Density based Traffic Control System with Green Corridor for Emergency Vehicles

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***Abstract*:- In developing countries like India, the population is significantly growing. As the population grows, the number of vehicles on the roads are also exponentially increasing, which results in increase in road accidents and traffic congestion. Specifically, when an emergency vehicle such as Ambulance or Fire engine gets stuck in traffic jam, saving the human life becomes difficult. Under such circumstances, a promising system which can clear the traffic congestions especially in peak hours and thereby providing a safe path for emergency vehicles is very much essential. In the existing literature, less focus is given towards the problem of providing a clear path for emergency vehicles during traffic congestions.**

To solve these issues, an Ultrasonic sensor and RFID-based system is proposed, which manages and regulates the traffic signals at junctions when the emergency vehicle arrives, by allowing the easy passage out of the traffic congestions. The proposed frame work is modelled by means of an experimental setup using ARDUINO and LED's which simulates a real time traffic scenario. Ultrasonic sensors are installed on the roads to manage the traffic efficiently.

The simulation results illustrate the better performance of the proposed framework in terms of detection as well as management of emergency vehicle by providing passage out of traffic congestions during peak hours.

The ultrasonic sensor which is placed at a threshold distance from the junction calculates the vehicles density. This density is used by ARDUINO to regulate the traffic. The RFID receiver is also placed at a threshold distance from the junction. The RFID receiver informs the ARDUINO about the arrival of the emergency vehicle. The ARDUINO then takes the required measures to allow a safety passage for the emergency vehicle.

1. INTRODUCTION

Population growth is significant in developing countries like India. With the increase in the population the number of vehicles also increases. This results in a major problem of heavy traffic congestion. Traffic congestion is a condition on road networks that occurs as use increases, and is characterized by slower speeds, longer trip times, and increased vehicular queuing. Due to high traffic density the waiting time at signals is increased. The crossing time (time taken to cross a signal) will also be increased. Further, traffic congestions lead to fuel loss and also the wastage of money. Specifically, traffic congestions result in high pollution levels which affect the health of the local people, commuters and animals. Most of this is due to the bad timing cycle in the countdown timers. The timer is set equally both to the high density lanes and low density lanes. This causes the unnecessary waiting of vehicles in the high density lane even though the other lanes are empty.

In general, traffic congestions are also associated with few more traffic problems such as emergency vehicles get blocked. Precisely, the traffic congestion often blocks the path of the emergency vehicles which may prove fatal at times. Also, the number of deaths due to delay in arrival of emergency vehicles have increased to a greater extent in recent times. Therefore, emergency vehicles like Ambulance and Fire- engines needs to be on time to prevent loss of human life. Thus, helping an emergency vehicle to move out of traffic congestion is very much essential in the current traffic scenario. In order to solve the above given problems, Ultrasonic sensor and RFID-based technology can be used. Ultrasonic sensor helps in calculating the density of vehicles to control the traffic signals and hence reducing the traffic density. Eventually, this would help relieve suffocating streets of heavy bottlenecks, saving people their precious time. The main aim of designing these density based traffic controllers is that, the traffic controllers have the ability to adapt to the real time data from detectors to perform constant optimizations on the signal timing plan for intersections in a network in order to reduce traffic congestions, which is the main concern in traffic flow control nowadays, at traffic intersections. On other hand the emergency vehicles are detected using RFID tags which are installed on the emergency vehicle. When emergency vehicles are detected the particular lane is cleared of to help the easy passage of the emergency vehicles.

2. LITERATURE SURVEY

Density, speed, and flow of the vehicles are the three critical parameters for road traffic analysis. The management systems which involve in maintaining the traffic are all static in nature. Either getting inputs for the system or changing of traffic lights accordingly take more time than the time required for the traffic to clear. Few algorithms which involve faster clearance involve the algorithm which enhances accidents.

In 2017, Younis and Moayeri proposed a system in which a dynamic traffic light control (DTLC) is placed at the road intersections to collect traffic data [1]. It includes few protocols to handle congestion and facilitate efficient traffic flow by proposing low-overhead algorithms. Though this system efficiently manages traffic flow yet it is not focusing towards the emergency vehicles. In 2017, Jin and Ma introduced a group-based traffic control system capable of decision making based on its understanding of traffic conditions [2]. The control problem is formulated using a stochastic optimal control for multi-agent system where each signal group is considered as an intelligent agent. The disadvantage in this system was the problems of emergency vehicles were not addressed. In 2016, Vilarinho et al. proposed a system which was based on multi-agent system in which each isolated intersection includes a multi-agent [3]. These agents are designed for intersections for creating, managing, and evolving its plans for traffic signal. Again, the agents were designed to solve the traffic problem no help for the emergency vehicles was provided.

Ghazal et al. presented a PIC microcontroller-based traffic control system that uses IR sensors to evaluate the traffic density [4]. It provides dynamic time slots for different levels of traffic and also portable controller device is used to track the emergency vehicles. The disadvantage of this system is that each time the portable device is to be carried along with the emergency vehicle.

Recently in 2016, M.Kumaar et al. used a barrier gate and a GSM technology to design a density based traffic light control system. In their system the density of the traffic is used to change the signal timing automatically and microcontroller is used to provide the delay [5]. However, this system
fails to address the problem of emergency vehicle.

Sk Riyazhussain et al. introduced a raspberry pi-controlled traffic system which computes the density of the vehicles [6]. Jinyang Li et al. introduced a system which is an instance of V2I (Vehicle to Infrastructure) communication model, realizing data transmission between vehicles and traffic lights [7]. Vehicles send speed messages to the traffic light when passing an intersection, then the traffic light analyzes the information and adjusts the signal time in real time. Each traffic light in each direction has a control strategy of itself without the orthogonal requirement. Therefore, the traffic light is a kind of cyber-physical system. This traffic light control system can maximize the number of vehicles passing intersection, and as a result, minimize the congestion and pollution.

3. HARDWARE REQUIREMENTS

3.1 ULTRASONIC SENSORS

An Ultrasonic sensor is a sensor that measures the distance to an object by using sound waves. Figure 3.1 shows an Ultrasonic sensor.

Figure 3.1: Ultrasonic Senor

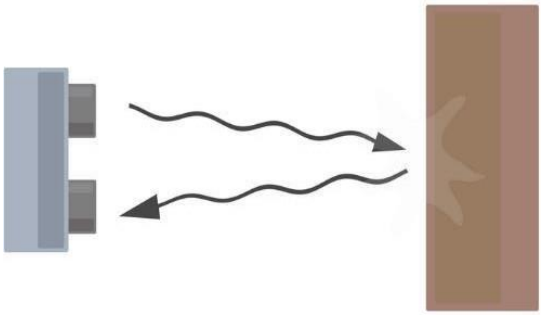

Figure 3.2: Working of Ultrasonic Sensor.

Figure 3.2 shows the working of the Ultrasonic sensor. The transmitter emits an ultrasonic sound wave. Whenever the sound wave finds an obstacle it gets deflected back to the receiver. Based upon time required for the wave to get back the distance will be calculated.

3.2 RFID-module

An RFID module (radio frequency identification module) is a small electronic device used to transmit and/or receive radio signals between two devices. In an embedded system when it is often desirable to communicate with another device wirelessly. Figure 3.2 shows a RFID module.

Figure 3.2: RFID module.

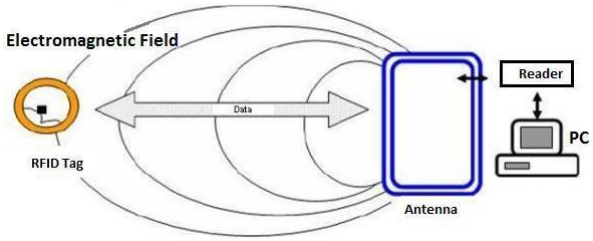

Figure 3.4: Working of an RFID module.

Figure 3.4 shows the working of an RFID module. RFID module consists of transmitter and receiver. The receiver produces an electromagnetic field. Whenever the transmitter comes in the range of electromagnetic wave it starts responding to the waves. This helps the receiver detect a device (emergency vehicle) containing the RFID tag.

3.3 ARDUINO MEGA

ARDUINO Mega is a single-board microcontroller used for building digital devices and interactive objects that can sense and control objects in the physical world. The Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. Figure 3.5 shows an ARDUINO mega board.

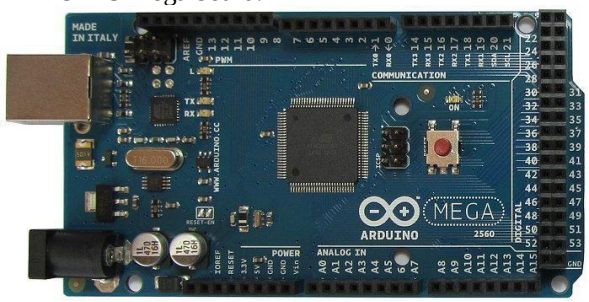

Figure 3.5: ARDUINO mega

3.4 LED's

LED (Light Emitting Diode) is basically a small light emitting device that comes under "active" semiconductor electronic component. It's quite comparable to the normal general- purpose diode, with the only big difference being its capability to emit light in different colours. The two terminals (anode and cathode) of a LED when connected to a voltage source in the correct polarity may produce lights of different colours, as per the semiconductor substance used inside it. Figure 6 shows the light emitting diode (LED).

Figure 6: Light Emitting Diode.

Fig. 3.7 shows the working principle of an LED. A light- emitting diode (LED) is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated. When a suitable current is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the colour of the light is determined by the energy band gap of the semiconductor. Different wavelengths involved in the process determine the different colours produced from the LEDs. Hence, light emitted by the device depends on the semiconductor material used. Infrared light is produced by using Gallium Arsenide (GaAs) as a semiconductor. Red or yellow light is produced by using Gallium-Arsenide-Phosphorus (GaAsP) as a semiconductor. Red or green light is produced by using Gallium-Phosphorus (GaP) as a semiconductor.

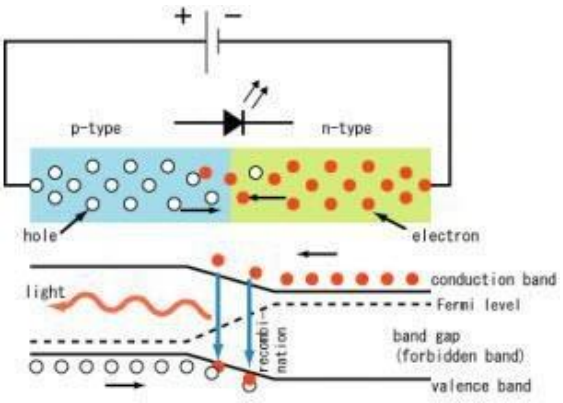

Figure 3.7: Working principle of LED.

4. SOFTWARE REQUIREMENTS

4.1 ARDUINO

The ARDUINO Software (IDE) is an open-source makes it easy to write code and upload it to the ARDUINO board. The environment is written in Java and based on Processing and other open-source software. Programs written using ARDUINO Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays

errors. The console displays text output by the ARDUINO Software (IDE), including complete error messages and other information. The bottom right corner of the window displays the configured board and serial port. The toolbar buttons allow verifying and uploading programs, creating, opening, and saving sketches, and opening the serial monitor.The ARDUINO Software (IDE) uses the concept of a sketchbook: a standard place to store the programs (or sketches). The sketches in the sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time the ARDUINO software is used, it will automatically create a directory for your sketchbook. The user can view or change the location of the sketchbook location from with the Preferences dialog.

When a sketch is uploaded, the ARDUINO boot loader, a small program that has been loaded on to the microcontroller on your board, is used. It allows to upload the code without using any additional hardware. The boot loader is active for a few seconds when the board resets; then it starts whichever sketch was most recently uploaded to the microcontroller. The boot loader will blink the on-board (pin 13) LED when it starts. Figure 10 shows the ARDUINO-IDE.

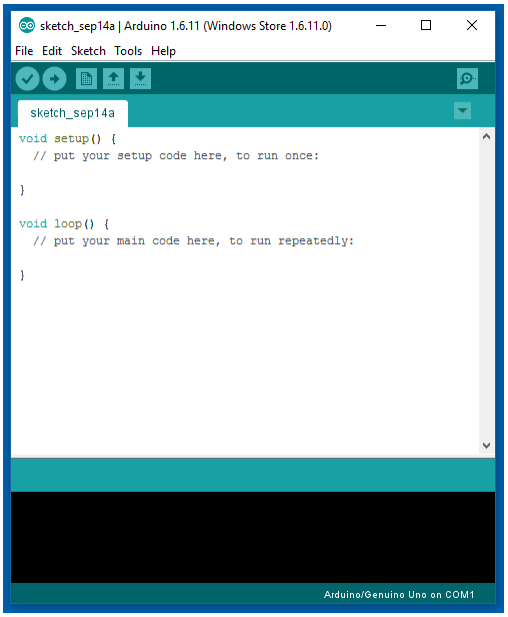

Figure 4.1: ARDUINO Software

5. IMPLEMENTION

5.1 Traffic Signal module

The ARDUINO controller is installed at the traffic junction. Small toy cars (including an emergency vehicle) are used to simulate a traffic scenario on the traffic junction. RFID transmitter is installed on the emergency vehicles. The Ultrasonic sensor is placed at a distance of one meter away from the junction.

Once the vehicle reaches this point, the collected signals from ultrasonic sensor is sent to the ARDUINO controller through copper wirings. The ultrasonic sensor reads every object which comes in its range. The vehicles can be separated from other objects by considering its height factor. An average height for the vehicle is assumed and if any object of size greater or equal to this average height is found then the vehicle count is incremented by sending a signal to the ARDUINO. The ARDUINO calculates the vehicle density and effectively changes the traffic signal timer. The traffic signals are shown using small led display.

5.2 Emergency vehicle module

RFID module is used to detect the emergency vehicle. The RFID tags are installed on small vehicle toys representing an emergency vehicle. The RFID receiver are placed along with the ultrasonic sensor. The RFID receiver keeps on searching for any available RFID tags in its range. As soon as any emergency vehicle is detected, the RFID receiver sends a signal to the ARDUINO. The ARDUINO identifies the received signal as an emergency vehicle. It immediately makes the signal green for that particular lane. This allows the already present vehicle of that lane near the junction to pass away. Since the vehicles moves away easily, the emergency vehicles get a clear path to pass from. This helps in providing a safe passage for the emergency vehicle and reducing its waiting time in the traffic.

The implementation of this application can be explained as a sequence of simple steps as followed:

1. Ultrasonic sensors and RFID receiver are placed at a threshold distance (1 metre) from the traffic junction.
2. The number of vehicles is calculated as the vehicle comes in range of the ultrasonic sensor. The RFID receiver detects whether any emergency vehicle is approaching the signal.
3. The ultrasonic sensor and RFID receiver sends the information to the ARDUINO microcontroller.
4. The ARDUINO processes this signal which results to have two possible cases.

Case 1: If an emergency vehicle is detected, then make the traffic signal of that particular lane as green and allow all the vehicles to move. This will result in a clear path for the emergency vehicle.

Case 2: If the vehicle is not in emergency then calculate the density of the vehicle and manage the signal accordingly. Signal is changed in clockwise manner itself. Time is allotted based upon the density of vehicles in the road.

6. RESULT

The smart traffic control system changes the traffic signal in clockwise manner. Thus, the starvation problem for the roads with less number of vehicle is eradicated. The time for each lane was allotted dynamically. The density of the vehicle was divided into three ranges and then based upon the number of vehicle the time was allotted dynamically.

The ultrasonic sensor keeps track of every vehicle entering the road. Thus, the ARDUINO gets the exact count of the vehicles present on each of the road. The time for each road is allotted based upon the number of

vehicle present in that road. The signals changed in clockwise direction itself thus no roads were neglected. Also, the emergency vehicle was allowed to pass straight away on their arrival.

7. CONCLUSION

To overcome the problems faced by the emergency vehicles, a smart traffic control system is developed that will assist the emergency vehicle in effectively finding a safe path out of traffic. This system helps the emergency vehicle to save its time by allowing it to pass as soon as it arrives near the junction.

The existing systems do not effectively handle the problem of providing a clear path for emergency vehicles during traffic congestion. Ultrasonic sensor based smart traffic control system proposes a solution to the traffic congestion problem. The density of the traffic is calculated and the timer displayed is shifted dynamically. Thus, the sensor helps in keeping the count of the vehicles entering the road and subsequently allotting the time delay by accurately giving priority to each road.

The major advantage of the proposed system is it rules out the happening of 'unwanted wait' for the vehicles in the more crowded region. It is also cost inexpensive and does not require any external device in the vehicle making it more practical than the existing system with great result. Also, an efficient method is provided a clear path for the emergency vehicles during peak hours. The emergency vehicles were easily identified and a clear path was provided.

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