**MARMARA UNIVERSITY**

**FACULTY OF ENGINEERING**



**OPTIMIZED SMART TRAFFIC LIGHTS**

FURKAN KAHYA

BURAK BOSTANCIOĞLU

**GRADUATION PROJECT REPORT**

Department of Electrical and Electronics Engineering

**Supervisor**

Doç. Dr. FULYA ÇALLIALP

ISTANBUL,2022

**MARMARA UNIVERSITY**

**FACULTY OF ENGINEERING**

**Optimized Smart Traffic Lights**

**by**

**Furkan KAHYA**

**Burak BOSTANCIOĞLU**

**February 1, 2022, Istanbul**

**SUMBITTED TO THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING IN**

**PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE**

**OF**

**BACHELOR OF SCIENCE**

**AT**

**MARMARA UNIVERSITY**

**The author(s) hereby grant(s) to Marmara University permission to reproduce and to distribute publicly paper and electronic copies of this document in whole or in part and declare that the prepared document does not in any way include copying of previous work on the subject or the use of ideas, concepts, words, or structures regarding the subject without appropriate acknowledgement of the source material.**

Signature of Author(s) …………………………………………………………………………

Department of Electrical and Electronics Engineering

Certified By …………………………………………………………………………

Project Supervisor, Department of Electrical and Electronics Engineering

Accepted By …………………………………………………………………………

Head of the Department of Electrical and Electronics Engineering

# TABLE OF CONTENTS

[TABLE OF CONTENTS ii](#_Toc534727489)

[ABSTRACT iii](#_Toc534727490)

[LIST OF SYMBOLS iv](#_Toc534727491)

[ABBREVIATIONS v](#_Toc534727492)

[LIST OF FIGURES vi](#_Toc534727493)

[LIST OF TABLES vii](#_Toc534727494)

[1. INTRODUCTION 1](#_Toc534727496)

[2. RESEARCH OBJECTIVE 3](#_Toc534727498)

[3. RELATED LITERATURE 4](#_Toc534727499)

[4. DESIGN 9](#_Toc534727500)

[4.1. Realistic constraints and conditions 9](#_Toc534727501)

[4.2. Cost of the design](#_Toc534727502) 9

[4.3. Engineering Standards 12](#_Toc534727503)

[4.4. Details of the design 12](#_Toc534727504)

[5. METHODS 17](#_Toc534727505)

[6. RESULTS AND DISCUSSION 29](#_Toc534727506)

[7. CONCLUSION 30](#_Toc534727507)

[REFERENCES 3](#_Toc534727508)1

[APPENDICES 3](#_Toc534727509)2

[Appendix A 3](#_Toc534727510)2

[Appendix B 3](#_Toc534727510)7

# ABSTRACT

Many people who live in crowded cities like Istanbul and Mumbai has traffic problem. Due to insufficient infrastructures in these cities, people waste too much time especially when they use personal cars. Also heavy traffic has a negative impact on the people. When they are waiting in the traffic, they get angry and this situation is harmful for human health.

Another disadvantage of traffic jams is carbon dioxide gas emission. Today our world’s biggest problem is global warming. Due to harmful gas emissions our world is warming and this leads to environmental disasters such as heavy rain, extreme temperature, water shortage etc...

To be able to solve the traffic problems, engineers try to design many devices like smart traffic lights, smart roads and autonomic vehicles. In this article, we explain our project optimized smart traffic lights based on algorithm.

# LIST OF SYMBOLS

**DIN:** Control Data Signal Input

**DOUT:** Control Data Signal Output

**Li:** Conveyor or Light Source(Laser)

**Pi:** Collector or Optical Laser

**:** Heat degree at the Intersection of Operations

**:** The Scope for Temperature Store

**VDD:** Power Supply Voltage

**VSS:** Ground

**:** Input Voltage

# ABBREVIATIONS

**d:** Density

**IN:** Input

**IR:** Infrared Sensor

**OUT:** Output

**n:** Numbers

# LIST OF FIGURES

[Figure 1 Suggestion of sensor settings for traffic scenario forecast 5](#_Toc534727322)

[Figure 2 Singapore enhanced electronic signboards on roads. 7](#_Toc534727322)

[Figure 3 Proposed piece chart for keen activity light framework 7](#_Toc534727322)

[Figure 4 Block diagram of power supply 8](#_Toc534727322)

[Figure 5 Intelligent Traffic Management Systems 13](#_Toc534727322)

[Figure 6 Process Scheme. 14](#_Toc534727322)

[Figure 7 Red Green Yellow LED 14](#_Toc534727322)

[Figure 8 Square Graph for WS2812B Driven chain execution in arrangement. 16](#_Toc534727322)

[Figure 9 Smart Traffic Lights Working Scheme… 1](#_Toc534727322)7

[Figure 10 Target Area is detected by CCTV and sensor… 1](#_Toc534727322)8

[Figure 11 Mbed Simulation - 1 22](#_Toc534727322)

[Figure 12 Traffic Density Calculation between 07:00 – 08:00. 23](#_Toc534727322)

[Figure 13 Traffic Density Calculation between 08:00 – 10:00. 2](#_Toc534727322)5

[Figure 14 Traffic Density Calculation between 18:00 – 19:00 26](#_Toc534727322)

[Figure 15 Mbed Simulation - 2 27](#_Toc534727322)

[Figure 16 Mbed Simulation - 3 28](#_Toc534727322)

# LIST OF TABLES

[Table 1 The Stade of Traffic and Updated green Light Time 6](#_Toc534727066)

[Table 2 For The Control Mechanism](#_Toc534727066) 10

[Table 3 PIN Function 15](#_Toc534727066)

[Table 4 Supreme Most extreme Ratings 15](#_Toc534727066)

[Table 5 Coefficient Values for Normal Way 2](#_Toc534727066)0

[Table 6 Coefficient Values for Hospital Area 2](#_Toc534727066)0

[Table 7 Coefficient Values for School Area 2](#_Toc534727066)1

# INTRODUCTION

Traffic lights have been creating since 1912, are signaling gadgets that are planned to control the activity streams particularly at street crossing points, person on foot intersections, rails, and other areas. There are three main colored lights as we know. These colors are green, red and yellow. The green light permits activity to stream within the demonstrated heading, the yellow light cautions vehicles to get ready for brief halt, and the red flag stops activity streaming at a particular course [1].

Numerous swarmed cities such as Istanbul, Tokyo or Mumbai persevere from the activity clog issues that influence the transportation framework in cities and cause genuine halt. In spite of supplanting activity officers by programmed activity frameworks, the optimization of the overwhelming activity stick is still an enormous issue for swarmed cities. However automatic traffic systems are better than the manual controller for traffic flowing [2]. The unexpected increase of the numbers of vehicles and population without sufficient infrastructures leads to high traffic density. Of course, there are a few fractional arrangements such as developing unused streets, actualizing overpasses and bypass streets, making rings, and repairing broken streets to be able to diminish the activity thickness. On the other hand, these solutions are very expensive and take too much time to implement.

Another truth almost activity thickness is that activity stream depends on the hours of the day. Activity top hours can alter with regard to particular areas or days of the week. For example, between 5-pm and 7-pm traffic density is higher than other hours on weekdays in Istanbul. Also Mondays and Fridays generally traffic flowing is slow.

**What are Optimized Smart Traffic Lights?**

Most current traffic light frameworks are planned with difficult coded delays where the lights’ move time openings are settled routinely and don't depend on genuine time activity flow.

Tech companies like ASELSAN, Deutsche BAHN, BMW and Siemens that work on smart traffic lights which depend on the real time traffic flow to optimize the traffic lights to be able to decrease the traffic density [3].

Design of an optimized smart traffic control framework could be a current inquire about theme. Engineers around the world attempt to plan imaginative frameworks to unravel activity issue. There are models based on numerical operations are connected to appraise the car holding up time at a determined intersection, the thickness of vehicles within the holding up line, the separate of the holding up cars along the street, the ideal timing for green, yellow, and ruddy lights that best case and productive combination of routing.

What are the advantages of Optimized Smart Traffic Lights?

* Optimize the traffic light times.
* Decrease the red light times.
* Prevent too much time wasting in the traffic.
* Give priority to emergency vehicles.
* Decrease gas emissions to the atmosphere.
* Help to save fuel, energy and time.

# RESEARCH OBJECTIVE

Time is critically important for some vehicles. We got to allow higher need to crisis vehicles such as Ambulance, rescue and fire vehicles, police or VIP cars. If these cars stuck at the traffic problems can be getting increase. Also heavy traffic has a negative impact on the people. When they are waiting in the traffic, they get angry and this situation is harmful for human health.

That’s why, we chose research objective about smart traffic systems that optimize the traffic lights and give higher priority to emergency vehicles and prevent wasting time in the traffic.

# RELATED LITERATURE

In our world, time is very important. Traffic jam also causes wasting time and gas. We want to save time and money. Time is critically important for some vehicles. We got to allow higher need to crisis vehicles such as Ambulance, rescue and fire vehicles, police or VIP cars. If these cars stuck at the traffic problems can be getting increase. That’s why we need to smart traffic systems that optimize the traffic lights and give higher priority to emergency vehicles [4].

Engineers from distinctive offices are trying with experts to plan maintainable arrangements that diminish activity clog. Many techniques are used from the technologically advanced microcomputers or quantum computers, new manufactured smart devices and sensors, to complicated algorithms modeling, to be able to solve traffic problems [5].

Current traffic systems must be upgraded or designed to solve the traffic problems, better service, decrease traffic density and optimize the traffic lights for a better world.

There is a system that is related to our optimized smart traffic lights project. The framework is based on micro-controller which controls the distinctive operations, screens the activity thickness stream through infrared sensors (IR), also changes the traffic lights' move times appropriately. This framework makes a difference to permit the smooth development of crisis vehicles through the crossing point and optimize the activity lights to decrease activity thickness [6].

This sensors framework is introduced as it were in one of the two meeting roads. On the other hand, for real life, we need to think the activity circumstance of both headings. In Figure 1, Li speaks to the Conveyor or Light Source (Laser), whereas Pi is the Collector or Optical Laser individually. These sensors are designed with the course of the approaching laser bars. We assume that n be the number of all Li-Pi sets. This n esteem depends on the specified evaluated determination and exactness [7].

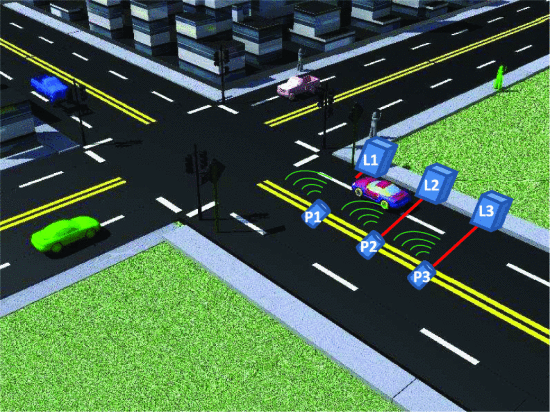


Figure1. Suggestion of sensor settings for traffic scenario forecast [6].

Each Li-Pi combine will make one not real association between the Conveyor and the Collector. We title all of them as imaginary lines (We can see the red lines in Figure 1). These Lines distinguish whether a vehicle passes through into the crossing point zone or not.

We accept that when a car is going to the crossing point range and blocks an imaginary line, the related optical sensor yield will be a number in terms of volts (or 1 in case encoded to a computerized esteem). In the event that not, the optical sensor yield will be Y volts (or in case encoded to a computerized esteem). Agreeing to the optical sensor yield microcontroller gets it whether vehicles are entering the crossing point or not. Microcontroller will take all information from the sensors. This information will be handled within the calculation and after that activity lights will work at the finest optimization [8].

Definition of traffic circumstance levels:

• Level 0 (Typical activity): the space from the halt line to virtual line L1-P 1,

• Level 1 (Smooth activity): the space from virtual line L1-P1 to virtual line L2-P2,

• Level 2 (Very swarmed): the space from L2-P2 virtual line to virtual line L3-P3,

• ...

• Level n (Almost inactive traffic): the space - virtual line to the back.

Table I gives an illustration for state of activity and suitable green light time comes about in case of utilizing n = 3 transmitter-receiver sets.

Table 1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **The state of** | | | **State of activity** | **Optimized Green Light Time**  **In seconds** |
| L3-P3 | L2-P2 | L1-P1 |
| 0 | 0 | 0 | Typical activity | 20 |
| 0 | 0 | 1 | Smooth activity | 30 |
| 0 | 1 | 1 | Very swarmed | 40 |
| 1 | 1 | 1 | Almost inactive traffic | 60 |

There are different states of traffic depend on traffic density such as Typical activity, Smooth activity, very swarmed, almost inactive traffic. According to the calculated of traffic density, on the notice boards LEDs will inform to us state of traffic along the way.



Figure 2. Singapore enhanced electronic signboards on roads

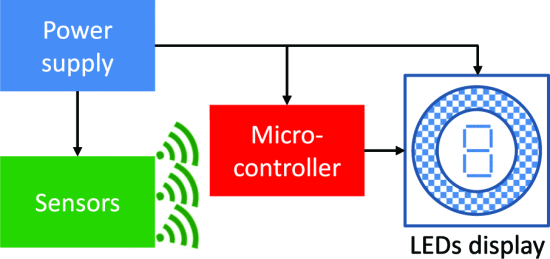


Figure 3. Proposed piece chart for keen activity light framework [6].

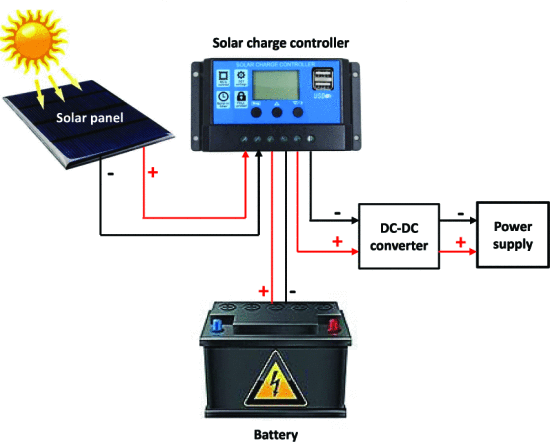


Figure 4. Block diagram of power supply [6].

# DESIGN

## Realistic constraints and conditions

Optimized smart traffic lights are used to regulate the traffic flowing and prevent accidents on the roads, streets and railways. It makes life safer for pedestrians, bicycles, trains and vehicles that need to move on the roads. They work effectively even in hot and cold cities.

On the other hand, due to extreme air conditions our traffic lights may not work work properly. Also it should be considered that this system may be disabled as a result of an accident or in case of insufficient electrical energy.

## Cost of the design

Here you can find a cost estimation for the design. (Table 2)

Table 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| For the Control Mechanism | | | | |
| Components | Price | | Source of component | |
| Ardunio Nano Mega UNO 174 | 830 TL | | https://www.hepsiburada.com/arduino-nano-mega-uno-174-parca-5-in-1-robotik-kodlama-mega256-ve-uno-r3-akrilik-diy-case-muhafazali-proje-uygulama-seti-p-HBV00000JGANY | |
| 100W  Solar Panel | 1,285.35 TL | | https://www.hepsiburada.com/solarland-100-watt-gunes-paneli-solar-panel-p-HBCV00000QNF1M | |
| 12V-70Ah rechargeable battery | 9,413.70 TL | | https://tr.aliexpress.com/item/1005003473061183.html?spm=a2g0o.search0304.0.0.71ac36ccNBGTjH&algo\_pvid=8a6a9901-4f77-4cd3-a32a-6611ec0cc60b&algo\_exp\_id=8a6a9901-4f77-4cd3-a32a-6611ec0cc60b-4 | |
| 12V-10A solar charge controller | € 61.11 | | https://tr.farnell.com/samlex/msk-10a/solar-charge-controller-12v-24v/dp/3778667 | |
| (Entry voltage: 4-40VDC and output voltage: 1.5- 36VDC) step down DC-DC converter. | 191.90 TL | | https://www.gittigidiyor.com/ev-elektronigi/voltaj-dusurucu-step-down-modulu-dc-dc-voltaj-cevirici-lm2596-voltaj-dusurucu-ayarlanabilir\_pdp\_532965294 | |
| 60m-Light Laser Measurement Sensor | ( For 50-99 pieces )  $ 54.32 | | https://www.alibaba.com/product-detail/Laser-Sensor-Measurement-Laser-Sensor-60m\_62474436388.html?spm=a2700.7724857.normal\_offer.d\_title.29b13e48kjovZ1&s=p | |
| Photo resistor Sensor | $ 14.89 | https://www.amazon.com/Glarks-Photoresistor-Sensitive-Dependent-Assortment/dp/B08K2GZYN9/ref=sr\_1\_1\_sspa?keywords=Photoresistor&qid=1643308250&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzNThVNkpERjlPWlZKJmVuY3J5cHRlZElkPUExMDQwMDkwMVFSRElHRE9KSVpBRyZlbmNyeXB0ZWRBZElkPUEwMzI2MzcxWDlFQ0lITUQwTEpIJndpZGdldE5hbWU9c3BfYXRmJmFjdGlvbj1jbGlja1JlZGlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ== | | |
| ARM Micro-controller (LPC1768FBD100 LQFP100 LPC1768FBD QFP LPC1768 32-bit) | 567.86 TL | https://tr.aliexpress.com/item/4000830393111.html?gatewayAdapt=glo2tur&spm=a2g0o.search0304.0.0.695d134fkTJulb&algo\_pvid=e39b938b-c8ef-4d10-826b-34b5debf8d15&aem\_p4p\_detail=20220127103317609775693279420025181565&algo\_exp\_id=e39b938b-c8ef-4d10-826b-34b5debf8d15-3 | | |
| WS2812B LED | 199 TL | https://www.gittigidiyor.com/ev-bahce/btf-lighting-ws2812b-adreslenebilir-led-serit-ip65-metrede-30-led-5m\_pdp\_748275860 | | |
| CCTV Camera For Car Number Recognition | $ 1,299 | | | https://www.alibaba.com/product-detail/Cctv-Camera-Plate-Recognition-Camera-LPR\_62095195250.html?spm=a2700.7724857.normal\_offer.d\_image.5f6d66ddjvEwMl&s=p |

## Engineering Standards

Bluetooth standards: Send or receive some data for small distances between devices such as mobile phones, computers or music boxes.

Wireless standards: Send or receive information and data for normal distances such as at home, office or school between devices such as mobile phones, computers or music boxes.

Microprocessor standards: System for real-time interchange information and operate some mathematical functions to initialize our orders.

## Details of the design

The framework is based on implanted framework which operates the diverse operations, screens the activity thickness stream by means of infrared sensors (IR), and changes the activity lights' move times in like manner. CCTVs and sensors help to detect the vehicles and produce output data that has information about total number of vehicles. After that, our algorithm uses this data and optimize the traffic lights to reduce traffic density. This system makes a difference to permit the smooth development of crisis vehicles through the crossing point [9].

Sensors framework is introduced as it were in one of the two crossing roads. On the other hand, for real life, we need to think the activity circumstance for each way. However, it is difficult to us to calculate all directions. We focused on one direction lights’ optimization. We commonly use CCTV, laser light (or transmitter) and optical sensor or collector. These collectors are orchestrated with the course of the approaching laser pillars.

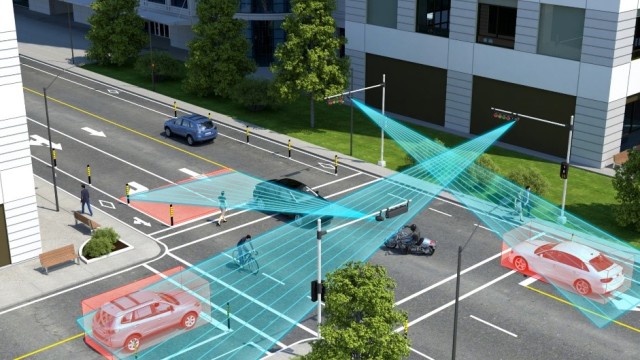


Figure 5. Intelligent Traffic Management Systems

Capturing images, using CCTVs installed along the way and laser light and optical sensor at the intersections. Our system detects vehicles such as cars, emergency vehicles, motorbikes and pedestrians using image processing and produces data. After that this data is sent to server for calculating signal times. Then our algorithms calculate the traffic density using data and via microcontroller we optimize traffic lights.

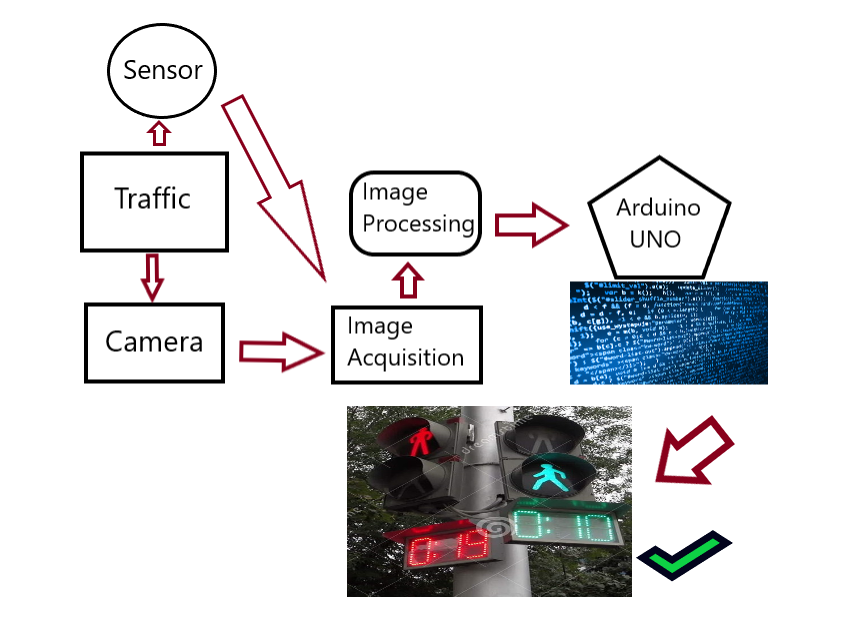


Figure 6. Process Scheme

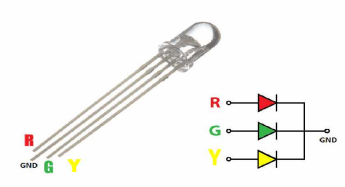


Figure 7. Red Green Yellow LED

Table 3 PIN Function

|  |  |  |
| --- | --- | --- |
| NO. | SYMBOL | Work portrayal |
| 1 | VDD | Power supply LED |
| 2 | DOUT | Control information flag yield |
| 3 | VSS | Floor or Ground means  0-Voltage |
| 4 | DIN | Control information flag input |

Table 4 Supreme Most extreme Ranges

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Symbol | Ranges | Unit |
| Power supply voltage | VDD | Between +3.6 and +5.4 | V |
| Input voltage |  | -0.5 VDD+0.5 | V |
| Operation intersection temperature |  | Between -24 and +85 | °C |
| Capacity temperature run |  | Between -56 and +151 | °C |

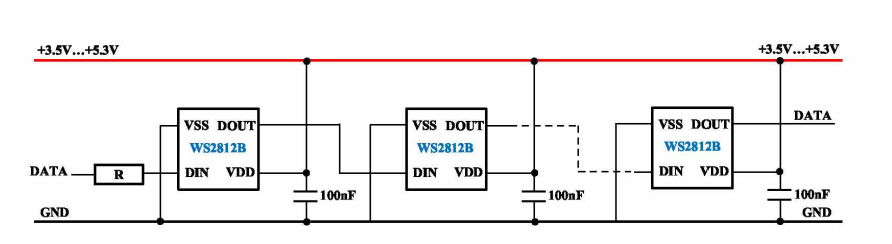


Figure 8. Square Graph for special LED (WS2812B) Driven chain execution in arrangement

# METHODS

Time plays an important role in our lives. Many people waste too much time in one day it the traffic in Istanbul. If this happens many times in a month it will add up to a large amount of time to get wasted. Our main aim is to design optimized smart traffic lights to reduce wasting time in the traffic in a specific location in Istanbul for better traffic flow. That’s why we created simulations about optimized smart traffic lights.

Our design in based on algorithm that calculates the traffic density and optimizes traffic lights using image processing data which is obtained by the CCTVs and sensors.

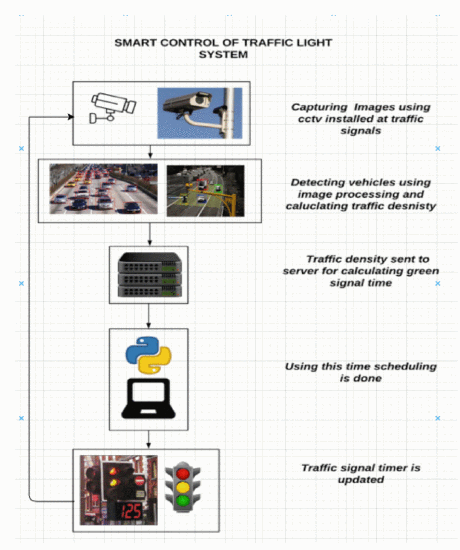


Figure 9. Smart Traffic Lights Working Scheme

Our responsibility at this project is only the algorithm part. We will not discuss about the image processing. Because we don’t have enough knowledge and experience for image processing. We will explain our algorithm about this project.

Assume that, image processing part has been done successfully and data obtained.

According to the kind of vehicles and their numbers, traffic density changes. Because cars, trucks, buses or motorbikes have different acceleration, size and weight. Every vehicle has a unique value for traffic density calculation. We take the average value for every different kind of vehicle with respect to one car to calculate traffic density in the target area where is detected via CCTVs and sensors [10].

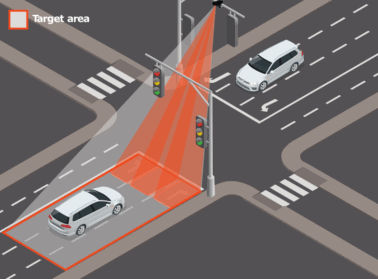


Figure 10. Target Area is detected by CCTV and sensor

Of course, traffic light time depends on the traffic density and vehicle’s value related to the priority of the vehicle. However, a vehicle’s value can change time to time and place to place. For instance, on the normal way, the value of one bus equals two cars and one ambulance’s value equals four cars. On the other hand, at hospital areas ambulance’s value increases, such as one ambulance’s value equal to the sixteen cars or at school areas value of the one bus equals the four cars value. So, at specific areas values of the vehicles can change with respect to their priority. Also, if there is no vehicle or pedestrian in the target area, traffic lights brightness will decrease to be able to save energy. Our algorithm design is based on these logics.

Assume that, image processing part has been done successfully and data obtained. We will use this data in the C Program and Mbed Simulator to calculate traffic density and optimize the traffic lights.

Our optimized smart traffic lights simulation is below.

There are three different areas in our design:

1. Normal way area in the city.
2. A way around the hospital area.
3. A way around the school area.

There are six different moving object (vehicle) parameters in our design:

1. Ambulance.
2. Bus.
3. Car.
4. Motorbike.
5. Truck.
6. Walker.

Every vehicle has its own coefficient value with respect to one car to calculate traffic density. Also, the coefficient of vehicles can change related to the three different areas in the city.

Table 5 Coefficient Values for Normal Way

|  |  |  |
| --- | --- | --- |
| Area | Vehicle | Coefficient Value |
| Normal Way | Ambulance | 8\*car |
| Normal Way | Bus | 3\*car |
| Normal Way | Car | 1\*car |
| Normal Way | Motorbike | 0.5\*car |
| Normal Way | Truck | 2.5\*car |
| Normal Way | Walker | 0.5\*car |

Table 6 Coefficient Values for Hospital Area

|  |  |  |
| --- | --- | --- |
| Area | Vehicle | Coefficient Value |
| Hospital Area | Ambulance | 16\*car |
| Hospital Area | Bus | 2\*car |
| Hospital Area | Car | 1\*car |
| Hospital Area | Motorbike | 0.25\*car |
| Hospital Area | Truck | 2\*car |
| Hospital Area | Walker | 1.5\*car |

Table 7 Coefficient Values for School Area

|  |  |  |
| --- | --- | --- |
| Area | Vehicle | Coefficient Value |
| School Area | Ambulance | 8\*car |
| School Area | Bus | 6\*car |
| School Area | Car | 1\*car |
| School Area | Motorbike | 0.5\*car |
| School Area | Truck | 3\*car |
| School Area | Walker | 1.25\*car |

According to the values at the tables, we created imaginary three different ways. These ways are:

1. Normal way for 150 cars.
2. A way around the hospital area for 120 cars.
3. A way around the school area for 100 cars.

CCTVs and sensors located along the ways. Vehicles and pedestrians are detected by the CCTVs and sensors and produce data. Our algorithm will use this data to be able to calculate traffic density and optimize the traffic lights.

1. **Simulation Example**

Our first example is about an interrupt algorithm that decreases red light time and increases green light time for pedestrians. So, pedestrians saved time.

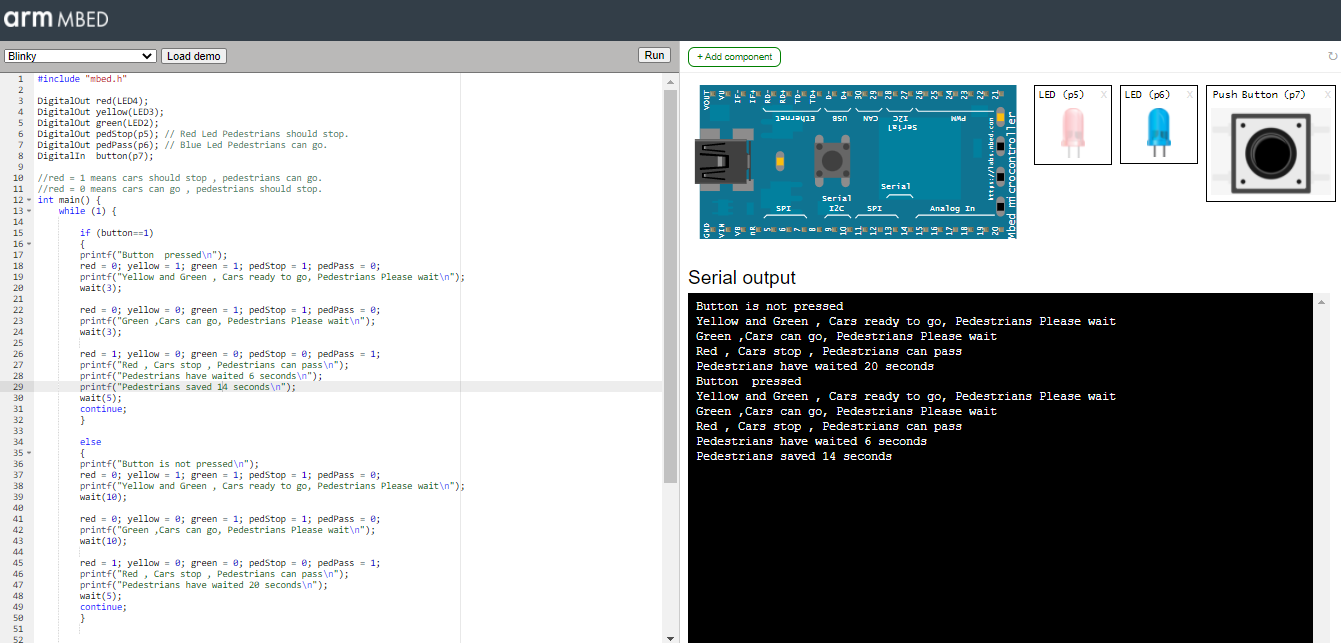


Figure 11. Mbed Simulation - 1

In Mbed Simulation-1, we designed an interrupt algorithm that gives priority to pedestrians to cross the road. LED (p5) RED means pedestrians should stop. LED (p6) BLUE means pedestrians can go. If the button is not pressed, the red light is active for 20 seconds for pedestrians, it means pedestrians have to wait 20 seconds. On the other hand, if the button is pressed, the red light is active for 6 seconds for pedestrians, it means pedestrians have to wait 6 seconds. As a result pedestrians saved 14 seconds, thanks to the interrupt button.

1. **Simulation Example**

Second example is about calculating traffic density in three different ways at different times of day. According to the values at Table 5,6 and 7 our algorithm calculates the traffic density and optimizes the traffic light times.

**First**, we will calculate the traffic density for three areas between 07:00 – 08:00 according to the data coming to us from the image processing center.

At this time of day, CCTVs and sensor detected:

* 2 Ambulances, 5 buses, 20 cars, 5 motorbikes, 4 trucks and 10 walkers at the normal way.
* 3 Ambulances, 3 buses, 15 cars, 2 motorbikes, 0 trucks and 40 walkers at the hospital way.
* 1 Ambulances, 8 buses, 12 cars, 3 motorbikes, 0 trucks and 25 walkers at the school area.

According to these numbers our algorithms will calculate traffic density for each way and optimizes traffic lights.

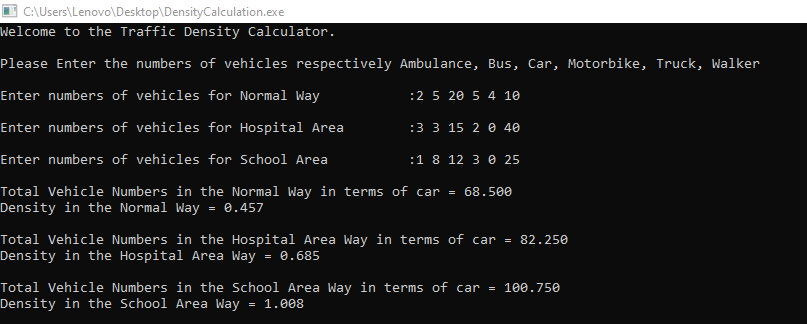


Figure 12. Traffic Density Calculation between 07:00 – 08:00

From the Figure 12 result, we see that, traffic density of the school area is higher than the hospital way and normal way. According to the result of the algorithm of Figure 15 Mbed Simulation – 2 and result of the traffic density between 7 – 8 am, we understand that:

* For Normal Way: Traffic is crowded and green light time adjusted 40 seconds for vehicles for the best traffic flow.
* For Hospital Way: Traffic is high crowded and green light time adjusted 50 seconds for vehicles for the best traffic flow.
* For School Way: Traffic is extremely crowded and green light time adjusted 60 seconds for vehicles for the best traffic flow.

**Second**, we will calculate the traffic density for three areas between 08:00 – 10:00 according to the data coming to us from the image processing center.

At this time of day, CCTVs and sensor detected:

* 1 Ambulances, 3 buses, 35 cars, 6 motorbikes, 5 trucks and 10 walkers at the normal way.
* 4 Ambulances, 10 buses, 15 cars, 5 motorbikes, 0 trucks and 25 walkers at the hospital way.
* 0 Ambulances, 5 buses, 6 cars, 2 motorbikes, 0 trucks and 10 walkers at the school area.

According to these numbers our algorithms will calculate traffic density for each way and optimizes traffic lights.

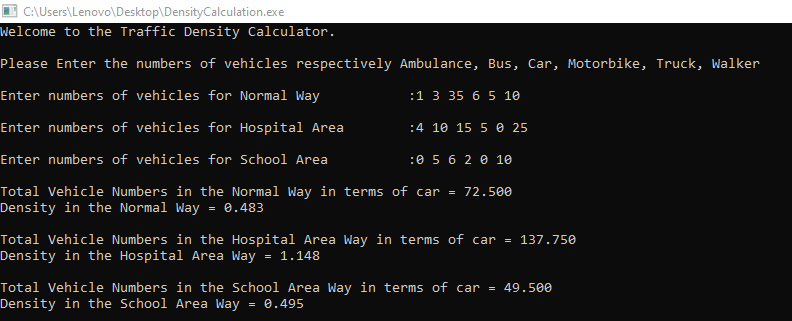


Figure 13. Traffic Density Calculation between 08:00 – 10:00.

From the Figure 13 result, we see that, traffic density of the hospital area is higher than the school way and normal way. According to the result of the algorithm of Figure 15 Mbed Simulation – 2 and result of the traffic density between 8 – 10 am, we understand that:

* For Normal Way: Traffic is crowded and green light time adjusted 40 seconds for vehicles for the best traffic flow.
* For Hospital Way: Traffic is extremely high crowded and green light time adjusted 60 seconds for vehicles for the best traffic flow.
* For School Way: Traffic is crowded and green light time adjusted 40 seconds for vehicles for the best traffic flow.

**Third**, we will calculate the traffic density for three areas between 18:00 – 19:00 according to the data coming to us from the image processing center.

At this time of day, CCTVs and sensor detected:

* 1 Ambulances, 15 buses, 75 cars, 15 motorbikes, 10 trucks and 5 walkers at the normal way.
* 2 Ambulances, 3 buses, 10 cars, 1motorbikes, 0 trucks and 20 walkers at the hospital way.
* 0 Ambulances, 3 buses, 10 cars, 2 motorbikes, 0 trucks and 25 walkers at the school area.

According to these numbers our algorithms will calculate traffic density for each way and optimizes traffic lights.

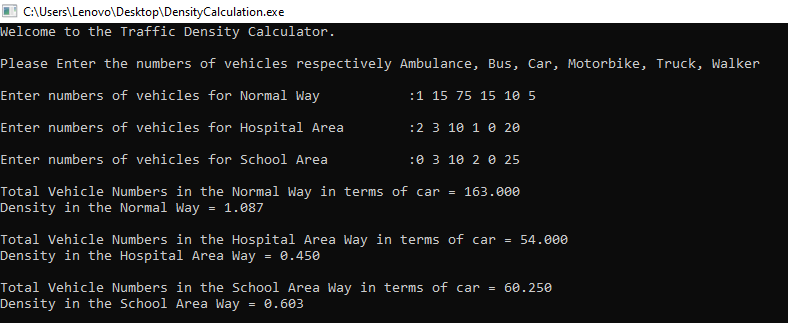


Figure 14. Traffic Density Calculation between 18:00 – 19:00

From the Figure 14 result, we see that, traffic density of the normal way is higher than the school way and hospital way. According to the result of the algorithm of Figure 15. Mbed Simulation – 2 and result of the traffic density between 6 – 7 pm, we understand that:

* For Normal Way: Traffic is extremely crowded and green light time adjusted 60 seconds for vehicles for the best traffic flow.
* For Hospital Way: Traffic is crowded and green light time adjusted 40 seconds for vehicles for the best traffic flow.
* For School Way: Traffic is high crowded and green light time adjusted 50 seconds for vehicles for the best traffic flow.

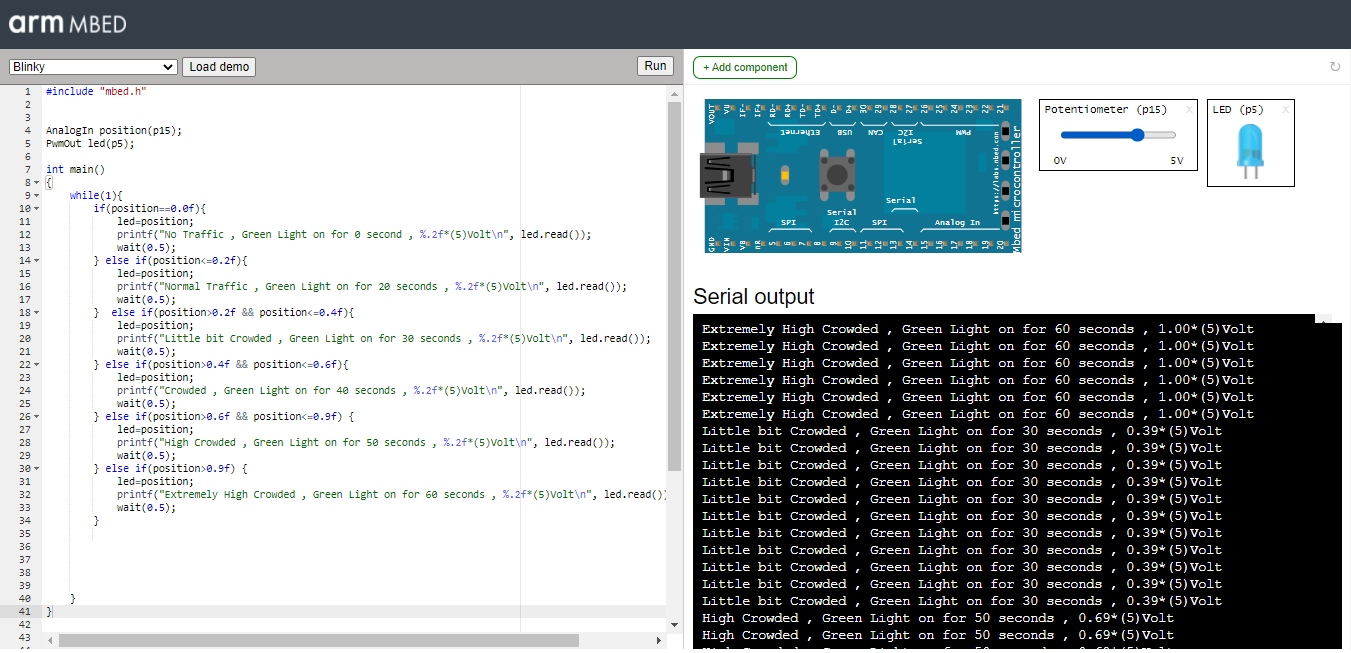
****

Figure 15. Mbed Simulation - 2

1. **Simulation Example**

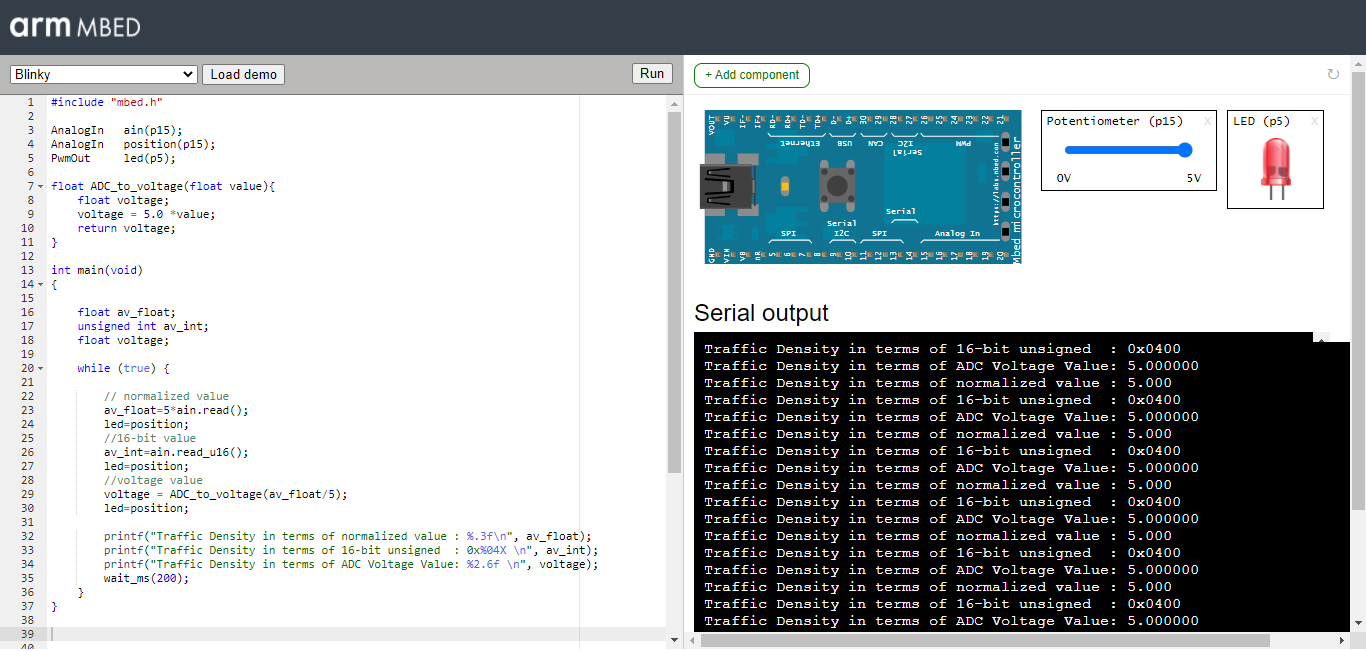
****

Figure 16. Mbed Simulation –3

In this simulation, our algorithm calculates the traffic density with respect to potentiometer’s value as 16-bit unsigned value, ADC value and [0 - 5] decimal value.

* If the potentiometer’s value is the 5 Volt, it means that traffic density is extremely high and our LED lights brightest. We can see the traffic density is 0x0400 as 16-bit unsigned value, 5.000000 as ADC value and 5.00 as decimal value.
* If the potentiometer’s value is [4 – 5) Volt, it means that traffic density is high crowded and our LED lights are close to the brightest. For instance, potentiometer’s value is 4.336 Volt, traffic density is 0x0378 as 16-bit unsigned value, 4.335937500 as ADC value and 4.336 as decimal value.
* If the potentiometer’s value is [3 – 4) Volt, it means that traffic density is crowded and our LED light is half brightness. When potentiometer’s value is 3.417 Volt, traffic density is 0x02BC as 16-bit unsigned value, 3.417968 as ADC value and 3.418 as decimal value.
* If potentiometer’s value is (0 – 3) Volt, it means that traffic density is normal and our LED light is low brightness. For example, when potentiometer’s value is 0.356 Volt, traffic density is 0x0049 as 16-bit unsigned value, 0.3564453 as ADC value and 0.356 as decimal value.
* If potentiometer’s value is 0 Volt, each value is 0.000.

# RESULTS AND DISCUSSION

Results of our study according to the traffic density calculation are:

* Pedestrians saved 14 seconds, thanks to the interrupt button.
* Traffic density is highest in the school area between 7am and 8am. Traffic density of the hospital area is higher than the density of the normal way between 7am and 8am. At this time, green light time adjusted 60 seconds for the vehicles to smooth traffic for the school area.
* Traffic density is highest in the hospital area between 8am and 10am. Traffic density of the school area is almost same with the density of the normal way between 8am and 10am. At this time, green light time adjusted 60 seconds for the vehicles to smooth traffic for the hospital area.
* Traffic density is highest in the normal way between 6pm and 7pm. Traffic density of the school area is higher than the density of the hospital area between 6pm and 7pm. At this time, green light time adjusted 60 seconds for the vehicles to smooth traffic for the normal way.

According to the results, our design works properly to decrease the traffic jam in the three different areas and it makes smoother traffic. However, CCTVs and sensors are placed in a limited way, that’s why our system is not enough for the whole city.

On the other hand, calculation in the Figure 15. Mbed Simulation – 2 is not good. Because, we calculated green light time with respect to averagely. Actually there are many parameters, such as bicycles, animals and other vehicles. Due to insufficient data and to avoid complexity, we ignored them. With the experts and advanced components, we can develop our project and include ignored parameters.

However, with the limited data and possibilities our system works properly on the simulations.

# CONCLUSION

As you can see in our research, we have explained the importance of optimized smart traffic lights in our lives for saving time, decreasing harmful gases to the atmosphere and smooth traffic.

You can see how to calculate the traffic density and optimize traffic lights with respect to three different areas and six different vehicles.

In this context, each vehicle has a different coefficient value for calculating traffic density in the three different areas. According to these parameters, traffic density of areas can change. As we explained:

* Traffic density is highest in the school area between 7am and 8am.
* Traffic density is highest in the hospital area between 8am and 10am.
* Traffic density is highest in the normal way between 6pm and 7pm.

Our contribution is creating imaginary three different areas with a limited size. Normal way for 150 cars, way around the hospital area for 120 cars and the way around the school area for 100 cars. Also adding interrupt button to save time for pedestrians.

In addition to our contribution, our algorithm calculates the traffic density with respect to potentiometer’s value as 16-bit unsigned value, ADC value and [0 - 5] decimal value and with respect to traffic density brightness of RED LED change. For example:

* If the potentiometer’s value is the 5 Volt, it means that traffic density is extremely high and our RED LED light is the brightest. We can see the traffic density is 0x0400 as 16-bit unsigned value, 5.000000 as ADC value and 5.00 as decimal value.
* If the potentiometer’s value is 0 Volt, each value is 0.000. RED LED does not shine.

# REFERENCES

[1] N. Kham, and C. Nwe, “Implementation of modern traffic light control system”, International journal of scientific and research publications, Vol. 4, Issue 6, Jun. 2014.

[2] I. Isa, N. Shaari, A. Fayeez, and N. Azlin, "Portable wireless traffic light system (PWTLS)", International journal of research in engineering and technology, Vol. 3, Issue 2, pp. 242-247, Feb 2014.

[3] Michael Graham Richard (March 18, 2010). ["Networked Traffic Lights Could Save Time, Fuel, and Lives"](https://www.treehugger.com/cars/networked-traffic-lights-could-save-time-fuel-and-lives.html). Narrative Content Group. Retrieved October 21, 2011.

[4] Max Glaskin (February 12, 2008). ["Could smart traffic lights stop motorists fuming?"](https://www.newscientist.com/article/dn13306-could-smart-traffic-lights-stop-motorists-fuming/). Retrieved October 21, 2011.

[5] P. Sinhmar, "Intelligent traffic light and density control using IR sensors and microcontroller", International journal of advanced technology & engineering research (IJATER), Vol. 2, Issue 2, pp. 30- 35, March 2012.

[6] G. Kavya, and B. Saranya, "Density based intelligent traffic signal system using PIC microcontroller", International journal of research in applied science & engineering technology (IJRASET), Vol. 3, Issue 1, pp. 205-209, Jan 2015.

[7] Ho Chi Minh City University of Technology — VNU-HCM under grant number T-DDT-2018- 74.

[8] S. S. Chavan, R. Deshpande, and J. Rana, “Design of intelligent traffic light controller using embedded system,” in International Conference on Emerging Trends in Engineering & Technology, 2009, pp. 1086-1091.

[9] M. Tubaishat, Y. Shang, and H. Shi, “Adaptive traffic light control with wireless sensor networks,” in 4th IEEE Consumer Communications and Networking Conference, 2007, pp. 187-191.

[10] Ms. Saili Shinde, Prof. Sheetal Jagtap, Vishwakarma Institute Of Technology, Intelligent traffic management system:a Review, IJIRST 2016

# APPENDICES

## Appendix A

**C Code for Mbed Simulation - 1**

#include "mbed.h"

DigitalOut red(LED4);

DigitalOut yellow(LED3);

DigitalOut green(LED2);

DigitalOut pedStop(p5); // Red Led Pedestrians should stop.

DigitalOut pedPass(p6); // Blue Led Pedestrians can go.

DigitalIn button(p7);

//red = 1 means cars should stop , pedestrians can go.

//red = 0 means cars can go , pedestrians should stop.

int main() {

while (1) {

if (button==1)

{

printf("Button pressed\n");

red = 0; yellow = 1; green = 1; pedStop = 1; pedPass = 0;

printf("Yellow and Green , Cars ready to go, Pedestrians Please wait\n");

wait(3);

red = 0; yellow = 0; green = 1; pedStop = 1; pedPass = 0;

printf("Green ,Cars can go, Pedestrians Please wait\n");

wait(3);

red = 1; yellow = 0; green = 0; pedStop = 0; pedPass = 1;

printf("Red , Cars stop , Pedestrians can pass\n");

printf("Pedestrians have waited 6 seconds\n");

printf("Pedestrians saved 14 seconds\n");

wait(5);

continue;

}

else

{

printf("Button is not pressed\n");

red = 0; yellow = 1; green = 1; pedStop = 1; pedPass = 0;

printf("Yellow and Green , Cars ready to go, Pedestrians Please wait\n");

wait(10);

red = 0; yellow = 0; green = 1; pedStop = 1; pedPass = 0;

printf("Green ,Cars can go, Pedestrians Please wait\n");

wait(10);

red = 1; yellow = 0; green = 0; pedStop = 0; pedPass = 1;

printf("Red , Cars stop , Pedestrians can pass\n");

printf("Pedestrians have waited 20 seconds\n");

wait(5);

continue;

}

}

}

**C Code for Mbed Simulation - 2**

#include "mbed.h"

AnalogIn position(p15);

PwmOut led(p5);

int main()

{

while(1){

if(position==0.0f){

led=position;

printf("No Traffic, Green Light on for 0 second, Traffic Denisty is: %.2f\*(5)Volt\n", led.read());

wait(0.5);

} else if(position<=0.2f){

led=position;

printf("Normal Traffic, Green Light on for 20 seconds, Traffic Denisty is: %.2f\*(5)Volt\n", led.read());

wait(0.5);

} else if(position>0.2f && position<=0.4f){

led=position;

printf("Little bit Crowded, Green Light on for 30 seconds, Traffic Denisty is : %.2f\*(5)Volt\n", led.read());

wait(0.5);

} else if(position>0.4f && position<=0.6f){

led=position;

printf("Crowded, Green Light on for 40 seconds, Traffic Denisty is : %.2f\*(5)Volt\n", led.read());

wait(0.5);

} else if(position>0.6f && position<=0.9f) {

led=position;

printf("High Crowded, Green Light on for 50 seconds, Traffic Denisty is : %.2f\*(5)Volt\n", led.read());

wait(0.5);

} else if(position>0.9f) {

led=position;

printf("Extremely High Crowded, Green Light on for 60 seconds, Traffic Denisty is : %.2f\*(5)Volt\n", led.read());

wait(0.5);

}

}

}

**C Code for Mbed Simulation - 3**

#include "mbed.h"

AnalogIn ain(p15);

AnalogIn position(p15);

PwmOut led(p5);

float ADC\_to\_voltage(float value){

float voltage;

voltage = 5.0 \*value;

return voltage;

}

int main(void)

{

float av\_float;

unsigned int av\_int;

float voltage;

while (true) {

// normalized value

av\_float=5\*ain.read();

led=position;

//16-bit value

av\_int=ain.read\_u16();

led=position;

//voltage value

voltage = ADC\_to\_voltage(av\_float/5);

led=position;

printf("Traffic Density in terms of normalized value : %.3f\n", av\_float);

printf("Traffic Density in terms of 16-bit unsigned : 0x%04X \n", av\_int);

printf("Traffic Density in terms of ADC Voltage Value: %2.9f \n", voltage);

wait\_ms(200);

}

}

## Appendix B

**C Code for Traffic Density Calculation**

#include <stdio.h>

int main()

{

float a\_n, b\_n, c\_n, m\_n, t\_n, w\_n;

float a\_h, b\_h, c\_h, m\_h, t\_h, w\_h;

float a\_s, b\_s, c\_s, m\_s, t\_s, w\_s;

/\*Coefficient values for Normal Way

ambulance=8\*car;

bus=3\*car;

car=car;

motorbike=0.5\*car;

truck=2.5\*car;

walker=0.5\*car;

Coefficient values for Hospital Area

ambulance=16\*car;

bus=2\*car;

car=car;

motorbike=0.25\*car;

truck=2\*car;

walker=1.5\*car;

Coefficient values for School Area

ambulance=8\*car;

bus=6\*car;

car=car;

motorbike=0.5\*car;

truck=3\*car;

walker=1.25\*car;

\*/

printf("Welcome to the Traffic Density Calculator.\n\nPlease Enter the numbers of vehicles respectively Ambulance, Bus, Car, Motorbike, Truck, Walker\n");

printf("\n");

printf("Enter numbers of vehicles for Normal Way :"); scanf("%f%f%f%f%f%f", &a\_n, &b\_n, &c\_n, &m\_n, &t\_n, &w\_n);

printf("\n");

printf("Enter numbers of vehicles for Hospital Area :"); scanf("%f%f%f%f%f%f", &a\_h, &b\_h, &c\_h, &m\_h, &t\_h, &w\_h);

printf("\n");

printf("Enter numbers of vehicles for School Area :"); scanf("%f%f%f%f%f%f", &a\_s, &b\_s, &c\_s, &m\_s, &t\_s, &w\_s);

printf("\n");

float total\_n = (8\*a\_n +3\*b\_n + c\_n+ 0.5\*m\_n + 2.5\*t\_n + 0.5\*w\_n);//Total vehicle in terms of car for Normal Way

float density\_n = (float)total\_n / (float)150;//Density formula for 150 cars on Normal Way

float total\_h = (16\*a\_h + 2\*b\_h + c\_h+ 0.25\*m\_h+2\*t\_h+1.5\*w\_h);//Total vehicle in terms of car for Hospital Area

float density\_h = (float)total\_h / (float)120;//Density formula for 120 cars in Hospital Area

float total\_s = (8\*a\_s + 6\*b\_s + c\_s + 0.5\*m\_s + 3\*t\_s + 1.25\*w\_s);//Total vehicle in terms of car for School Area

float density\_s = (float)total\_s / (float)100;//Density formula for 100 cars in School Area

printf("Total Vehicle Numbers in the Normal Way in terms of car = %.3f\n",total\_n);

printf("Density in the Normal Way = %.3f \n", density\_n);

printf("\n");

printf("Total Vehicle Numbers in the Hospital Area Way in terms of car = %.3f\n",total\_h);

printf("Density in the Hospital Area Way = %.3f \n", density\_h);

printf("\n");

printf("Total Vehicle Numbers in the School Area Way in terms of car = %.3f\n",total\_s);

printf("Density in the School Area Way = %.3f \n", density\_s);

}