DESIGN AND CONSTRUCTION OF AN INTELLIGENT TRAFFIC CONTROL SYSTEM

BY

UBANI BRIGHT C.

CPE/12/0893

A Project Submitted to the Department of Computer Engineering, Faculty of Engineering,

Federal University Oye- Ekiti (FUOYE),

Ekiti, Nigeria.

In partial fulfillment of the requirements for the degree of Bachelor of Engineering (B.Eng) in Computer Engineering,

NOVEMBER, 2017

CERTIFICATION

This project with the title

DESIGN AND CONSTRUCTION OF AN INTELLIGENT TRAFFIC CONTROL SYSTEM

Submitted by

UBANI BRIGHT C.

Has satisfied the regulations governing the award of degree of

BACHELOR OF ENGINEERING (B.Eng) in Computer Engineering

Federal University Oye-Ekiti. Ekiti

....

Dr.A. S.Falohun **Date**

Supervisor

.... 26-03-2018

Engr. G. Okoli **Date**

Supervisor

DEPARTMENT OF COMPUTER ENGINEERING
HOD SIGN
DATE 26/3/18
FEDERAL UNIVERSITY OYE-EKITI

.... 26-03-2018

Dr. I.A. Adeyanju **Date**

Ag. Head of Department

DECLARATION

I Ubani Bright hereby declare that this project work is the result of my personal effort under the supervision of Engr G. Okoli and Dr. A. S. Falohun of the department of Computer Engineering, Federal University Oye-Ekiti, Ekiti State, as part of the requirements for the award of Bachelor Degree of Computer Engineering, and has not been submitted elsewhere for this purpose. All sources of information are explicitly acknowledged by means of reference.

.... 16-12-2017

UBANI, BRIGHT C. **DATE**

CPE/12/0893

DEDICATION

This project work is dedicated to God Almighty, the Alpha and Omega of my life, who has been there right from the beginning to this very point. Special dedication also to my parents, Mr and Mrs Ubani, for their relentless support and compassion towards me during the course of my university program.

To God be the glory.

ACKNOWLEDGEMENTS

Firstly, I appreciate God, the greatest researcher, the creator of the heavens and one that has always led me through the path of the unknown. He has been faithful in the journey of my life. His understanding is more than what human can fathom, there is no way I can honor Him enough for all He has done for me.

A big thanks to Federal University Oye-Ekiti (FUOYE) for opening their door for me to learn. Also, I appreciate the acting Head of Department of Computer Engineering, Dr I.A. Adeyanju, all the staff and students of the department for their advice, love, moral support and care. May God bless them all.

A special thanks to my supervisor, Engr. G. Okoli for guidance, counseling and support during the course of the project and also for putting me through both morally and academically right from the beginning of the project till the latter before he had to travel out for some reasons. God bless you.

Finally, I will forever be grateful to my dear Parents, Mr and Mrs Ubani, My project supervisor, Dr A. S. Falohun who took over from Engr. Okoli for putting me through, both morally and academically. May God bless you all. Amen.

ABSTRACT

One of the major problems encountered in rural and urban communities is that of traffic congestion and accidents at blind spots on the road. Several traffic control systems has been designed but in most cases it is targeted towards road intersections, T-junctions, and round-abouts, whereas, congestions and accidents on road blind spots is on the rise. This project, Intelligent Traffic Control System is aimed at controlling the traffic at such points. The system function is based on three variables; Distance, Number of vehicles and Time.

This system shows when there is heavy traffic, low traffic or no traffic. It is a rule-based system which gives passage to the vehicles at both end of the road bend based on the rule it follows. IR sensors, LEDs, ATMEL microcontroller, etc. are some of the components used to design the system and, is programmed with arduino.

The system is an efficient and highly economic solution to traffic problems on road blind spots in Nigeria. The use of real time data obtained through Infrared sensor technique that serves as input to traffic light will be an innovative way of controlling traffic volume on blind spots in developing countries.

TABLE OF CONTENTS

CONTENT	PAGE

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

An intelligent system is a machine with an embedded, connected computer that has the capacity to gather and analyze data and communicate with other systems. (Techtarget.com, 2015) .

Intelligent traffic lights are a vehicle traffic control system that combines traditional traffic lights with an array of sensors and artificial intelligence to intelligently route vehicles and pedestrian traffic, unlike other dynamic control signals that adjust the timing and phasing of lights according to limits that are set in controller programming, this system combines existing technology with artificial intelligence. Intelligent Transportation Systems (ITS) applications for traffic signals – including communications systems, adaptive control systems, traffic responsive, real-time data collection and analysis, and maintenance management systems – enable signal control systems to operate with greater efficiency. Sharing traffic signal and operations data with other systems will improve overall transportation system performance in freeway management, incident and special event management, and maintenance/failure response times. Constructing new roads could be one of the solutions for handling the traffic congestion problem, but it is often less feasible due to political and environmental concerns. An alternative would be to make more efficient use of the existing infrastructure. Traffic management and control approaches are used to control the traffic flows and to prevent or reduce traffic jams, or more generally to improve the performance of the traffic system. Possible performance measures in this context are throughput, travel times, safety, fuel consumption, emissions, reliability, etc. Currently implemented traffic management approaches primarily make use of roadside-based traffic control measures (such as ramp metering, traffic signals, dynamic route information panels, and dynamic speed limits) and infrastructure-based equipment (including sensors and traffic control centers). Artificial Neural Networks (ANNs), as techniques that mimic the processing way of information in human brain have emerged as promising methods in dealing with non-linear and complex relations. The ability to learn, tolerance to data noises and capability to model incomplete data have made them unique analyzing approaches in many scientific procedures. When employing neural nets, once the network has been trained, new data in similar domain may be analyzed and predicted avoiding the time- and money- consuming experiments. Taking into account to solve problems, ANNs may combine the data from literature and experiments, the potential of this approach can be easily estimated in traffic light control.

1.2 Statement of Problem

One of the major problems encountered in rural and urban communities is that of traffic congestion and accidents at blind spots on the road. Data from the Chartered Institute of Traffic and Logistic in Nigeria revealed that about 75 per cent mobility needs in the country is accounted for by road mode; and that more than seven million vehicles operate on Nigerian roads on a daily basis (Ugwu, 2009).

This figure was also confirmed by the Federal Road Safety Corporation of Nigeria; the institution responsible for maintaining safety on the roads. (Mbawike, 2007) The commission further affirmed that the high traffic density was caused by the influx of vehicles as a result of breakdown in other transport sectors and is most prevalent in the road bends. Several measures had been deployed to address the problem of bend roads traffic congestion and accidents in large cities in Nigeria; namely among these are: the construction of flyovers and bypass roads, creating ring roads, posting of traffic wardens to trouble spots and construction of conventional traffic light based on counters. These measures however, had failed to meet the target of freeing major blind spots on the road, resulting in loss of human lives and waste of valuable man hour during the working days.

1.3 Aim and Objectives

The aim of this project is to develop an intelligent traffic control system for blind spots based on an arduino microcontroller and an infrared sensor basically to measure distance of an oncoming vehicle to ensure safety on such roads.The specific objectives are:

1. Design an intelligent wireless traffic system that work with infrared radiation allowing the transfer of light signal over a particular distance.
2. To implement the designed traffic controlled system using a hardware prototype.
3. To test the effectiveness of the developed system.

1.4 Scope of Study

The project has developed an intelligent traffic control system. It was tested to measure heavy traffic, low traffic and low traffic regime. The traffic system will make use of an infrared radiation sensor (IR) which works over wavelength and frequency for detecting oncoming vehicles from either side of the road bend. The project is majorly for blind spots or road bends and not T junctions or round about.

1.5 Significance of Study

Some examples of the benefits of using ITS applications for traffic signal control include:

1. Updated traffic signal control equipment used at blind spots with signal timing optimization can reduce congestion. The Texas Traffic Light Synchronization program reduced delays by 23 percent by updating traffic signal control equipment and optimizing signal timing. (Administration, 2005)

2. Coordinated signal systems improve operational efficiency. A project in Syracuse that connected intersections to a communications network produced reductions in travel time of up to 34 percent. (Transportation, 2003.)

3. An added benefit to connected intersections is a simplified signal timing process and automated monitoring of equipment failures.

4. Adaptive signal systems improve the responsiveness of signal timing in rapidly changing traffic conditions. Various adaptive signal systems have demonstrated network performance enhancement from 5 percent to over 30 percent. (Center, 2003)

5. ITS communication and sensor networks are the enabling technologies that allow adaptive signal control to be deployed.

6. Incorporating ITS into the planning, design, and operation of traffic signal control systems will provide motorists with recognizable improvements in travel time, lower vehicle operating costs, and reduced vehicle emissions. (Abdel-Rahim, 1998)

1.6 Method of Study

The methods used in achieving this project will include the following:

i. Continual review of relevant literatures in the library and online resources related to traffic light, neural networks and traffic control systems.

ii. Interaction with experts on rule based systems and also Federal Road Safety Corps so as to gain more knowledge about intelligent systems as well as traffic control.

iii. Design of the intelligent traffic control system.

iv. Determining where and how this traffic light would be mounted on blind spots or road bends across the country.

v. Estimating how long the green light signal would stay on more congested roads.

vi. Implementation of the intelligent traffic light system.

vii. Testing of the implemented system.

CHAPTER TWO

LITERATURE REVIEW

2.1 Intelligent Traffic Control System for Blind Spot

Traffic Control is a traffic management strategy in which traffic signal timing changes, or adapts, based on actual traffic demand. This is accomplished using an adaptive traffic control system consisting of both hardware and software. It involves control of the flow of traffic in a city, in the air, on the sea, or on the railways. (Wikipedia.com, 2017)

A blind spot in a vehicle is an area around the vehicle that cannot be directly observed by the driver while at the controls, under existing circumstances. (freedictionary.com, 2017). Blind spots exist in a wide range of vehicles: aircraft, cars, motorboats, sailboats, and trucks. Other types of transport have no blind spots at all, such as bicycles, horses, and motorcycles. Blind spots may occur in the front of the driver when the A-pillar (also called the windshield pillar), side-view mirror, or interior rear-view mirror blocks a driver's view of the road. Behind the driver, cargo, headrests, and additional pillars may reduce visibility.

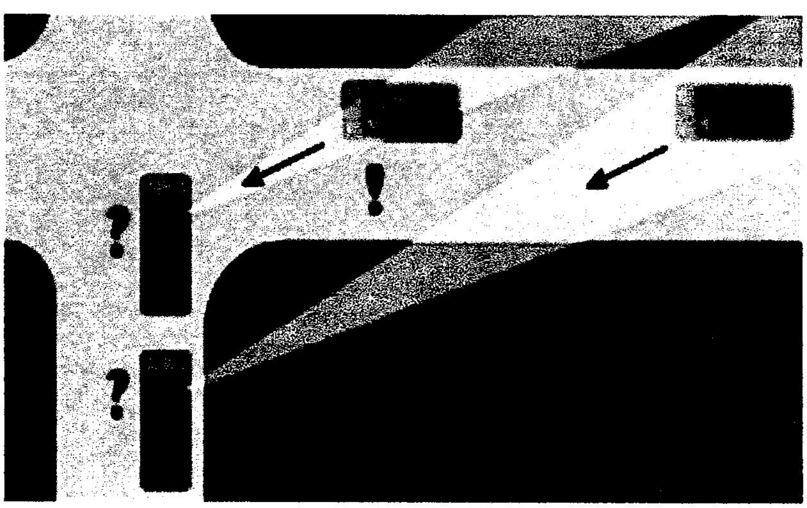


*figure 2.1: a pillar Blind Spot (*freedictionary.com, 2017*)*

2.2 Traffic Control by Human

Road traffic control involves directing vehicular and pedestrian traffic around a construction zone, accident or other road disruption, thus ensuring the safety of construction workers and the general public. Road Traffic control is an outdoor occupation, night or day for long hours in all weathers, and is considered a dangerous occupation due to the high risk of being struck by passing vehicles that lost control as well as weather impacted health conditions. Safety equipment is vitally important. Fatigue is a big issue, as tired Traffic Controllers (TC's) may forget to watch their traffic, or may inadvertently turn their "Stop bats" to the "Slow" position. Many drivers are annoyed by the disruption to their route, and some are sufficiently antisocial as to aim at traffic controllers. Other drivers simply don't pay enough attention to the road, often from using their mobile cell-phones, or because they are tired from a night shift at work. Not a few are exceeding the posted speed limit. (Jones, 2011)

Air Traffic Controllers (ATC) are people trained to maintain the safe, orderly, and expeditious flow of air traffic in the global air traffic control system. The position of air traffic controller is one that requires highly specialized knowledge, skills, and abilities. Controllers apply separation rules to keep aircraft at a safe distance from each other in their area of responsibility and move all aircraft safely and efficiently through their assigned sector of airspace, as well as on the ground. Because controllers have an incredibly large responsibility while on duty (often in aviation, "on position") and make countless real-time decisions on a daily basis, the ATC profession is consistently regarded around the world as one of the most mentally challenging careers, and can be notoriously stressful depending on many variables (equipment, configurations, weather, traffic volume, human factors, etc.) (Kator, 2015).

Centralized Traffic Control (CTC) is a form of railway signaling that originated in North America. CTC consolidates train routing decisions that were previously carried out by local signal operators or the train crews themselves. The system consists of a centralized train dispatcher's office that controls railroad interlocking and traffic flows in portions of the rail system designated as CTC territory. One hallmark of CTC is a control panel with a graphical depiction of the railroad. On this panel the dispatcher can keep track of trains' locations across the territory that the dispatcher controls. Larger railroads may have multiple dispatchers' offices and even multiple dispatchers for each operating division. These offices are usually located near the busiest yards or stations, and their operational qualities can be compared to air traffic towers. (Calvert, 1999)

2.3 Smart Traffic Control System

Smart traffic lights or Intelligent traffic lights are a vehicle traffic control system that combines traditional traffic lights with an array of sensors and artificial intelligence to intelligently route vehicle and pedestrian traffic, unlike other dynamic control signals that adjust the timing and phasing of lights according to limits that are set in controller programming, this system combines existing technology with artificial intelligence.

The signals communicate with each other and adapt to changing traffic conditions to reduce the amount of time that cars spend waiting. Using fiber optic video receivers similar to those already employed in dynamic control system, the new technology monitors vehicle numbers and makes changes in real time to avoid congestion wherever possible. Initial results from the pilot study are encouraging: the amount of time that motorists spent waiting at lights was reduced by 40% and travel times across the city were reduced by 26%. (Calvert, 1999)

2.4 Traffic Light Control and Coordination

The normal function of traffic lights requires more than slight control and coordination to ensure that traffic moves as smoothly and safely as possible and that pedestrians are protected when they cross the roads. A variety of different control systems are used to accomplish this, ranging from simple clockwork mechanisms to sophisticated computerized control and coordination systems that self-adjust to minimize delay to people using the road.

2.5 Traffic Controller Systems

A traffic signal is typically controlled by a controller inside a cabinet mounted on a concrete pad. Some electro-mechanical controllers are still in use. However, modern traffic controllers are solid state. The cabinet typically contains a power panel, to distribute electrical power in the cabinet; a detector interface panel, to connect to loop detectors and other detectors; detector amplifiers; the controller itself; a conflict monitors unit; flash transfer relays; a police panel, to allow the police to disable the signal; and other components. (Tanny, 2006)

Solid state controllers are required to have an independent *conflict monitor unit* (CMU), which ensures fail-safe operation. The CMU monitors the outputs of the controller, and if a fault is detected, the CMU uses the flash transfer relays to put the intersection to *FLASH*, with all red lights flashing, rather than displaying a potentially hazardous combination of signals. The CMU is programmed with the allowable combinations of lights, and will detect if the controller gives conflicting directions a green signal, for instance.

In the late 1990s, a national standardization effort known as the Advanced transportation controller (ATC) was undertaken in the United States by the Institute of

Transportation Engineers. (Traffic Signal Standards,1999). The project attempts to create a single national standard for traffic light controllers. The standardization effort is part of the National Intelligent transportation system program funded by various highway bills. The controllers will communicate using *National Transportation Communications for ITS Protocol* (NTCIP), based on Internet Protocol, ISO/OSI, and ASN.1. (Uriel, 1999)

Traffic lights must be instructed when to change stage and they are usually coordinated so that the stage changes occur in some relationship to other nearby signals or to the press of a pedestrian button or to the action of a timer or a number of other inputs.

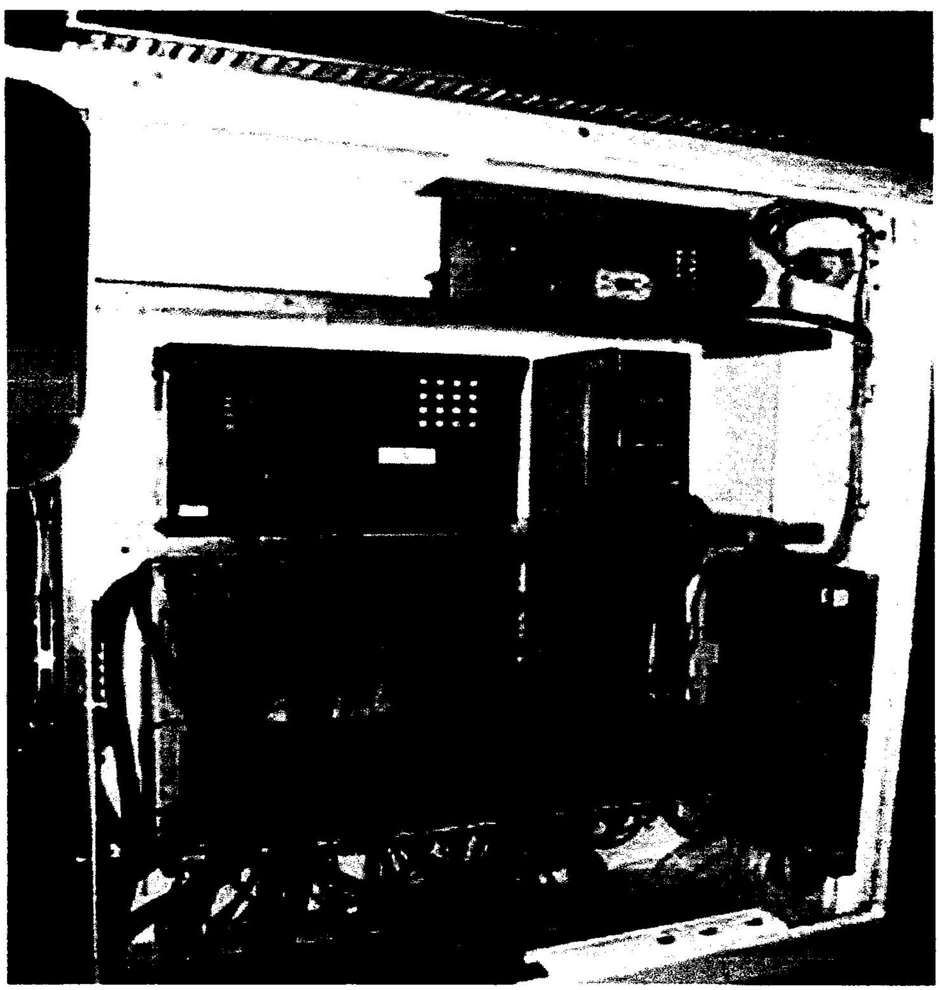


Figure 2.2: Computerized traffic control box (Tanny, 2006)

2.5.1 Battery Backup

In the areas that are prone to power interruptions, adding battery backups to the traffic controller systems can enhance the safety of the motorists and pedestrians. In the past, a larger capacity of uninterruptible power supply would be required to continue the full operations of the traffic signals using incandescent lights. The cost for such system would be prohibitive. After the newer generations of traffic signals that use LED lights which consume 85-90% less energy, it is now possible to incorporate battery backups into the traffic light systems. The battery backups would be installed in the traffic controller cabinet or in their own cabinet adjacent to the controller.

The battery backups can operate the controller in emergency mode with the red light flashing or in fully functional mode. In 2004, California Energy Commission recommended to have local governments to convert their traffic lights to LEDs with battery backups. This would lower the energy consumption and enhance the safety at major intersections. The recommendation was for a system which provides fully functional traffic signals for two hours after the power outage. Then the signals will have flashing red lights for another two hours (Sarah, 2004).

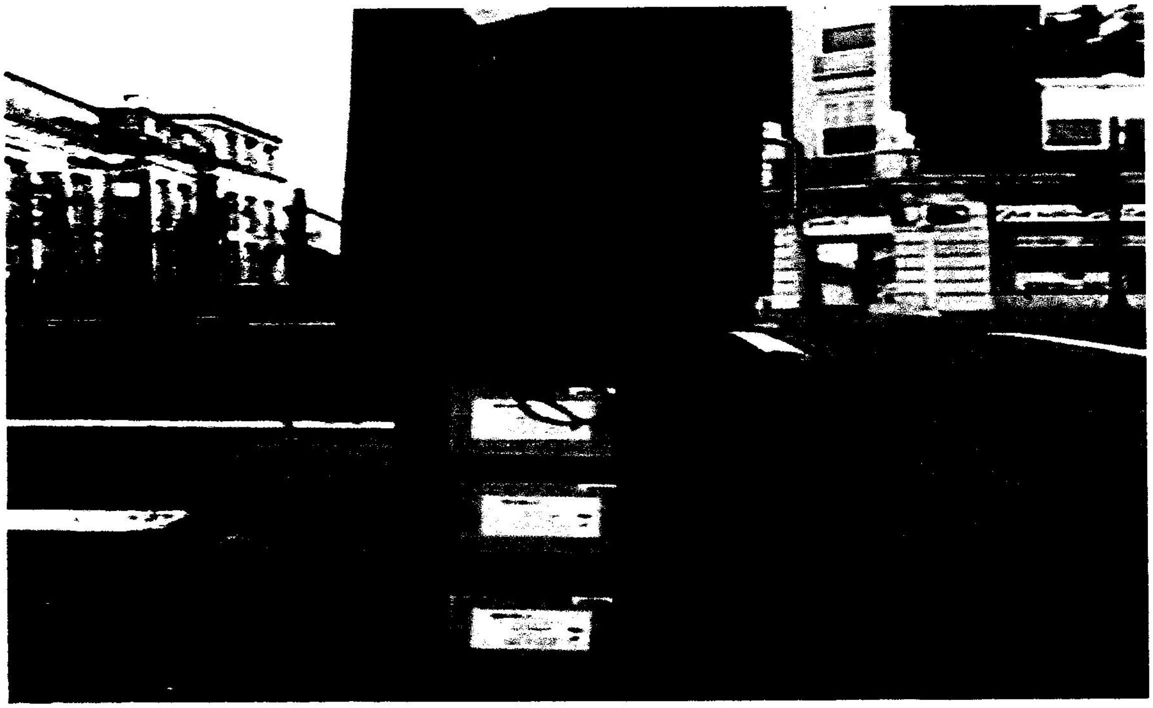


Figure 2.3: Battery backups installed in a separate cabinet from the traffic controller cabinet on the top (Sarah, 2004)

2.5.2 Fixed Time Control

In traffic control, simple and old forms of signal controllers are known as electro-mechanical signal controllers. Unlike computerized signal controllers, electro-mechanical signal controllers are mainly composed of movable parts (cams, dials, and shafts) that control signals that are wired to them correctly. Aside from movable parts, electrical relays are also used. In general, electro-mechanical signal controllers use dial timers that have fixed, signalized intersection time plans. Cycle lengths of signalized intersections are determined by small gears that are located within dial timers. Cycle gears, as they are commonly known, range from 35 seconds to 120 seconds. If a cycle gear in a dial timer results in a failure, it can be replaced with another cycle gear that would be appropriate to use. Since a dial timer has only one signalized intersection time plan, it can control phases at a signalized intersection in only one way. Many old signalized intersections still use electro-mechanical signal controllers, and signals that are controlled by them are effective in one way grids where it is often possible to coordinate the signals to the posted speed limit. They are however disadvantageous when the signal timing of an intersection would benefit from being adapted to the dominant flows changing over the time of the day. (Wikipedia.com, 2017)

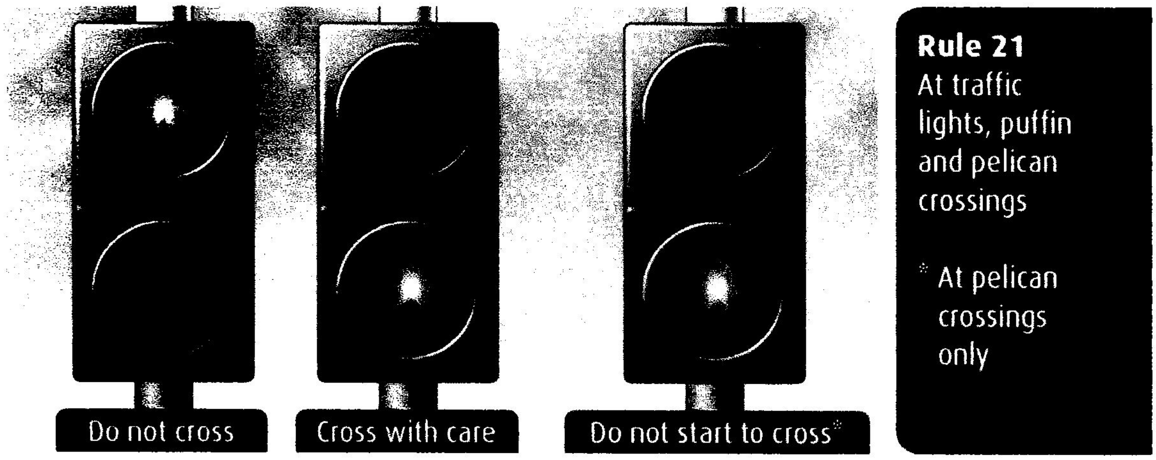


Figure 2.4: Pedestrian traffic signal in Nigeria, indicating either to cross or not

(Wikipedia.com, 2017)

2.5.3. Dynamic Control

The controller uses input from detectors, which are sensors that inform the controller processor whether vehicles or other road users are present, to adjust signal timing and phasing within the limits set by the controller's programming. It can give more time to an intersection approach that is experiencing heavy traffic, or shorten or even skip a phase that has little or no traffic waiting for a green light. Detectors can be grouped into three classes: in-pavement detectors, non-intrusive detectors, and detection for non-motorized road users.

2.6 Traffic Light in Railway

A signal is a mechanical or electrical device erected beside a railway line to pass information relating to the state of the line ahead to train/engine drivers. The driver interprets the signal's indication and acts accordingly. Typically, a signal might inform the driver of the speed at which the train may safely proceed or it may instruct the driver to stop.

2.6.1 Application and Positions of Signal

Originally, signals displayed simple stop/proceed indications. As traffic density increased, this proved to be too limiting and refinements were added. One such refinement was the addition of distant signals on the approach to stop signals. The distant signal gave the driver warning that he was approaching a signal which might require a stop. This allowed for an overall increase in speed, since train drivers no longer had to drive at a speed within sighting distance of the stop signal.

Under timetable and train order operation, the signals did not directly convey orders to the train crew. Instead, they directed the crew to pick up orders, possibly stopping to do so if the order warranted it.

Signals are used to indicate one or more of the following:

- That the line ahead is clear (free of any obstruction) or blocked.
- That the driver has permission to proceed.
- That points (also called *switch* or *turnout* in the US) are set correctly.
- Which way points are set.
- The speed the train may travel.
- The state of the next signal.
- That the train orders are to be picked up by the crew.

Signals can be placed:

- At the start of a section of track.
- On the approach to a movable item of infrastructure, such as points/switches or a swing bridge.
- In advance of other signals.
- On the approach to a level crossing.
- At a switch or turnout.
- Ahead of platforms or other places that trains are likely to be stopped.
- At train order stations.

'Running lines' are usually continuously signaled. Each line of a double track railway is normally signaled in one direction only, with all signals facing the same direction on either line. Where 'bi-directional' signaling is installed, signals face in both directions on both tracks (sometimes known as 'reversible working' where lines are not normally used for bi-directional working). Signals are generally not provided for controlling movements within sidings or yard areas.

Figure 2.5: A signal used in the Delhi metro, typical of urban light rail signals.(Wikipedia.com, 2017)

2.7 Traffic Light in Seaport

A vessel traffic service (VTS) is a marine traffic monitoring system established by harbor or port authorities, similar to air traffic control for aircraft. Typical VTS systems use radar, closed-circuit-television (CCTV), VHF radiotelephony and automatic identification system to keep track of vessel movements and provide navigational safety in a limited geographical area.

2.8 Traffic Light on Road

Traffic lights, also known as traffic signals, traffic lamps, traffic semaphore, signal lights, stop lights, robots (in South Africa), and traffic control signals (in technical parlance), (Sites.Tufts.edu, 2017) are signaling devices positioned at road intersections, pedestrian crossings, blind spots and other locations to control flow of traffic.

The world's first, manually operated gas-lit traffic signal was short lived. Installed in London in December 1868, it exploded less than a month later, injuring or killing its policeman operator (McNeil, 1996). Traffic control started to seem necessary in the late 1890s and Earnest Serine from Chicago patented the first automated traffic control system in 1910. It used the words "STOP" and "PROCEED", although neither word lit up. (Motor, 2015)

Traffic lights alternate the right of way accorded to users by displaying lights of a standard colour (red, amber (yellow), and green) following a universal colour code. In the typical sequence of colour phases:

- The green light allows traffic to proceed in the direction denoted, if it is safe to do so and there is room on the other side of the intersection.
- The amber (yellow) light warns that the signal is about to change to red. In a number of countries – among them the United Kingdom – a phase during which red and yellow are displayed together indicates that the signal is about to change to green. (Traffic lights in use 2005). Actions required by drivers on a yellow light vary, with some jurisdictions requiring drivers to stop if it is safe to do so, and others allowing drivers to go through the intersection if safe to do so.
- A flashing amber indication is a warning signal. In the United Kingdom, a flashing amber light is used only at pelican crossings, in place of the combined red–amber signal, and indicates that drivers may pass if no pedestrians are on the crossing.

- The red signal prohibits any traffic from proceeding.
- A flashing red indication is treated as a stop sign.

In some countries traffic signals will go into a flashing mode if the Conflict Monitor detects a problem, such as a fault that tries to display green lights to conflicting traffic. The signal may display flashing yellow to the main road and flashing red to the side road, or flashing red in all directions. Flashing operation can also be used during times of day when traffic is light, such as late at night. (Wikipedia.com, 2014)

2.9 Traffic Light Signaling and Operation

The use of traffic lights to control the movement of traffic differs regionally and internationally in certain respects.

2.9.1 Light Signals

In the United States, a flashing red light is the equivalent of a stop sign. In the United States and Australia, flashing yellow does not require traffic to stop, but drivers should exercise caution since opposing traffic may enter the intersection after stopping. This may be used when there is a malfunction with the signals, or late at night when there is little traffic. A single four-way flashing light showing only one color in each direction may be used at intersections where full three-color operation is not needed, but stop or yield signs alone have not had acceptable safety performance. Yellow lights are displayed to the main road, to highlight the intersection and inform drivers of the need for caution. Red lights supplement stop signs on the side road approaches. All-way red flashing lights can supplement all-way stop control, but all-way yellow beacons are prohibited by United States regulations.

In New Zealand, paired red/red traffic lights are often installed outside Fire and Ambulance Stations on major roads, which when activated by the station, flash alternatively (so that at any time one red light is always showing), the purpose being to cause to traffic to stop for a set amount of time to allow emergency vehicles to exit their station safely.

In some parts of Canada, a flashing green (known as Advanced Green) light signals permission for a left turn before the opposing traffic is allowed to enter the intersection, *i.e.*, oncoming traffic is facing a RED light. Similarly, a flashing green may be an Extended Green, for left turns after the opposing traffic's full green phase. The flashing light may be a "full" green, or a green left arrow, both meaning the same thing. At least one traffic light in Montreal (on the Island of Montreal, 'Right-on-Red' is not allowed), has a flashing *right*-turn arrow, indicating that the pedestrian crossing has a red light, so it is safe to turn right and drive across it. At some intersections in Winnipeg, Manitoba, a flashing green right-turn arrow appears with a red light when traffic from the right has a green flashing *left*-turn arrow and is not allowed to make a U-turn. In other parts of the same country (*e.g.*, Vancouver) a flashing green light conveys a very different meaning: the crossing road has stop signs with no lights of its own, and oncoming traffic also has a flashing green, not a red stop-light. This functions the same as a European "priority" sign (a yellow-and-white diamond shaped sign indicating that the current street is a Priority or "main" road, which cross streets must yield to at uncontrolled junctions, opposite to the usual arrangement in many European countries), for which there is no direct equivalent in North America.

The new US 2009 Manual on Uniform Traffic Control Devices specifically prohibits flashing any green signal indication.

In Nigeria, red light is the equivalent of a stop sign, yellow does not require traffic to stop, but drivers should exercise caution since opposing traffic may enter the intersection after stopping. This may be used when there is a malfunction with the signals, or late at night when there is little traffic. Yellow lights are displayed to the main road, to highlight the intersection and inform drivers of the need for caution. Red lights supplement stop signs on the side road approaches. All-way red flashing lights can supplement all-way stop control. Green light signifies go sign and unlike other countries likes United states and North America, Nigeria exhibits the Right hand drive which makes their signaling totally different as the car is always on the left side of the road. (Edition, 2009)

2.9.2 Artificial Neural Networks (ANN)

The major difference between ANN (learning systems) and Fuzzy Expert System (FES) is that; while an FES uses present knowledge to make decisions, in a learning system, the decisions are computed using the accumulated experience or knowledge from successfully solved examples. Since ANNs try to mimic the human brain they possess an adaptive feature that allows each node within the network to modify its state in response to past and present knowledge ((Beattie, 2011), (Patel, 2001)).

Patel *et al.* present an ANN system used to control traffic. The input given to the ANN models are the list of data collected by the sensors which are placed around the traffic lights. The sensors give the traffic light ANN model all the data which are related to the past and present traffic parameters. The model then processes this input and selects the most suitable output that suits current traffic situation. These results are then used by the traffic lights to set the timing for the red and green lights. In their ANN approach they evaluate that for the ANN to produce accurate decisions it required 83 neural nodes, their system produced 73% accuracy level for the derived

solutions. Michael (2014) also presented a neural networks based traffic light controller called Environment Observation Method based on Artificial Neural Networks Controller (EOM-ANN) to control urban traffic. The approach is different from that of Patel *et al* (2001) & Dai (2011) because they incorporate mathematical strategies (EOM) to make signal allocation decisions. EOM is a mathematical methodology for obtaining timing plans for isolated intersections. It achieves this by calculating the minimal green time for each phase then to prevent congestion an additional green time is allocated to each lane that still has cars even after getting green light. However the downside of EOM is that it sets traffic light timing based on averages of the basic parameters. Due to the fact that these figures are constants, the EOM doesn't incorporate the real time nature of traffic which means that the traffic parameter values (data) keep changing every time, this is further backed by Dai (2011) that traditional mathematical methods have limitations when they are applied in traffic control. The EOM-ANN is an attempt to resolve this issue of real time data, Michael (2014) propose the use of ANN to obtain this traffic data patterns. That way, the green light timing and allocation is based on actual/prevailing traffic conditions rather than analytical calculations (Michael, 2014). EOM-ANN uses the feed-forward method with 8 neural nodes in total for input, hidden and output layers. It is further divided into two modules; reviser and the neural. The former defines correct traffic light timing and the latter provides te most appropriate value for the current traffic behavior. The inputs of the ANN are the number of light, medium and heavy vehicles. From a comparison between static time controller and EOM, EOM-ANN reported better traffic flow and congestion management. The average traffic flow of the individual controllers was as follows:

static controller - 82.55, EOM - 68.70 and EOM-ANN registered an average of 53.75. (Michael, 2014)

2.9.3 Related Works

Intelligent Transportation Systems (ITS) are advanced applications which, without embodying intelligence as such, aimed to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks. (Coleman, 2015). Several research works has been done in this field of intelligent traffic control systems and are as reported in this sub-section.

Ashwini et al (2005) carried out a research where a design of an Intelligent traffic control system based on ARM was done. The architecture and design theory of the system was integrated by lot of hardware modules such as ARM PLC 2148 microcontroller as a control unit to combine with global positioning system and CC2500 RF module by the hardware/software co-design.

Micheal *et al* (2004) carried out a research on the design and development of traffic light control system based on hybrid lightning system. In the paper , hybrid lighting technology was used to mitigate incandescent lightings with deployed halogen bulbs provided an instantaneous source of highly efficacious illumination which is brighter than the drivers' ambient lights (both daylight, electrical lights and their reflections), which can help drivers get access to enough warning and help them initiate traffic safety warning as necessary. The halogen lightings also offered the required high current draw needed in electrical circuitry to help brighten the LED displays. The problem of heat generated was eliminated by aerating the T-junction traffic light control unit designed for this technology. The result of hybrid lighting system design was found to be high luminosity and capability of gaining driver's attention in real-time. It also allowed enhanced sign's image detection and processing for smart based technologies by providing the "light punch" needed for a wide range of visual concerns.

In Toronto the traffic control systems is based on two different researches;

TransSuite Traffic Control System (TransSuite TCS): TransSuite TCS is a hybrid traffic control system that relies on second-by-second communication to monitor signal operations, but relies on field equipment to maintain coordination (i.e. the field equipment can maintain signal coordination for about 24 hours if there is a loss of communication). TransSuite TCS does not directly control signal movements, but commands each intersection controller to follow a timing plan that resides within its local database. TransSuite then verifies that the controller adheres to the commanded timing plan. Intersection controllers are monitored and controlled through a user interface. TransSuite TCS supports a variety of phase-based controllers.

Split Cycle Offset Optimization Technique/Urban Traffic Control (SCOOT/UTC): SCOOT is an adaptive traffic control system that determines its traffic timing plans based on real-time information received from vehicle detectors located on the approaches to signalized intersections. Like MTSS, SCOOT relies on telephone communication to maintain signal coordination. UTC is a traffic control system that operates in tandem with SCOOT; it also relies on telephone communications. UTC provides pre-determined signal timing plans and is used as a stopgap measure if SCOOT is not available. SCOOT signals are sometimes called "smart" signals. (Sabhijiit et al, 2005)

Sabhijiit et al (2005) made a research on Agent Based Intelligent Traffic Management System for Smart Cities; the paper was on the performance of traffic systems which is greatly dependent on the ability to react to changing traffic patterns and different situations. On traditional traffic systems, the lights run green for fixed intervals of time no matter what the density of the traffic is. Here an intelligent-agent traffic model was implemented that controls the amount of time a light runs green for, based on the number of cars (density) standing in the light.

Pasy et al (2003) made research on intelligent Blind Spot Detection system for Heavy Goods Vehicles. The research was on Blind Spot Mirrors and advanced Blind Spot Detection systems assist in avoiding collisions. Blind Spot Mirrors are however only useful if the drivers are trained to use them. The paper describes the development of a monitoring solution for assist in truck driver training. The system also can be used as a blind spot detection system to warn truck drivers. The work is performed within the DESERVE project, which aims at designing and developing a Tool Platform for embedded Advanced Driver Assistance Systems (ADAS) to exploit the benefits of cross-domain software reuse, standardized interfaces, and easy and safety-compliant integration of heterogeneous modules to cope with the expected increase of functions complexity and the impellent need of cost reduction.

Mohit et al (1998) carried out research on SMART TRAFFIC CONTROL SYSTEM USING PLC and SCADA. The scope of the paper is to present the initial steps in the implementation of a smart traffic light control system based on Programmable Logic Controller (PLC) technology. The method measured the traffic density by counting the number of vehicles in each lane and their weight, then park in automated parking or diverge them accordingly. It is also difficult for a traffic police to monitor the whole scenario round the clock. So, this system can be implemented on highways and city traffic. The method has two parts:

A. Diversion

Weight sensor was placed at toll booth. It senses the weight & sends signal to PLC. PLC will generate a slip having the info about the vehicle in the form of barcode. PLC will give the diversion according to the weight of the vehicle.

B. Congestion Control

In this there are two counters– UP Counter (at the starting of the road) & DOWN Counter (at the end of the road) whose max value is 100. When a vehicle enters the road, UP Counter is set and

vice versa. There are 3 conditions for allowing the vehicle in the area;

• If UP Counter==100 & DOWN Counter==0, then red light will be shown i.e. no vehicle will be allowed to enter the area.

• If 100>UP Counter>80 & 20>Down Counter>0, then yellow light will be shown i.e. vehicles will be told to be ready to enter the area.

• If UP Counter<60 & DOWN Counter>40, then green light will be shown i.e. vehicles will be allowed to enter the area.

C. SCADA view of proposed method

The method used In Touch Software by Wonder ware in this method. There are two SCADA views:

1. Showing congestion & diversion in city.

2. Showing traffic status & diversion for vehicles at Toll Booth.

The proposed Intelligent Traffic Light Control System For Blind Spots on the road utilized some of the processes and functional characteristics of most of the related works being mentioned, as it measured the traffic density by counting the number of vehicles on each lane and their weight, then park in automated parking or diverge them accordingly like that of Mohit et al. Also the Intelligent Traffic system is similar to that of Sabhijiit et al as its performance is greatly dependent on its ability to react to changing traffic patterns and different situations (number of vehicles and distance of vehicles). Moreso, it is an adaptive traffic control system that determines its traffic timing plans based on real-time information received from vehicle detectors located on the approaches to signalized intersections which makes it similar to that practiced in Toronto.

Here, in this work, the developed system is unique in its functions and processes as it has different approaches for heavy traffic, light traffic and no traffic at all, based on three variables ; Distance, number of vehicles and Time.

CHAPTER THREE

DESIGN METHODOLOGY

3.1 Overview of the Intelligent Traffic Control System

The proposed Intelligent Traffic Control System is majorly for blind spots on the road. The system would comprise of software and hardware components. The processes involved in this system are based on three variables Distance, Number of Vehicles and Time. There would be two traffic light placed at both ends of the bend road, Light A and Light B, Both interconnected, A receives input signal from sensors at point B and signifies at point A as light signal and vice versa.

3.2. Hardware

Components used in actualization of this project include;

Programmable Microcontroller (ATMEL):- Atmel was used because the system is going to be programmed on an arduino. Also it has a delivering ease-of-use, low power consumption and a high level of integration. They are optimized to reduce time to market, they are based on the industry's most code-efficient architecture for C and assembly programming. No other microcontroller delivers more computing performance with better power efficiency.

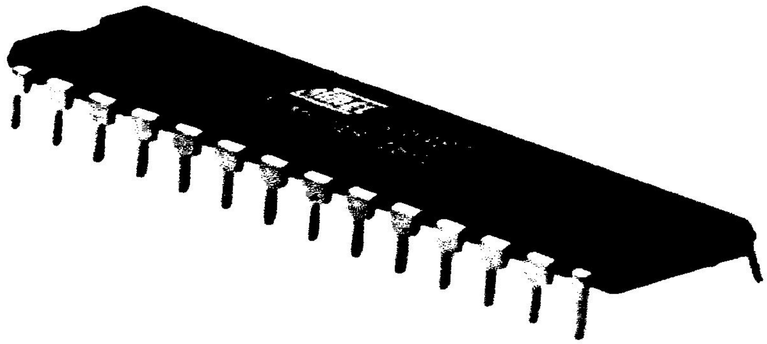


Figure 3.1: Atmel AtMega8

Sensors: - There are several sensors that can be used for vehicle detection which include: Acceleration detectors, Magnetic Detectors, Inductive loop detectors, Spread-spectrum wideband radar, photoelectric, Piezoelectric Detectors, Passive Acoustic Detector Arrays, Microwave/Millimeter wave radar, Ultrasonic detectors, Infrared Sensors, Video Image Processors.

An Infrared sensor was used for the prototype. An infrared sensor is an electronic instrument which is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared radiation. There are two types of infrared (IR) detectors, active and passive. Active infrared sensors operate by transmitting energy from either a light emitting diode (LED) or a laser diode. An LED is used for a non-imaging active IR detector, and a laser diode is used for an imaging active IR detector. In both types of detectors the LED or laser diode illuminates the target, and the reflected energy is focused onto a detector consisting of a pixel or an array of pixels. The measured data is then processed using various signal-processing algorithms to extract the desired information. Active IR detectors provide count, presence, speed, and occupancy data in both night and day operation. The laser diode type can also be used for vehicle classification because it provides vehicle profile and shape data. A passive infrared system detects energy emitted by objects in the field of view and may use signal-processing algorithms to extract the desired information. It does not emit any energy of its own for the purposes of detection. Passive infrared systems can detect presence, occupancy, and count.

Some of the advantages of infrared detectors are that they can be operated during both day and night, and they can be mounted in both side and overhead configurations.

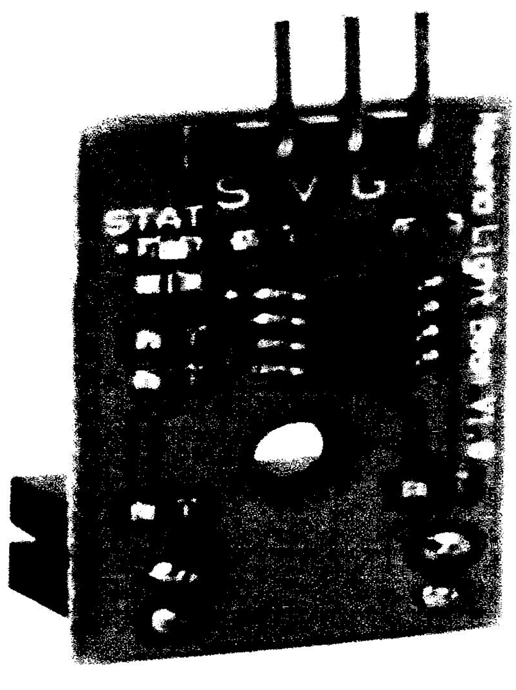


Figure 3.2: Meeno Infrared Radiation Sensor Module for Arduino

Indicator Lights:- Basically Light Emitting Diode (LED), it is a p–n junction diode that emits light when activated which includes the green LED, red LED and yellow LED. I am making use of LEDs because of its lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching, also it is inexpensive.

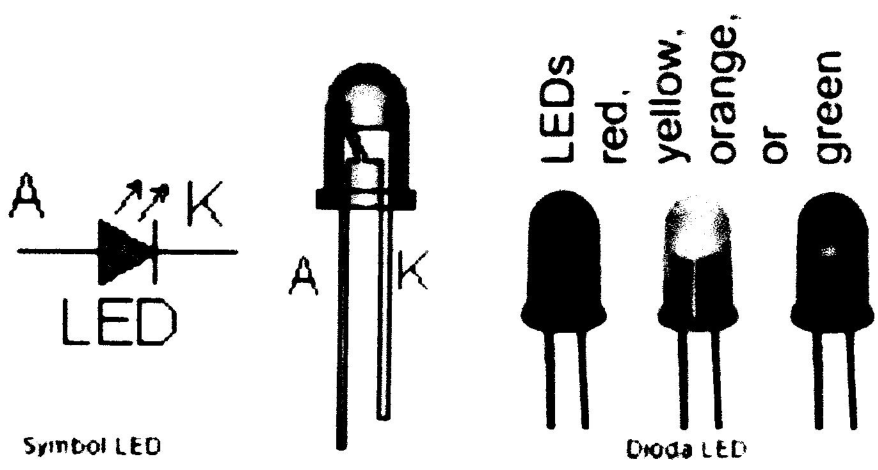


Figure 3.3: Types of LED

Power Supply:- A 9V battery was used for the prototype.

Other Components includes; 2 stands (where my LEDs would be mounted on), Resistors, Capacitors, Voltage Divider, voltage and current resistors.

3.2.1 Software

An Arduino was used to program the microcontroller.

Arduino is an open source, computer hardware and software company, project, and user community that designs and manufactures microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world. Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (*shields*) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment(IDE) based on the Processing language project.

Arduino microcontrollers are pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory. The default boot loader of the Aduino UNO is the optiboot boot loader. Boards are loaded with program code via a serial connection to another computer. Some serial Arduino boards contain a level shifter circuit to convert between RS-232 logic levels and transistor–transistor logic (TTL) level signals. Current Arduino boards are programmed via Universal Serial Bus (USB), implemented using USB-to-serial adapter chips such as the FTDI FT232. Some boards, such as later-model Uno boards, substitute the FTDI chip with a separate AVR chip containing USB-to-serial firmware, which is reprogrammable via its own ICSP header. Other variants, such as the Arduino Mini and the unofficial Boarduino, use a detachable USB-to-serial adapter board or cable, Bluetooth or other methods, when used with traditional microcontroller tools instead of the Arduino IDE, standard AVR in-system programming (ISP) is used. (Optiboot, 1999)

The Arduino board exposes most of the microcontroller's I/O pins for use by other circuits. The *Diecimila*, *Duemilanove*, and current *Uno* provide 14 digital I/O pins, six of which can produce pulse-width modulated signals, and six analog inputs, which can also be used as six digital I/O pins. These pins are on the top of the board, via female 0.1-inch (2.54 mm) headers. Several plug-in application shields are also commercially available. The Arduino Nano, and Arduino-compatible Bare Bones Board and

Boarduino boards may provide male header pins on the underside of the board that can plug into solderless breadboards.

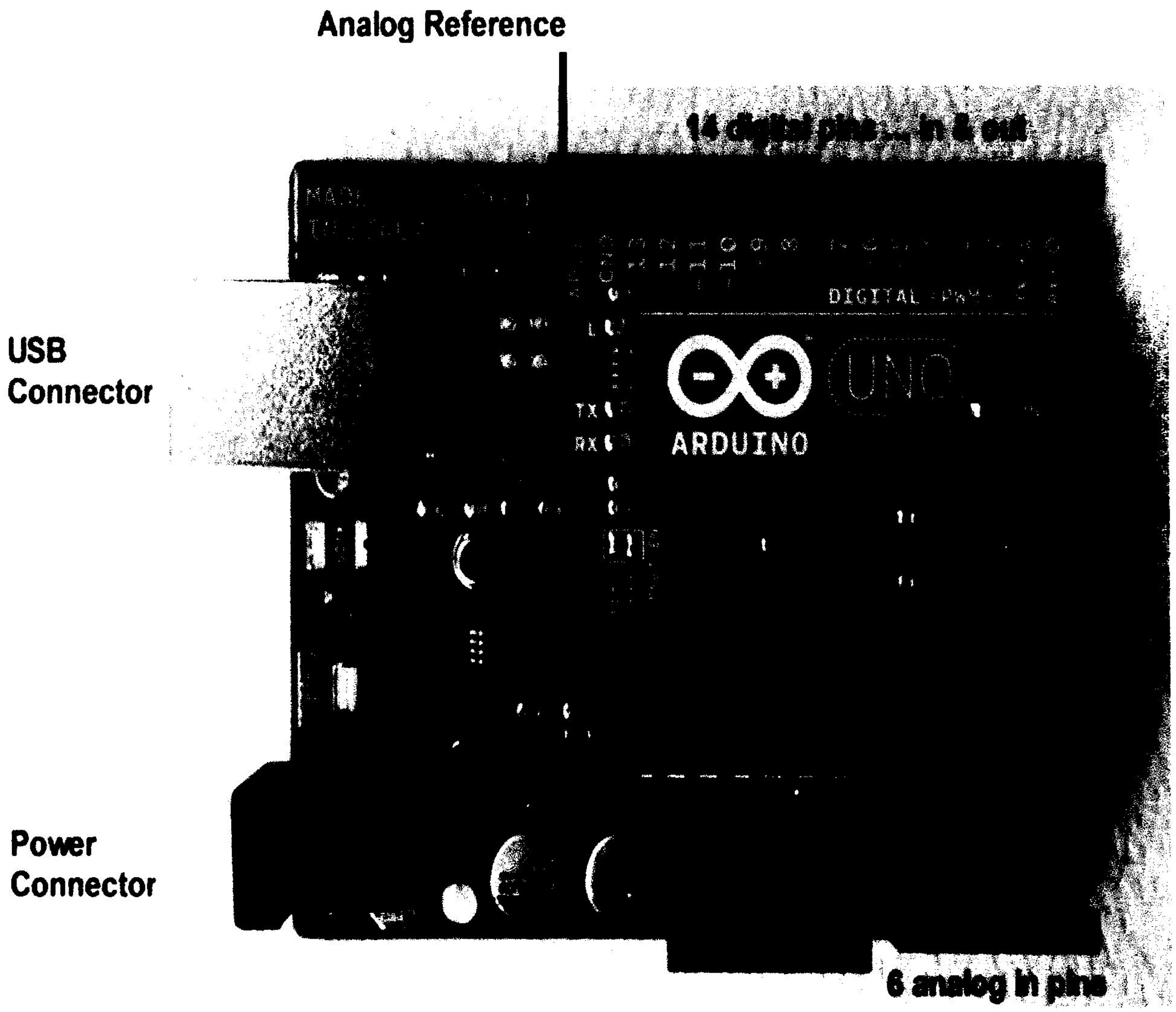


Figure 3.4: An Arduino Uno R2 with descriptions of the I/O locations

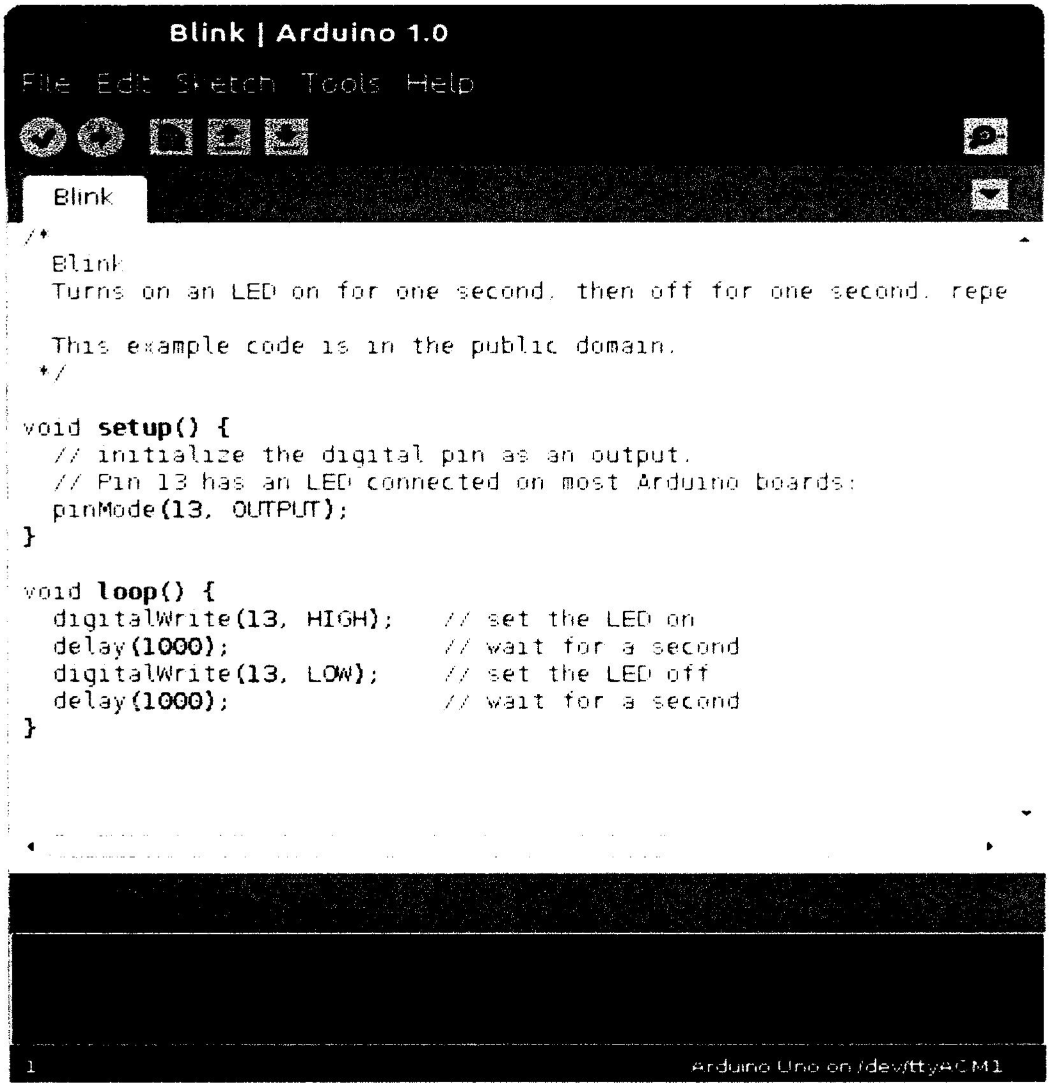


Figure 3.5: Arduino Software IDE

A minimal Arduino C/C++ sketch, as seen by the Arduino IDE programmer, consists of only two functions:

- *setup()*: This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.
- *loop()*: After *setup()* has been called, function *loop()* is executed repeatedly in the main program. It controls the board until the board is powered off or is reset.

Most Arduino boards contain a light-emitting diode (LED) and a load resistor connected between pin 13 and ground, which is a convenient feature for many tests and program functions. (Arduino, https://www.arduino.cc/en/Reference/Loop, 2000)

Arduino Software Development

A program for Arduino may be written in any programming language for a compiler that produces binary machine code for the target processor. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio. (Arduino, Using Atmel Studio for Arduino development"., 2005)

The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the Java programming language. It originated from the IDE for the languages *Processing* and *Wiring*. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple *one-click* mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus.

A program written with the IDE for Arduino is called a *sketch.* (McGraw-Hil, 2011) Sketches are saved on the development computer as text files with the file extension *.ino*. Arduino Software (IDE) pre-1.0 saved sketches with the extension *.pde*.

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub *main()* into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program *avrdude* to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

The Programmed Arduino Uno chip would be removed from the Arduino board and placed in the IC socket on the Programmable Circuit Board (PCB).

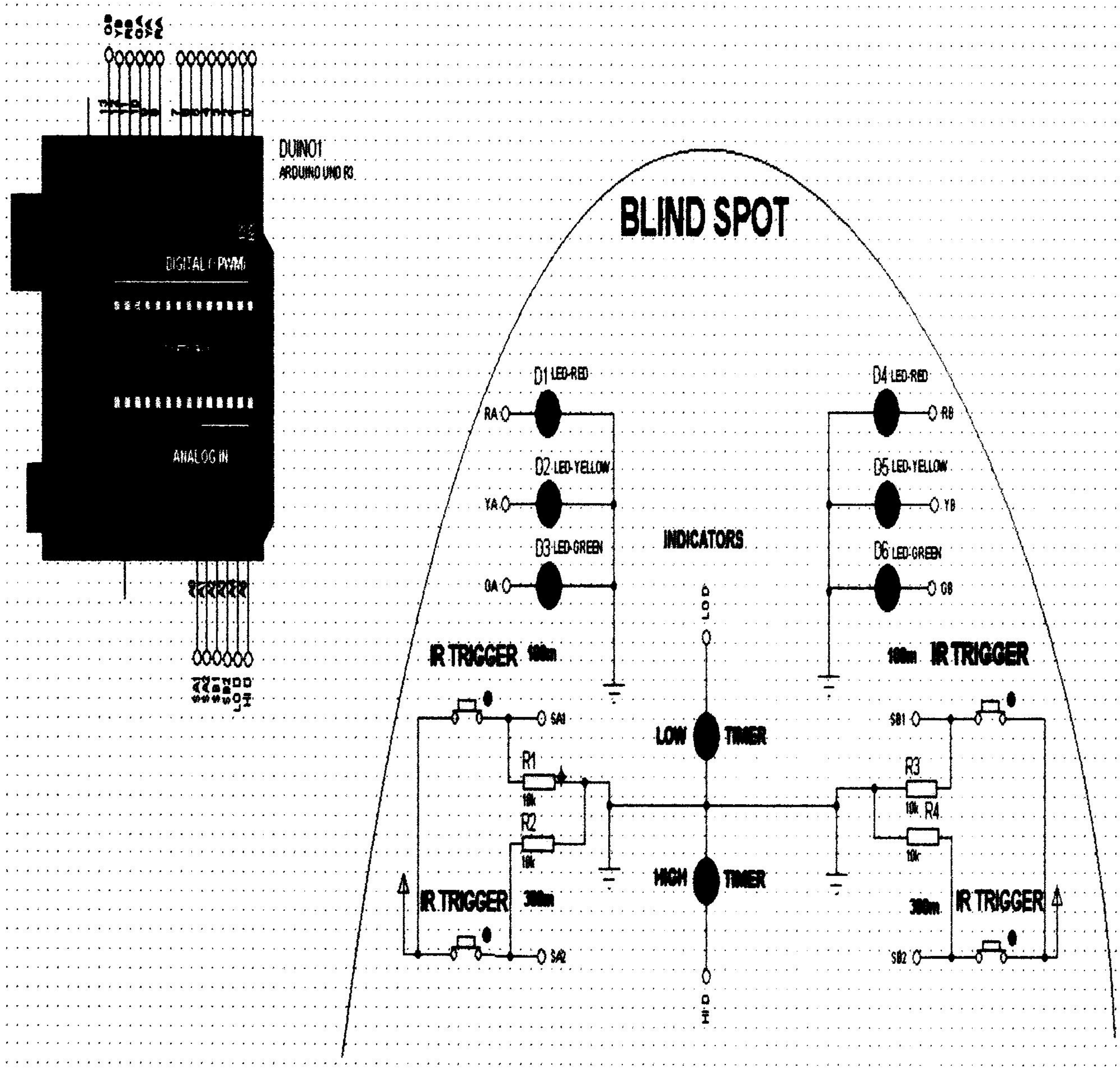


Figure 3.6: Circuit Diagram

3.3 Algorithm

1. Start
2. Sensor A and B receives signals at both ends
3. Sends the message to the microcontroller
4. Microcontroller compares both signals from A and B
5. A. Heavy Traffic Regime; Compare the number of vehicles at A and B

    I. If Vehicles at A is much more than vehicles at B, Let A go first.

    II. Else Let B go first

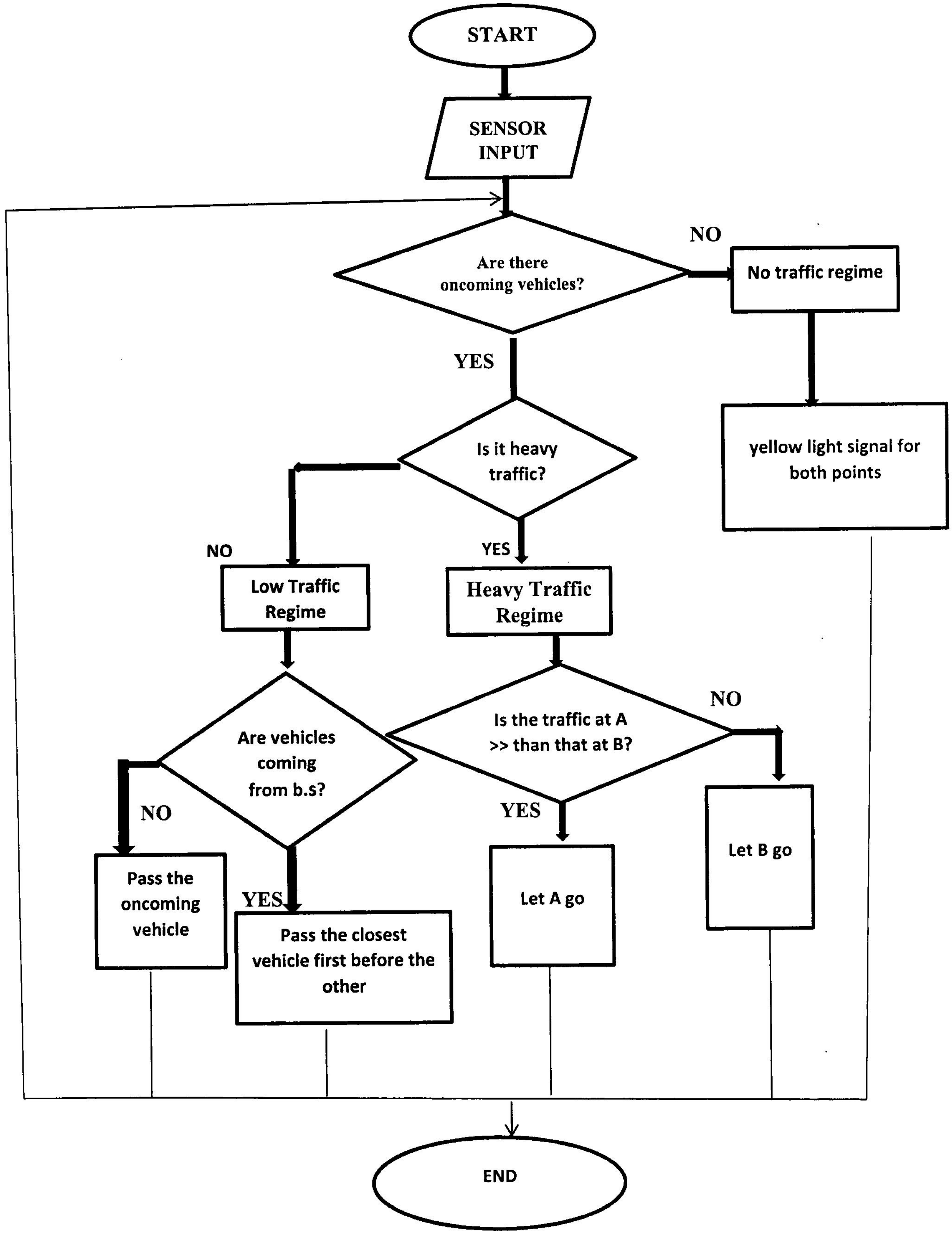
    B. Low Traffic Regime; when number of vehicles at A is same with number of vehicles at B, then compare their distance

    I. When of the same Distance, let the first vehicle to arrive within the range of the sensor go first

    II. When of different distance, Let the vehicle closest to the light signal go first before the other

    C. No Traffic Regime; When no Vehicle, Yellow Light signal for both point
6. End

3.4 Flowchart of the Light Signal



3.5 Positioning of the Light Signal

There would be two traffic light signals each placed at both road bend as seen in figure 3.1 above, this positioning is best for such roads because it enables drivers to get notified about possible oncoming vehicles before they get to the blind spot as this aids in totally eliminating any occurrence of accidents. This is shown in the figure below;

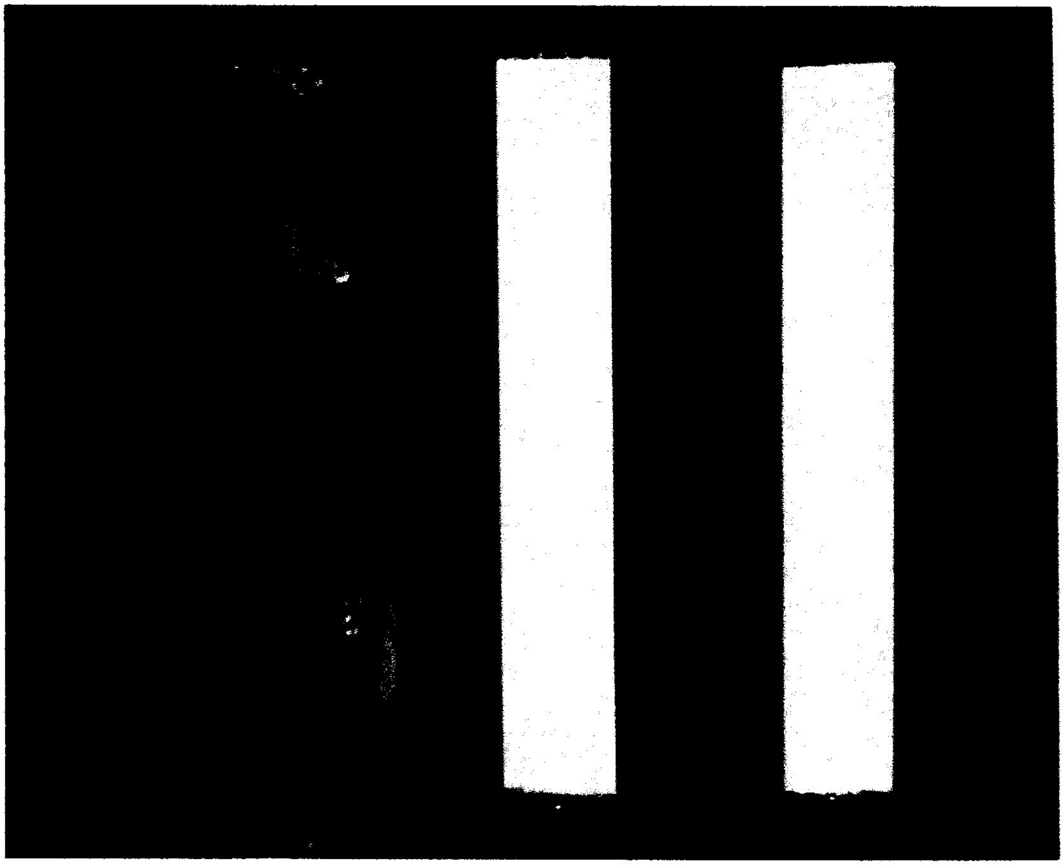


Plate 3.1: The position of the light signals

3.6 System Performance

The process of the Intelligent Traffic System is Based on three variables; Distance, Number of vehicles and Time

Distance: - The system measures the distance between the oncoming vehicle and the light signal in real time operations at both ends of the road, this attribute is one of its intelligent feature as it is able to tell at what point (either A or B) is the vehicle closer to the traffic light, the closer vehicle is allowed to go first (green light signal) before the other. This process is achieved by placing the two (2) Infrared sensors at both point A and B away from the light signal, on both ends on the road. For this project, the sensors would be placed at 400m away from the light signal; Sensor 1 is placed 300m and sensor 2 is placed 100m, when a vehicle comes within the range of the sensor at one end A; it senses it and transmits the signal to the microcontroller which then compares the signal sent by the sensor at the other end B. The vehicle closer would then be allowed to go first before the other, that is, If the vehicle at point A is closer, a green light signal would be displayed on the LED at point A and a red light signal would be displayed at point B, this light displays for steady 45 seconds before switching a green light signal for B and RED signal for A.

Number of vehicles: - The proposed system also exhibits and displays its Intelligence as it is able to calculate the number of vehicle approaching the blind spots at both ends in real time. When a vehicle comes within the range of the sensor (IR), it sends a HIGH (1) signal to the microcontroller and if there are no vehicles the signal are LOW (0), when there are 3 vehicles at one point it sends 3 HIGH (1) signals to the microcontroller. In cases when the vehicles at both point A and B are of the same distance, this criterion determines the passage of the vehicles as the point with more vehicles is allowed to go first before the other. 45 seconds is also allocated each for such circumstances. This variable is mostly exhibited when there is heavy traffic.

Time: - This variable is rather an independent variable, which is dependent on the number of vehicles, the process involved is to consider instances when there are no oncoming vehicles, the default light signal is yellow which is not indicating go nor stop. The purpose for this is to curb the menace of reckless drivers; this forces such drivers to slow down when approaching the light signal, the yellow light signal persist until a vehicle comes within the range of the sensor then its processes begins.

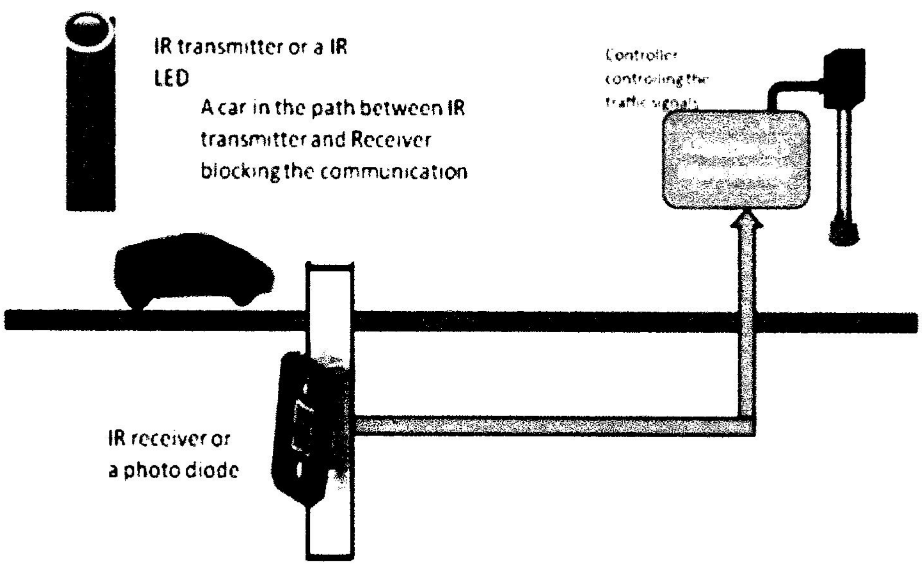


Figure 3.7: A dynamic process of one section of the proposed system

Both light signals are interconnected together and they are always in communication with each other at every point in time.

CHAPTER FOUR

RESULT AND ANALYSIS

4.1 Results

For effective and efficient control of traffic on blind spots on the road, the system would be based on three traffic regimes; heavy traffic, low traffic and no traffic regime. This explains the Intelligence of the system.

No Traffic: at this regime it means there is no oncoming vehicle (no vehicle is within the range of the sensor 100m away from the light signal). In this regime, the traffic light shows yellow at both ends of the road. The diagram below in the stimulation explains the process. Here, the traffic light shows amber at both ends as seen in the simulation result of figure 4.1

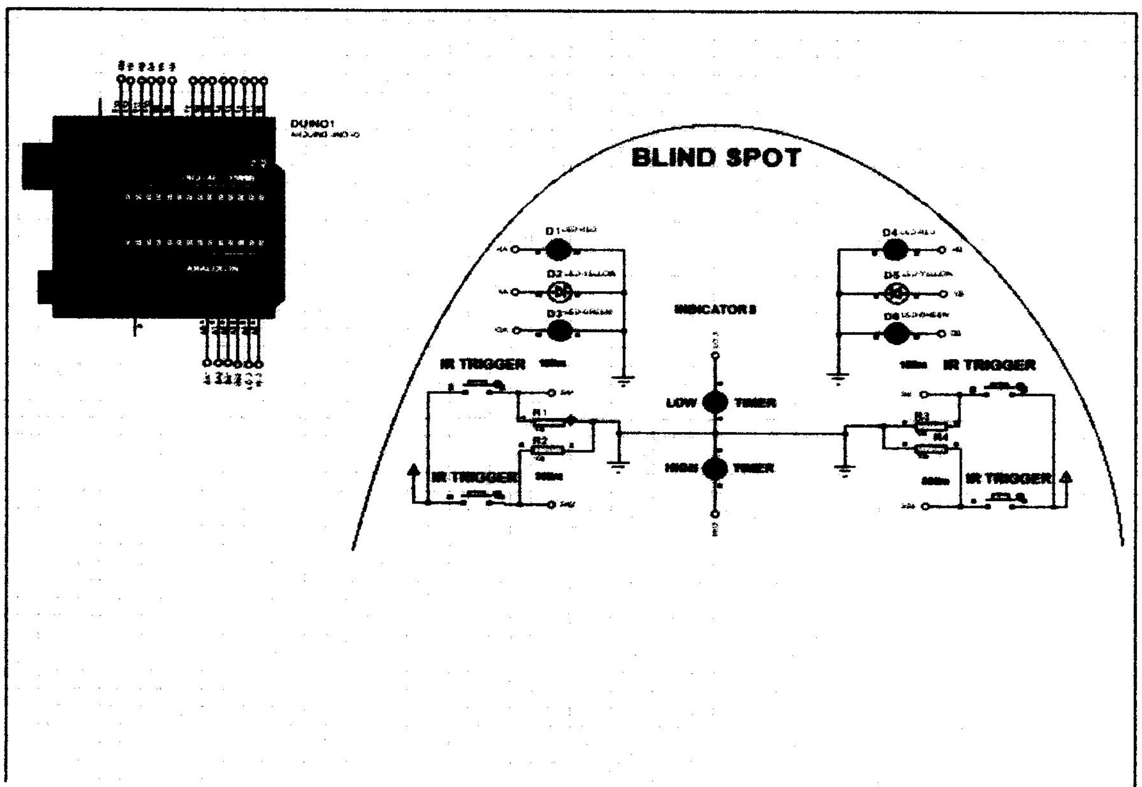


Figure 4.1: simulation for no traffic regime

Heavy Traffic

This is based on the variable; number of vehicle. When the traffic is heavy at both lanes, the system would detect which lane that has more number of vehicles and allow that lane to go first before the other, until the vehicle at one lane becomes lesser than the other. But since the sytem is also dependent on time, the system measures also the time in which the vehicle arrives within the range of the sensor, this solves the case of when one lane remains busy.The sensor allows vehicles at the othe lane to pass by repeatedly measuring their time of arrival. The diagram below shows heavy traffic at point B, that is, more vehicles at B, a green light signal is used to give passage to the vehicle at that point and a red light at the other point signifying "stop".

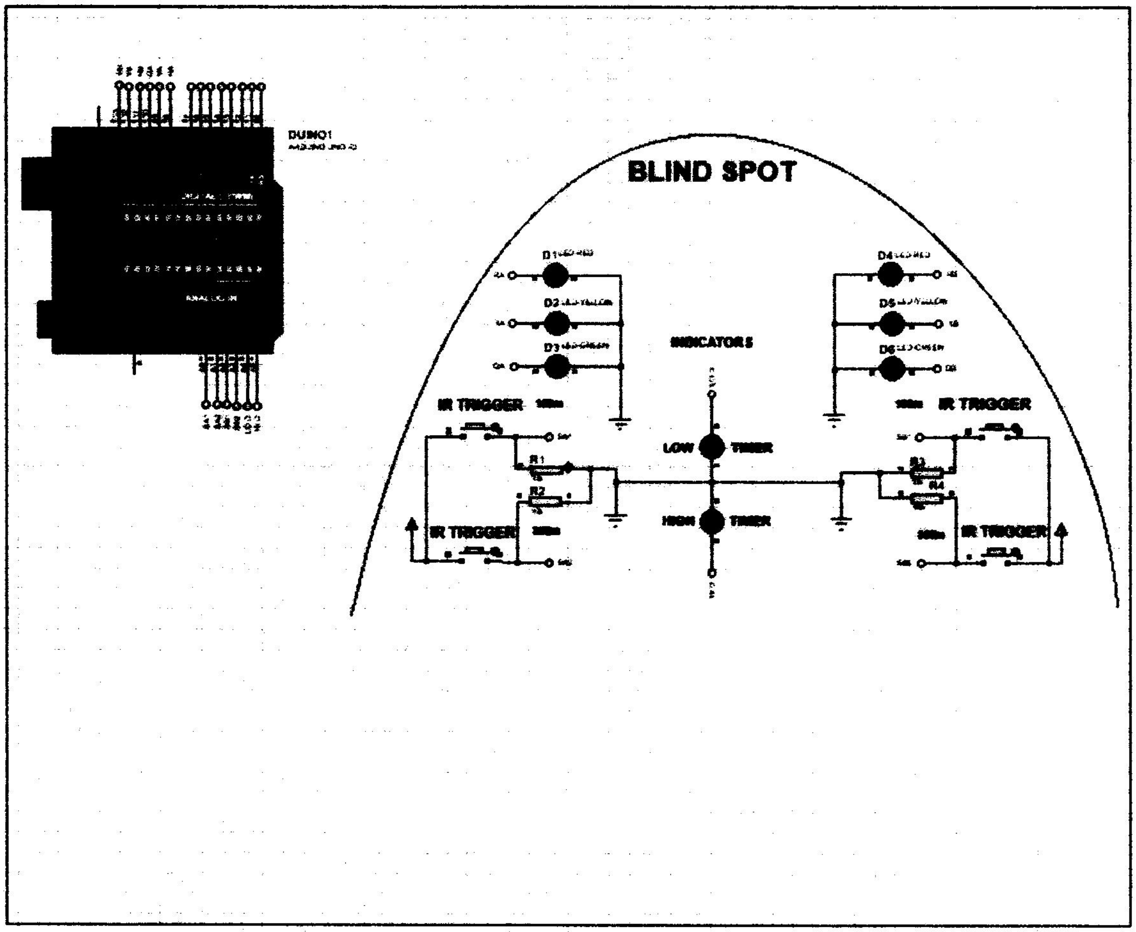


Figure 4.2: simulation of heavy traffic at "B"

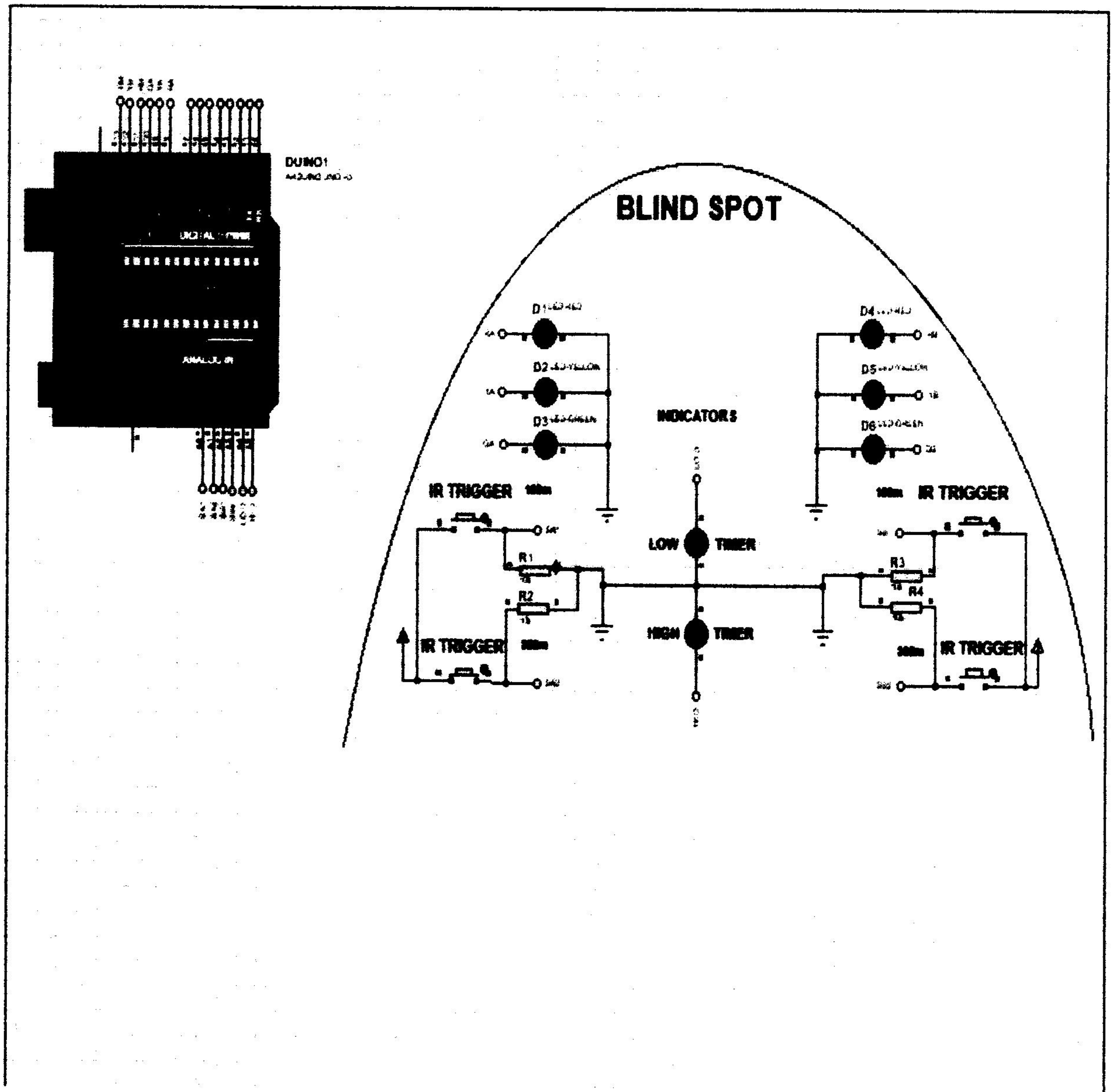


Figure 4.3: Simulation of heavy traffic at "A"

Figure 4.3 shows Heavy traffic regime at point A

Low Traffic

This is based on the variable; distance of vehicle. When there is not much vehicle at both lanes, the system would detect which vehicle arrives within the range of the sensor first and allows that lane to go first before the other. The figures below shows low traffic regime at points A and B respectively.

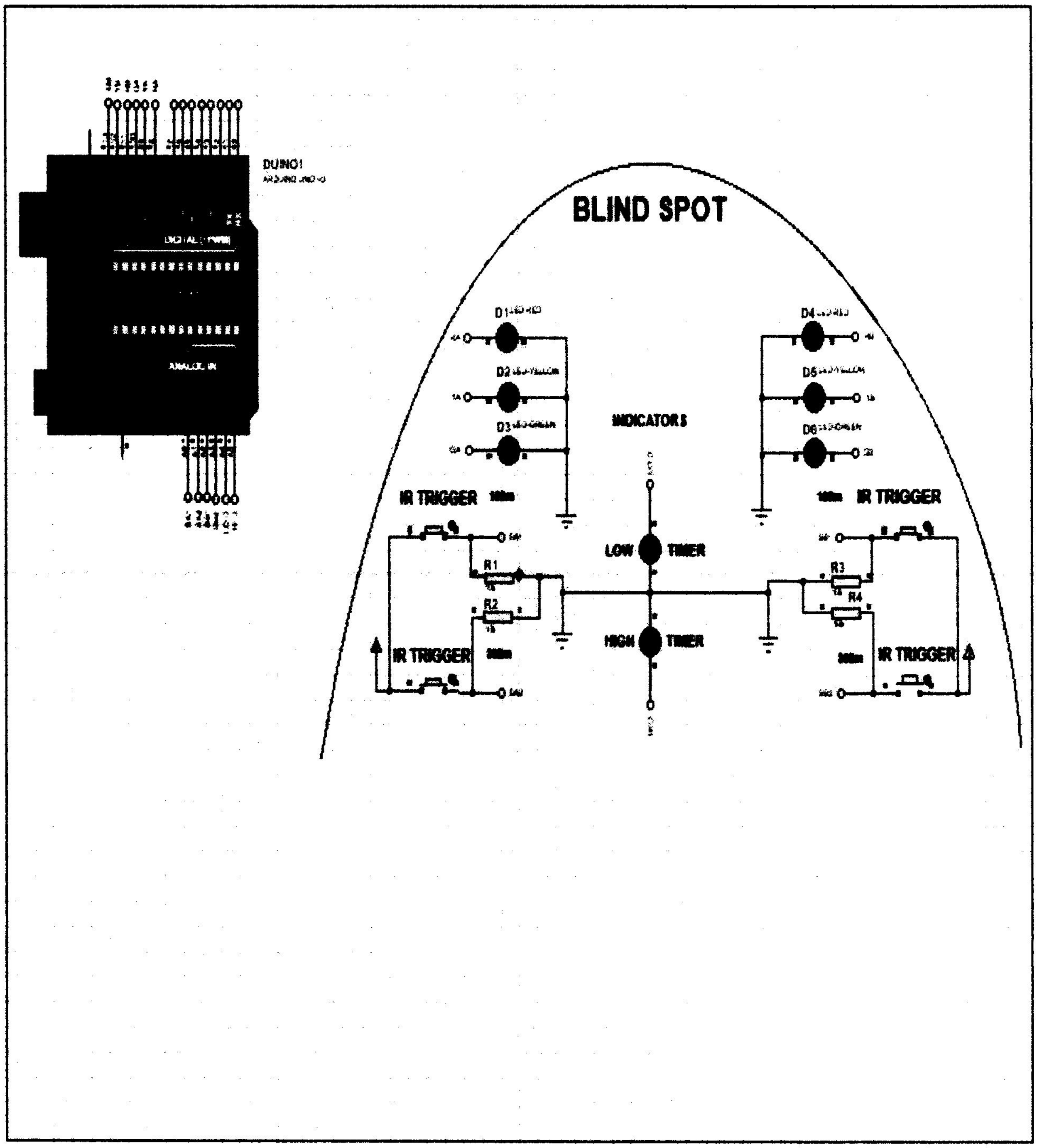


Figure 4.4: Simulation of low traffic at "A"

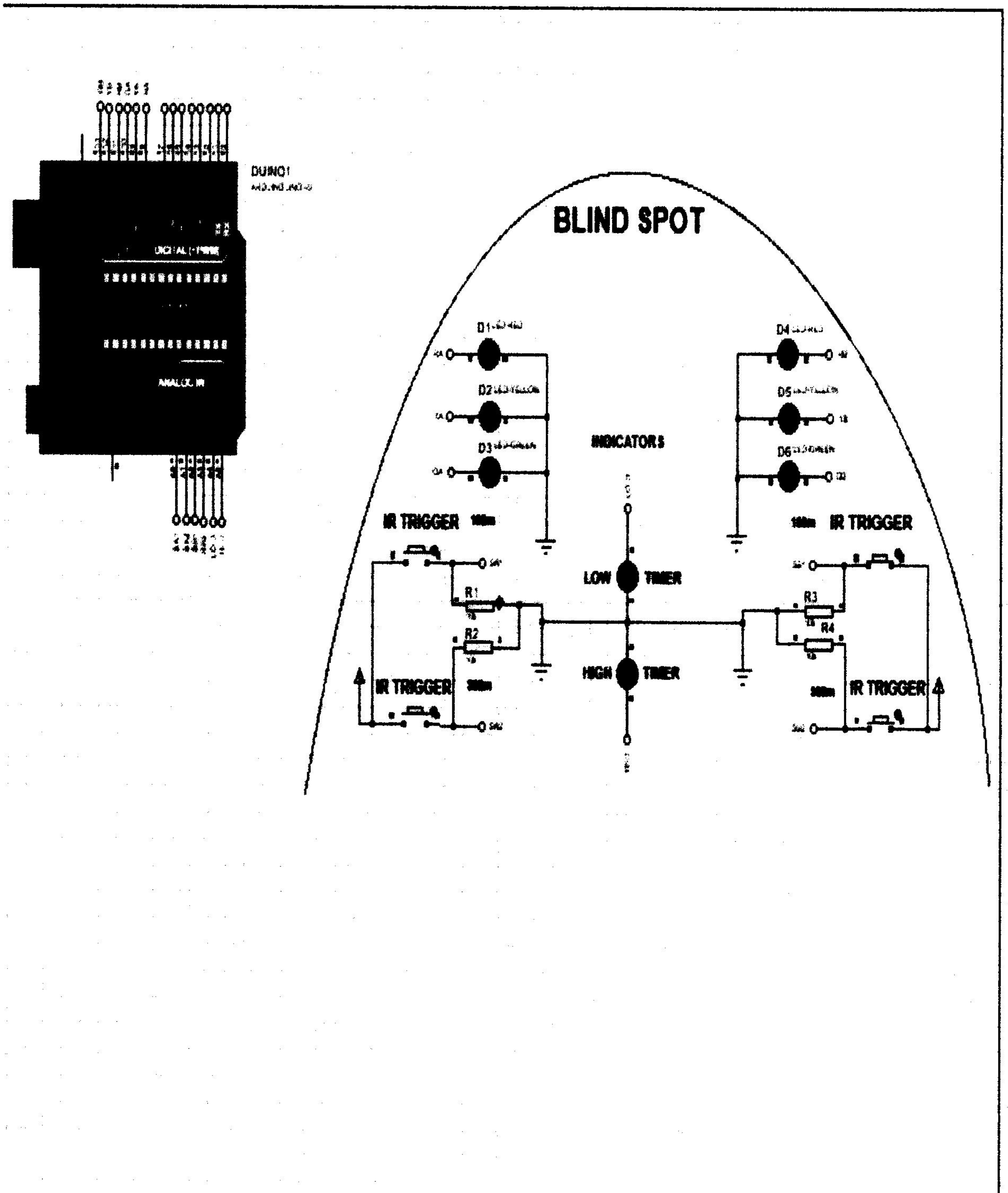


Figure 4.5: Simulation of low traffic at B

4.2 ANALYSIS

4.2.1 Hardware Prototype

The microcontroller is inserted to its pouch on the Project Circuit Board (PCB), after being booted from arduino as shown in the diagram below;

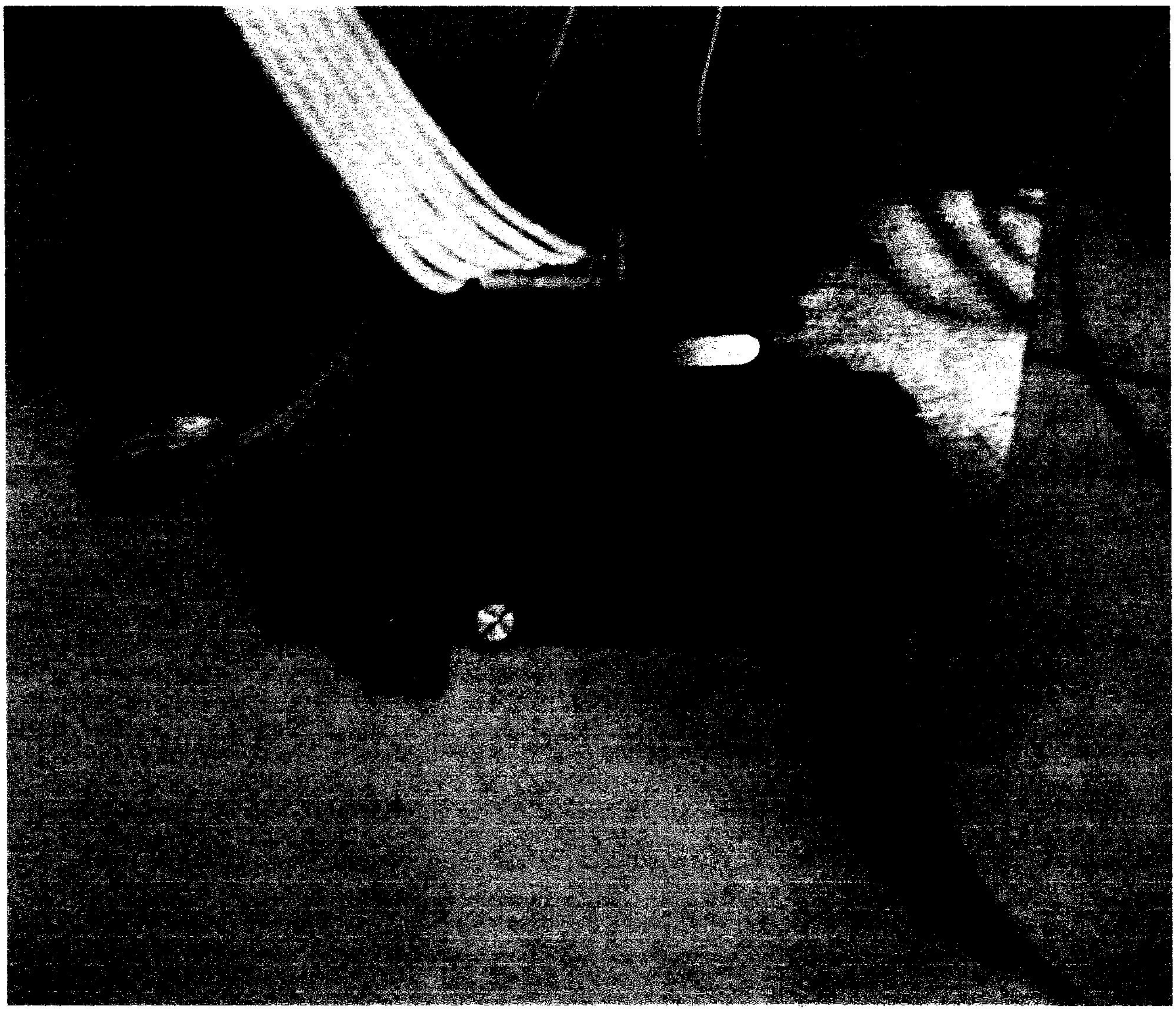


Plate 4.1: The booted microcontroller in its pouch on the PCB

There are two sensors at both ends each placed at 400m and 100m respectively, away from the light signal as shown in the diagram below;

Plate 4.2: The positions of the Sensors

Plate 4.3: back view of the prototype showing the connections

Plate 4.4: front view of the prototype

4.2.2 Software

The system was programmed on an arduino, the entire codes can be found in the appendix of this report.

4.3 Testing

The system was tested at both indoor (with little or no light) and outdoor (with more light) and the system performed better indoors because of transient light that affects the infrared sensors. The system runs continuously so far it is powered on.

The system function was tested based on these rules:

- More vehicles at A? A goes,
- If more vehicles at B? B goes,
- Car at A arrives first? Car A goes first, else, Car B goes
- When no oncoming vehicle, yellow light signal.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The system is an efficient and highly economic solution to traffic problems on road blind spots in Nigeria, where exponentially increasing traffic is a growing concern. The system is easy to implement, doesn't involve a great deal of complex computation, takes into account real world parameters and almost accurately determines when there is heavy traffic, low traffic and no traffic.

The system which was designed using infrared sensors to monitor vehicles on road bends was implemented and tested using toy-like cars acting as real cars in real life scenario and decisions are made by the microcontroller based on the system's rules.

The Intelligent change of state using rule based method is successful in solving the issue of fixed timing controller in controlling traffic and consequently will minimize the traffic congestion on the bend roads. The use of real time data obtained through Infrared sensor technique that serves as input to traffic light will be an innovative way of controlling traffic volume on blind spots in developing countries.

5.2 Limitations and Challenges

While this intelligent traffic control system can benefit commoners on the road, there are also some limitations to using this system; `

- The sensor (IR) is affected by excess transient light and this causes abnormality in the input signals it sends to the microcontroller.

- Due to the abnormality in the input, the output which is the light signal would be incorrect at both ends of the road and this can cause more road congestions or/and accident.
- The sensor (IR) is absorbed by certain materials such as glass etc., also the absorbance of light depends very much on the wavelength, so a perfect material was needed to demonstrate as a vehicle that doesn't absorbs Infrared radiation so as to get the right results.

5.2 Recommendation

This project can be enhanced in such a way as to control automatically the signals depending on the traffic density on the roads using sensors like IR detector/receiver module extended with automatic turn off when no vehicles are running on any side of the road which helps in power consumption saving.

In future this system can be used to inform people about traffic conditions at different places. This can be done through radio. Data transfer between the microcontroller and computer can also be done through telephone network, data call activated SIM, this technique allows the operator to gather the recorded data from a far end to his home computer or smart phone application without going there.

The system's traffic lights can be powered by electricity and have an automatic backup power as solar when electricity supply goes off suddenly, this way the system would be more reliable.

Reference

Abdel-Rahim, A. (1998). "The Impact of SCATS on Travel Time and Delay," paper presented at the 8th ITS America Annual Meeting, Detroit Michigan.

Administration, F. H. (2005). Federal Highway Administration, Traffic Control Systems Handbook, . pp. p. 3-93. ITS Benefits Database Entry: www.itsbenefits.its.dot.gov/its/benecost.nsf/0/74754268229175D98525726000678C76.

Arduino. (2000). https://www.arduino.cc/en/Reference/Loop. Retrieved April 19, 2017, from Arduino.cc

Arduino. (2005). Using Atmel Studio for Arduino development". Retrieved April 30, 2017, from Megunolink.com

Barr, M. (2007). Michael Barr. "Embedded Systems Glossary". Retrieved 2017-04-21.: Neutrino Technical Library.

Beattie, A. (2011). "What is the difference between artificial intelligence and neural networks?" Technopedia.

Blind spot definition". (n.d.). Retrieved April 25, 2017, from . Thefreedictionary.com: Blind spot definition"/ Thefreedictionary.com

Calvert, J. (1999). "Centralized Traffic Control." Paper presented at 5th IEEE International Conference on Intelligent Transportation Systems.

Center, T (2003). "Adaptive Control Software," . Turner-Fairbank Highway Research Center Report No. HRTS-04-037. Washington, DC: Document: ops.fhwa.dot.gov/publications/adaptivecontrol.

Coleman. (2015). Timingbased on Artificial Neural Networks". Paper presented at 17th IEEE International Conference on Intelligent Transportation Systems.

Dai, Y. H. (2011). "Neural network based online traffic signal controller design with reinforcement training". Intelligent Transportation Systems (ITSC),1045-1050. Paper presented at 14th International IEEE Conference. Washington.

Driving in America. (2014). Retrieved April 16, 2017, from What is USA News. Wikipedia.com.

Edition, M. (2009). MUTCD Edition: Chapter 4D, item D of paragraph 3 states specifically, "A flashing green signal indication has no meaning and shall not be used.

Giovino, B. (2008). Embedded Systems supersite. Retrieved (2017, April 15) from www.Microcontroller.com.

Jones, N. (2011). "Police question traffic control costs". Aldergrove Star. US. Retrieved from www.Techtarget.com

Kator, Z. (2015). "traffic control" Paper presented at 12th IEEE International Conference on Intelligent Transportation Systems.

"Learning Traffic Light Control Policies". Retrieved (2017, April 15), from Wikipedia.com

Mbawike, N. (2007). Mbawike, N. (2007). 7 Million Vehicles Operate On Nigerian Roads – FRSC. LEADERSHIP Newspaper, Posted by Nigerian Muse Projects.

McGraw-Hil. (2011). Programming Arduino Getting Started with Sketches. Retrieved April 29, 2017, from www.Techtarget.com.

McNeil, I. (1996). Biographical dictionary of the history of technology. Taylor & Francis. pp. 404–5. ISBN 0-415-06042-7.

Michael P, (2014). "Optimization of Traffic Light Paper presented at 13th IEEE International Conference on Intelligent Transportation Systems .

Micheal O and Olumuyiwa A (2004). "Design and development of traffic light control" Paper presented at 13th IEEE International Conference on Intelligent Transportation Systems .

Motor. (2015). "Traffic lights in use before there were motorcars". Retrieved April 25, 2017, from didyouknow.org

Optiboot. (1999). Optiboot Bootloader for Arduino and Atmel AVR". . Retrieved April 17, 2017 from www.Techtarget.com.

Origins and Globalization, 2017. Retrieved April 08, 2017, from The Origins and Globalization of Traffic Control Signals: Sites.Tufts.edu

Patel, M. &. Dessre (2001). "IDUTC: An Intelligent Decision-Making System for Urban Traffic-Control Applications". . IEEE Transactions on Vehicular Technology, 50(3), 816-829.

Sarah. (2004). Senate Bill 84 XX Battery Backup Program for Light Emitting Diode (LED) Traffic Signals" (PDF). California Energy Commission. California.

Uriel. S. (1999). "National Transportation Operations Coalition" Retrieved June 30, 2017, from didyouknow.org.

Tanny S. (2006). Minnesota Department of Transportation paper presented at the 8th, ITS America annual meeting, Detroit Michigan.

Tech. (2015). http://whatis.techtarget.com/definition/intelligent-system. Retrieved April 20,2017,fromhttp://whatis.techtarget.com:http://whatis.techtarget.com/definition /intelligent-system

Transportation, N. Y. (September 2003.). Syracuse Signal Interconnect Project: Before and After Analysis Final Report. Syracuse, NY: ITS Benefits Database Entry.

Ugwu. (2009). Over 7 Million Vehicles Ply Nigerian Roads Daily- Filani. Champion Newspapers, Nigeria 2nd October 2009. Posted by AllAfrica.com project. Nigeria.

APPENDIX I

```
const int SA1Pin = 14;

const int SA2Pin = 15;

const int SB1Pin = 16;

const int SB2Pin = 17;

int SA1State = 0;

int SA2State = 0;

int SB1State = 0;

int SB2State = 0;


//LED Pin Variables

int ledPins[] = {8, 9, 10, 11, 12, 13, 18, 19}; //An array to hold the pin each LED is connected to

//i.e. LED #0 is connected to pin 2, LED #1, 3 and so on

//to address an array use ledPins[0] this would equal 2

//and ledPins[7] would equal 9


// The setup() method runs once, when the sketch starts

void setup()

{

 pinMode(SA1Pin, INPUT);

 pinMode(SA2Pin, INPUT);

 pinMode(SB1Pin, INPUT);

 pinMode(SB2Pin, INPUT);

 // read the state of the pushbutton value:
```

```
 // initialize the digital pin as an output:
 pinMode(ledPins[0], OUTPUT);
 pinMode(ledPins[1], OUTPUT);
 pinMode(ledPins[2], OUTPUT);
 pinMode(ledPins[3], OUTPUT);
 pinMode(ledPins[4], OUTPUT);
 pinMode(ledPins[5], OUTPUT);
 pinMode(ledPins[6], OUTPUT);
 pinMode(ledPins[7], OUTPUT);
}
// the loop() method runs over and over again,
// as long as the Arduino has power
void loop()
{
 // read the state of the pushbutton value:
 SA1State = digitalRead(SA1Pin);
 SA2State = digitalRead(SA2Pin);
 SB1State = digitalRead(SB1Pin);
 SB2State = digitalRead(SB2Pin);
 // check if the pushbutton is pressed.
 // if it is, the buttonState is HIGH:
 if (SA2State == 0 && SA1State == 0) {
   apr_d2();
 }
```

```
 else {
  if (SB2State == 0 && SB1State == 0 ) {
   bpr_d2();
  }
  else {
   if (SA1State == 0) {
    apr_d();
   }
   else {
    if (SB1State == 0) {
     bpr_d();
    }
    else {
     digitalWrite(ledPins[1], HIGH);   // set the LED on
     digitalWrite(ledPins[4], HIGH);   // set the LED off
     delay(2);
    }
   }
  }
 }
}
void apr_d()
{
 digitalWrite(ledPins[1], HIGH);   // set the LED on
```

```
 digitalWrite(ledPins[4], HIGH);   // set the LED off
 digitalWrite(ledPins[2], HIGH);  // set the LED on
 digitalWrite(ledPins[3], HIGH);   // set the LED off
 digitalWrite(ledPins[6], HIGH);   // set the LED off
 delay(500);
 digitalWrite(ledPins[1], LOW);  // set the LED on
 digitalWrite(ledPins[4], LOW);   // set the LED off
 delay(1000);                // wait for a second

 digitalWrite(ledPins[2], LOW);  // set the LED on
 digitalWrite(ledPins[3], LOW);   // set the LED off
 digitalWrite(ledPins[6], LOW);
 // wait for a second
}

void bpr_d() {
 digitalWrite(ledPins[1], HIGH);  // set the LED on
 digitalWrite(ledPins[4], HIGH);   // set the LED off
 digitalWrite(ledPins[0], HIGH);  // set the LED on
 digitalWrite(ledPins[5], HIGH);   // set the LED off
 digitalWrite(ledPins[6], HIGH);
 delay(500);
 digitalWrite(ledPins[1], LOW);  // set the LED on
 digitalWrite(ledPins[4], LOW);   // set the LED off
 delay(1000);                // wait for a second
```

```
 digitalWrite(ledPins[0], LOW);   // set the LED on                // wait for a second
 digitalWrite(ledPins[5], LOW);    // set the LED off
 digitalWrite(ledPins[6], LOW);
 // wait for a second
}

void apr_d2()
{
 digitalWrite(ledPins[1], HIGH);  // set the LED on
 digitalWrite(ledPins[4], HIGH);   // set the LED on
 digitalWrite(ledPins[2], HIGH);  // set the LED on
 digitalWrite(ledPins[3], HIGH);   // set the LED off
 digitalWrite(ledPins[7], HIGH);
 delay(1000);
 digitalWrite(ledPins[1], LOW);  // set the LED off
 digitalWrite(ledPins[4], LOW);   // set the LED off
 delay(3000);             // wait for a second

 digitalWrite(ledPins[2], LOW);  // set the LED on
 digitalWrite(ledPins[3], LOW);   // set the LED off
 digitalWrite(ledPins[7], LOW);
 // wait for a second
}
```

```
void bpr_d2() {
 digitalWrite(ledPins[1], HIGH);  // set the LED on
 digitalWrite(ledPins[4], HIGH);   // set the LED off
 digitalWrite(ledPins[0], HIGH);  // set the LED on
 digitalWrite(ledPins[5], HIGH);   // set the LED off
 digitalWrite(ledPins[7], HIGH);
 delay(1000);
 digitalWrite(ledPins[1], LOW);  // set the LED on
 digitalWrite(ledPins[4], LOW);   // set the LED off
 delay(3000);              // wait for a second

 digitalWrite(ledPins[0], LOW);  // set the LED on                // wait for a second
 digitalWrite(ledPins[5], LOW);   // set the LED off
 digitalWrite(ledPins[7], LOW);
 // wait for a second
}
```

APPENDIX II

Qty.	Description	Cost (Naira)	Total (Naira)
4	DIODE,1N4001	50	200
1	ARDUINO	1,500	1,500
4	IR SENSOR	200	800
6	LED	150	900
2	CAPACITOR, 0.1uF	50	100
2	CAPACITOR, 30uF	50	100
1	CAPACITOR, 100uF	50	50
1	CAPACITOR, 2200uF	150	150
1	9 V BATTERY	150	150
4	RESISTOR, 10K OHM	50	200
1	PCB BOARD	200	200
1	CASING	3,500	3,100
4	SOLDERING LEAD	100	400
50	CONNECTOR/JUMPER WIRE	10	500
	TOTAL (Naira)		8,150