Density Based Traffic System via IR Sensor

*Nik Nur Shaaadah Nik Dzulkefli, Suziyani Rohafauzi, Afiza Nur Jaafer, Rina Abdullah, Rosmawati Shafie, Muhammad Shahmir Selamat, Nazrul Syafi Azman, and Muhammad Zakwan Zakaria Muhammad
Faculty of Electrical Engineering, Universiti Teknologi MARA, Terengganu
23000 Dungun, Terengganu, Malaysia

*niknu5502@uitm.edu.my

Abstract. This paper presents an inventive prototype design of a traffic light which is purposely used at junctioned roads since traffic light is the best way to supervise and manage traffic at any busy junction or intersection. This project is designed to develop a density based traffic signal system where its signal timing changes automatically after sensing the traffic density at the intersection. Traffic density is defined as the amount of vehicle congested at a certain place, in this case an intersection. The more vehicles available, the higher the traffic density is. This increasing number of vehicles on the road will produce many problems such as traffic jammed which will also drive to road accidents. Conventional traffic light uses fixed time which cause difficulties in controlling the traffic itself. In order to resolve this problem, design of this traffic light will help to reduce traffic jammed at a particular location. This traffic light uses an Arduino UNO microcontroller to create an automation function together with an Infrared sensor (IR sensor) to detect the density of the traffic. Each vehicle is set to 3 seconds. All vehicles pass through the traffic light is measured and processed accordingly to delays. If there is no vehicle on the road for at least 1 second, then it will change to another traffic light. By using this, all vehicles will be counted and interacted with the system thus increase delay period for the green light at each traffic light which may have high density of traffic. Thus, it will reduce problems which might root from traffic congestion at the intersection.

1. Introduction
In today’s challenging life, transportation has evolved to an important aspect in human’s activities day by day. The increasing number of vehicles on the road shows an economic growth of any country. However, this has also caused traffic congestion and road accidents thus becoming more difficult to control. Apart from traffic light, which might not be useful enough in controlling traffic efficiently, there is no current technology up to date that proved to control situations such as availability of vehicles at a certain lane compared to other lane making that certain lane crowded eventually.

According to a survey, violation of traffic rules and failure of the maintenance are reasons to major accidents worldwide [1]. The first traffic light was introduced in London in 1868 and from that moment they came into existence and now they were implemented with many existing techniques [2]. Traffic lights consist of three common colored lights. It consists of green light which allows traffic to proceed in the indicated direction, yellow light warns the road users to prepare for short stop, and last one red light signal prohibits any traffic from continuing [3].
There are many problems occurred with the conventional traffic light controller. One of them is heavy traffic jammed where there has not been any realization on how to measure the level of this ‘jammed’ thus pounder on the solution especially using time delay. Another problem with conventional traffic lights is when there is no traffic, but the waiting still continues [2]. Both development of economy and increasing population are factors contributor to traffic congestions. Traffic congestion is a condition on road networks that happened as the road users increased thus leading to slower speeds, longer trip times, and increased queuing time [4].

2. Literature Review

In the last few years, a large number of researches have been done to reduce problems regarding these jams. For example, a traffic light with microcontroller, ultrasonic sensor, automatic switch, manual controller switch, circuit and displayer which were functioning to handle all the system process, figure out jammed level in traffic, switch between manual and auto mode, control traffic light manually, make sure process happened and display the wanted output, respectively was created [5]. In 2014, a traffic light controlling system using microcontroller and light emitting diode (LED) was introduced by Ganiyu R. The microcontroller job is to receive a logic one instruction indicating that a switch, in this case a pressure switch sensed a weight of a car which passed on it. Each time microcontroller received logic one, time will be added to another 15 seconds and eventually trigger LED to light on at 15 seconds delay in that particular lane or traffic light [6].

Microcontroller also is used by Sachin Jaiswal in 2013, along with few IR sensors and modified arrangements put across the loads in purpose of sensing the traffic density. An RF transmitter and receiver are installed at both vehicle and traffic light control circuit, respectively to manipulate the traffic light. It comprises of three different jam levels namely high density, medium density and, low density [7]. Also in 2013, Rashid Hussian exhibits a system called Intelligent Traffic Routing using a Wireless Sensor Networks (WSN). This system incorporates microcontroller too along with WSN to manage traffic. According to his research, a vehicle can be route according to the density of traffic into the desired road if the presence of that traffic is sensed near any node [8].

Again in 2016, microcontroller and IR sensors were used [3]. In this research, dynamic timing slots with different level is proposed. A year after, in 2014, development of a dynamic traffic signal system according to density is established where upon sensing any traffic density at any junctions, signal timing will change automatically. Raspberry pi is used as its microcontroller which provides the signal timing based on the traffic density [6]. Moving forward to July 2017, traffic jammed was control via a camera system. In this research, series of free scale line scan cameras, a microcontroller named KL25Z microcontroller, FRDM board, sound sensor, LEDs and a software called MBED.ORG software were used [1]. These are all to obtain a better output.

This paper proposes a design of an automatic, save and efficient traffic flow. This project is to limit the vehicle based on density of the traffic at any junction when it comes to green light. The main problem of the present traffic control system are fixed time interval. Vehicles at the particular junction need to wait for a few minutes until the traffic light turn green to proceed due to the fixed time interval although the traffic at the junction is not so congest.

The main part of this circuit is an Arduino, which is connected to four IR sensors measuring the number of vehicles passing through road especially at the junction. Each car were set to 3 seconds, all the vehicles passing through the junction is measured and then processed accordingly to delays. Each sensor was set to a range of 100 meter from traffic light. If there is no car after 1 second it will turn to another traffic light. Thus, the green light will have longer delay time at the road with more traffic density which makes it possible for more efficient traffic control.
3. Methodology

3.1. Block Diagram of Density Based Traffic Control System Using IR Sensor
The integrated system of this density based traffic control consists of an IR sensor for input, an Arduino UNO microcontroller for data interpretation, a red, yellow and green LED for traffic light lighting and an LED Dot Matrix Module for output of this project.

Figure 1. Block diagram of this density based traffic control system using IR sensor

This project comprises of two major parts of design and development, hardware and software. In the hardware design, a prototype is built as an intersection. It consisted of four traffic lights equipped with one IR sensor each installed at the intersection. These IR sensors are positioned about a 100 meter from each traffic light. The LED display is set up only at one traffic light (Traffic Light 1).

3.2. Flowchart of Density Based Traffic Control System Using IR Sensor
Figure 2 presents the flowchart of this density based traffic control system using IR sensor. At start, each traffic light is sensing any vehicle using the IR sensor. IR sensor has two parts; i) IR receiver and, ii) IR transmitter. IR transmitter is to transmit signal ray and the reflected signal ray will be received by the IR receiver. Signal ray is reflected when it struck a vehicle. One reflected signal ray counted as one vehicle. Then, the time is adjusted where one vehicle equal to 3 seconds delay time making the traffic light to delay. The maximum distance of a counted vehicle is at a 100 meter from the traffic light. LED dot matrix is used to display friendly reminder to the road users such as “Berhati-hati di jalanraya, pandu cermat jiwa selamat” that is set up at Traffic Light 1. For the development of the software, Proteus 6.8 Lite software was used and simulation was made virtually before uploading and eventually carried out using Arduino UNO.
Figure 2. Flowchart of density based traffic control system using IR sensor

4. Result and Discussion
The traffic control system which is controlled by Arduino UNO microcontroller is setup. It is placed at each traffic light at the intersection road to count the timing period. Three LED lights; green, yellow and red are installed at each traffic light named Traffic Light 1, Traffic Light 2, Traffic Light 3 and Traffic Light 4 together with IR sensors which installed at a 100 meter distance from each traffic light.

Arduino UNO will provides flexible timing period of traffic light depending on the density of the traffic at each traffic light. Each vehicle is set to 3 seconds. All vehicles passing through the junction is measured and processed accordingly to delays. If there is no vehicle on road for 1 second it will change to another junction.
Figure 3. Schematic diagram of density based traffic control system using IR sensor

Figure 3 shows the complete prototype design of this density based traffic control system using IR sensor. A 5 Volt Direct Current (DC) supply is used to operate the circuit when turned on. Then, the IR sensor starts its function to detect the number of vehicles on the road. Arduino UNO is the main module controlling all operations in producing the output. The counting of the vehicles is then analysed by the microcontroller.

Figure 4. Circuit of density based traffic control system using IR sensor on PCB
The hardware part of this project is depicted in Figure 4 and Figure 5. Figure 4 shows circuit of this density based traffic control system using IR sensor on a Printed Circuit Board (PCB). While the circuit of this density based traffic control system using IR sensor on a breadboard is shown in Figure 5. In Figure 5, LEDs which are ‘ON’ represent the traffic lights at the intersection. Time delay for LED green to switch on is according to the traffic density which is measured by how many vehicles sensed at the IR sensor. Table 1 shows the results where according to Table 1, it shows that delay time is the longest when the number of vehicles is at the most.

| Traffic Lights | Number of Vehicles | Delay Time (s) |
|----------------|--------------------|----------------|
| 1              | 3                  | 9              |
| 2              | 4                  | 12             |
| 3              | 6                  | 18             |
| 4              | 1                  | 3              |

LED display is install at Traffic Light 1. This LED display will only switch on when Traffic Light 1 turn red. LED display is used to remind and advice road users to always keep caution when driving. Problems regarding traffic congestion is expected to reduce by using this density based traffic control system using IR sensor.

5. Conclusion
In conclusion, development of this density based traffic control system using IR sensor is done very well. By applying this system, it can reduce traffic congestion especially during peak hour and hence also can reduce road accidents in the present and future since traffic density will always increase as the population increase. The usage of Arduino UNO microcontroller contributes a very appropriate model
in order to implement the embedded control system because it is easy to be modified to any possibility in meeting future requirements hassle-free and quickly.

In the upcoming times, enhancement to improve the features of this project can be done such as changing the power source of the traffic light to solar power panels in order to lessen the electricity usage and hence can contribute to green energy. LED light also can be use in future for the traffic light since it will decrease the energy consumption which can save up to 90% of energy and cut cost too. Besides, LED light have long life service which can minimize the operating and maintenance cost. Most important thing is LED light offers better visibility even in direct sunlight.

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