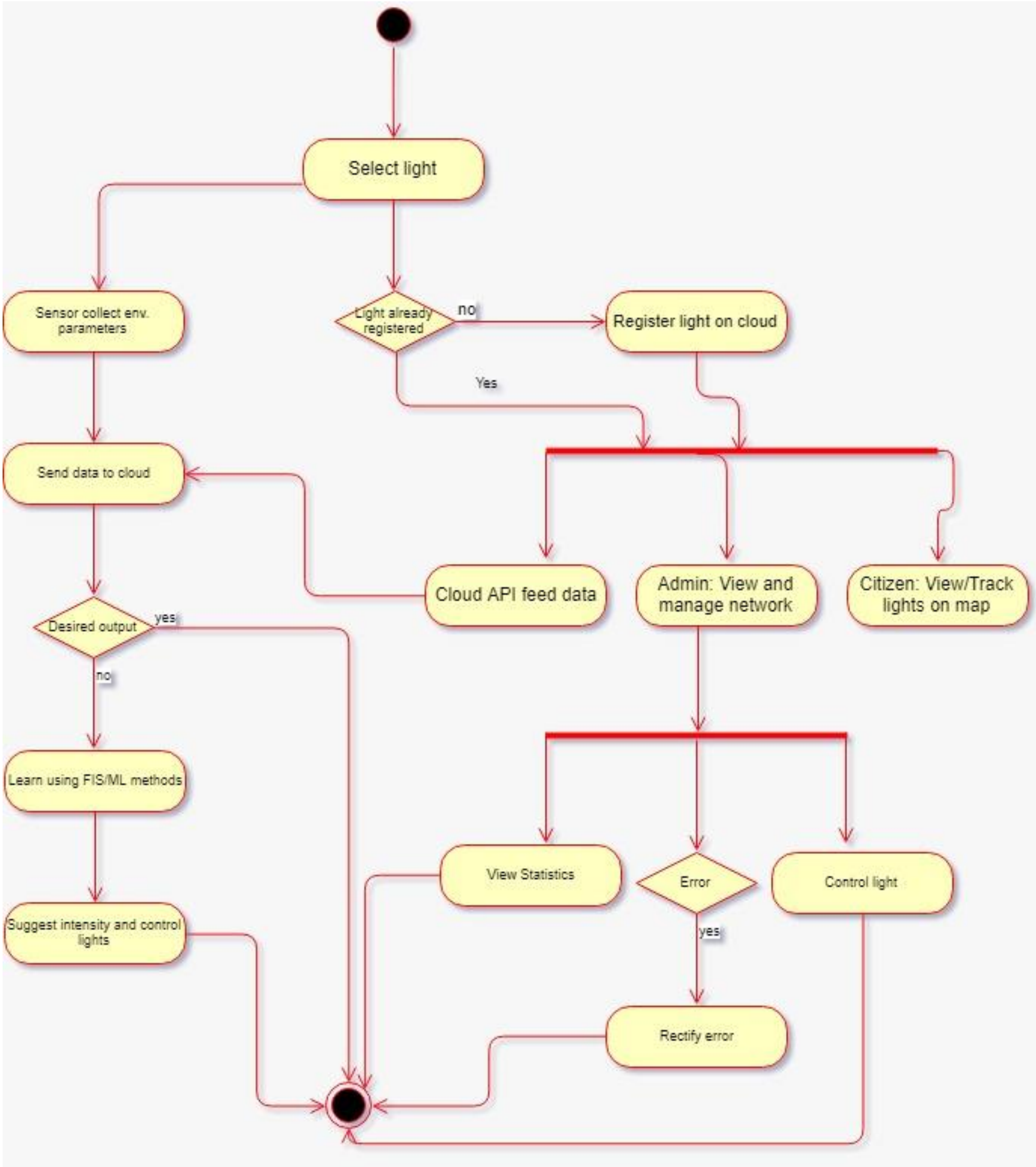


Fig. 3.6: Activity Diagram

3.5.6 Screenshots

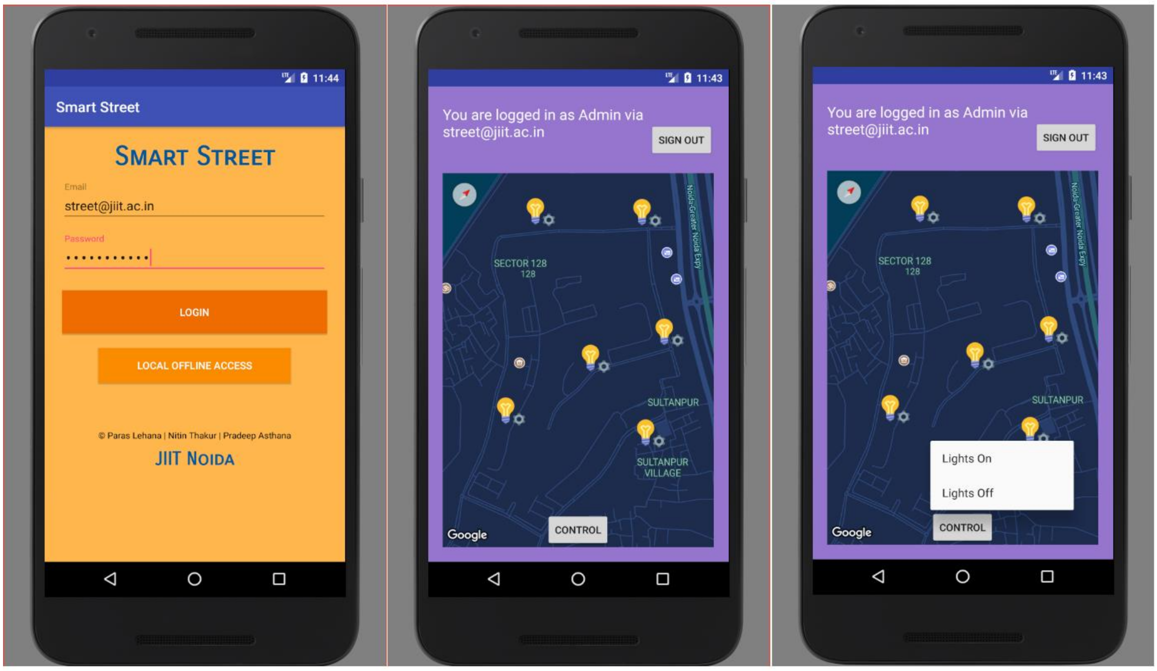


Fig. 4.4: SMART STREET App

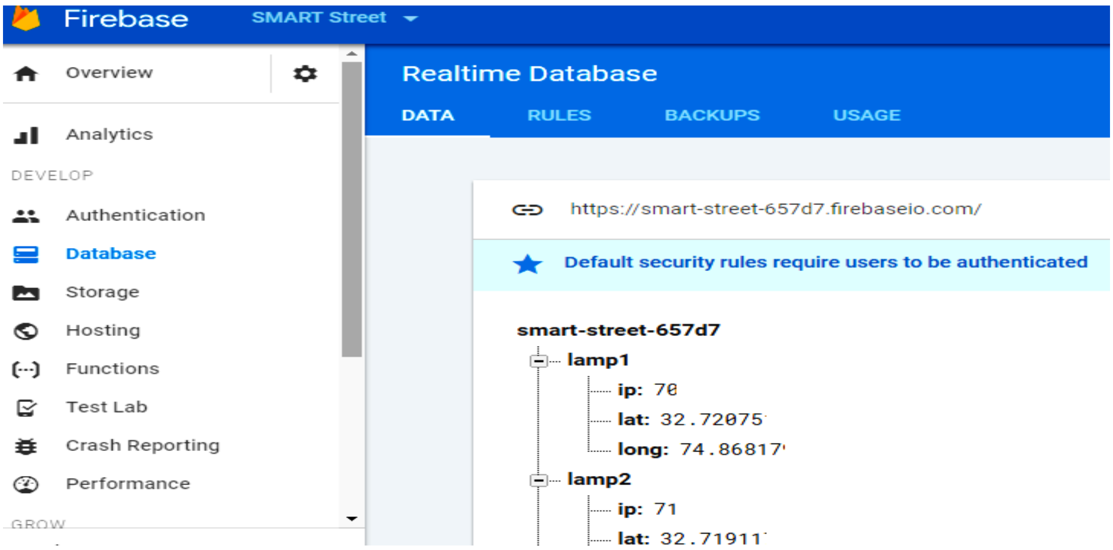


Fig. 4.5: Firebase Authentication and Database

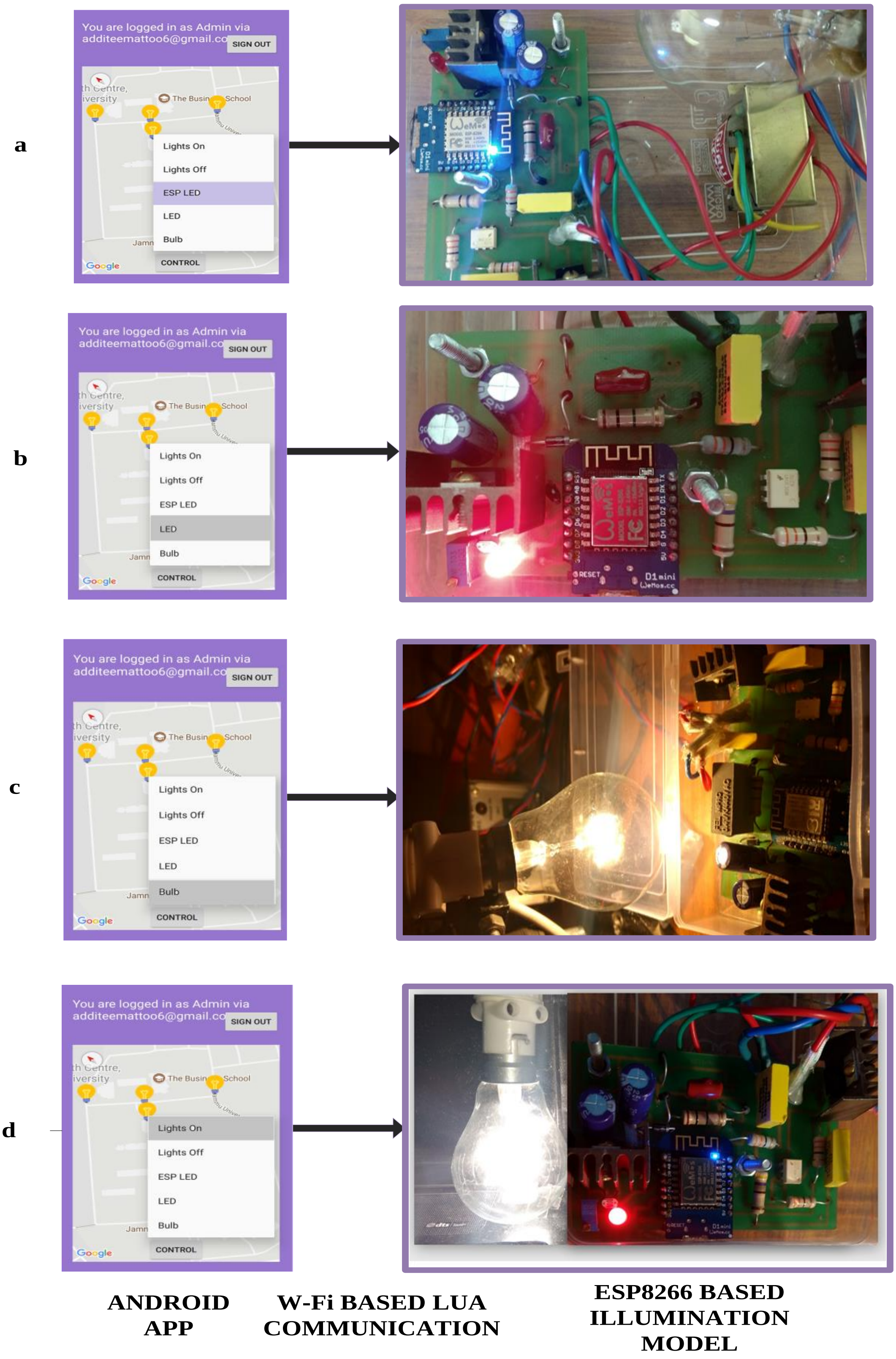
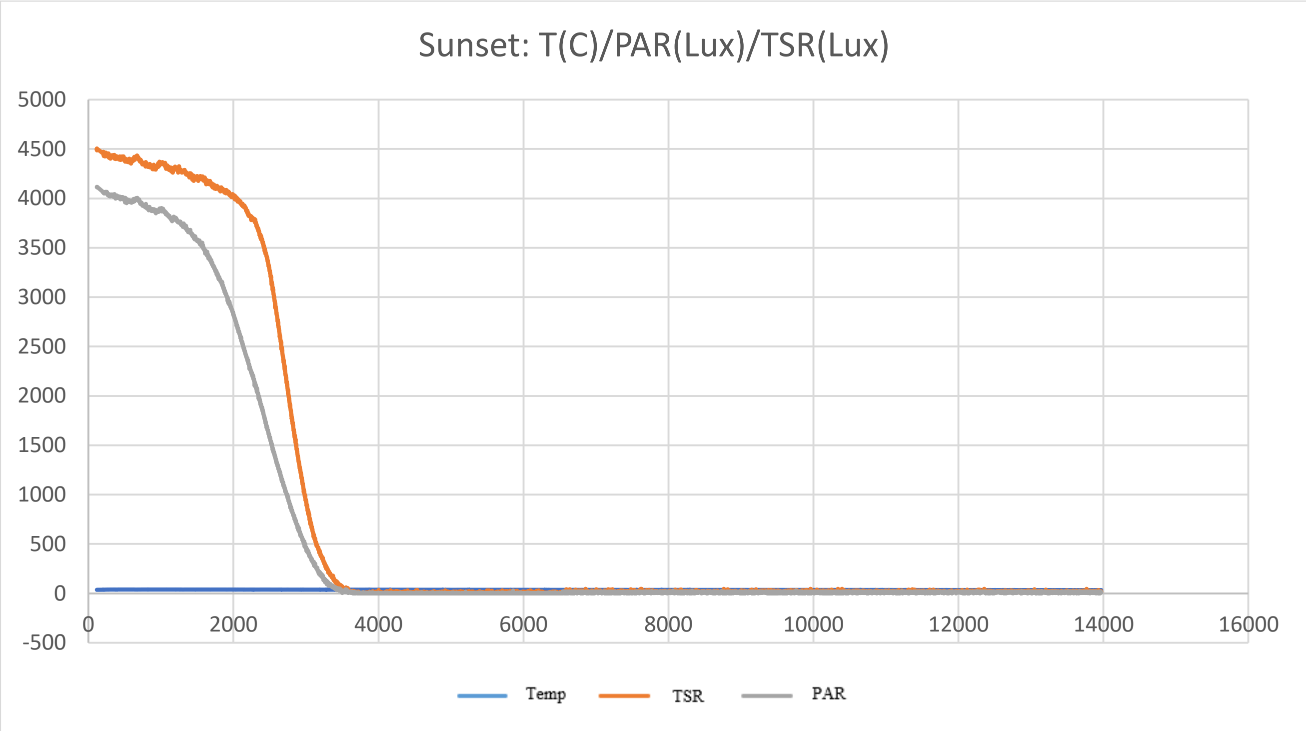
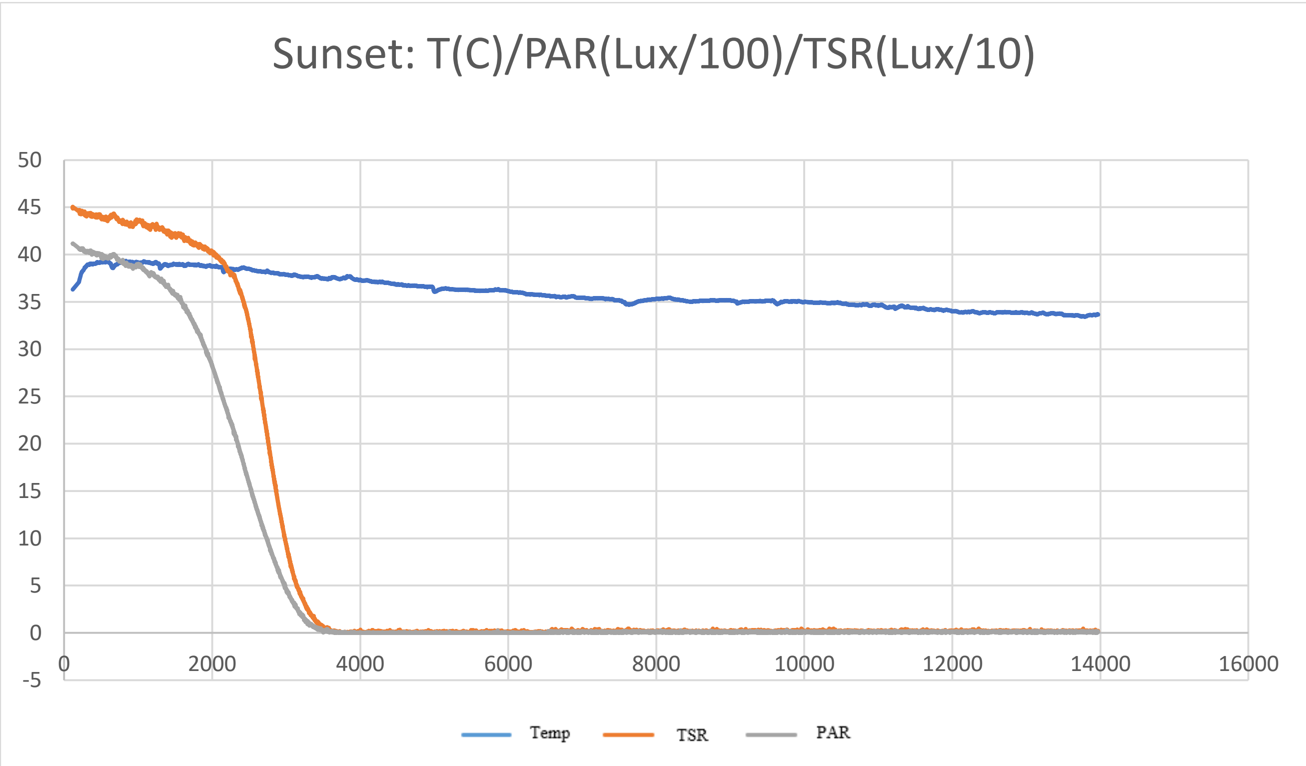
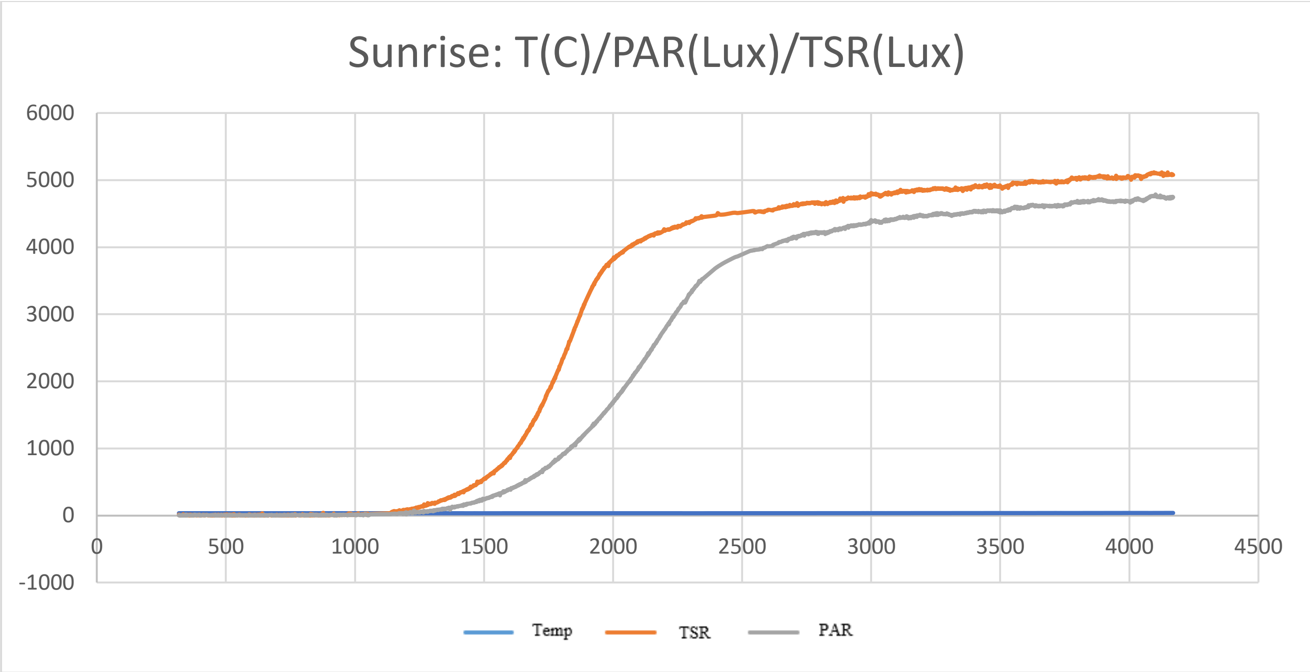


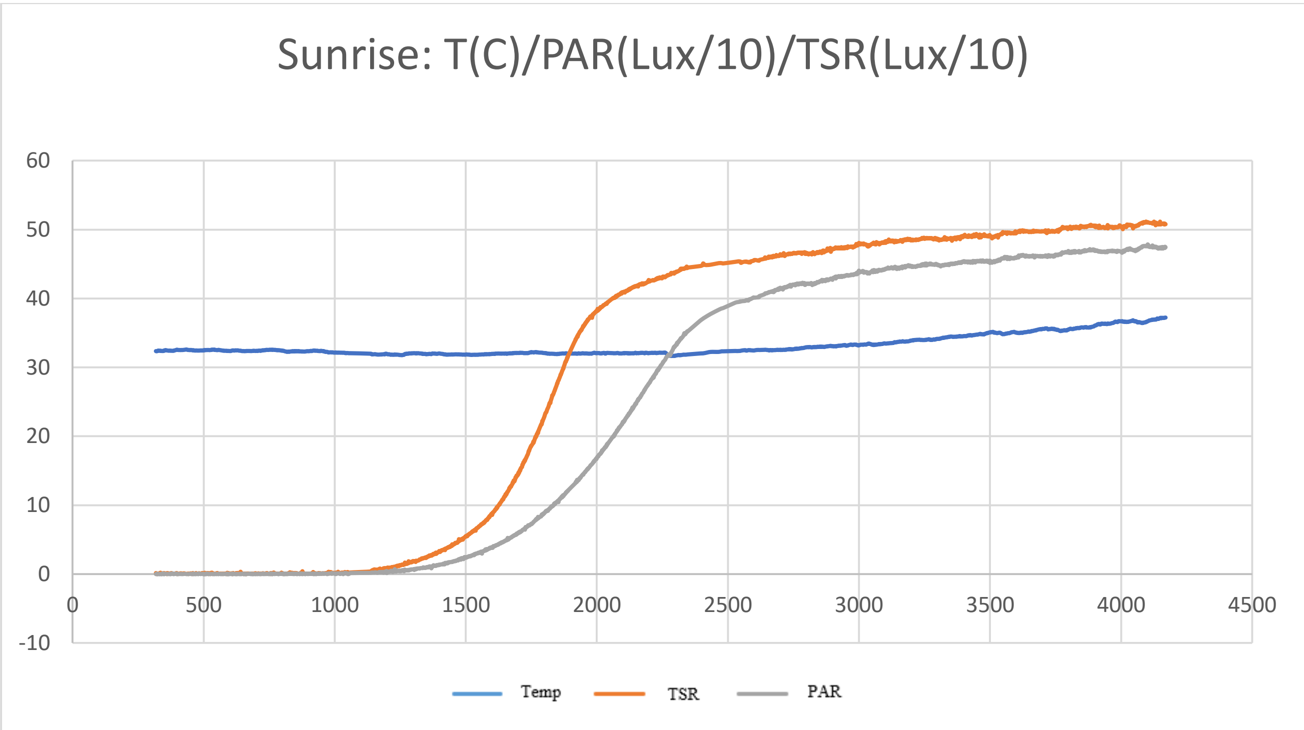
Fig. 4.6: Controlling the illumination system using proposed android based Wi-Fi enabled ESP8266 model from remote PDA device using Firebase Database in different states. *Controlling (a) ESP LED (b) LED (c) Bulb (d) All above three components*

3.5.7 Statistics






Sunrise: T(C)/PAR(Lux)/TSR(Lux)
6000
5000
4000
3000
2000
1000
0
-1000
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Temp
TSR
PAR


Sunrise: T(C)/PAR(Lux/10)/TSR(Lux/10)
60
50
40
30
20
10
0
-10
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Temp
TSR
PAR

FINDINGS & CONCLUSION

6.1 Findings

The ESP module worked with the input threshold levels and toggled the LEDs in as less than as 100-milliseconds testing environment. Wireless commands through the master control interface took less than a minute to communicate while Weather APIs generated local weather data instantly. All the 6 LEDs are connected on a single ESP which still have ample number of pins available for even more of the connections. Thus, costing around INR 500 only, this prototype is economical as well as reliable. The real-time location data is fed by Google Maps API that makes the changes in local geographical conditions to reflect immediately over the interface. As the light bulbs data is hosted on cloud, it is very easy to add new bulbs or edit their locations without changing the source code of the interface applications. The current issues with the LDR could be termed as Machine Errors and needs a human supervisor to guide learning the desired outcomes. For example, a bird sitting on the sensor even in the daylight would cause the module to toggle off the connected LED if there's no other perimeter to decide this. The outputs from each of the bulbs in the cluster can also help determine the output. Moreover, machine learning methods can make the module learn the outcomes through the environmental perimeters described in the text.

6.2 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 measure the intensity and hence 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.

6.3 Future Work

The above project could be developed using solar street light panels along with the automatic street light controller. The system could then supply itself power by harvesting the solar energy through a solar cell during day time through battery and provides a productive way for the operation of hardware circuit and controlling the light system. Automatic lighting 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. The Phase III of the project deals with Data-Mining and Machine Learning techniques implemented over the data collected by the sensors. This would make the local data available for even smallest of the streets and could make the whole of the area autonomous just attaching the module to the existing infrastructure.

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