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IoT and ML Based Approach for Highway Monitoring and Streetlamp Controlling

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Abstract. Excessive speed and violating traffic rules may cause dangerous road accident. Some reports show that around 3700 people die every day due to road accident. Controlling vehicle speed and proper automated street lighting system may mitigate this problem. This work implements an automated internet of things and machine learning based system to control streetlamps with vehicle speed tracking. The developed machine learning model is capable to guesstimate the speed of the vehicle on the highway and report if there is any excessive speed. The automated streetlamp is integrated with the system that can provide proper illumination considering the environment condition. The proposed system showed good results after practical implementation.

Keywords: Internet of Things (IoT) · Machine Learning (ML) · automated streetlamp · highway monitoring · vehicle detection · speed estimation

1 Introduction

Street lighting is the traditional energy recipient in metropolises. Up to 60% to 70% minimal money can be spent on street illuminating owing to lampposts [1]. The lights are turned on in the dark and switched off when it is adequately light outdoors.

The mechanism might also no longer be done remotely. Despite the fact that there are scant energy resources, the world's energy expenditure is climbing at the sharpest classify worldwide as a result of cohort increase and economic expansion. As a result, there are significant energy deficits since resource and energy gen consoles development cannot keep up with rising demand [11]. Streetlights are a vital element of every burgeoning metropolis. They can ever be revealed on all major highways including in the suburbs. Every day, from sunset to daybreak, lampposts are switched on at a high level, even when alone. These lamps cost far too much money each day to provide the required quantity of light energy on a world basis. Maintenance and replacement costs for mainstream incandescent bulbs are astronomically high. They produce a lot of heat and require a lot of electricity to operate. As a result, there is a greater need for electricity right now,

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which raises the amount of carbon dioxide that power plants emit into the atmosphere. As a result, this interaction hurts our environment in addition to producing excessive light pollution. The key goal of the venture is to create an energy-powered "Street Lamp-Post" for use at night. The lamppost is powered by the system, which considers the motion's trajectory of objects and supports them by lighting their path prior the next streetlight [14]. The embedded system can help pedestrians in faraway places with pressing supply constraints meet their objectives by consolidating with the street light system [13]. A convenient solution is to dim the lights during idol hours. When locomotion is perceived in the region, the lights in the surrounding will turn on in a predictable pattern [15]. This scheme would slash the cost of lighting while simultaneously preserving a significant amount of energy. Subsequently, we may leverage IoT to autonomously and in real-time monitor a system's status using the internet. This project's goal is to establish a speed camera without sensors and rely simply on neuroimaging of films using Python's OpenCV library [10]. A Doppler radar was eventually employed to measure the speed of vehicular traffic on highways. Then, fast cars were photographed using cameras. The speed of a passing vehicle is calculated by a Doppler radar using the frequency change of the approaching automobile [9]. Later, sensors were used by Traffic Radars to determine speeds. In order to detect traffic violators, traffic radars currently blend the use of sensors with image processing [16]. It is not sufficient to be speeding in order to commit a traffic infraction; other transgressions include the improper or reserved lane, running a red light, tailgating, overtaking out from wrong side, etc. Traffic radars may eventually be able to detect violations involving seatbelts and chatting while pursuing [9]. Wellas a piece is currently being researched and could be published soon. The streetlights gadget in Bangladesh remains manual. That suggests the road lighting fixtures gadget isn't automated, and technological innovation hasn't been assembled yet. There are three sorts of lighting fixtures hired in our country's streets: sodium, fluorescent, and energy-saving lighting. The city of Dhaka will deploy LED lights in all streetlamps to safeguard citizen reliability and give ample lighting on the streets for policy enforcement agents to do their jobs efficiently. Sensors and controllers are tied to construct an energy-saving lighting system, which is self-regulating, cost-effective, and acceptable for street lighting. Make a lighting system that is modular in order to allow for system expansion and customization. Our primary objective is to create a lighting mechanism that is scalable and compatible with various retail commodities and automated processes that can include more than simply lighting systems. And the project's initial focus is to build an IoT-based system for customizable street lighting that uses modern methods of technology, deliver an expedient lighting system that is totally based on biofuels, is long-lasting and durable, and saves energy.

As traffic steadily diminishes throughout the night, lights can be adjusted automatically until the morning to achieve power efficiency, and streetlamps switch on in the dark and then off in the sunlight [13]. In mild of the above goals, the task can pursue the subsequent effects:

- Most pivotal immediate advantage is that we've been able to tackle conventional switching until it's not necessary. As a result, a person's presence is not required while tapping on or off the streetlights.

- When the luminous flux drops due to bad weather, the lamp will automatically turn on and off in complies with the luminance. Consequently, we won't have to deal with turning on the lights.
- Monitoring the highway vehicle, track their speed and notify if high speed is found.

2 Literature Review

In many circumstances, IoT's positive impacts are evident [17]. An intelligent traffic and transportation system based on cutting-edge technology may be enabled feasible by the Internet of Things (IoT) [16]. Traffic jams, traffic accidents, and arrival delays will all be reduced because of this. A variety of studies were utilized to enhance the street lighting system. The illumination system was replaced or improved in the meantime to make it more user-friendly. In certain cases, the way things are happening was tweaked to generate a more reliable design. Today's street lighting system debuted vapor lamps with LEDs, protecting a significant amount of energy [2]. The system's linked research revealed a thorough review of several old lighting systems, their power consumption, and the aspects of new tech that is used to convert those customary lamps [3]. The country has adopted traditional lights after collecting data into the discrepancies in power efficiency, quality, and cost-savings compared to folklore bulbs and LED. Later work has explored using Wi-Fi to monitor the street light management system [5]. It lets cities have a more effective and affordable lighting control technique. The system consisted of a multiphase, digitally controlled LED lamp drive system and an LED light. A invention was made by including a transceiver inside the photoelectric circuit that regulates the ON/OFF of the High-Pressure Sodium bulbs [20]. Additionally, it enables the system's usage for a number of new municipal tasks. To alleviate the overload difficulties during peak hours, technology advanced. The street lighting system is mechanically generated, which allows for four disconnections during peak hours and optimizes the distribution of electrical energy [4]. Then a system for dynamically altering lighting based on pedestrian positions and safety zones was simulated using a gadget. The streetlamps are integrated with one using multi-hop relaying to reap commands of the cloud server [4]. The latter study concentrated on two areas: adopting the optimal protocol and looking for a network architecture that will support the prototype. The work focuses on anterior to this evaluating the effectiveness of mesh and tree community designs that might be used in conjunction with the ZigBee reliable wireless in the road lighting control structure [5]. A wi-fi tool with progressed handling and performance became implemented, giving stepped forward control performance, trendy interface, and manipulate architecture. Numerous sensors were employed to communicate data through ZigBee transmitters and receivers [5]. Assessing the device's condition and taking the appropriate action in the event of failure. An costly, high-performance LED module was created for favoured illumination. It has been developed and tested to be the 9-LED Module (9-LEDM). To extend longevity and improve induction therapy, an associate's degree harmonizing with a pair of frequencies has been devised. All three aspects—Three metrics—photometric, radiative, and electronic been presumed. Finally, experimental results based on the suggested method were acquired via lab measurements and a demonstration project. In terms of the pedestrian area and safety, an SSL device was proposed to explain a quick, stable, and powerful road light switching device [13]. A consolidated platform may be

used to monitor the lane markers. The IRS2530D and a dimming control circuit may both change the lighting's brightness., which is a new dimming ballast control IC in a small 8-pin shape, and addressing the deployment of a sensor to detect the ambient light, A contraption emerges in which the microcontroller is intended to just control the rhythm and brightness of the lighting [14]. They incorporated a Real-Time Clock and an LDR that progressed into being connected to a microcontroller. LDR was incorporated to locate the mild extrude. The amended variant was provided to the analog to digital converter, which altered it into a voltage signal and forwarded it to the microcontroller (ADC), with the capability to control when the lighting should turn on or off. Then, when the ambient light intensity drops below an optimum criterion, the road lights are set up to turn on [15]. When the site visitors' depth is just too low, the RTC inside the device assessments the time and dims the mild among hours. Finally, mild Acceleration via way of means of Stimulated Emission of Radiation (LASER) gates come across motion and spark off positive avenue lighting fixtures to most depth for public use. Slightly less electricity is consumed. System and lamp spacing is optimal., the "Timer and Dimmer" project can optimize performance by up to 40% and can augment suction by up to 35% [19]. The lifespan of the burned-out lamps can be increased by this gadget by two times. A robust and durable road delicate manage device, which desires negligible maintenance, became delivered later. It works at the depth of mild, in which time sensing is used for deciphering the depth of mild A real-time clock, a microprocessor, and a driver circuit based on Metal Oxide Semiconductor Field Effect Transistors are employed in this plan to regulate the intensity of LEDs. It minimizes annual energy consumption per streetlight by 16.96 kwhr when compared to the standard regulating mechanism [12]. In comparison to wireless sensor networks, it is more dependable and needs less upkeep. The Mask R-CNN architecture is used for vehicle detection. Masking was used to highlight vehicle-accessible areas on the road video [6]. Equations are used to calculate the speed of a vehicle as it travels over a rectangular territory. The length of a road segment is calculated via Direct Linear Transformation [7]. Afterwards, a Gaussian mixture is used to calculate speed and Background Subtraction to estimate the vehicle's position [8]. Finally, camera calibration was employed to the 3D space segment stance of the vehicle. All of the aforementioned research indicates the necessity for a street lighting system that is more ecological [9] as well as convenient and adaptable to operate. Remote sensing is facilitated for individuals by IoT-based initiatives [22, 25, 29], patient management [23, 27, 28], medical management [34], poultry farm [24], agriculture [32], hotel management [26], Electronic voting [31], security management [30], solar panel monitoring [35] and so on in secure way [33]. So, we hope streetlamp management system can be maintained with IoT in an efficient way.

3 Proposed Methodology

Two fundamental parts of this proposed framework are artificial intelligence (AI) cameras and LED lighting, which integrate energy-saving technology and management to reduce carbon emissions and capture community actual traffic stats dissemination and observing of freight. The two primary components of this suggested approach are artificial intelligence (AI) cameras and LED lighting, which employ energy-saving technology and management to reduce carbon emissions and capture real-time traffic metrics

for use in inspection and public release. To implement this system the requirements that include hardware, software, and online services are Arduino Uno, Breadboard, LDR Sensor, IR Sensor, Jumper wire, ESP8266, Camera-SQ11 Mini DV, Arduino IDE, ThingSpeak API, and PyCharm CE.

3.1 IoT Based Street Lamp

This flowchart (Fig. 1) will show the working procedure of IoT based streetlamp post of our proposed model. It will be operated in three modes. They are- Idol mode (When there's sufficient mild in the surrounding, at some stage in the daytime, the whole machine will transfer to the idol and the batteries might be charging), Active mode (When the ambient mild drops underneath a sure degree the machine mechanically activates and the sensors might be activated) and Operating mode (On the presence of a human, the sensors switch on and the machine will switch on the LED lighting fixtures. Following a while, these luminaires will turn off.).

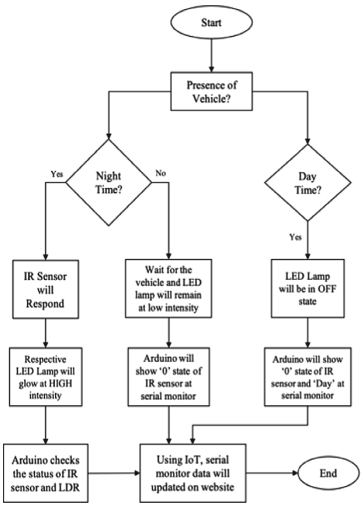


Fig. 1. Flowchart

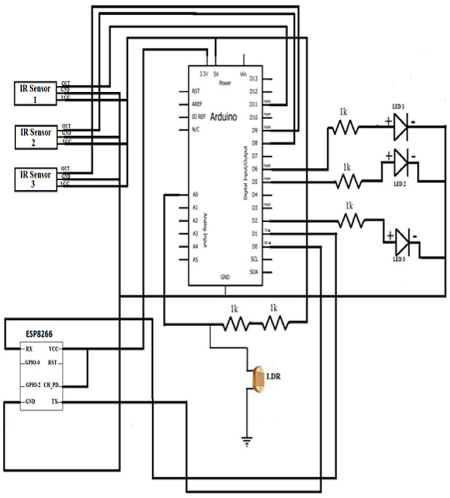


Fig. 2. Schematic Architecture

This envisioned system's IoT-based streetlamp is exhibited by this schematic architecture (Fig. 2), which exhibits the circuit indicating the operations connection between various electrical components.

3.2 Highway Monitoring

Here Project model block diagram (Fig. 3) is showing the entire process of highway monitoring systems using IoT. Then, A low fraction of the original footage is taken up by Region of Interest (ROI). Image subtraction is used on this ROI to find moving vehicles. (Image subtraction aids in determining the distinction between two frames.)

Masking (Fig. 4) is used to make the background black and the moving vehicles appear white. The contours are recognized according to the area barrier of the number of pixels (Fig. 5). The threshold prevents the wrinkles of smaller moving objects that are not automobiles from being detected. Using the gap between two textures over frames as a premise, the object is tracked. Each contour is allotted an ID.

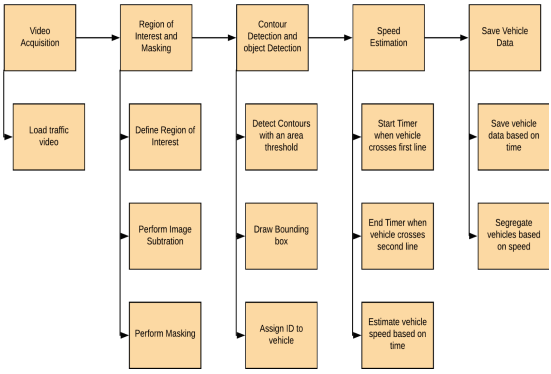


Fig. 3. Project Model Block Diagram

Fig. 4. Masked Image

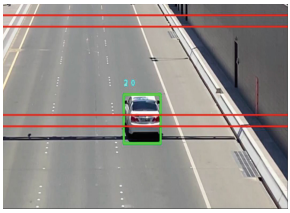


Fig. 5. Contour Detection

3.3 Vehicle Detection and Speed Estimation

Image subtraction is used to detect moving cars because the background of the vehicles is immovable (due to the stationary nature of the speed camera) (Fig. 6). When a tracked vehicle travels a portion of the route, the speed of the vehicle can then be approximated. A formula is used to determine and anticipate the amount of time that will pass between a vehicle's position and speed. As immediately as the vehicle passes the first point, the timer begins, and it expires when it crosses the second line (Fig. 7). Thus, the speed is only shown when the car crosses both lines on top of the enclosing box [9].

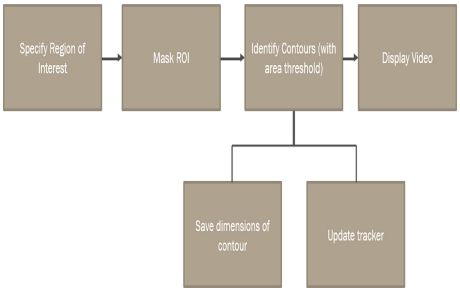


Fig. 6. Vehicle Detection Block Diagram

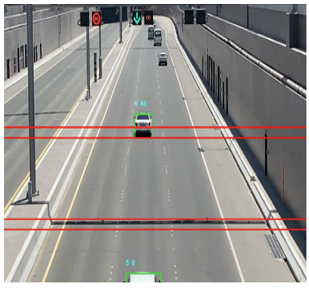


Fig. 7. Speed Estimation

4 Results

Along with the speed, a file is also recorded with a picture of the bounding box (the vehicle). Vehicles that exceed the speed limit are separated and placed in a different folder (Fig. 8). A text file contains the vehicle information. It is highlighted out which cars went over the pace seal. There is a summary of the handful of vehicles and the tailgaters (Fig. 9).

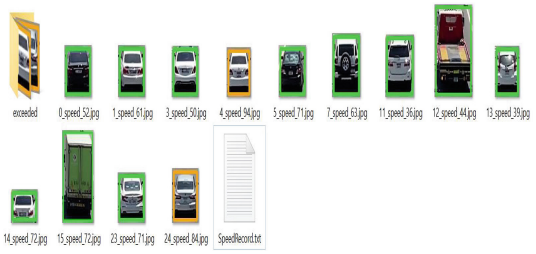
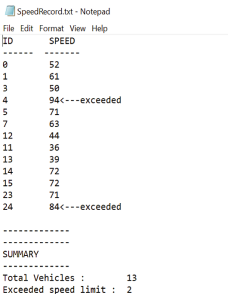


Fig. 8. Saved Vehicle Pictures


SpeedRecord.txt - Notepad

File Edit Format View Help

```
ID        SPEED
-------  -------
0         52
1         61
3         50
4         94<---exceeded
5         71
7         63
12        44
11        36
13        39
14        72
15        72
23        71
24        84<---exceeded

-------------
-------------
SUMMARY
-------------
Total Vehicles :        13
Exceeded speed limit :  2
```

Fig. 9. Sample Summary

The streetlamp controlling system also worked properly.
The obtained features are as follows:

1. Can monitor the vehicles on the road and tack the speed.
2. If any excessive speed found it can notify.
3. Measure the sun light intensity and control the streetlamp illumination.
4. Can Detect human near the streetlamp with IR sensor and automatically illuminate if human found.

The system was tested for multiple times. Following Table 1 shows the results.

Table 1. System Results Analysis

Objectives	Test time	Original	System output	Success rate
Speed tracking and Vehicle monitoring	100 vehicles	28 were in high speed	25 found in high speed	$\frac{25}{28} * 100\% = 89.3\%$
Streetlamp controlling	100 times	35 times in day, 35 times in night, 30 times in present of human in night	Day time turned off 35 times, turned on 34 times in night, turned on 29 times in presence of human motion	$\frac{\left(\frac{35}{35}+\frac{34}{35}+\frac{29}{30}\right)}{3} * 100\% = 97.9\%$

5 Conclusion

The proposed system is quite effective. The automated IoT based system was able to control the illumination of the streetlamps in proper time which can save energy and help the drivers. The developed machine learning model was able to monitor the vehicle speed on the highway and notify. The system has certain constraints too. The mechanism cannot interpret the damaged streetlamps. Some features like number plate detection and driver's attention level detection can make the proposed system more effective in future. The success rate should be increased in future development.

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