Density Based Traffic Control System

A Project Report

Submitted to the APJ Abdul Kalam Technological University

in partial fulfillment of requirements for the award of degree

Bachelor of Technology

in

ELECTRONICS AND COMMUNICATION ENGINEERING

by

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CERTIFICATE

This is to certify that the report entitled **Density Based Traffic Control System** submitted by **ABHINAND DINESH (MAC19EC002), AHAMMADUNNY NAVAS (MAC19EC007), ARJUN R (MAC19EC025), ASHIL SIBY (MAC19EC030)** , to the APJ Abdul Kalam Technological University in partial fulfillment of the B.Tech. degree in ELECTRONICS AND COMMUNICATION ENGINEERING is a bonafide record of the project work carried out by him under our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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DECLARATION

We ABHINAND DINESH (MAC19EC002), AHAMMADUNNY NAVAS (MAC19EC007), ARJUN R (MAC19EC025), ASHIL SIBY (MAC19EC030) hereby declare that the project report **Density Based Traffic Control System**, submitted for partial fulfillment of the requirements for the award of degree of Master of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under supervision of Prof Belma Joseph .

This submission represents our ideas in our own words and where ideas or words of others have been included, we have adequately and accurately cited and referenced the original sources.

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Abstract

Traffic congestion is becoming one of the critical issues with increasing population and automobiles in cities. Traffic jams not only cause extra delay and stress for the drivers, but also increase fuel consumption and air pollution. Although it seems to pervade everywhere, megacities are the ones most affected by it. And its ever-increasing nature makes it necessary to calculate the road traffic density in real-time for better signal control and effective traffic management. The traffic controller is one of the critical factors affecting traffic flow. Therefore, the need for optimizing traffic control to better accommodate this increasing demand arises. Our proposed system aims to utilize live images from the cameras at traffic junctions for traffic density calculation using image processing and AI. It focuses on the algorithm for switching the traffic lights based on the vehicle density and also different time allocation during day,night and rainy time to reduce congestion, thereby providing faster transit to people and reducing pollution.

Acknowledgement

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Chapter 1

Introduction

Road traffic is one of the biggest concerns in almost every country in the world. With roads designed to handle a certain amount of traffic, it is almost impossible to maintain traffic to stay at the same rate with a growing population and economy. Some alternate solutions to control the traffic is either through expanding the roads or installing new roadways which can be time consuming. Most cities employ a density-based traffic signal system , which measures the number of vehicles in each lane before deciding the green time. However, the density is measured through sensors and does not estimate the exact count of vehicles but gives only a rough estimate. With the advancement in technology concerning image processing and machine learning, it is possible to capture the image of the lane and estimate the exact number of vehicles present in the lane to determine the green time for a particular lane in the intersection. The regulation of traffic lights in the intersection has to be done based on traffic congestion which can be measured through advanced image processing techniques.

In this paper, we present a YOLO Framework-based vehicle count estimation and green time determination for each lane in the intersection. The YOLO or You only look once is an algorithm that uses convolution neural networks for object detection in realtime. They apply a single neural network to the full image and divide the image into regions and predict the bounding boxes which probabilities for each region. These bounding boxes are weighted by the predicted probabilities. YOLO has high accuracy and also its multiple bounding boxes and class probabilities for these boxes. The hardware setup for this project is developed using the raspberry pi,Stm32f103 and a webcam to capture real-time images. Once the captured image is subjected to YOLO detection, the number of vehicles in the image is known. Based on the number of vehicles the green time is decided and is deployed into the LED drivers acting as traffic signal systems for the particular lane. The green time is decided based on the burst technique. This technique allows the congestion to be under control and the maximum wait time of any lane is not more than 90 seconds.

1.1 Motivation

With the increasing number of vehicles in urban areas, many road networks are facing problems with the capacity drop of roads and the corresponding Level of Service. Many traffic-related issues occur because of traffic control systems on intersections that use fixed signal timers. They repeat the same phase sequence and its duration with no changes. Increased demand for road capacity also increases the need for new solutions for traffic control that can be found in the field of Intelligent Transport Systems.

Let us take the case study of Mumbai and Bangalore. Traffic flow in Bangalore is the worst in the world while Mumbai is close behind in fourth position, according to a report detailing the traffic situation in 416 cities across 57 countries. In Bangalore, a journey during rush-hour takes 71longer. In Mumbai, it is 65

The manual controlling system requires a large amount of manpower. As there is poor strength of traffic police, we cannot have them controlling traffic manually in all areas of a city or town. So a better system to control the traffic is needed. Static traffic controlling uses a traffic light with a timer for every phase, which is fixed and does not adapt according to the real-time traffic on that road. While using electronic sensors i.e., proximity sensors or loop detectors, the accuracy and coverage are often in conflict because the collection of high-quality information is usually based on sophisticated and expensive technologies, and thus limited budget will reduce the number of facilities. Moreover, due to the limited effective range of most sensors, the total coverage on a network of facilities usually requires a lot of sensors.

1.2 Objective

The main objective of this project is to control the traffic lights or signal based on the density of the vehicles in particular lane.In this system, Machine learining is used to evaluate the density of the vehicles which are fixed within a fixed space. By using this system traffic can be cleared without any worry and time delays even though there is no traffic on the other side can be avoided.

The main advantage of this system is that it decreases the waiting time for vehicles. As we know that time is the most precious thing nowadays, so many of people breaks the traffic set of laws just to reach on time to their destination. The reason behind betrayal the traffic rules are to wait for an additional time whether the traffic is there or not.

Time delay on the road, fuel efficiency, Carbon emmission, fuel cost the all things can be minimised to a certain extend.

Chapter 2

Literature Review

In literature[1]The proposed system takes an image from the CCTV cameras at traffic junctions as input for real-time traffic density calculation using image processing and object detection.This image is passed on to the vehicle detection algorithm, which uses YOLO. The number of vehicles of each class, such as car, bike, bus, and truck, is detected, which isto calculate the density of traffic. The signal switching algorithm uses this density, among some other factors, to set the green signal timer for each lane. The red signal times are updated accordingly. The green signal time is restricted to a maximum and minimum value in order to avoid starvation of a particular lane. A simulation is also developed to demonstrate the system's effectiveness and compare it with the existing static system.The proposed system uses YOLO (You only look once) for vehicle detection, which provides the desired accuracy and processing time. A custom YOLO model was trained for vehicle detection, which can detect vehicles of different classes like cars, bikes, heavy vehicles (buses and trucks), and rickshaws. Proposed System Model YOLO is a clever convolutional neural network (CNN) for performing object detection in real-time. The algorithm applies a single neural network to the full image, and then divides the image into regions and predicts bounding boxes and probabilities for each region. These bounding boxes are weighted by the predicted probabilities. YOLO is popular because it achieves high accuracy while also being able to run in real-time. The algorithm "only looks once" at the image in the sense that it requires only one forward propagation pass through the neural network to make predictions. After non max suppression (which makes sure the object detection algorithm only detects each object once), it then outputs recognized objects together with the bounding boxes. With YOLO, a single CNN simultaneously predicts multiple bounding boxes and class probabilities for those boxes

In literature[2]The model aims to provide a solution for current traffic issue by managing traffic signal on the basis of real time scenario. Here a pretrained model YOLO is used to perform the basic task of object detection, and correspondingly the count of the vehicles are stored in order to process further request of signal processing. Also the model is compatible with almost every type of camera, even the cheaper ones including the normal surveillance camera can be used to capture image at an initial level. Now the captured image will be passed to the model for vehicle detection purpose followed by vehicle counting process . This whole process of capturing image and detection will be repeated for all four sides of the road using one single camera i.e. pi camera, as pi camera is the most compatible camera for raspberry pi3 board. The camera w ill be fixed on a rotational motor (servo motor/stepper motor), so that it rotates 360 degree to capture image. The captured image is then passed to a filter where the region is defined in terms of height and width, only vehicles present in that predefined region are detected and counted. This regions size remains constant for all image being captured. OpenCV is the library that plays important role in object detection, also as and when the object gets detected it forms a rectangular box around the object, so that one can even visually verify that the object detected as vehicle is actually a vehicle only. The count obtained from the image obtained from all for side of the road is now passed as input to the raspberry board. The raspberry computes the result by comparing all the count obtained from four different images. The model has some of its fixed threshold value fitted in to it, if the result form the four images is in limit of threshold then simple static switching will be practiced and every signal will be allotted with same switching time, as the traffic on all sides is either sparse or is densely populated by vehicles from all sides. Also in case if the computed result from either of signal crosses the threshold value than dynamic signal switching comes in to action. In dynamic switching the switching time will be assigned on the basis of how densely the road is jammed. The model is designed keeping the point into consideration that the amount of traffic on all signal does not remains the same then how can threshold value remain the same, hence after few computational processes the model will learn by itself to set threshold value on the basis of how heaped signal is.

Chapter 3

Methodology

3.1 Block Diagram

Project uses Raspberry Pi 3b+ and YOLO framework to determine the green time for each lane based on images captured at the lanes. The system is designed considering the parameters like delay, accuracy, performance, cost, and reliability. The system uses a single webcam to capture images of the vehicle in the lane that can be rotated after green time is concluded for a particular lane and has to be estimated for the next lane. The master controller unit which is the raspberry pi is powerful enough to run ML-based algorithms that can be subjected to the input images obtained from the webcam. The entire system works in real-time and can have a very minimal delay.

The YOLO Framework is used to determine the number of vehicles in each lane from the obtained images and the green time is scheduled accordingly concerning minimum and maximum allotted green time for each lane. In general considerations, it is assumed that each vehicle takes 3 seconds on average to exit the lane in the intersection. The maximum time for any lane a set for 30 seconds, and a minimum of five seconds of green time is given to each lane irrespective of the number of vehicles. If the number of vehicles is large and the green time exceeds 30 seconds for the number of vehicles present in the lane, cycles may have to wait for the next cycle, no longer than 90 seconds. Python Language is used for the design of the system. The hardware setup consists of a traffic signal prototype designed from red, green, and yellow LEDs controlled from the STM32F103C8T6.Rain sensor and LDR sensor are used to detect the presence of rain and light and set up a different time allocation for rainy,day and night time.

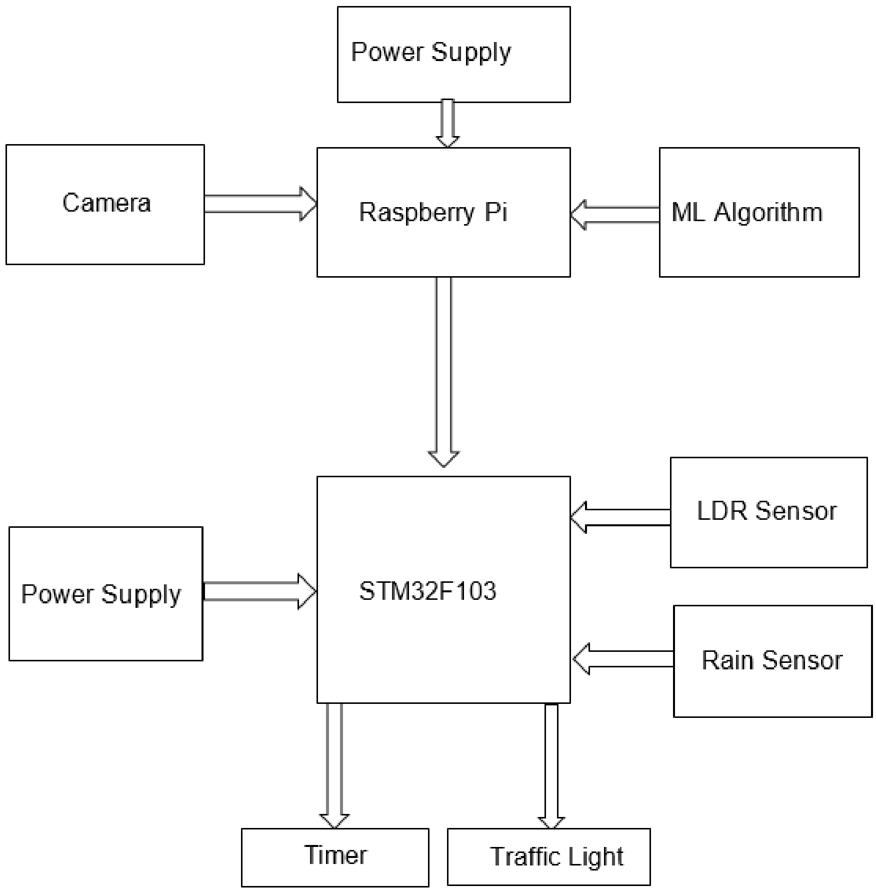

Figure 3.1: Block Diagram of Proposed System

3.2 Raspberry pi 3b+

It has ARM based Broadcom Processor SoC along with on-chip GPU (Graphics Processing Unit). The CPU speed of Raspberry Pi varies from 700 MHz to 1.2 GHz. Also, it has on-board SDRAM that ranges from 256 MB to 1 GB.Low cost ,Huge processing power in a compact board, Many interfaces (HDMI, multiple USB, Ethernet, onboard Wi-Fi and Bluetooth, many GPIOs, USB powered, etc.)and Supports Linux, Python are the main advantages. In this project Raspberry pi is used for the image processing and python language is used for this.

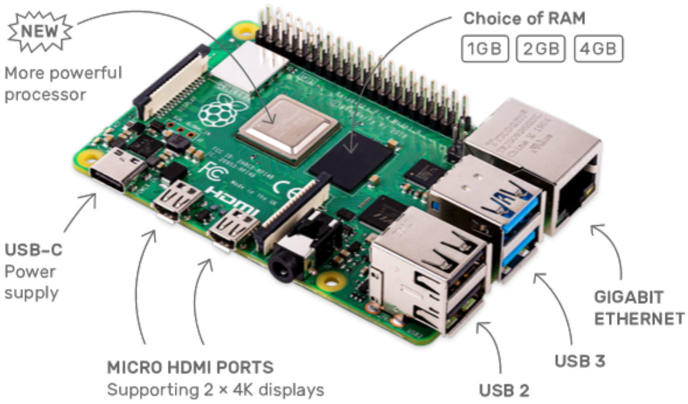

Figure 3.2: Raspberry pi 3b+

3.3 Stm32f103c8

The STMicroelectronics STM32F103C8 is an ARM 32-bit Cortex-M3 Microcontroller, 72MHz, 64kB Flash, 20kB SRAM, PLL, Embedded Internal RC 8MHz and 32kHz, Real-Time Clock, Nested Interrupt Controller, Power Saving Modes, JTAG and SWD, 3 Synch. The STM32 interrupt system is based on the ARM Cortex M core NVIC peripheral. The STM32 MCUs support multiple maskable interrupt channels apart from the 16 interrupt channels of the ARM core.

In this project data from the Raspberry pi is directly transffered to the stm through serial communication and by monitoring all the things green time is calculated by the stm itself. Keil development tools provide comprehensive support for STMicroelectronics device families in a complete development environment for creating, debugging and verifying embedded applications.

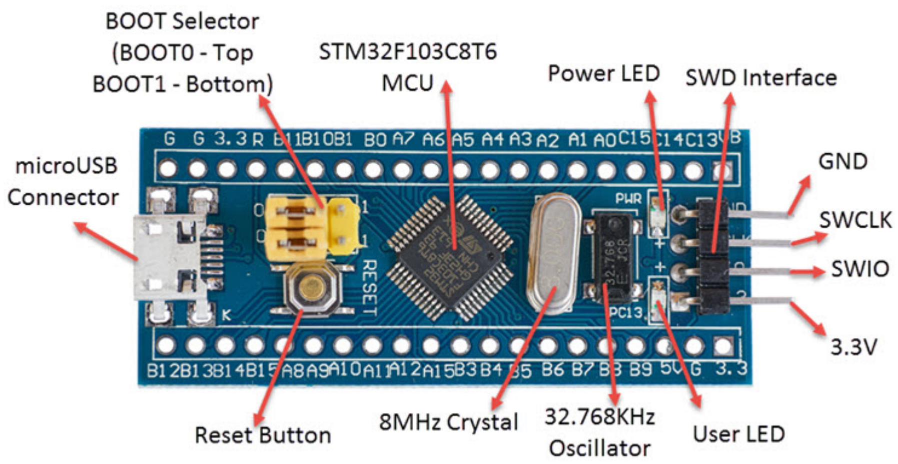

Figure 3.3: STM32 Board

3.4 PI Camera

The Raspberry Pi Camera Board is a custom designed add-on module for Raspberry Pi hardware. It attaches to Raspberry Pi hardware through a custom CSI interface. The sensor has 5 megapixel native resolution in still capture mode. In video mode it supports capture resolutions up to 1080p at 30 frames per second. Pi Camera module is a camera which can be used to take pictures and high definition video. Raspberry Pi Board has CSI (Camera Serial Interface) interface to which we can attach PiCamera module directly. This Pi Camera module can attach to the Raspberry Pi's CSI port using 15-pin ribbon cable.

Figure 3.4: pi camera

3.5 LDR sensor

LDR is a light-dependent resistor that changes its resistance when different amounts of light fall on it. They work on the principle of photo conductivity where it gives less resistance in high light intensity and high resistance in low light intensity.

These devices are used where there is a need to sense the presence and absence of light is necessary. These resistors are used as light sensors and the applications of LDR mainly include alarm clocks, street lights, light intensity meters, burglar alarm circuits.

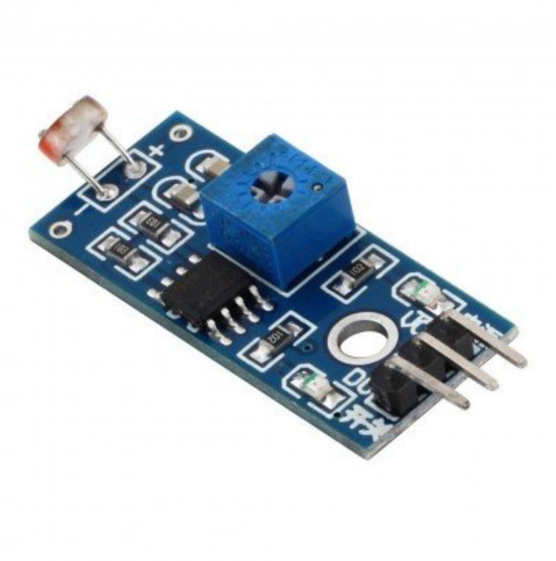

Figure 3.5: LDR sensor

3.6 Rain sensor

The rain sensor module is an easy tool for rain detection. It can be used as a switch when raindrop falls through the raining board and also for measuring rainfall intensity.

It sends out a beam of infrared light that, when water droplets are on the windshield, is reflected back at different angles. This tells the system to activate the wipers, as well as adjust wiper speed and frequency based on the intensity of the precipitation combined with the vehicle's speed.

Figure 3.6: Rain sensor

3.7 LED(Red,Green,Yellow)

There are three led such as Red , Green , Yellow which are used to manage the traffic signal light and LED are controlled through the STM32F103C8T6.

Figure 3.7: LED

3.8 Seven Segment LED

A seven-segment LED is a digital display module specialized to display numerical information. Light-emitting diodes (LEDs) arranged in the shape of numbers offer an easily visible display. They are sometimes called ”seven-segment displays” or ”seven-

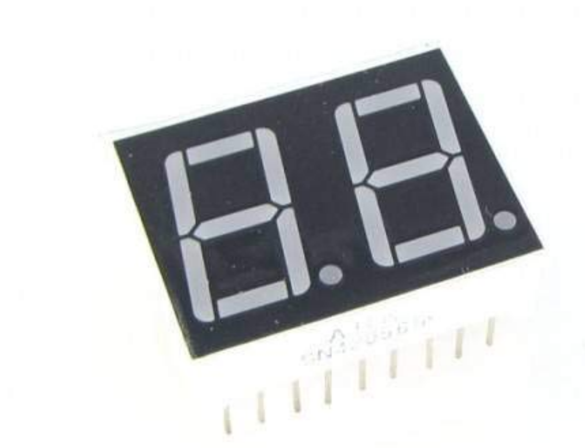

Figure 3.8: Seven segment led dispaly

segment indicators."

A seven-segment display uses Light Emitting Diodes to release light energy in photons. The production emits light to show digits in all seven segments, with the eighth segment being a decimal point. While the phenomenon happens, bear in mind that an LED is a solid-state optical p-n junction diode.

Chapter 4

Schematics And Simulation

4.1 Schematic Diagrams

Figure 4.1 shows STM32F103C8T6 microcontroller having 48 pins of which 31 pins are general purpose I/O pins. Four capacitors of 0.1uF is used for filtering VDD. A red LED is used to indicate powering of microcontroller. There is a 32.768KHz crystal oscillator used for real time clock whose inut and output pins are connected to third and fourth pins of microcontroller and named as XTALC and XTALD respectively.2X3 berg strip is used to select boot mode. In order to program the microcontroller we should connect boot0 to VCC. Boot0 is the third pin and boot1 is the fourth pin of 2X3 berg strip. 8 MHz crystal oscillator is used for the working of our microcontroller whose inut and output pins are connected to fifth and sixth pins of microcontroller and named as XTALA and XTALB respectively.Reset switch is used for resetting the microcontroller. The reset switch is connected to the seventh pin of microcontroller which is named as NRST.Pin 34 and 37 of microcontroller is set as SWDIO AND SWCLK of serial wire debug.There is a voltage regulator for converting the 5V to 3.3V

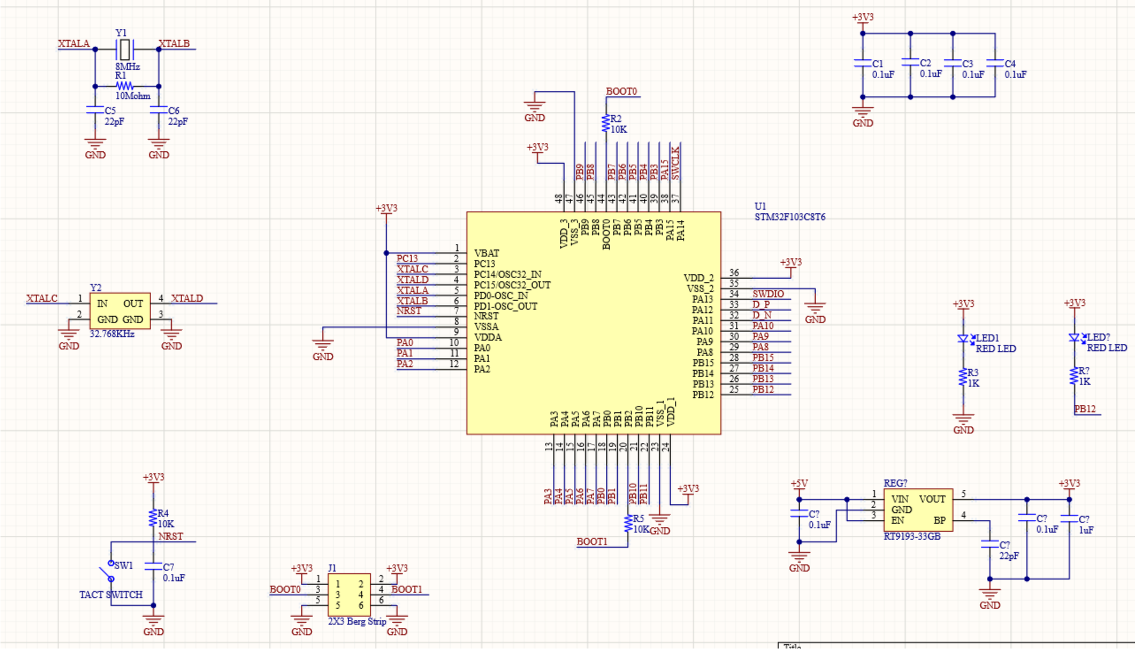

Figure 4.1: Schematic Model of STM32F103C8T6

Figure 4.2shows the interfacing of Rain sensor,LDR sensor,LEDs and seven segments with the microcontroller.There is four set of red,green,yellow LEDs and seven segments for indicating the traffic signal and time allocation.The LED pins are connected to general purpose I/O pins of microcontroller and the other pin is connected to VDD.The seven segment consist of seven pins which control the seven LEDs and a common pin which all are connected to the general purpose I/O pins of microcontroller.Rain sensor and LDR sensor consist of three pins a ground, VCC and analog pin which is connected to the general purpose I/O pin of microcontroller.

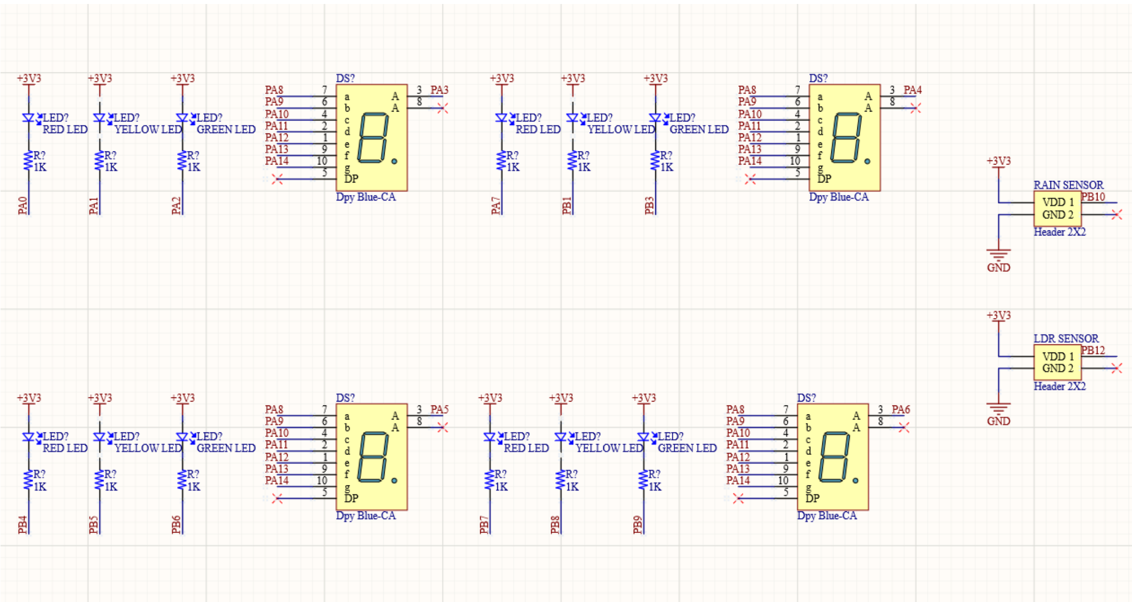

Figure 4.2: Schematic Model of LEDs,Seven Segments,Rain Sensor,LDR Sensor

4.2 Simulation Results

Figure 4.3 depicts the vehicle detection and counting using Open CV .The vehicle counting system is made up of three main components: a detector, tracker and counter. The detector identifies vehicles in a given frame of video and returns a list of bounding boxes around the vehicles to the tracker. The tracker uses the bounding boxes to track the vehicles in subsequent frames. The detector is also used to update the trackers periodically to ensure that they are still tracking the vehicles correctly. The counter counts vehicles when they leave the frame or makes use of a counting line drawn across a road.

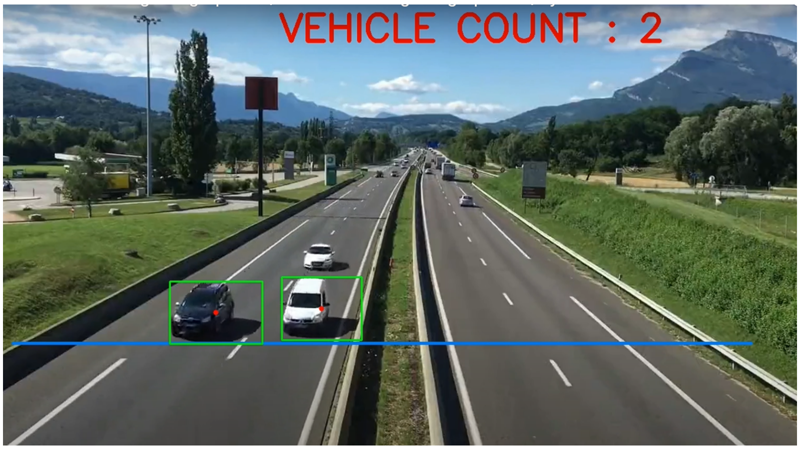

Figure 4.3: Detection and Counting of vehicles using Open CV

Figure 4.4 depicts the control of LEDs using STM32F108C8T6,simulation done in Proteus.

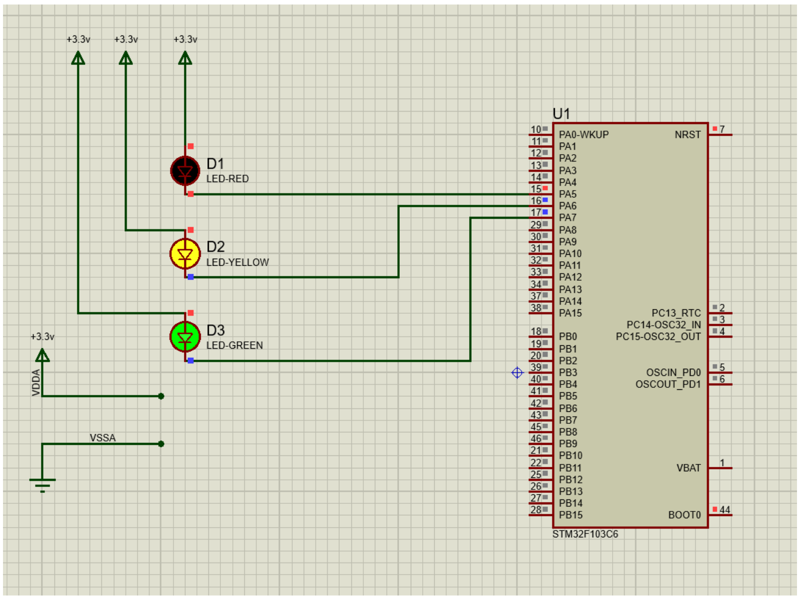

Figure 4.4: LEDs Control-Simulation in Proteus

Chapter 5

Software Description

5.1 Altium Designer 21.4.1

Altium Designer is a software package for PCB and electronic design automation tool for printed circuit boards. It is developed by Australian software company Altium Limited. Altium Designer's software encompasses four main functional areas: schematic capture, 3D PCB design, Field-programmable gate array (FPGA) development and release/data management. Altium Designer combines a myriad of features and functionality, including, Advanced routing technology Support for cutting-edge rigid-flex board design Powerful data management tools Powerful design reuse tools Real-time cost estimation and tracking Dynamic supply chain intelligence Native 3D visualizations and clearance checking flexible release management tools.

5.2 STM32 CUBE IDE 1.10.1

STM32CubeIDE is an advanced C/C++ development platform with peripheral configuration, code generation, code compilation, and debug features for STM32 microcontrollers and microprocessors. It is based on the Eclipse®/CDT™ framework and GCC toolchain for the development, and GDB for the debugging. It allows the integration of the hundreds of existing plugins that complete the features of the Eclipse® IDE.

5.3 OpenCV

Open CV is an open-source computer vision machine learning software library built to provide a common infrastructure of computer vision applications to accelerate the use of perception among the commercial products. It has 2500 optimise algorithms including a comprehensive set of classic and state-of-art CVs. Most of these are used to detect faces, identify objects, classify human actions vehicle detection 3D model extraction stereo camera extractions and many more. It is also used in enhancing upscaling downscaling interpolating and other image processing applications in a simple and effective manner. It has c++, Java and MATLAB interface and supports multi-paradigm programming for higher level project synthesis. In this project cv2 is trained with yolo weights identify the region of interest in an image and extract if an animal is found. Since CV support libraries are strong enough, multiple presence of vehicles can be detected and identified.

5.4 NumPy

NumPy is another powerful library for python programming language which supports multidimensional array and matrices with a collection of high-level mathematical functions to perform operations on the arrays. It targets the reference implementation which is a non-optimising bytecode interpreter. It analyses the slowness of the compiler by providing the multidimensional array and functions which could operate efficiently.

Chapter 6

Conclusion and Future Work

In conclusion, the proposed system sets the green signal time adaptively according to the traffic density at the signal and ensures that the direction with more traffic is allotted a green signal for a longer duration of time as compared to the direction with lesser traffic. This will lower the unwanted delays and reduce congestion and waiting time, which in turn will reduce fuel consumption and pollution.The setup requires camera, Stm32f103c8t6, Raspberry pi board, rain sensor, LDR sensor, Seven segments and LEDs as its hardware requirement and interfacing thereby forming portable medium. The model trained can be used for efficient traffic flow without creating much chaos on the road.Moreover, the proposed system possesses certain advantages over the existing intelligent traffic control systems prevalent such as Pressure Mats and Infrared Sensors. The cost required to deploy the system is negligible as footage from CCTV cameras from traffic signals is used, which requires no additional hardware in most cases, as intersections with heavy traffic are already equipped with such cameras. Only minor alignment may need to be performed. The maintenance cost also goes down as compared to other traffic monitoring systems.

6.1 FUTURE WORK

The project can be further expanded to include the following functionalities to enhance traffic management and bring down congestion:

1) Identification of vehicles violating traffic rules: The vehicles running red lights can be identified in an image or a video stream by defining a violation line and capturing the number plate of the image if that line is crossed when the signal is red. Lane changing can also be identified similarly. These can be achieved by background subtraction or image processing techniques.

2) Accident or breakdown detection: Intersections also tend to experience severe crashes due to the fact that several types of injurious crashes, such as angle and left-turn collisions, commonly occur there. Therefore, accurate and prompt detection of accidents at intersections offers tremendous benefits of saving properties and lives and minimizing congestion and delay. This can be achieved by identifying the vehicles that remain stationary for a long time in an inappropriate position such as in the middle of the road, so that parked vehicles are not included in this.

3) Synchronization of traffic signals across multiple intersections: Synchronizing signals along a street can benefit the commuters as once a vehicle enters the street, it may continue with minimal stopping.

4) Adapting to emergency vehicles: Emergency vehicles such as an ambulance need to be given quicker passage through the traffic signals. The model can be trained to detect not just vehicles but also be able to recognize that it is an emergency vehicle and accordingly adapt the timers such that the emergency vehicle is given priority and is able to cross the signal at the earliest.

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