

IoT BASED STREET LAMP POST WITH HIGHWAY MONITORING SYSTEM

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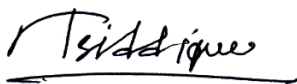
DHAKA, BANGLADESH

JANUARY 2022

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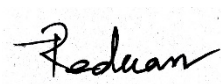
This Project titled “**IOT BASED STREET LAMP-POST WITH HIGHWAY MONITORING SYSTEM**”, submitted by **Nahidul Islam Nihal, A. B. M. Mohiuddin** and **Md. Arafat Uddin Saki** to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on January 13, 2022.

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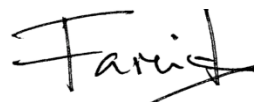
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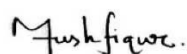
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DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Mushfiqur Rahman, Lecturer (Senior Scale), Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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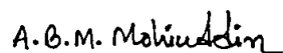


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ACKNOWLEDGEMENT

First, we express our heartiest thanks and gratefulness to almighty God for His divine blessing makes us possible to complete the final year project/internship successfully.

We really grateful and wish our profound our indebtedness to **Mushfiqur Rahman, Lecturer (Senior Scale)**, Department of CSE Daffodil International University, Dhaka. Deep Knowledge & keen interest of our supervisor in the field of “*Internet of Things & Machine Learning*” to carry out this project. His endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior drafts and correcting them at all stage have made it possible to complete this project.

We would like to express our heartiest gratitude to Professor Dr. Touhid Bhuiyan, Head, Department of CSE, for his kind help to finish our project and also to other faculty member and the staff of CSE department of Daffodil International University.

We would like to thank our entire course mate in Daffodil International University, who took part in this discuss while completing the course work.

Finally, we must acknowledge with due respect the constant support and patients of our parents.

ABSTRACT

Automation, Power Consumption, and Cost-effectiveness are the three most important factors to consider in today's technological area. With the assistance of systems, automatic systems are meant to minimize labor. Power conservation is always a priority since the supply of power is dwindling for a variety of reasons. We all know that energy consumption has been increasing rapidly. Therefore, to overcome these consequences, we are using IoT devices. This project is all about upgrading street lamps with sensors to reduce electrical energy usage while increasing traffic safety. When motion is detected, the system activates the brightest setting of the lamps; otherwise, they remain in the dim mode. LED bulbs are used because they outperform traditional incandescent lamps in every manner. Heat emissions, electricity usage, maintenance and replacement expenses, and carbon dioxide emissions are all reduced as a result. This project is also concerned with making a speed camera without sensors and only deals with the image processing of videos by using OpenCV in Python. Object's movements would be tracked, and the speeds of vehicles would be estimated. Because road safety is an integral part of today's roads. Therefore, speed limits are given for roads depending on the quality of the road and how prone the road is to accidents. Speed cameras should be installed at intervals along the road to catch speed-limit violators. Just like any other technology, speed cameras have progressed over the years. Moreover, a presentation with a demo model implementation technique has been designed to show real-time street changes utilizing the internet of things.

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CHAPTER 1

Introduction

1.1 Introduction

The most substantial energy expenditures in modern cities are for street lighting. A Street lamppost can reduce the city's street lighting expenditures by up to 60% -80% ^[1]. When it is dark, the lights are switched on, and when there is enough light outside, they are shut off. On bright and wet days, the ON and OFF periods fluctuate noticeably, which is one of the major shortcomings of current street light systems ^[3]. Furthermore, the system can no longer be operated manually. Energy consumption is expanding at the fastest rate in the world due to population growth and economic development, despite the fact that energy sources are critically limited ^[13]. As a result, resource and energy generation development is unable to keep up with increased demand, resulting in severe energy shortages ^[12]. Streetlights are an important feature of every growing city. They may be found along all main roads and in the suburbs. Every day, even when no one is there, streetlights are turned on at a high level from sunset until daybreak. Every day, much too much money is spent on these lamps to deliver the necessary light energy on a worldwide scale ^[13]. Traditional incandescent bulbs are extremely expensive to maintain and replace. They use much electricity to run, and their heat outputs are also rather substantial. Therefore, currently, there is a higher demand for electricity, resulting in increased carbon dioxide emissions from power plants ^[12]. As a result, in addition to causing excessive light pollution, this behavior also harms our environment. The project's main aim is to provide a "Street Lamp-Post" powered with energy during night time. The system powers the lamppost, detects the direction of movement of things, and assists them by lighting their line of movement till the next street light ^[15]. By connecting the embedded system with the Street light system, it is feasible to assist walkers in remote regions with severe energy power supply challenges in reaching their destination ^[14]. The similar technique may be applied in large cities. Dimming the lights during idle hours is a simple and practical solution to this issue. When motion is detected, the lights in the area will illuminate in the regular manner ^[16]. This project would save a significant amount of energy and reduce the cost of powering the

lights. In addition, we can use IoT to monitor the status of a system over the internet in real-time from anywhere ^[14]. This project also focuses on making a speed camera without sensors and only with Image processing of videos by using OpenCV in Python ^[11]. Initially, a Doppler radar was used to capture the speed of Vehicles on roads. Then, cameras were used to capture speeding vehicles. A Doppler radar uses the change in frequency of a passing vehicle to determine the vehicle's speed ^[10]. Later, Traffic Radars started using sensors to detect speeds. At present, traffic radars integrate the use of sensors and image processing to catch traffic violators ^[17]. The traffic violation need not be speeding, and it can also be wrong/reserved lane detection, passing the red-light detection, tailgating, wrong side overtaking, etc. In the future, traffic radars may even detect seatbelts and texting while driving offenses ^[10]. Such work is currently under research and may come out soon.

1.2 Motivation

In Bangladesh, the street lighting system is still manual. That means the street lighting system is not automated, and modern technologies are yet to be implemented. The lights currently used in the streets of our country are of three kinds – sodium, fluorescent and energy-saving lights ^[12]. The Dhaka city authorities are going to install LED lights in all street lamps to ensure security for the citizens and provide enough lighting on the streets for the law enforcers to perform their duties properly. According to a survey by the government's Power Cell conducted in 2014, there are 71,276 street lights in the capital of different types stated above ^[13]. In most developed countries, LEDs are already replacing the existing streetlights as an economically beneficial alternative. As part of the "Modern City" idea, modern nations are also focused on replacing old lighting with improved street lights. Street lights assist cities in further lowering expenses by reducing maintenance costs and electrical energy waste. The World Bank launched a \$1 billion fund dedicated only to LED street lighting in 2014 ^[13]. Overall, the LED and Street lighting markets are progressively expanding. Given these obvious benefits, governments estimated budget for streets lights is more than \$53 billion between 2015 and 2025 ^[13]. By 2025, LED and streetlights system are expected to account for 83% and 39 % of total streetlight market, respectively. The total market value will worth more than \$63 billion ^[12].

To create a lighting system for the streets that is energy efficient and self-regulating at an affordable price build an energy-saving lighting system sensors and controls are combined. Create a lighting system with a modular design that enables system adaptability and extension. To develop a lighting system that is compatible and scalable with other commercial products and automation systems that may involve more than just lighting systems are our main goal.

1.3 Objective

Initial goal of this project is to make an IoT-based adaptive street lighting system using cutting-edge technology. As traffic gradually drops over the night hours, lights may be managed automatically until the morning to save energy, and street lamps turn on in the dark and subsequently turn off in the sun, all automatically ^[14]. When it is dark, the process is repeated. White LEDs replace traditional halogen bulbs in street lighting systems, allowing for dimming. The high-intensity discharge lamp, which is commonly used in city street lights, does not control the intensity. Because of their low energy use, LED lights represent the next generation of illumination because of their low energy consumption and long life ^[12]. LED lights are increasingly replacing traditional lights due to the ability to alter intensity using pulse width modulation ^[16]. The suggested system makes use of an Arduino UNO board. The Arduino board is connected to a series of LEDs. When it is dark, an Arduino board is configured to produce different intensities at different times ^[6]. This concept was created by combining the LDR to accurately track the switching operations and the IoT to display the state of the roadway in the cloud and assist in regulating it ^[4].

The following are the primary goals:

- To reduce the light pollution.
- Provide an efficient though lighting system.
- Fully based on Renewable energy sources.
- Long lasting and Durable.
- Power Saving.

1.4 Feature

- LED Lighting – to adopt energy-saving equipment and management for carbon emission reduction.
- Artificial Intelligence (AI) Camera – to collect real-time traffic data for public dissemination and traffic monitoring.

1.5 Expected Outcome

The project can accomplish following outcome considering the above objectives:

- a. The most significant benefit of this project is that we can simply eliminate manual switching when it is required. As a result, the presence of a person while switching ON/OFF the street lights is not necessary.
- b. When the light intensity goes down in case of bad weather, the lights will be switched ON/OFF according to the light intensity automatically. Thereby, we do not need to worry about switching the lights.
- c. However, a disadvantage of this project is, when there is fog or rain, the sensor used here may not function properly while measuring the light intensity. However, it can be easily overcome by using a better-quality sensor can be used for flawless outcome.
- d. The project can be used in diverse ways with a little modification of the system.
- e. This project would be able to successfully save electricity and determine the speed of a vehicle and save the vehicle picture in a separate folder. Due to video clarity issues, number-plate detection is beyond the scope of this project. This project focuses on making the city and secure road by vehicle detection and tracking and speed estimation.

1.6 Problem Statement

Statement 1: In the presence of light, street lights are turned on

Statement 2: The System will be activated when it will detect any kind of object.

Statement 3: Vehicle tracking with object detection and speed estimation.

Difficulties of this project are to create a traffic radar using Image Processing in Python by using OpenCV and TensorFlow.

When it comes to tracking the speed of vehicles on a segment of road, the vital steps of this section are:

1.6.1 Vehicle Detection

As the background of the vehicles is stationary (as the speed camera is stationary) image subtraction is used to detect moving vehicle.

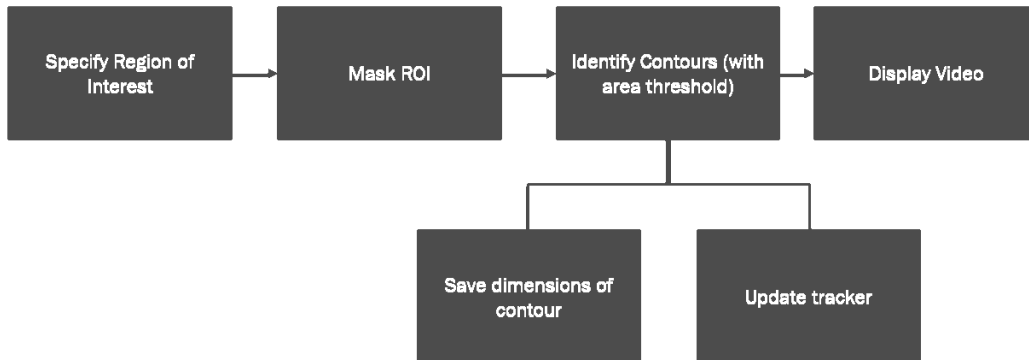


Figure 1.6.1: Vehicle Detection Block Diagram

1.6.2 Speed Estimation

The speed of a vehicle can be estimated when a tracked vehicle covers a segment of road.

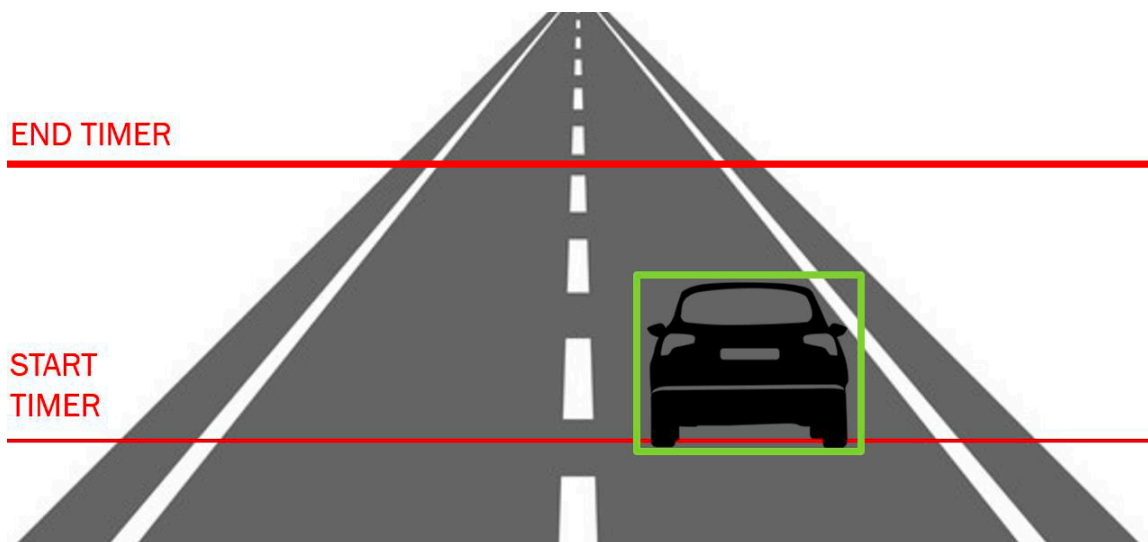


Figure 1.6.2: Speed Timer Diagram

1.6.3 Capturing Vehicle Picture

The picture of a certain ID, as well as the speed, is stored to a folder using Contour detection. As shortly the speed is measured, the picture is stored.

Traditional street lighting has the following drawbacks:

- Even when there is no light, streetlights remain.
- Currently, streetlights require manual switching.
- It also needs human connection.
- In the absence of any activity on the street, these lamps are uselessly shining at full power.
- High power use and waste of electricity

Benefits of the Proposed System:

- Automatic streetlight switching
- Cost of Upkeep CO2 emissions are being reduced.
- Light pollution is being reduced.
- Conserving energy.
- Human resource reduction.
- Reduced number of traffic accidents.

CHAPTER 2

Literature Review

Literature Review

Several works have been done to develop the street lighting system. Sometimes the lighting system has been changed or modified to make an easier system. In addition, sometimes the way of operation was changed to make an efficient system. Today's existing street lighting system started replacing vapor lamps with LED, saving much power ^[2]. The associated research of the system showed a complete analysis of different traditional lamps, power consumed by them, and features of new technology and their features to replace those traditional lamps ^[3]. After some study regarding the difference in power consumption and efficiency and cost-saving between various traditional bulbs and LED, the country has projected to replace the traditional lights. Later, Ethernet-based research has proposed to monitor and manage the street light control system ^[5]. It enables a better and cheap lighting control system for small cities. The project comprises of an LED light and a digitally controlled multiphase LED lamp drive system. By incorporating a transceiver on the inside the photoelectric circuit that controls the ON/OFF of the High-Pressure Sodium bulbs, a technology was developed ^[12]. Furthermore, it allows the system to be used in a various additional municipal function. There was a technological advancement to solve the overload issues during peak hour. It permits the four disconnections of during peak hours, the street lighting system is powered by the mains, system's and making electrical energy distribution easier. Following this, a device was used to simulate a System for dynamically switching lamps depending on pedestrian positions and safety zones ^[13]. The lampposts are outfitted with a device that receives control information from the cloud server through multi hop routing ^[4]. Later study concentrated on two aspects: selecting a suitable communication protocol on the one hand, and selecting a network topology that supports the design on the other. In light of this situation, the research focuses on analyzing the performance of mesh and tree network topologies that may be employed in a street lighting control architecture alongside the ZigBee communication protocol ^[5]. A wireless system with improved handling and efficiency was implemented, giving improved management

efficiency, sophisticated interface, and control architecture. Many sensors were used for transferring the information through the ZigBee transmitters and receivers ^[5]. The state of the system is checked, and appropriate measures are taken in case of failure. For general illumination, a high-performance, high-priced LED module was devised. The 9-LED Module (9-LEDM) has been created and tested ^[13]. An adaptive with 2 frequencies has been developed to increase longevity and simplify induction therapy. Photometric, thermal, and electrical aspects have all been taken into account. Finally, laboratory measurements and a demonstration project yielded experimental findings based on the recommended technique. An SSL system was presented to explain a rapid, reliable, and power-efficient street light switching system in terms of pedestrian location and safety ^[14]. The street light can be monitored from a centralized position. A dimming control circuit, such as the IRS2530D, can regulate the brightness of the lights., which is a new dimming ballast control IC in a compact 8-pin form, and with respect to the surrounding ambience-using sensor, A system was developed in which the microcontroller was programmed to turn on and off the lights based on the time and intensity of the light ^[15]. They employed an LDR and a Real-Time Clock that was linked to a microcontroller. The light was detected using the LDR. The variation was processed as a voltage signal to the microcontroller through the Analog to Digital Converter (ADC), with the ability to determine the time the lights required to be turned on/off. The street lights are then configured to turn on when the intensity of the ambient light falls below a certain threshold ^[16]. When the traffic intensity is too low, the RTC in the system checks the time and dims the light between specific hours. Finally, light Acceleration by Stimulated Emission of Radiation (LASER) gates detect movement and activate certain street lights to maximum intensity for public use. It reduces power consumption a lot. The project 'Timer & Dimmer' is capable of energy consumption up to 35% and can increase this efficiency up to 40% with a good distribution of networks and lamps ^[12]. This system is capable of increasing the lifetime of the lamps used up to two times ^[3]. A strong and long-lasting street light control system, which needs minimum maintenance, was introduced later. It works on the intensity of light, where time sensing is used for decoding the intensity of light. For managing the intensity of LEDs, the system employs a microprocessor, a real-time clock, and a driver circuit based on Metal Oxide Semiconductor Field Effect Transistors. In comparison to the conventional

regulating method, it saves 16.96 kwhr per street light each year ^[13]. It is dependable, and it requires less maintenance than wireless sensor networks. For vehicle detection, the Mask R-CNN architecture is employed. On the road video, masking was utilized to identify vehicle-accessible sections ^[6]. A rectangular territory is chosen, and the speed of a vehicle traversing the rectangle is determined using equations. Direct Linear Transformation is used to calculate the length of a road segment ^[7]. The vehicle's location is then estimated using Background Subtraction, and speed is computed using a Gaussian mixture ^[8]. Finally compute the vehicle's target location in 3D space, camera calibration was used. All of the above research points to the need for a street lighting system that is both convenient and flexible to operate, as well as more sustainable ^[10].

CHAPTER 3

Requirement Analysis and Methodology

3.1 Requirement Analysis

We have used many equipment and spare parts in this project. This chapter will demonstrate the functionality, availability, and working principle of the major equipment used in this project. The basic principles, pin diagrams, the features and specifications of our essential equipment such as Arduino Uno, IR Sensor, LDR sensor, ESP8266, etc., will be discussed in detail and give a clear idea about the project ^[2]. ESP8266 module mainly sends data to the cloud so the controller can read data via an online platform like ThingSpeak in the project. The sensor is used to detect light brightness, and it turns ON/OFF the streetlights accordingly ^[15]. For example, in the daytime, light intensity is higher, turning the streetlights OFF. Along with these, the other components used for this project are discussed in this chapter.

3.1.1 Street Lamp-Post

3.1.1.1 Arduino Uno

Arduino.cc launched Arduino microcontroller board in 2010 that is based on the Microchip ATmega328P microprocessor. It is an open source software also free to use. Arduino Uno boards are often used to develop projects in digital electronics, embedded systems, robotics, automation, the Internet of Things, and other related fields ^[1]. The latest variety of Arduino Uno has a Universal Serial Bus port, 6 pins are used analog input (A0 to A5), and 14 Input/Output digital pins, which are used to interact with outer electrical circuits. When it comes to PWM output, six pins are available out of the 14 Input/Output pins ^[2]. All of them may help the microcontroller by connecting it to the computer for further functioning. The Arduino Uno board may be powered via an alternating current (AC) to direct current (DC) converter or a USB connection; alternatively, a battery may be utilized.

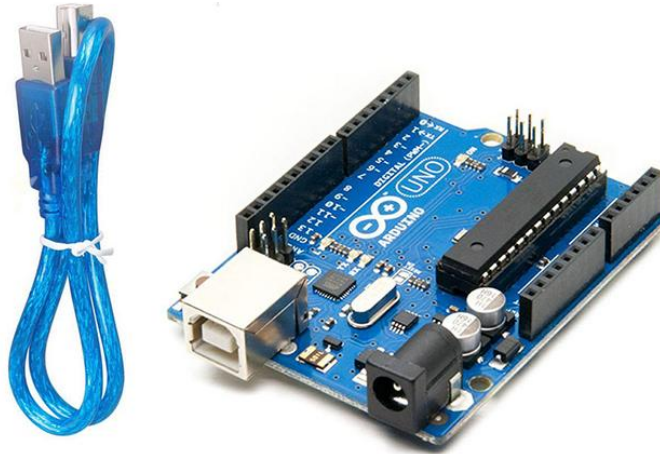


Figure 3.1.1.1: Arduino Uno R3

Technical specifications of Arduino Uno are given below:

- Microcontroller used: ATmega328P
- Required Voltage for Operation: 5 volts
- Voltage Recommendation for Input: 7V to 12V
- Range of Input Voltage: 6V-20V
- Pins for Analog Input: 6 (A0 to A6)
- Pins for digital input and output: 14 (6 Pin for PWM output)
- Required Direct Current for 3.3V Pin: 50 mA
- Required DC Current for input/output Pins: 20 milliampere
- Flash Memory size: 32 kilobytes
- The Arduino has a Static Random-Access Memory which size is 2 kilobytes. It also an electronically erasable programmable read-only memory size of 1 kilobyte.
- CLK /frequency: 16 MHz
- Built-in Light Emitting Diode: 13 number digital pin
- The Arduino length, width, and weight are respectively 68.6 mm, 53.4 mm, and 25 g.

3.1.1.2 Breadboard

The breadboard would be a quadrilateral plastic panel that has a slew of small holes drilled into it along its length. Breadboards are also used to develop prototypes of electrical circuits

and may be applied for other applications in the future. The breadboard central half contains two columns, separately with 30 connection strips similar to the one on the breadboard that has been pushed out and to the side ^[2]. These attach whatever that is strapped through from the forward-facing into single of the five holes to form a cohesive unit. Both borders of the breadboard have significantly longer portions of the clip that connect the columns of holes represented by red and blue lines on its exterior. Red lines are intended for 5V and blue line are meant for ground (GND). The interior of a breadboard is constructed of small metal clips, it is possible that the leads will be accommodated by the board ^[14].

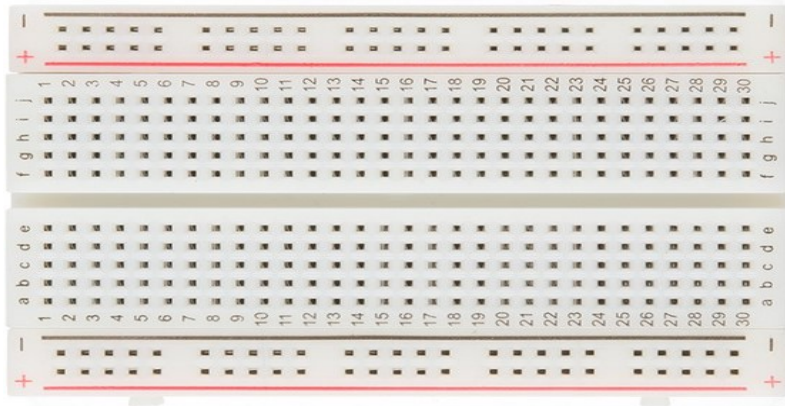


Figure 3.1.1.2: Breadboard

3.1.1.3 LDR Sensor

This resistor is a type of resistor that responds to light. It is also known as a photo resistor, photoconductor or photocell ^[2]. This resistor resistance changes with intensity of the light when it hits resistor surface. In short when light shines on a resistor, the resistance of the resistor changes. These resistors are frequently employed in various circuits where the presence of light is necessary. These resistors offer a wide range of resistance and purposes. For example, when it is become dark, LDR can be used to turn on a streetlamp, and when light comes, it may be used to turn off the street lamps ^[2]. Normal LDR resistor has a resistance of 2M Ω in the dark and in the light ambient resistance of a couple of 5K Ω .

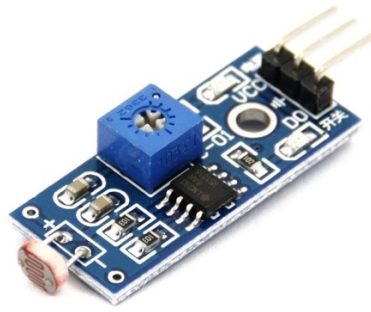


Figure 3.1.1.3: LDR Sensor

3.1.1.4 IR Sensor

This sensor produces infrared light to detect particular type of its surroundings. For example, may detect movements and can measure the temperature of an object. Passive infrared sensor can detects more than infrared radiation. Everything releases some infrared heat radiation [2].

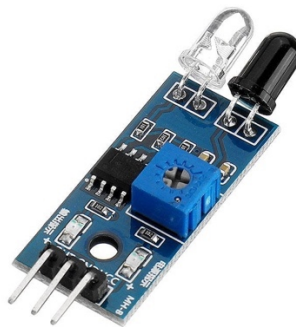


Figure 3.1.1.4: IR Sensor

These radiations are not detectable to the naked eye; an infrared sensor can detect them. The emitter is a basic IR LED, and the detector is an infrared photodiode that detects IR light of the same wavelength as the IR LED. When infrared light reaches the photodiode, the resistances and output voltages fluctuate in proportion to the intensity of the IR light [2].

Infrared sensors work in the same way that object detection sensors do. Because this sensor has both an infrared LED and an infrared photodiode, it may be used as a photo-coupler or

an optocoupler by combining the two. The IR LED is an infrared radiation transmitter. This LED seems to be a standard LED, and the radiation it produces is imperceptible to the naked eye. Infrared receivers use an infrared transmitter to detect the radiation. These infrared receivers are also available in photodiode form. IR Photodiodes are distinct from other types of photodiodes in that they detect infrared energy ^[2]. There are several varieties of infrared receivers depending on voltage, wavelength, packaging, and other criteria. Once an infrared sender and receiver are connected, the reception wavelength should match the wavelength of the transmitter ^[14]. An infrared LED serves as the transmitter, when an infrared photodiode serves as the receiver. An infrared LED generates infrared light, which activates the infrared photodiode. This same resistance of the photodiode and the change in output voltage are proportional to the quantity of infrared light received. The basic functioning of an infrared sensor is as follows. When the infrared transmitter produces light, some of it bounces off the object and the rest reach the infrared receiver ^[15]. The IR receiver may choose the sensor output based on the strength of the source.

3.1.1.5 Jumper Wire

A wire is a particular stick of metal that is generally cylindrical in shape and it is flexible. Mechanical weights or messages for electricity and telecommunication signal are all carried on wire. Jumper wires are basic cables that include connection pins on both ends, allowing them to link two locations without the requirement for soldering between them. Jumper wires are generally used in conjunction with breadboards and other equipment to create it simple to modify the configuration of a circuit as required ^[2]. Although jumper wires are available in several colors, the colors themselves have no significance. Although jumper wires are available in several colors, the colors themselves have no significance.

Jumper wires are commonly available in three different variants.

- Male to Female
- Female to Female
- Male to Male



Figure 3.1.1.5: Jumper Wire

A pin protrudes from the male end, allowing it to plug into objects, but female points do not, allowing them to plug into other objects.

3.1.1.6 ESP8266

The Espressif system has created the Wi-Fi-enabled system on chip module. It is mostly used to develop embedded Internet of Things devices.

ESP8266 has the capabilities of

- General-purpose input/output,
- Pulse-width modulation (PWM).
- Inter-Integrated Circuit serial communication protocol,
- 10 bit Analog-to-digital conversion.
- Serial Peripheral Interface serial communication protocol,
- Inter-IC Sound interfaces with DMA (sharing pins with GPIO),
- 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2),
- UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2), and it runs at 80 MHz on a 32-bit RISC CPU based on the Tensilica Xtensa L106 (or overclocked to 160 MHz).
- It features a 64-kilobyte boot ROM, a 64-kilobyte instruction RAM, and a 96-kilobyte data RAM. In addition, SPI can be used to access external flash memory.

The ESP8266 module is a cheap wireless transceiver that is used for end-point IoT developments. First, the controller communicates with the ESP8266-01 module using UART using special Baud rat.



Figure 3.8: ESP8266 WIFI Module

ESP8266 Module Pin Details

- GND is an abbreviation for Ground Pin.
- RST - "Active Low Reset Pin."
- 3.3 V Power Pin (3V3)
- EN: - High Enable Pin Active.
- TX: UART's Serial Transmit Pin.
- RX: UART's Serial Receive Pin.

3.1.2 Highway Monitoring

3.1.2.1 Camera – SQ11 Mini DV

We'll be able to record footage from the camera. It allows you to construct a video capture object that can be used to record movies from a camera and then conduct operations on them.

Video resolution

The video recording standby mode on the tiny camcorder can capture 720p and 1080p quality.

Motion sensor video recording

The video recording will begin if motion is detected, with red and blue LEDs glowing simultaneously. Additionally, when the motion sensor is recorded, the video footage is immediately preserved.

Features

- 1920x1080 and 1280x720 pixels are the video resolutions.
- 15-30 frames per second frame rate
- Photo resolution: 4032x3024
- Photo resolution: 4032x3024
- JPEG photo file.
- The angle of view is 140 degrees.
- 6 IR LEDs (range of 5 meters, do not produce light!) for night illumination
- There is a motion sensor (range 5 meters)
- Continuous recording up to 100 minutes.
- In motion sensor mode, it lasts around 5 hours.
- Run all day long when external power is connected
- Micro SD cards up to 64GB are supported.
- Temperature of operation: $-10^{\circ}\text{C} + 60^{\circ}\text{C}$
- The humidity level in the atmosphere is between 15 and 85%.
- Size: 23x23x23 mm, weight: 15g



Figure 3.1.2.1: Camera - SQ11 Mini DV

3.2 Methodology

3.2.1 Street Lamp

3.2.1.1 Schematic Architecture

A schematic architecture is a two-dimensional illustration of a circuit that shows the operation and connections between various electrical components.

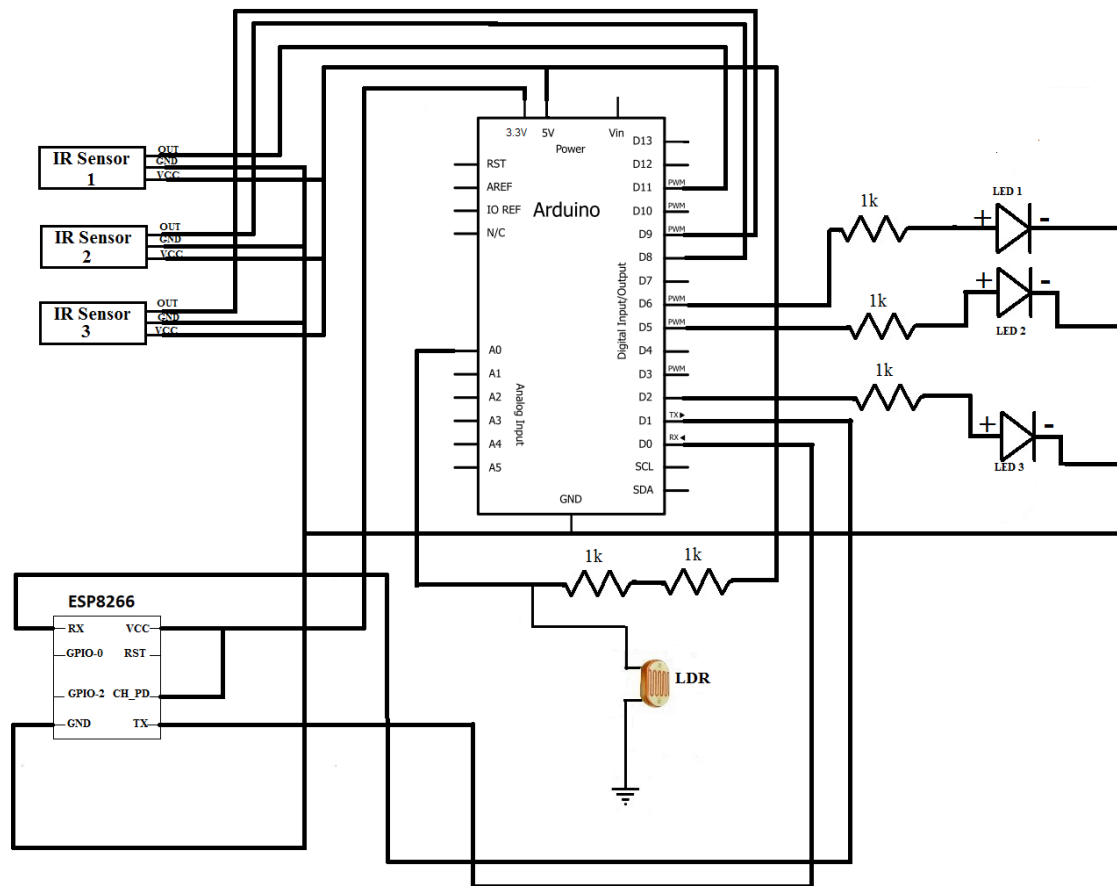


Figure 3.2.1.1: Schematic Architecture of Street Lamp

3.2.1.2 Flow Chart

In a flowchart, there are steps involved in completing a process works, workflow, or a method. On the flowchart, the stages are represented as various types of boxes, with arrows connecting them in sequence. This diagrammatic representation illustrates a solution model for a particular problem.

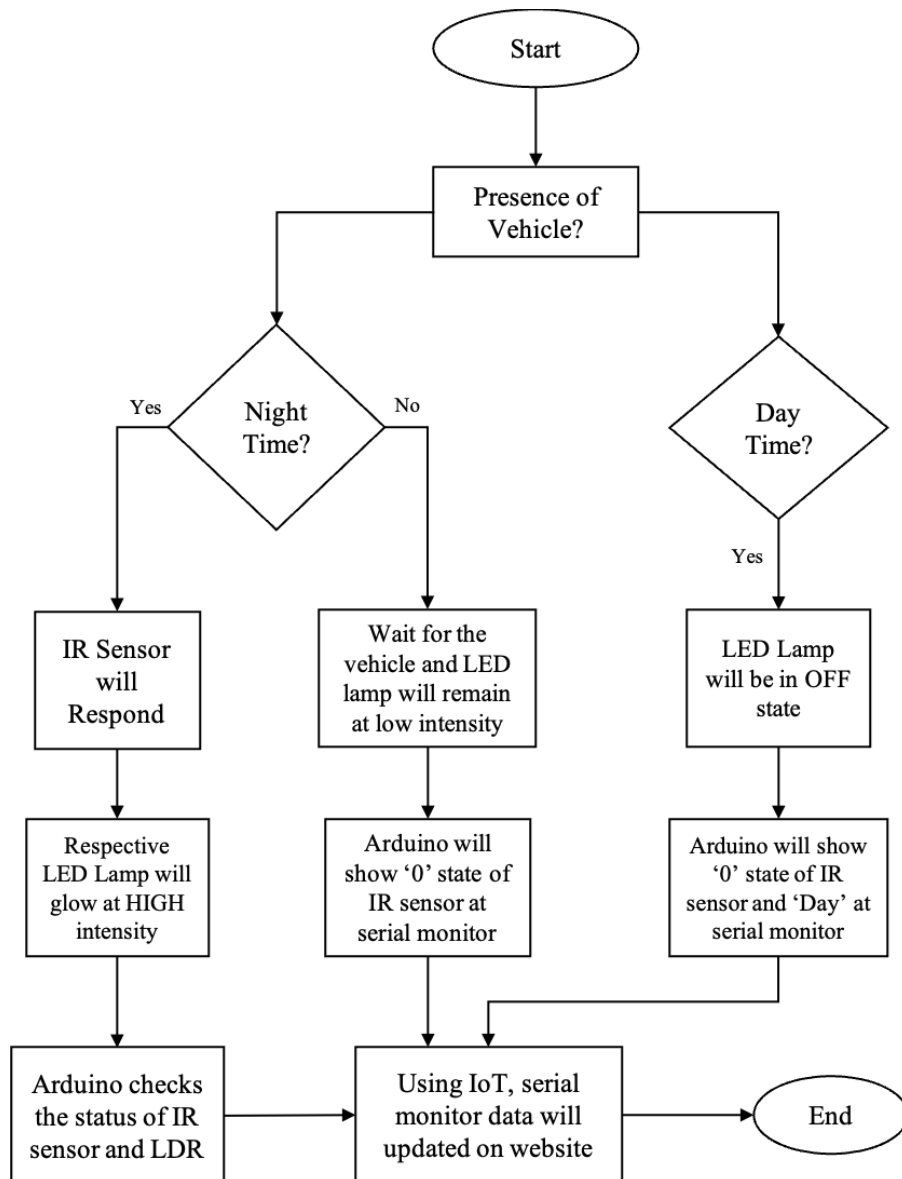


Figure 3.2.1.2: Flow Chart of Street Lamp

3.2.1.3 Mode of Operation

The design includes three working period:

- **Idol mode:** When there is enough light in the surrounding, during the daytime, the entire system will switch to idol and the batteries will be charging.
- **Active mode:** When the ambient light drops below a certain level the system automatically turns on and the sensors will be activated.

- **Operating mode:** On the presence of human, the sensors turn on and the system will turn on the LED lights. These lights will turn off after a period.

3.2.2 Highway Monitoring

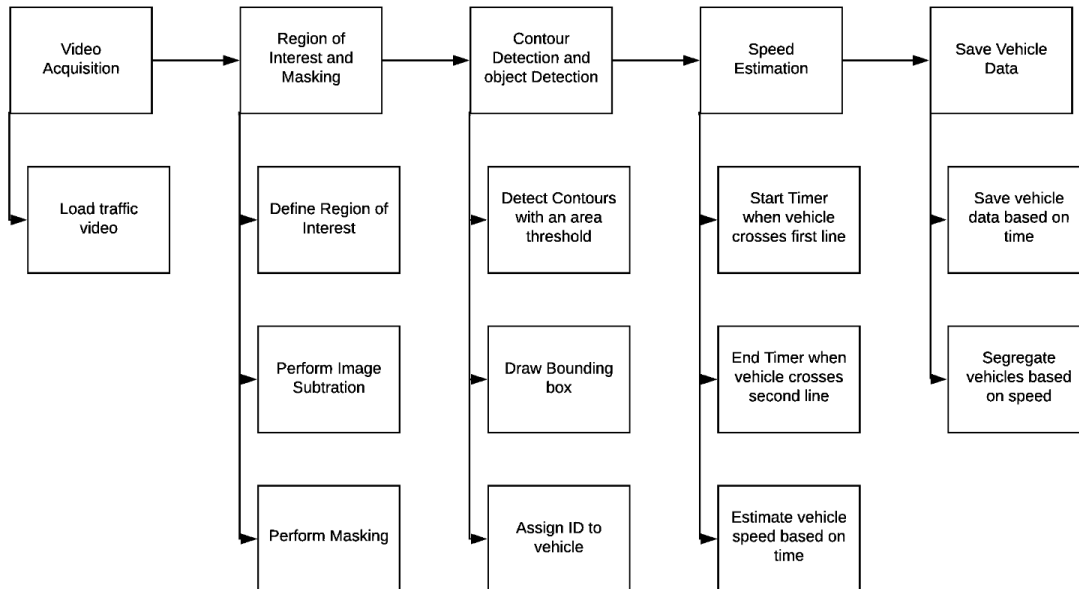


Figure 3.2.2: Project Model Block Diagram ^[9]

3.2.2.1 Region of Interest and Masking

Region of Interest (ROI) takes a smaller portion of the original video. On this ROI, Image subtraction is performed to detect a moving vehicle. (Image Subtraction helps find the difference between two frames). Masking is performed to make the moving vehicles appear white and the rest of the image black ^[11].

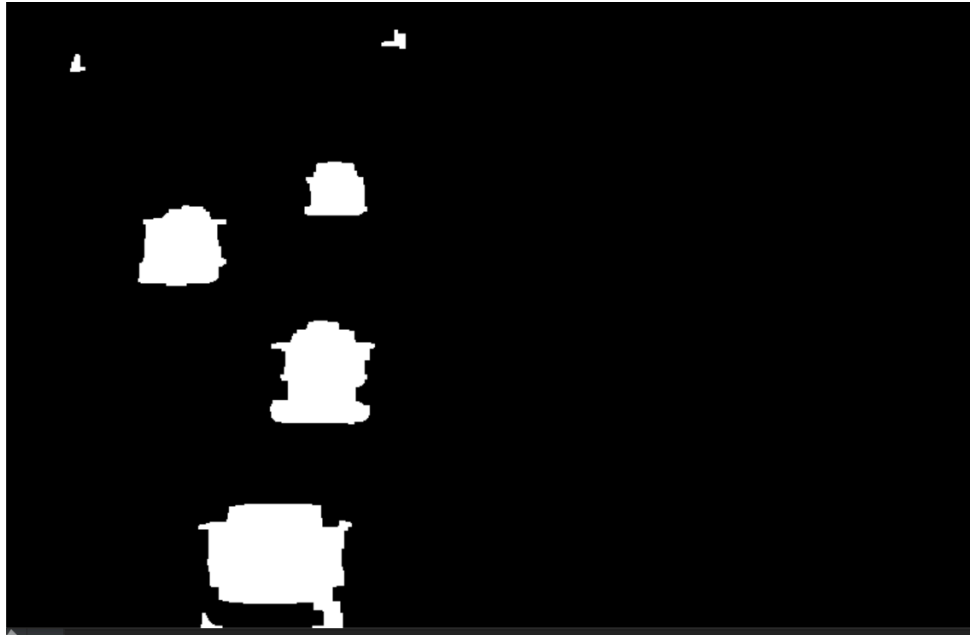


Figure 3.2.2.1: Masked Image

3.2.2.2 Contour Detection and Object Tracking

Based on the area threshold of number of pixels, the contours are detected. The threshold is used to avoid detecting contours of smaller moving objects that are not vehicles. The object is tracked based on the distance between two contours between frames. An ID is assigned to each contour

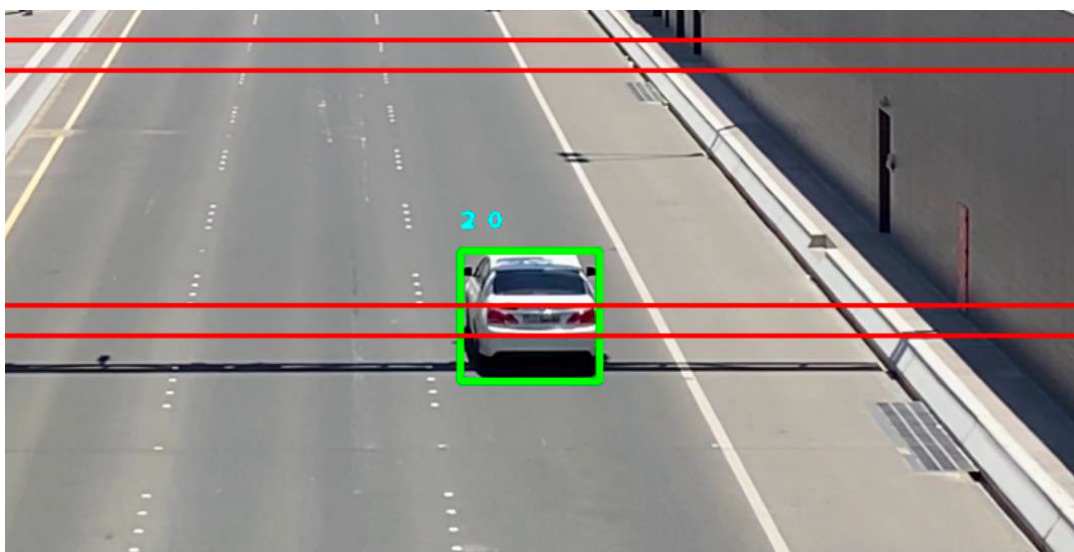


Figure 3.2.2.2: Contour Detection

3.2.2.3 Speed Estimation

The time difference between a vehicle's position and its speed is determined and predicted using a formula. The timer starts when the vehicle crosses the first line and ends when the vehicle crosses the second line. Thus, the speed is displayed on top of the bounding box only when the vehicle crosses both lines ^[10].

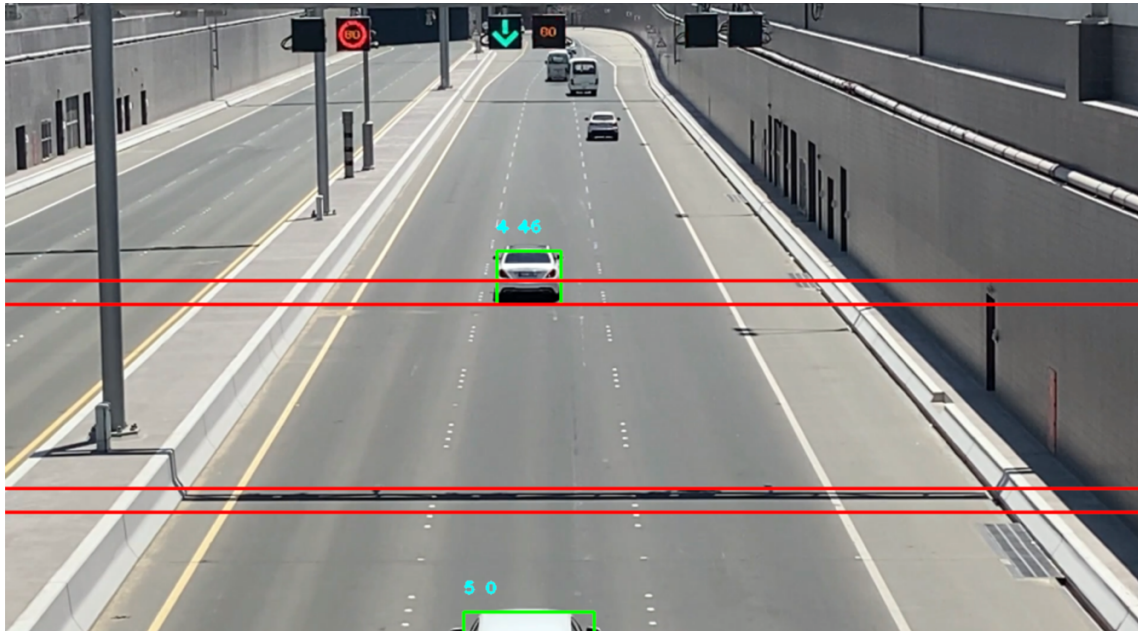


Figure 3.2.2.3: Speed Estimation

3.2.2.4 Save Vehicle Data

The picture of the bounding box (the vehicle) is saved into a file along with the speed. Vehicles crossing the speed limit is segregated into a separate folder.

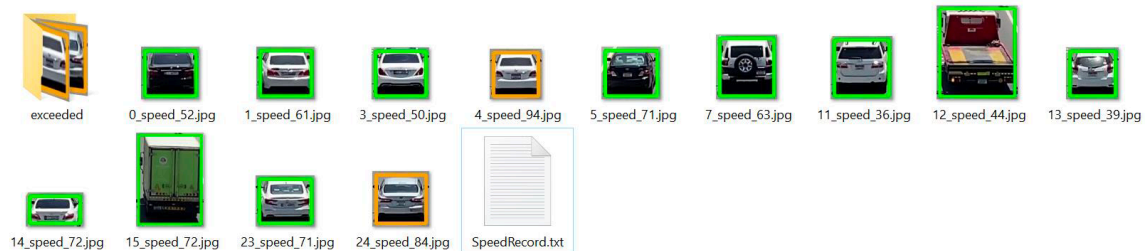
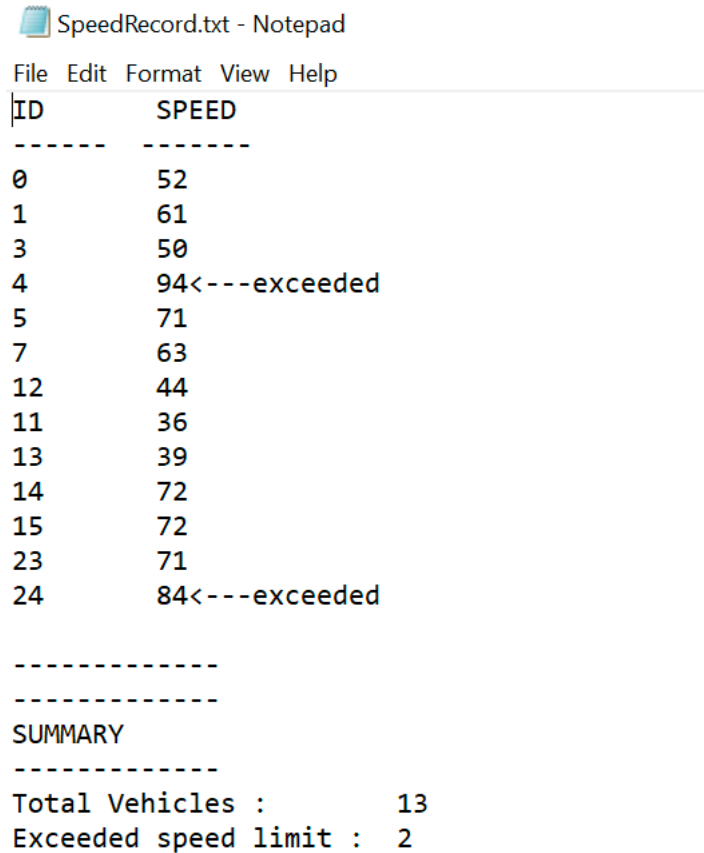


Figure 3.2.2.4: Saved Vehicle Pictures

3.2.2.5 Create Summary

The vehicle data is saved in a text file. The vehicles that exceeded the speed limit are pointed. A summary of number of vehicles and the speed violators are displayed.



```
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
```

Figure 3.2.2.5: Saved Summary

3.3 Software and Online Services

3.3.1 Arduino IDE

Software is used for programming purpose. Without programming the Arduino, it is impossible to run the project. In the system, we have programmed Arduino UNO by using Arduino software. It is one of the most popular comprehensive compilers, including an editor, simulator, and programmer. The Arduino IDE supports languages like C and C++ for using code structuring.

3.3.2 ThingSpeak API

This is an open-source web that helps users to connect with IoT device. It enables retrieval, data access, and logging by offering an API to multiple devices and websites. ThingSpeak was first released in 2010 by ioBridge as a service to help IoT applications.

3.3.3 PyCharm CE

PyCharm (Community Edition) Environment (IDE) is a Python integrated development that allows you to write code in Python contains a variety of important tools for Python developers that create a suitable environment for practical Python, data science development and web.

CHAPTER 4

Implementation and Result

4.1 Implementation

4.1.1 Street Lamp-Post

4.1.1.1 Overview

We used a single LDR circuit to distinguish between day and night. The LDR and a low resistance register are linked in series to the Arduino Uno's 5V and GND. The output of the LDR circuit is sent to the Arduino's 'A0' pin, which turns on the full street lighting system, which is represented by an LED linked to the output pin. The LDR sensor is a resistor whose value is determined by the brightness of the light shining on it. It has a resistance of about 2M-ohm in total darkness but only 5k-ohm in daylight. To detect movement, three IR receiver and transmitter circuits are built, and the output from the receiver is delivered to the input terminal, which corresponds to the LEDs attached to 5, 6, 7, 8, and 9, L0, LI, L2, and L3, respectively. All of the components and sensors are wired between the Arduino UNO's 5V and GND. ^[2]

4.1.1.2 Working of the Circuit

- The LDR receiver is linked to A0, and the LDR flag and output value are both set to zero. The LDR reference value output value is predominantly and is set to 550. (Baud rate). If the Arduino UNO reads any value from the LDR that is less than the LDR reference value, the system will activate the street lights.
- The output of IR0, IR1, and IR2 is linked to pins A1, A2, and A3, and the reference value of all sensors is set to 550 (baud rate), which corresponds to LEDs attached to 3, 5, 6, 9, and 10.
- Other three-proxy values for each object sensor are set to zero, and if any object sensor detects movement, Arduino UNO compares the value to the object's supplied reference value. If indeed the measured value will be less than the setpoint, the LED will light at full intensity; otherwise, the voltage will be reduced, and the LED will glow at 40%. ^[2]

- The first and the last LED glows continuously to detect the start and end of the road.

4.1.2 Highway Monitoring

4.1.2.1 Video Acquisition

```
cap = cv2.VideoCapture("traffic4.mp4")
```

4.1.2.2 Region of Interest and Masking

```
# KERNELS
kernelOp = np.ones((3, 3), np.uint8)
kernelOp2 = np.ones((5, 5), np.uint8)
kernelCl = np.ones((11, 11), np.uint8)
fgbg = cv2.createBackgroundSubtractorMOG2(detectShadows=True)
kernel_e = np.ones((5, 5), np.uint8)

# MASKING METHOD 1
mask = object_detector.apply(roi)
_, mask = cv2.threshold(mask, 250, 255, cv2.THRESH_BINARY)
mask1 = cv2.morphologyEx(imBin, cv2.MORPH_OPEN, kernelOp)
mask2 = cv2.morphologyEx(mask1, cv2.MORPH_CLOSE, kernelCl)
```

4.1.2.3 Contour Detection

```
contours, _ = cv2.findContours(e_img, cv2.RETR_TREE, cv2.CHAIN_APPROX_SIMPLE)
detections = []
for cnt in contours:
    area = cv2.contourArea(cnt)
    # THRESHOLD
    if area > 1000:
        x, y, w, h = cv2.boundingRect(cnt)
        cv2.rectangle(roi, (x, y), (x + w, y + h), (0, 255, 0), 3)
        detections.append([x, y, w, h])
```

4.1.2.4 Object Tracking

```
# Object Tracking
boxes_ids = tracker.update(detections)
for box_id in boxes_ids:
    x, y, w, h, id = box_id
    if (tracker.getsp(id) < tracker.limit()):
        cv2.putText(roi, str(id) + " " + str(tracker.getsp(id)), (x, y - 15), cv2.FONT_HERSHEY_PLAIN, 1,
                    (255, 255, 0), 2)
        cv2.rectangle(roi, (x, y), (x + w, y + h), (0, 255, 0), 3)
    else:
        cv2.putText(roi, str(id) + " " + str(tracker.getsp(id)), (x, y - 15), cv2.FONT_HERSHEY_PLAIN, 1,
                    (0, 0, 255), 2)
        cv2.rectangle(roi, (x, y), (x + w, y + h), (0, 165, 255), 3)

    s = tracker.getsp(id)
    if (tracker.f[id] == 1 and s != 0):
        tracker.capture(roi, x, y, h, w, s, id)
```

4.1.2.5 Speed Estimation

4.1.2.5.1 Timer Start and Stop

```
# START TIMER
if (y >= 325 and y <= 345):
    self.s1[0, id] = time.time()
# STOP TIMER and FIND DIFFERENCE
if (y >= 235 and y <= 255):
    self.s2[0, id] = time.time()
    self.s[0, id] = self.s2[0, id] - self.s1[0, id]
```

4.1.2.5.2 Speed Formula

```
# SPEED FUNCTION
def getsp(self, id):
    if (self.s[0, id] != 0):
        s = 45 / self.s[0, id]
    else:
        s = 0
    return int(s)
```

4.1.2.6 Drawing Rectangles and displaying on the screen

```
for box_id in boxes_ids:
    x, y, w, h, id = box_id
    if (tracker.getsp(id) < tracker.limit()):
        cv2.putText(roi, str(id) + " " + str(tracker.getsp(id)), (x, y - 15), cv2.FONT_HERSHEY_PLAIN, 1,
                    (255, 255, 0), 2)
        cv2.rectangle(roi, (x, y), (x + w, y + h), (0, 255, 0), 3)
```

4.1.2.7 Drawing Reference Lines

```
# DRAW LINES
cv2.line(roi, (0, 410), (960, 410), (0, 0, 255), 2)
cv2.line(roi, (0, 430), (960, 430), (0, 0, 255), 2)
cv2.line(roi, (0, 235), (960, 235), (0, 0, 255), 2)
cv2.line(roi, (0, 255), (960, 255), (0, 0, 255), 2)
```

4.1.2.8 Save Vehicle Images and speeds

```
# SAVE VEHICLE DATA
def capture(self, img, x, y, h, w, sp, id):
    if (self.capf[id] == 0):
        self.capf[id] = 1
        self.f[id] = 0
        crop_img = img[y - 5:y + h + 5, x - 5:x + w + 5]
        n = str(id) + "_speed_" + str(sp)
        file = '/Users/moheuddinsarker/TrafficRecord/' + n + '.jpg'
        cv2.imwrite(file, crop_img)
        self.count += 1
        file1 = open("/Users/moheuddinsarker/TrafficRecord/SpeedRecord.txt", "a")
        if (sp > limit):
            file2 = '/Users/moheuddinsarker/TrafficRecord/exceeded/' + n + '.jpg'
            cv2.imwrite(file2, crop_img)
            file1.write(str(id) + " \t " + str(sp) + "<---exceeded\n")
            self.exceeded += 1
        else:
            file1.write(str(id) + " \t " + str(sp) + "\n")
        file1.close()
```

4.1.2.9 Create Summary

```
# TEXT FILE SUMMARY
def end(self):
    file = open("/Users/moheuddinsarker/Downloads/SpeedRadar-OpenCV--main/TrafficRecord/SpeedRecord.txt", "a")
    file.write("\n-----\n")
    file.write("-----\n")
    file.write("SUMMARY\n")
    file.write("-----\n")
    file.write("Total Vehicles :\t" + str(self.count) + "\n")
    file.write("Exceeded speed limit :\t" + str(self.exceeded))
    file.close()
```

4.2 Accuracy of Measurement

4.2.1 Street Lamp

This project's goals were to eliminate light pollution from the present lighting system and to find a way to conserve energy. We created an inputs and outputs system to control the lights in this project. The prototype of the system detects obstacles on the route using an infrared sensor, which recognizes the impediment and boosts the voltage of the lights. Otherwise, the light will operate at a low voltage to conserve energy. If there is no movement for 10 minutes, the system will automatically turn off 60% of its lights while working.

4.2.2 Highway Monitoring

This project is successfully able to track vehicles and estimate their speed. Accuracy in detecting vehicles is 80% as long as there is no movement in the camera. Estimation of speed can have a difference of 0-5 km/hr depending on the program execution speed. Multiple vehicles can be detected, and their speeds can be detected. However, if two vehicles are moving extremely close to each other, it may be detected as a single object. This project requires the camera to be as still as possible, as movement distinguishes vehicles from the background.

4.3 Field of Application

The system can be expanded and used in many other fields other than street lights. With a little modification and in accordance to the area of use, the system can be used for many purposes.

The field of application of the project is written below,

- a. The project can be implemented in very long Highway where vehicle used to drive over speeding.
- b. It can also be implemented in city road for maintaining traffic rule.
- c. The same way it can be implemented in all over Bangladesh.

CHAPTER 5

Future Possibilities and Final Thoughts

5.1 Future Possibilities

Our infrastructure is undergoing tremendous developments as our societies evolve and are influenced by urbanization, increased mobility, climate change, and new technology. In this century, climate change, become the most challenging problem for our humanity. Climate change affects our environment in many ways, including higher temperatures, rising sea levels, natural disasters, drought, rise in precipitation patterns, and compromised food security. The global temperature has increased to 1.4 degrees Fahrenheit after the 1870s ^[13]. Two-thirds of that increase has occurred within 1973. Over 36 million kilotons of CO₂ were emitted in 2017. Emissions in 2020 were projected to increase by about 3 percent compared to an about 2 percent rise in 2018 ^[13]. Our lamp post system is designed to save electricity and impact our national power supply. Our lamppost will have one square meter of solar panel with 20%-25%, which will be rated for at least generating 200-250 watts of electricity per hour. An article from the research gate website written by 'Kazy Fayeem Shariar' (IUT, EEE, 2011) said about the number of hours of sunlight in Bangladesh in a year. From his research, he said that Bangladesh got strong sunshine entirely the whole year, and it has been calculated that the average sunshine hours are respectively 6.16, 6.69, and 4.81 in summer, winter, and monsoon in this country. If we consider the average sunshine hours in winter, summer, and monsoon, together, we will have an average of 5.89 hours daily per year. Many roads, highways, City roads, and local area roads are all used for communication and transportation in our country. If we talk about only usable highways in Bangladesh, we have about 21000+kms of highway roads all over the country. Our lamppost is designed to be versatile and efficient. It can be used in City, Footpath, Highways, Railways, Parks, Industrial areas, Runways, and many more. On the highway, if we use our lamppost with solar panel in every 25m interval and if we take 18000kms of the road from 21000kms as usable for a lamppost, we can calculate the electricity production our lamppost in an hour. So, we have usable roads = 18000kms. If we placed a lamppost every 25m interval than in 1 km road we will need

$$\rightarrow 1\text{km}/25\text{m} = 1000\text{m}/25\text{m} = 40 \text{ lamppost per km.}$$

Therefore, in 18000kms, we will need $40 \times 18000 = 720000$ lampposts. From a square meter of solar panel with 20% efficiency, we can get 200-watts/0.2kwatts of electric power in an hour. So, From the 720000 lampposts with solar panels from all over the country, we can get,

$$\rightarrow 720000 \times 0.2\text{kw} = 144000 \text{ kilowatt or } 144 \text{ megawatts in an hour.}$$

Bangladesh's deployed renewable power generation capacity was 579 MW at the end of 2018, with on-grid & off-grid deployment included. The sources are Solar PV (59.5%), small-scale hydropower (39.7%), biogas (0.8%), and biomass. However, it is only 3.3% of the total demand. Bangladesh Sustainable and Renewable Energy Development Authority (SREDA) estimates home solar generated 327 megawatts in 2020. TSEL power plant in Teknaf with an area of 116 acres. Currently, it is feeding 20 MW to the national grid. More than 85,000 solar panels were used to construct the plant, and the plant has five sub-stations surrounded by panels. Bangladesh was aimed to produce 10 percent of its electric power from renewable sources in the year 2020. From this contrast, 144 megawatts of power can be a significant contribution to the national grid. Because if we consider the Teknaf solar project, yes, we are getting 20 MW of power, but it also required 116 acres / 469,435 squares meters of land. Highways are essential, and we can use the highways as our renewable power source with our lamppost system. If we think about our yearly power consumption, it is about 175,000 gigawatts. We can get Solar energy from highway lamppost;

$$\begin{aligned} \text{Yearly} &= 144 \text{ MW} \times 5.89 \text{ hours day (avg)} \times 365 \text{ days} \\ &= 3,095,784 \text{ megawatt} / 3096 \text{ gigawatts.} \end{aligned}$$

As telecommunications advanced, new technology like the 5G mobile network technology used for wireless mobile networks, which big mobile network brands began installed globally in early 2019. Which is the successor to the previous networks, 4G provides connectivity to the present's mobile device. 5G mobile technology are predicted to have more than 1.8 billion users globally within 2026, GSM Association said. Bangladesh government plans to launch 5G mobile network services on trial at the end of 2021. 5G uses a shorter wavelength than previous technology, which means it, requires more antennas than 4G technology. Therefore, it will be tough for travelers to connect 5G while

traveling on a motorway. Our lamppost can quickly help us to solve this problem. Nowadays, Electric vehicle sales are booming, and EVs can use 5G with their full potential.

5.2 Final Thoughts

As technology progresses, new and more advanced innovations or ideas will come. Our “Positron” team just wanted to make the most helpful thing for our road in the night, ‘the lamppost,’ even more valuable by integrating some advance and modern technologies. We believe that this lamppost can save energy by controlling its power uses. Also, it can give us a safer road and a better future. Road safety is an essential factor for the police force. Moreover, as citizens, it is our responsibility to follow the rules and maintain safety on our roads. This project can estimate the speed of vehicles and save vehicle data. It has many potentials, but many things can be added in the future for scale and resource limitation. This project will be incredibly beneficial to reduce the human resources necessary to maintain street lights on highways. The number of people used there can be deployed somewhere else, which will reduce the cost of the total system and will make it a cost-effective project. This project with better maintenance will easily last longer than the typical system. It will also digitalize the whole system and is convenient for an individual to control, when necessary, without any physical presence.

The future aspect of Street Lighting is very emerging. Almost all the modern countries are nowadays replacing the existing street lights and modernizing the system. Replacing the existing system may cost some money. However, it can be easily overcome by the electrical power and maintenance cost, which the new system and the system will save, which is also more sustainable than the conventional switching and control system. With apparently low cost, if this system can be utilized properly, it will have a more significant functionality effect than the other systems.

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