Automatic Streetlight Controller using IOT and Computer Vision

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Abstract

Automatic Streetlight Controlling is not only for smart cities and facilities purpose, but it is necessary because of 30% to 40% of electricity consumed by streetlight system in which some of the streetlight is in ON condition even during the daytime. The main motive of this paper is to make a wireless lighting system that can turn on automatically during the night and turn off during the day. An idea is implemented in such a way that the light will be switching on with minimum intensity and will glow with the maximum intensity only in the presence of vehicles and human on the road at night-time. Computer vision technology will be used for object detection. When the fault occurs in the system then the SMS will be sent to the user, with location and which pole has a fault. We will create a Database which will be used to store the data of lights, including light number, location etc.

Keywords: - *Sensor technology, Sensor node, camera node, Wireless sensor network, visual sensor network, Object detection, light dimmer, Raspberry pi, Lora WAN, GPS & GSM, Database.*

INTRODUCTION

Today streetlights continue performing a major part in urban and suburban zones and not only that, but it has also become a piece of living of the people. Streetlights play an important character in traffic safety, illuminate the city's streets during dark times of the day, social security, city appearance style and feature. The purpose of build that intelligent outdoor road lighting scheme to make people, vehicles, other objects on the road visible.

The current street lighting system operated manually in which some light continues to work even during the day so that energy consumption increases. Manual control street lighting systems are also more likely to malfunction as there are overhead power lines that increase the possibility of mechanical and electrical faults including that fault such as cyclone, high-speed wind, lighting struck, cable failing, temperature rise, and many electrical defects such as the corona effect, line losses, and many other problems can cause the

lighting system to malfunction. According to some electrical energy research the Surat Municipal Corporation, estimates that 17% of the total annual municipal bill is due to street lighting [1].

Further, the Central Electricity Authority (CEA) of India reports that 1% of all electricity consumption in India, equal to TWh in FY2010-11, goes to providing public lighting [2], costing ULBs more than $500M annually. In some municipalities, non-functioning streetlights are rampant, up to 70% reported non-functionality [3] and areas still exist with no electricity or streetlights [4], despite guidance from the Bureau of Indian Standards (BIS) in IS 1944. Code of Practice for Lighting of Public Thoroughfares and the National Lighting Code [5] [6], on proper levels of lighting for public streets.

In a 2010 report, the United States Agency for International Development (USAID) and the Bureau of Energy Efficiency in India (BEE) published guidelines to increase awareness of the BIS standards, to provide practical guidance on energy- efficient street lighting best practices, and to inform future updates to the standards. [7].They provided basic information on design, procurement, operations and maintenance, and measurement and verification options for street lighting projects in India.

The main advantage of the streetlight is the extension of human life quality for the dark period of the day. Life quality comprises the crime prevention, traffic safety on road, aesthetic impact, behaviour of human and many more. Street lighting consumes two percent of global energy and responsible for the annual exhaust of millions of Co2 [8].

The Automatic street lighting system - experimental installation

The smart street lighting system is to automatically control LED Street lights to turn on only when needed otherwise it will remain in a dim state. The main objective is to develop an automatic streetlight system, which will save electricity using IOT and computer vision technology and increase security. Here we will use the real team clock in which we can turn the light on and off on a fixed timer. If you don't need the light after 6:00 am time, then the light will be automatically off and the light will be on after 6:00 pm. Now one of the limitations of this system is that it will not use in summer sessions because it gets dark early in the summer and it seems to light up. Because in summer the light goes out early and in winter it seems to light up and it seems dark. To overcome this problem we will use an LDR (light dependent resistance) in which the LDR will have upper higher sunlight during the day so that its resistance will increase and the streetlight will not get voltage so it will be in off condition and its upper resistance will decrease at night time and the streetlight will be in on condition. For that we will create a node module in which we will use LDR (light dependent resistance, RTC circuit, microcontroller, RF Lora module. We will use renewable sources to provide electricity to this system in which solar is an efficient technology and we will use LED for streetlight which will create an energy efficient light system. In which the solar module is placed above the streetlight so that its upper sunlight will fall, and electricity will be generated, and it will provide light to the street lighting system.

To control the brightness of the light at night, we will use computer vision technology in which the brightness of the light is maximum only if there is a vehicle or humans are present on the road and if any other object is seen, the light is turned on with minimum intensity. To apply this technology, you will need a camera that will be mounted on a pole to detect a human or a vehicle and the maximum brightness of the next 4 lights will be. So that the vehicle can see if there is an object present in front of the vehicle so that the chances of an accident are also less. If there is no human or vehicles are present on the road, the brightness of the light will be minimum. In which a streetlight has been made where LDR is placed in a position where the light of the streetlight falls on the LDR at night. Detection purpose. Fig 2. We will use web camera that detect the object is present on the road or not.

Figure 1 LDR Sensor [9]

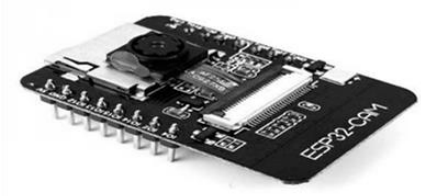


Figure 2 ESP camera [10]

Sensor Node

In this research, we developed networked sensor nodes using Microcontroller and LORA RF module. Microcontroller is nothing but a one single chip that use for controlling purpose. The microcontroller consists of microprocessor, RAM, ROM, CPU, CU etc. LORA RF module is used for long range application [11]. The maximum data rate of this module is approximately 50 kbps. CSS modulation technical is used for LORA module and link budget is approximately 150dbm. RF Lora module features the semtech sx1272 Lora chip. This makes it an ideal module for IOT device using LORAWAN network. The use of spread spectrum communication and minimum current consumption makes the module appealing for a range of application. The LDR sensor relates to a microcontroller using an analog to digital converter. The LDR is taking the data from the environment and it will be converting to digital form and given to the microcontroller. The microcontroller is programmed using the program module. The data taken by the sensor is sent to that base station for further processing using the Laura.

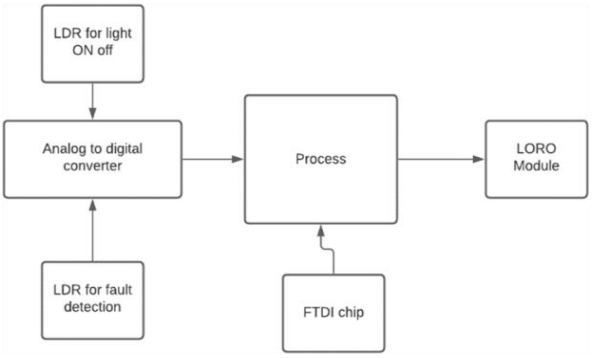


Figure 3: Sensor Node

Camera Node

It provides information from a monitored site, performing distributed and collaborative processing of their collected data. Image sensor is a part of camera node. The image sensors are composed of large number of photosensitive cells. One measurement of image sensor provides a 2D set of data point which we see as image [12]. Two type of Geometry is used for camera network one is Multi camera geometry and epi-polar geometry. Multi camera geometry [13].

WIRELESS SENSOR NETWORK

WSNs have a wide range of applications. WSNs are slowly becoming an integral part of our lives.

Recently, considerable amounts of research efforts have enabled the actual implementation and deployment of sensor networks tailored to the unique requirements of certain sensing and monitoring applications [14]. The collective information provided by the sensor nodes.

Components of WSN (Wireless sensor network)

1. Sensor
2. Sensor node or radio node
3. Base station
4. Evolution software

Wireless sensor network (WSN) connects to a group of spatially dispersed and dedicated sensors for detecting and reading the physical conditions of objectives an determining the signals at a central location [16]. In a WSN, a A huge number of autonomous low-complexity sensor nodes are deployed to generate collaborative networks by gathering, communicating and analysing data [17].

Algorithms for distance resolving:

We necessitate identifying the distance and location of the sensor node. We can determine those elements by equaling known node position with unknown node position.

$$X = Dimensional\ space\ can$$
$$be\ expressed$$
$$via\ the\ estimate\ vector$$

$$Suppose\ there\ are\ X\ known\ nodes$$
$$\{a1, a2, a3, \ldots . ax\}\ in\ one\ netwoek$$
$$Pi = \{Pi1, Pi2, \ldots \ldots . Pix\}$$
$$Pi = Measurement\ estimation$$
$$between\ node\ si\ and\ sj.$$
$$P = [P1, P2, \ldots \ldots . Pm]$$
$$Similarly\ the\ node\ distance\ can\ be\ decide\ by$$
$$Li = \{\ 1, li2 \ldots . . lix\}$$
$$Lif = distance\ betweeen\ node\ si\ and\ sj$$
$$L = [L1, L2 \ldots \ldots Lm]$$
$$Function\ T\ is\ present\ as\ X * X\ matrix$$
$$T = LPT\ (PPT) - 1$$

Visual sensor network

It consists of large number of low power camera nodes. VSN (Visual sensor network) support a great number of novel based application [17]. The characteristic of visual sensor network is in network image sensing & processing, Data streaming as well as evening, resource limitation (power, processing, and bandwidth), Autonomy & service – orientation, ease of deployment. The visual sensor network consists of tiny visual sensor nodes or camera node which integrate the sensor, embedded processor, wireless transceiver. One of the main differences between the visual sensor network and other types of sensor networks lies in the nature of how to image sensor perceives the information from the environment [18].

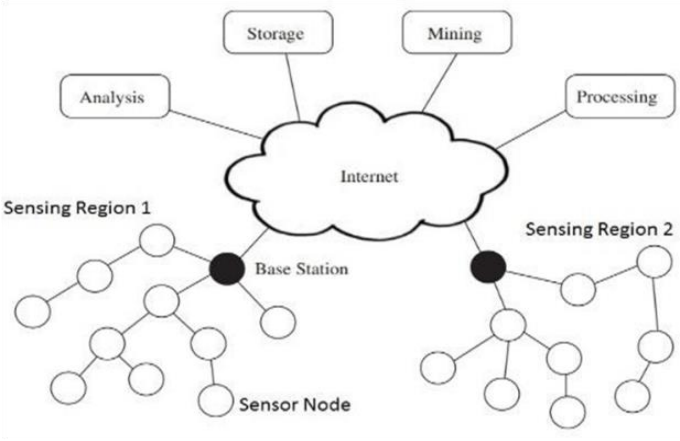


Figure 4: Wireless sensor network [15]

Object detection

The object detection is mostly based on the light-weight background subtraction algorithm & present the first step toward collective reasoning by the camera-node about the object that occupy the monitored space [20]. Image classification involves activities such as predicting the class of one object in fig. 6. Here we are going to use tensor flow. Tensor flow is an open-source software library for dataflow and differentiable programming across range of tasks. It is a symbolic math library and is also used for machine learning application such as neural networks, etc [21].

Light dimmer (PWM) module PWM (Pulse width modulation) technic is used for light dimming purpose. Here 16 channel PWM program module is wirelessly connected with Raspberry Pi. When camera sends the data to system that object is detected at that time, Raspberry pi will send command to PWM module for increasing brightness of LED light.

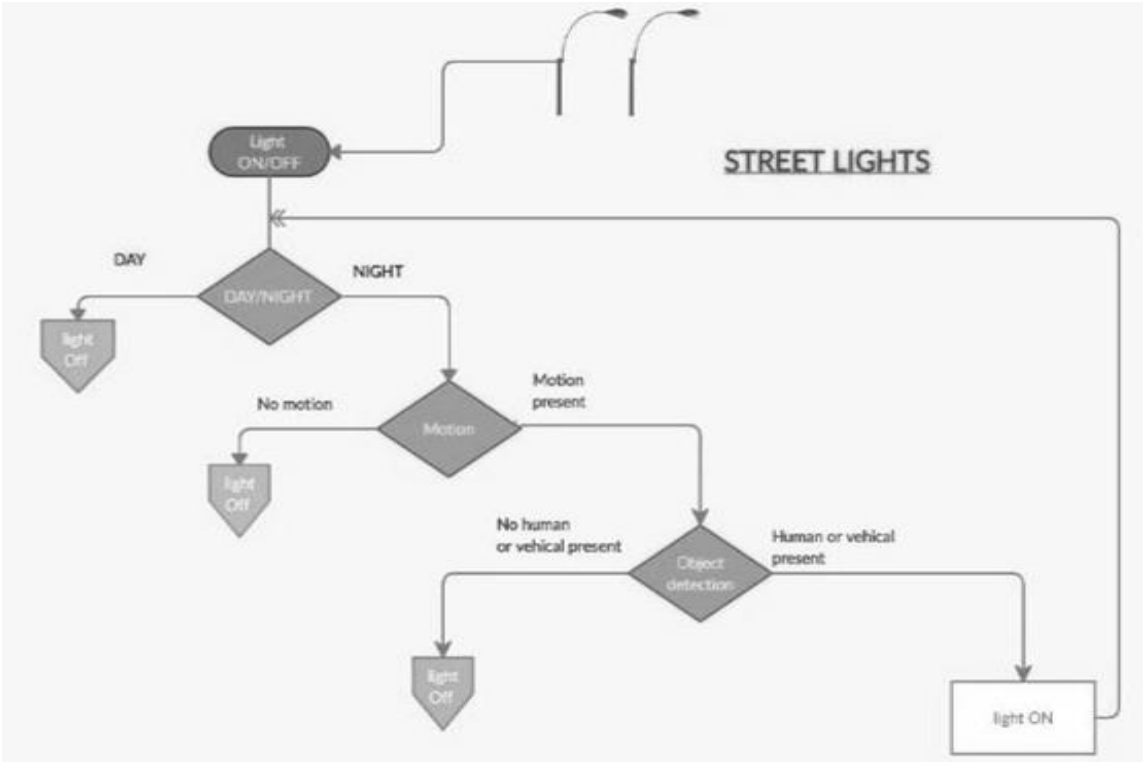


Figure 6: Object detection

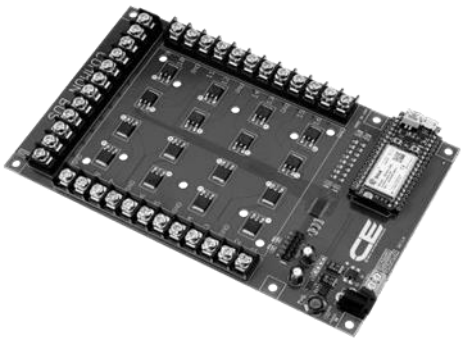


Figure 7: 16 channel PWM Module [22]

PWM (Pulse width modulation) is a technic of generating alternating signals using a digital signal. PWM signal is proportional to the frequency and duty cycle. We can adjust the output voltage by changing the duty cycle. The duty cycle finds the number of times the signal is high as a rate of the entire time it takes to make one cycle. Frequency can determine how fast PWM completes the cycle. By cycling a digital signal off and on at a fast-acceptable rate, and with a certain duty cycle, the output will appear to behave like a constant voltage analog signal when providing power to devices [23].

Dyty cycle = (ON time / period) *100 Vavg = DVH + (1- d) VL

Generation of PWM:

Several methods were used to generate PWM signal. One of them analog method. Analog PWM signal can be made by combining a saw tooth waveform and sinusoidal, the high the dc level is the wider the PWM pulses [24]

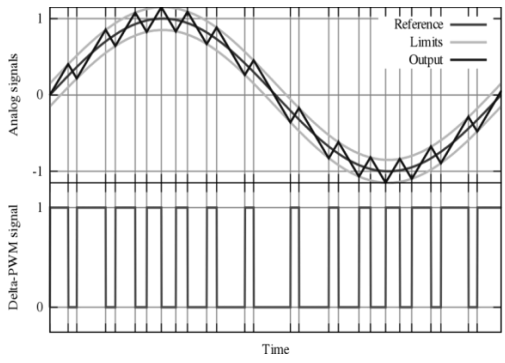


Figure 8: Generation of PWM pulses [25]

Raspberry Pi

The board includes processor(s), RAM, I/O, and networking ports for interfacing devices. Unlike traditional computer systems, single-board computers are not modular, and its hardware cannot be upgraded as its integrated on the board itself[26]. Here Raspberry Pi is used for data analysis and controlling. A Laura module is connected to the Raspberry Pi to create a base station. Raspberry pi is brain of our system.

LORAWAN

Lora is supported by an alliance (LORA alliances) that has defined LORAWAN. The network consists of end device and GATEWAY. Wireless link budget that define the maximum communication range for given transmission power.

Technology	LoRa
Technique	Chirp spread spectrum
Modulation	Frequency chirps
Channel bandwidth (uplink)	125 kHz 250 kHz 500 kHz
Long range	Tens of kilometers
Data rate	0.3-50 kbps
Sensitivity	-137 dBm

GPS & GSM

In our project GPS is used to track the location and send it to the warden. When there is a fault in the system, the GPS receiver will send the location and clock time to the user with the help of satellite.

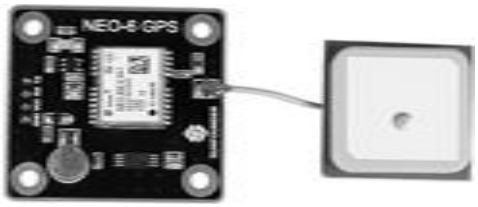


Figure 10: GPS Receiver [28]

GPS is interface with GSM and connected to Raspberry Pi. GPS is used to store location and time in the database so that live data can be retrieved and used as needed.

Figure 11: GSM Module [29]

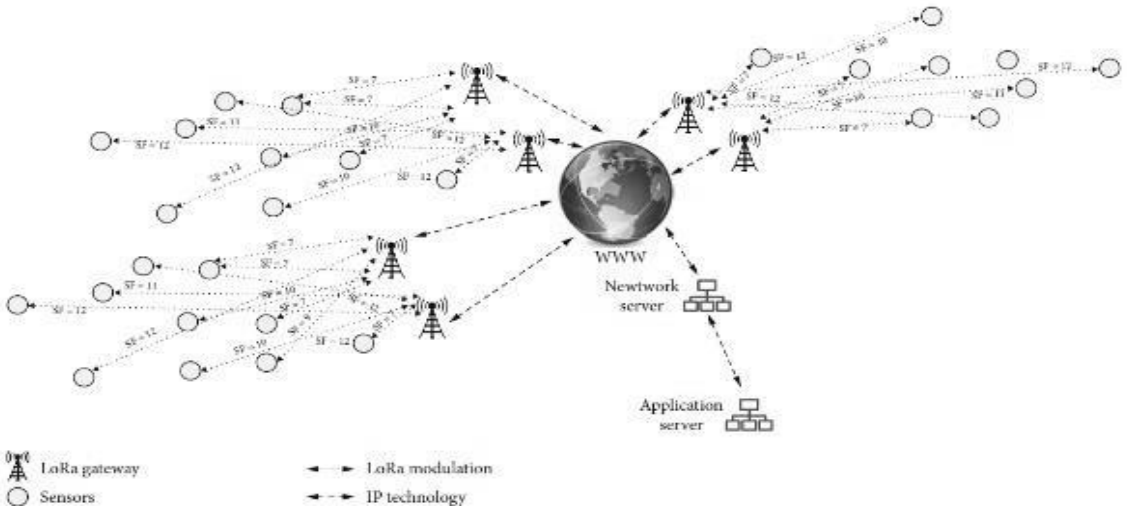


Figure 9: LORA technology Technology LoRa [27]

Database

The database is used to store the active position, location, power consumption, county, light rating of the light. These are stored in the cloud. Egg AWS, Microsoft azure, sales force, Rack space etc. There are two common deployment model first is user can run database in cloud independently using virtual machine and second user can purchase service, maintained by a cloud database provides.

Type of database that available on cloud (1) SQL based (2) No SQL.

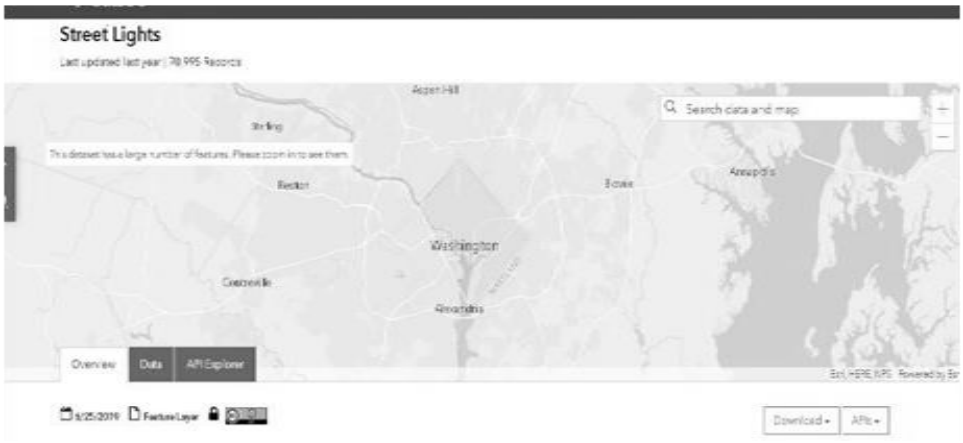


Figure 12: Location map

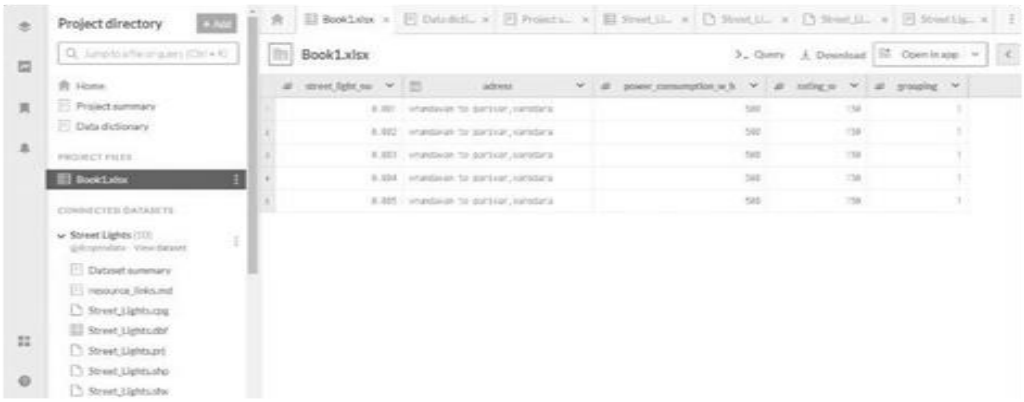


Figure 13: Database

PROPOSED SYSTEM

The RTC and LDR sensors are connected to a microcontroller where the LDR is a sensor that takes data from the environment and delivers it to the microcontroller using an analog to digital converter. RTC is a real time module that is useful for real time application. The RTC will have a fixed time when it will send signal to the microcontroller for data processing when night falls and the streetlight will turn on.

Sensing calculation for LDR:

$$R \text{ a } \frac{1}{E}$$

Where E = Illumination of streetlight

R = Resistance

We can measure light intensity by applying below method

R a amount of sun light that fall on sensor

$$R \quad \text{a} \quad \frac{\text{Maximume sun light that fall on the sensor}}{\text{Minimume sun light that falll on the sensor}}$$

$$R = \text{Resitanc of LDR}$$

$$\text{Relationship between RL and Lux}$$

$$Rl = \frac{500}{lux}$$

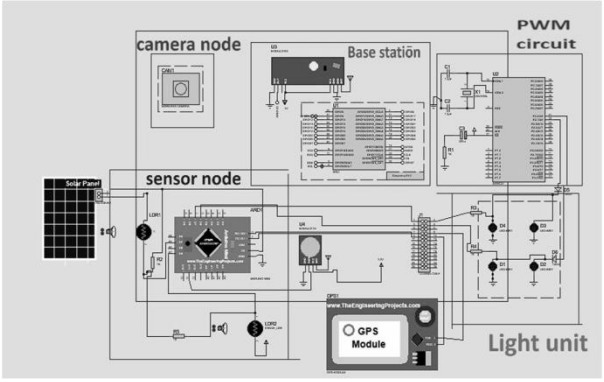
If we wat to find light intensity that fall on LDR

$$Lux = \frac{\frac{2500}{Vo} - (500)}{Rl}$$

=

- A sensor node is created using sensors, a microcontroller and a Lora module that will send data to the base station for processing and control over the Internet. Here the Raspberry Pi and radio frequency Lora module is used for the base station which will communicate with the sensor node and takes the data.
- The pulse width module is used to control the brightness of the streetlight. The 16 channels module is used here.

Node much is attached to this module which normally communicates with Raspberry Pi via internet so that it can be programmed and controlled with the help of Raspberry Pi. The whole system is controlled, monitored and accessed with the help of Raspberry Pi so it is the brain of the system.



- Computer vision technology is used for object detection in which the camera node is used to detect human or vehicle and the data is sent to the Internet through a visual sensor network and its monitoring and control and Store in database. GPS and GSM are used to track a location and send it to a system in which that location is stored in a database and to send an alert massage that includes location and time to the user when there is a fault in the system.
- This system is built using IOT (Internet of things) and Computer vision.

IOT

IOT "Internet" and "things" that require more classification. Initially RFID used to be the dominant technology behind the IOT development, but with further technology achievement, Wireless

sensor network (WSN) and Bluetooth enable devices augmented the mainstream adoption of the IOT trend. IOT ecosystem are classify in different layer like business layer, application layer, processing layer, transport layer and perception layer [30].

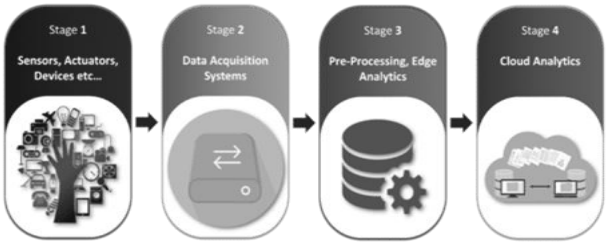


Figure: 15 IOT [31]

Stage 1: The sensor will take the data from the environment and send it for further processing. There are different kind of sensors are available for IOT requirement. It may be analog or digital sensor.

Stage 2: Data acquistion system is and an aggregation or assembly of devices united by some form of regular interaction of an interdependence. Data acquisition system is used to measure and record analog signal in basically two different way: (1) Signal which originate from direct measurement of electrical quantities. These signals may be d.c or a.c voltage, frequency or resistance etc. [32].

Stage 3: Storage, analysis and processes huge amount of data. Employs database, cloud computing & big data processing module.

Stage 4: In some system architecture the data processing is done in a large, centralized fashion on cloud.

COMPUTER VISION

It is a field that includes processing analysing and understanding image. In general, high dimensional data from the real world in order to produce numerical and symbolic information or it is a technology of science and machine that see it obtain information from the image [33].

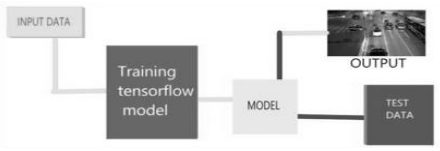


Figure 16: Computer Vision

We provide I/p data which is the image. The tensor will train a model and this model is trained using deep learning and the main objective of this model is to extract features.

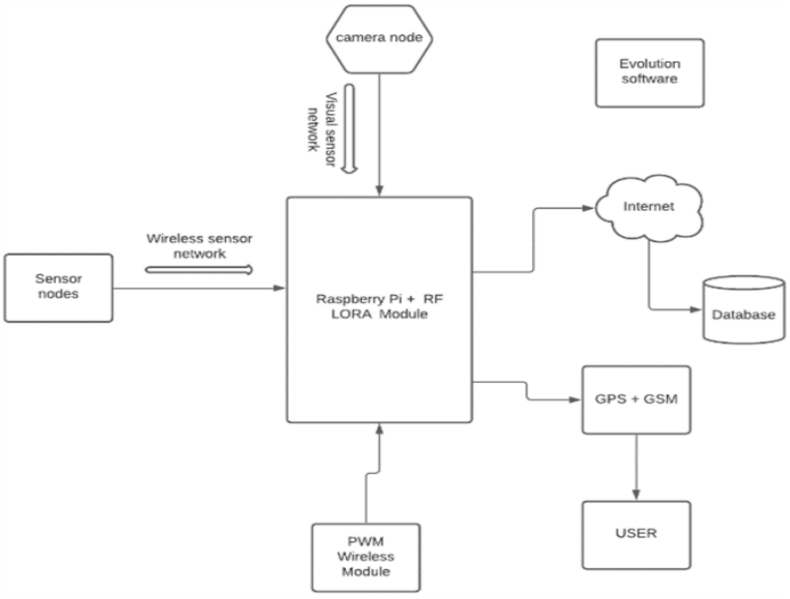


Figure 17: Proposed System architecture

Now, those are a visual feature, which is based on edge detection and the half of the face recognition and many more. When these features are extracted and then the model is created to test this model provided is test data. Which is can a set of images in our case. Using this model, we get a final o/p in the image. Now, these images are converted into a No of the array in a tensor flow object detection. So, the computation mode easy. We also use a tense record that contains a record of the image with a tag. In the image, we have a person tag, horse tag and dog tags.

Algorithms for architecture construction:

Step 1: The system gets power through the solar panel.

Step 2: LDR sensor is connected to the analog pin of the microcontroller.

Step 3: If (LDR Reading >threshold_val) then streetlight will be ON state.

Step 4: LORA module is connected with the microcontroller from sending the data of the sensor to the base station.

Step 5: The camera node is connected to the base station with the help of the ESP wife module.

Step 6: if (camera node.detect() = = people and vehicle present on-road) then video stream in the form of data will be sent to the base station.

Step 7: PWM module is connected to the light unit and base station using WIFI module, whenever the camera node sends data, at that time the base station will send the command to PWM module to set the light intensity of maximum.

Step 8: if (fault. Detect ()) in any light at that time LDR sensor will send information through radio frequency module to base station and go to step 9.

Step 9: Using GSM, staff members will notify by massage, and using GPS data will be stored in the Database.

RESULT AND DISCUSSION

After installing this system, the turn on and off time of the light can be decided as per the requirement.

Computer vision technology has been used for object detection so it will also be a support for security. With the help of the camera, we will be capable to perform analysis on the road. Applying computer vision rather than sensor technology will not cause any defect with the lighting system in the rainy season so that it will remain a reliable system.

1. Before installing this system Assume that streetlights ON during night at 6:00pm to morning 5:00 am.

Total No of light on the road: 60 Nos. Rating / streetlight = 150W

$AD = NO\ of\ street\ ligth$

$\times\ Rating\ per\ light$

Total Load = 60*150 = 9000W

(Electrical Power consumption for one night)

$POWER\ CONSUMPTION$

$= KW \times Total\ hour$

$= 9 \times 11\ hour$

$= 99\ KWH$

Electricity consumption / second

$= 9000 \times (3600 \times 11)$

$= 356400000\ joule$

These 356400000 joules of electricity consumed / night which is very high.

Assume that Unit cost / kwh = 9rs

$= kilowatt \times cost$

$= 99 \times 9 = 891$

Cost per night = 891

Cost per month = 891 × 30

= 26730 rs

After installing our system

Assume that No of vehicles on road during (6:00 pm to 5:00am) = 500

Streetlight ON for 1 min = 60 Second Total time for which lamp remain ON state

= (300) × 60 = 18000 second

Thus, total electricity consumed in one night for 60 streetlights.

= 9000 × 18000 = 162000000 $joules$

From above result one can conclude after, 10 times electricity can be saved.

18000 sec = 5 hours

Assume that Unit cost / kwh = 9rs

= $kilo\ watt \times hour \times$

$charge$= 9 × 5 × 9 = 405 rs

Cost per night = 405rs

Cost per month = 405 × 30 = 12150rs

Typical calculation of the system

LAMP RATING	ILLUMINATION	SPACING BETWEEN TWO LIGHT POLE	ILLUMINATION TIME
60W	26000 Lumens	5.75m	306 Hour
125W	5400 Lumens	11.50m	612 Hour
250W	11500 Lumens	23m	1225 Hour
400W	20500 lumens	40m	2000 Hour
500W	23000 lumens	46m	2450 Hour

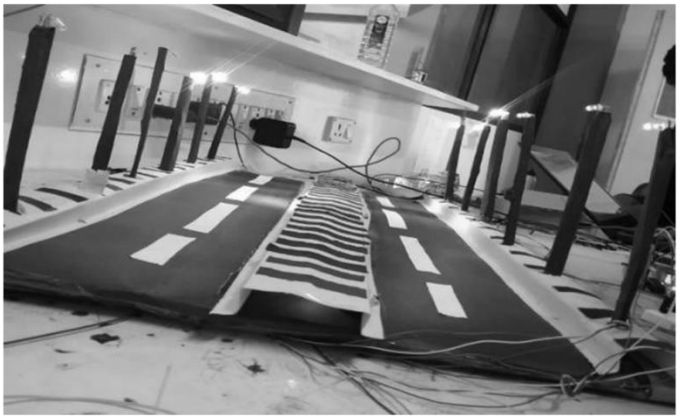
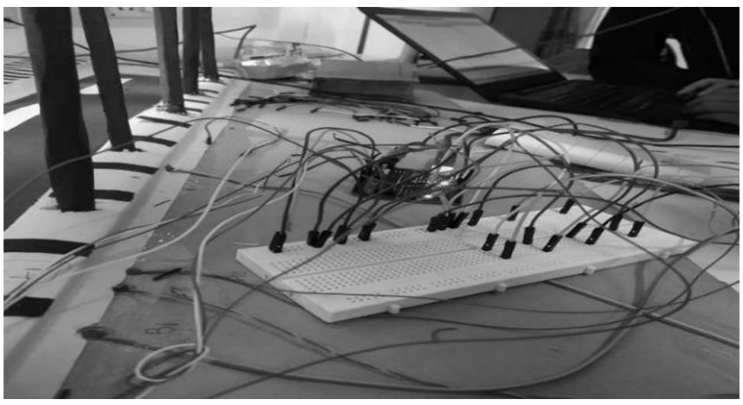


Figure 18: Prototype model

The span of the pole will be determined according to the height of the light pole.

Here four Street lights are turned on simultaneously.



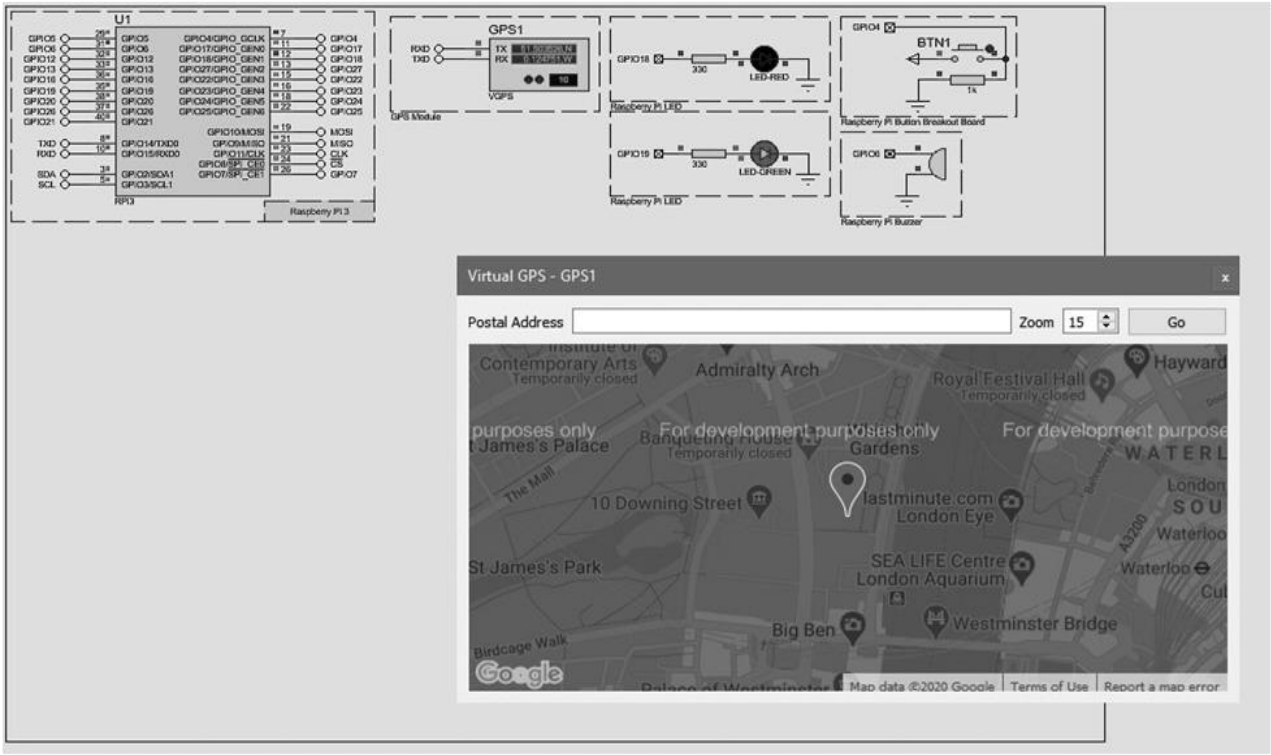


Figure 19: GPS Tracking

The location will be tracked by GPS (Globle positioning system receiver) and we must to first import some libraries of python viz. TK inter, serial, time, etc. Then initialize this GSM module at the base unit. The same message is displayed on the Graphical User Interface (GUI) and then uploaded on the Mobile.

POTENTIAL IMPACT

- Automatic street lighting is transforming the way cities and utility providers view streetlights.
- With smart streetlights, cities can realize significant benefits. They can increase citizen satisfaction can be seen in the map. This location can also be transferred with the help of GSM because Automatic Streetlights will improve safety and reduce congestion.
- They reduce energy costs by more efficiently managing electricity flow.
- Cities and utility providers seeking immediate cost savings or revenue opportunities can now evaluate a wide array of options that can address real needs, leading to enormous benefits now and in the future. Development of an outdoor street lighting system that can be done to make cities more energy-saving, secure, and Smart.

CONCLUSION & FUTURE SCOPE

This project aims to create and complete an automatic streetlight using IoT and computer vision technology, which can be employed to bypass manual operation for switching streetlight on and off. To save and efficiently conserve energy, streetlights are on only when a car or vehicle present on the road that recognizes by the camera. This advanced system is on the level with the government's policy of energy conservation by reducing the loss of electricity and efficient use of energy, so it can be termed as an innovative

project in street lightning that can be implemented in the roads like state and national highways.

Automatic streetlight project is cost effective; it will make things easy to access and will play a major role in smart cities and green city. Since main motive of the nation is to conserve electricity with the help of various or different resources. Automatic the system can be extended easily, is flexible and also adjustable according to the need of user. This project has scope for the

NOVELTY & UTILITY

- In Automatic Streetlight, we will be creating an automatic on / off lighting system using advanced technology such as IOT and computer vision.
- Using of Computer Vision with the help of IOT modules
- As there is a use of Computer Vision It will also be used for the security reasons.
- It will be a part of Digital Technology in future.

ACKNOWLEDGMENT

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