Intelligent and multipurpose smart pole

Mrudang Oza¹, Lav Hinsu², B C Goradiya³

¹,²,³Electronics and Communication, Birla Vishvakarma Mahavidyalaya, Anand, Indi

Abstract. Electric poles have been same from past 10 years. No advancement of technology was observed, except the transition from Sodium lamps to LED. While due to its availability and locational advantages, it could provide many fruitful solutions to many current problems we face. Yet the current generation street poles require high maintenance as well as are sometimes unable to perform the sole objective they were meant to. The proposed system aims to develop and upgrade the approach towards the smart pole and integrates into a complete system with multiple functionality and modularity. A better efficiency, better lighting and better interface and interaction are the sole objective of this newly proposed system. It will also address problem of stray animals camping around the poles, which are rarely addressed in yet significantly contribute to street problems we face. The proposed system proposes an autodetection and even effective way of reporting and resolving of issues. If we are talking about Smart city, every element of it has to be made smart.

1. INTRODUCTION

The street lights play a major role in human transit systems as well as it provides many benefits such as enhancing security of drivers and pedestrians. They are also useful for surveillance and security purposes. Hence it is one of the most expensive and important responsibilities of the city. Street Lighting can almost account for 10-38% of the total energy bill in the city worldwide. India uses 1.5% of its total electricity on street lighting. As the construction of multiple lane highways, roads increase, so does the energy consumption in lighting them. Many effective lighting solutions are being adopted but, unfortunately, in India, a major roads and highway do adopt a uniform approach towards the street lighting without proper planning according to the type of roads which leads to inefficient lightning and faults that wastes significant amount of electricity. Fig.1 shows projected energy consumption.
1.1 Problems due to inefficient lighting and planning:

1.1.1. Luminescence Problem: The one size fits all approach for design, lighting and integration has been outdated. The presence of lighting has been uniformed everywhere and doesn’t depend upon weather conditions of the surrounding area. The basic design doesn’t withstand with new modern lightings and also the feasibility for maintenance.

1.1.2. Power Consumption: The increase in power consumption cost doesn’t perform well with the results. Maintenance cost goes skywards after installation too. The increase in power cost also comes with usage of CFL, Sodium Lamps in semi urban and village areas and are not designed to meet area wise lighting needs.

1.1.3. Stray Animals: In country like India, with millions of people on road, Accidents are bound to happen but most unfortunate thing is that almost 5% of accidents happening in India are due to Stray cattle on the road \(^2\). Fig. 2 shows the stray animals due to accidents. A problem which has been neglected in the current system and yet contributes to majorly to injuries on the streets, both to human and animals. So, with the rapid growth of the highways and roads all over the world, the demand for streetlights also will grow.

Now in these times of IOT, AI and projects such as SMART CITY’s, it’s necessary to adapt and upgrade the current streetlight model to a new one. Hence, we propose Intelligent and Multipurpose Smart Pole System. It could be implemented on different types of roads according to the needs of users. It comprises of upgradation of management as well as maintenance aspect of the pole primarily, which can be further enhanced. Motion Detection, Automatic Fault detection, Automatic Lights control are one of the prime features of the proposed system. Also, Stray cattle detection, Problem Reporting are also included.

1.2 Solutions to the Problems:

1.2.1 Area Based Lightening: Indian Roads are classified into various types and each require different lighting conditions. The current streetlights approach has been uniformed everywhere which leads to more power wastage. Hence to overcome this problem, The Street light illuminance will be adjusted based on the time of the day and the Motion IR sensor present in the pole, on detection will increase the illuminance of the LED according to the need.

1.2.2 Website based Auto Handling: The proposed system will also employ the use of website for effective handling and operation for all the streetlights. All the poles will be connected to a server via internet and can be handled remotely from operation center with functions such as auto ON-OFF, auto LED fault detection and many more after upgrades and need of the user.

1.2.3. Higher Functionality: The proposed system will also comprise modules such as stray animal detection and auto – reporting. The LED will be dual color LED: Yellow in presence of fog/haze for better visibility and also include User reporting portal, where each pole will be given a unique id and user will be able to report the problem around them.
2. LITERATURE SURVEY:

Recent report by USAID 2004 reveals that majority cumulative street lighting load alone consumes 21 TWh of energy each year. Also, the energy saving scenarios are still not implemented, and even if did the energy consumption of normal lamps used for street lighting is also way more. Fig.3 shows the efficient energy saving scenario. The cost of maintenance of pre-existing streetlights as well as reporting of those problems is high. Approximately 8 crore Rs per annum are used by authorities in every major city for maintenance of these pre-existing streetlights according to Union government data 2011. The trivial solution to all these problems included offline reporting of faults, use of low illuminance LED. No central autonomous system was developed. Adoption of Smart Street Light system have already started and can reduce peak energy demand by 1500 MW and reduction in 6.2 million tons of carbon emission per year.

![Figure 3: Efficient Energy saving scenarios](image)

3. PROPOSED FRAMEWORK:

To overcome above mentioned problems, we propose a specially designed system which will be an automated system as well as semi-automated according to user’s needs. Our system is an all-in-one place for maintenance check as well as to provide efficient and smart lighting. Every pole will be assigned a unique id in the proposed system. Each pole will have a microcontroller that will be connected to authority server where its energy usage and other parameters could be measured.

**Traffic Problems:** To begin with - India road crashes killed 146,133 people in 2015. According to Times of India dated January 26, 2017, Ahmedabad the city traffic police registered 1,825 accidents in the previous year at an average of 5 accidents every day and the loss of six lives every week. That’s approximately three hundred and twelve lives in the year. More than 7000 cases were registered against vehicle owners for illegal parking. Traffic Police initiated a drive to enforce rules and bring offenders to book for parking vehicles illegally, which is one of the major reasons behind congestion. Along with Traffic problem, problems related to security, environment also exist. While the deployment of various types of camera on Traffic Poles has helped to subsidize some of the factors, but still lack of an integrated system exist.

**Luminescence Problem:** The one size fits all approach for design, lighting and integration has been outdated. The presence of lighting has been uniformed everywhere and doesn’t depend upon weather conditions of the surrounding area. The basic design doesn’t withstand with new modern lightings and also the feasibility for maintenance.

**Power Consumption Problem:** Street Lighting is an important component for worldwide power consumption. It accounts for almost 18-35% of total energy bill. There is almost no to little study or planning has gone into illuminance required in different areas of streets to address pedestrian and vehicular traffic. For example: Lighting needs in High Traffic zones is different from Low Traffic zones. This approach ends up in wasteful use of electricity that could have been utilized elsewhere.

**Stray Animals:** Almost 1 Lakh stray cows roam around the city with no care and usually rest near the street poles. A proper system needs to be form for detecting and bringing these stray cows to their gaushalas and save life both of people and animals.
Lack of Multi Functionality: In era of IOT and ML, there is a need of an integrated system working autonomously and capable of doing multiple functions under one command. Unfortunately, the current system couldn’t even successfully achieve its sole objective of lighting only. The integration of modules such as Weather Sensor, Smart Cams, Motion Sensors will give the modularity and functionality a significant increase.

4. PROPOSED SYSTEM:

![System Diagram](image)

Figure 4: System Diagram

The circuit diagram shown in Fig.4 is actual representation of working circuit taking in mind the working parameters of each instrument and sensors used. This circuit diagram satisfies the required voltage and current parameters of each and every instrument verified from various reference projects whose details are mentioned in the references below. The Whole setup could be powered by AC mains with a step-down regulator or Solar Powered. We have considered every aspect in the system as well as we have made our pole length and height measurements from the standard measurements guide used in India and worldwide.

The pole measurements and specifications are as listed in table 1

| Pole specifications |  |
|---------------------|--|
| Setback             | 3 feet/ 0.9 meter |
| Pole Height         | 6 meters |
| Tilt Angle          | 15 degree |
| Spacing             | 10-30 meters |
| Arm Length          | 1.5 meters |

The most efficient specifications were chosen for better lighting from LED with even low power. The optimum tilt angle was selected for better coverage of area by LED in the pole. We also have monitoring and control website of which the administrator would be capable enough to analyze and control the poles via Internet.

4.1 System Components:

- Raspberry Pi 3B+ - as a Microcontroller.
- 8 channel Relay board – for connecting high power with to LED
- High Power LED – for efficient lighting.
- Webcam – for stray-cattle detection.
- Battery – For powering PI and LED
• Step down Buck convertor – For converting battery voltage to Pi level.
• MTTP charge controller: Controlling solar panel voltage charging to battery.
• Solar Panel: For charging battery.
• PIR Motion Sensor: For detection of motion at base of pole.
• PPM sensor: To provide threshold for fog.
• Web App: For monitoring and control.
• Phone App: For reporting fault and maintenance.

The overall proposed system is divided into 3 parts:

1. Street Light Management.
2. Stray Cattle Detection System.
3. Fault Reporting System

5. SYSTEM FRAMEWORK:

5.1 Street Light Management

Fig. 5 shows the block diagram of SMS system. Microcontroller will include a Raspberry PI 3 /3B+ which will be connected to internet through a Wi-Fi module. Sensor will include motion detecting sensor which will adjust the Street light grouping of 3 if motion detects during night time where the intensity of light will be dimmed for power saving purpose. The pair of light intensity will be controlled by Microcontroller from the sensor input. Fig. 6 shows the flow Chart of the SMS mechanism.

The Website will be used for command and control where the status of the lights as well as on time off time, threat alerts will be maintained. The information regarding breakage will also be notified. The app will be of simple reporting of the poles for breakage and maintenance using unique POLE ID. Fig.7 shows the block diagram of weather detecting system.
The group main pole will be connected with various sensors such as PM 2.5, temperature, humidity and light sensors. It will be able to manage the lighting color according to surrounding weather such as Fog, Haze etc. The pole color lighting can be also be controlled by website according to weather prediction by Ministry too. The value of these sensor will be converted into .csv (Comma Separated Values) along with Timestamp and the various sensor output data taken hourly or quarterly. Fig. 8 shows the values from PPM sensors.

The criteria decided based of 280 lumen led lighting for respective time is as follows:

| Time            | Lighting ON (percentage) |
|-----------------|--------------------------|
| 7pm to 12 am    | 100%                     |
| 12 am to 2 am   | 70%                      |
| 2 am to 4 am    | 60%                      |
| 4 am to 5:30 am | 50%                      |

As the ON time of LED is decreased the battery and power left Raspberry Pi will be sufficient enough to power on the PIR motion sensor as well as ppm sensor in night. The PIR sensor will be active from 12 am to 6 am and will also be connected and the motion detected will bring the brightness of led back to 100% for 15 sec. The PPM sensor can be operated from the authority according to weather updates from the department or from the sensor, by providing the necessary threshold and if the threshold is achieved the light will turn to Yellow for 15 minutes.

5.2 Stray Cattle Detection System

The Cattle report system will work in 2 ways:

5.2.1. The automatic detection of cow using ML pre trained model which will send the unique code area of the detected stray cattle and alert to respected authorities in the day time.

5.2.2. The cattle report system on app will alert the respected authorities along with the unique id area of pole.

Flow chart and block diagram of the cattle detect system is shown in Fig. 9 and Fig.10 respectively. The timing buffer is kept so that if the stray cattle stay long enough on roads to pose a danger to the traffic or the pedestrians then only the notification will be sent to the respective authorities. A widely used model for animal detection was trained for cow detection with up to 100 model cow images. This increased its accuracy up to 90%.
5.3 Fault Reporting System:

We have developed a dedicated web app, website as well as mobile app for fault reporting on the pole. Each pole will have a unique ID/QR code to which its location will be embedded. This will be useful in providing quick and efficient maintenance.

The fault reporting system will work in two ways:

5.3.1 Auto Fault Detect: Every day at 7 pm, a relay current check will be performed to ensure the LED is ON. If not detected it would send a maintenance fault to the administrator along with pole ID.

5.3.2 Manual Fault Detect: Any citizen could report faulty lamp, sensor or even stray cattle through our web app or website. The user has to enter his/her email id and also the pole id along with the fault and the report would be sent to his email as well as to admin along with fault type.

Fig. 11 shown above is the screen detection image from the pretrained model. Once detected system will again detect the stray cattle in the vicinity after 5 min as chances of stray cattle passing through road is more. If again the cattle are detected the alert will be sent to the admin through the server and also the list of contacts added by the Municipal Corp. along with the pole ID location.
Fig.11 and Fig.12 show the flow of fault reporting and fault notification respectively. The front end of the website is ready up and running which displays the online poles connected to the server. The data is also recorded per day wise sensor wise which enables the operator to efficiently categorize more or less pole/power requirement according to the area in which poles are installed. Fig.14 shows the website report page and Fig.15 shows the snapshot of the Admin panel website.
Fig.16 shows WEB APP view, Fig.17 shows the charts and data from all the poles and Fig.18 shows the snapshot of the App. Thus, our system aims to transform the current poles into multi-functionality, more efficient poles to be used in future.

6. SCOPE AND APPLICATIONS:

The current poles design could be implemented in-place of the conventional pole designs and will be efficient in power saving which is wasted in the current poles along with the high maintenance cost. The deployment of these smart poles will increase energy saving up to 25% annually and will also help environment due to its one-time cost. The accidents occurring due to stray cattle will go down and the stray cattle will find home in municipality Gaushala’s and care center. The camera footage can also be accessed and act as monitoring device during various situations of national security. If these poles are deployed on large scale, it could be also used for traffic forecasting which in return will lead to less congestion in further roads and will increase speed track. As COVID-19 is on large, these poles could also be used to alert the passerby’s with COVID positive patient Count in the surrounding.

7. CONCLUSIONS:

Intelligent and Multipurpose Smart Pole System is a semi-automated integration of poles and its management. For many years the design of poles remained the same and its development was overlooked. The proposed system evolves the basic design of the poles to efficiently provide its basic objective lighting as well as comes with some upgraded features like more energy saving, autonomous ON/OFF, weather lighting etc. Various ML model could be trained on the Raspberry PI such as number plate detection, fugitive detection model and could be used to catch and locate crime violators. The proposed system could be integrated with renewable solar power supply as well as AC mains too. This modularity gives an upper hand in power management. The one-time cost for setting up a pole will be a cost-effective solution. Street poles are such instruments which are present near everyone and this location advantage should be utilized till maximum in future era of IOT, AI, Smart Devices. The street poles in the city are an important part of city infrastructure, yet they have been overlooked for decades. This novel approach will bring us one step closer to our dream of SMART CITY.
REFERENCES

[1] Mr. N. Sivaiah, Ch. Lakshmi Prasanna, Ch. Tejaswini, Ch. Manisha, D. Yasaswini, “Automated Street Light Controlling System”, e-ISSN: 2395-0056, (2018).

[2] T. Santhi Sri, Rajesh Varma, V VS. Hari Krishna, K. Varun Chowdary “Automated Street Lighting System”. ISSN: 2278-3075 (2019).

[3] Ngabo, C. I., & El Beqqali, O. (2016, November). Real-time Lighting Poles Monitoring by using Wireless Sensor Networks Applied to the Smart Cities. In Proceedings of the International Conference on Big Data and Advanced Wireless Technologies (pp. 1-8).

[4] Shaikh, A., Thapar, M., Koli, D., & Rambade, H. (2018, March). IOT Based Smart Electric Pole. In 2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA) (pp. 594-597). IEEE.

[5] Mammeri, A., Zhou, D., Boukerche, A., & Almulla, M. (2014, June). An efficient animal detection system for smart cars using cascaded classifiers. In 2014 IEEE International Conference on Communications (ICC) (pp. 1854-1859). IEEE.

[6] Zhou, D. (2014). Real-time animal detection system for intelligent vehicles (Doctoral dissertation, Université d’Ottawa/University of Ottawa).

[7] Mitchell, T. M. (2006). The discipline of machine learning (Vol. 9). Pittsburgh: Carnegie Mellon University, School of Computer Science, Machine Learning Department.

[8] Meena, S. D., & Agilandeeswari, L. Adaboost Cascade Classifier for Classification and Identification of Wild Animals using Movidius Neural Compute Stick.

[9] Doan, D. (1980). U.S. Patent No. 4,200,904. Washington, DC: U.S. Patent and Trademark Office.

[10] Müllner, R., & Riener, A. (2011). An energy efficient pedestrian aware Smart Street Lighting system. International Journal of Pervasive Computing and Communications.

[11] Costa, M. A., Costa, G. H., dos Santos, A. S., Schuch, L., & Pinheiro, J. R. (2009, September). A high efficiency autonomous street lighting system based on solar energy and LEDs. In 2009 Brazilian Power Electronics Conference (pp. 265-273). IEEE.

[12] Leccese, F., & Leonowicz, Z. (2012, May). Intelligent wireless street lighting system. In 2012 11th International Conference on Environment.

[13] Shahzad, G., Yang, H., Ahmad, A. W., & Lee, C. (2016). Energy-efficient intelligent street lighting system using traffic-adaptive control. IEEE Sensors Journal, 16(13), 5397-5405.

[14] Yusoff, Y. M., Rosli, R., Karnaluddin, M. U., & Samad, M. (2013, September). Towards smart street lighting system in Malaysia. In 2013 IEEE Symposium on Wireless Technology & Applications (ISWTA) (pp. 301-305). IEEE.

ACKNOWLEDGMENTS

Authors wishing to acknowledge support of the BVM Engineering College EC department to carry out our work using necessary resources