Smart Traffic Density-Based Signal Controller

Mr. Rajagopal[1], Prasanth.S. R[2], Sharath.S[3], Raghul.D[4], Saivel.M[5]
[1,2,3,4,5]*Department of Electronics and Communication Engineering RMK College of Engineering and Technology, Thiruvallur District, Tamilnadu, India*

Abstract **- In many developing countries, with fast growth of population, traffic congestion monitoring and traffic control has become a great challenge. Specifically, when an emergency vehicle gets stuck in traffic, 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. This paper proposes low cost real-time smart traffic management system using data analytics and Internet of Things (IOT). IR sensors and Ultrasonic sensors are used to detect the traffic congestion and to measure the traffic density. RFID module is used to detect the emergency vehicle. After analyzing all the sensor data, the system controller sends the data to a cloud server and also sets the traffic signal time by traffic system algorithm according to the data. This proposed system is cost efficient and very simple for installation**

Index Terms **- Internet of Things (IOT), IR and Ultrasonic sensors, RFID module, data analytics.**

1.INTRODUCTION

Traffic congestion is an extensive global phenomenon resulting from high population density growth of motor vehicles and their infrastructure, and proliferation of rideshare and delivery services [1]. From the delay-travel perspective, congestion occurs when the normal flow of traffic is interrupted by a high density of vehicles resulting in excess travel time [2]. According to the United States Department of Transportation Federal Highway Administration (DOT-FHWA), nonrecurring congestion contributes to more than 50% of all traffic congestion, where 40% of congestion is caused by recurring congestion [3].

In 2014, traffic congestion cost people in the United States (US) a total of $160 billion from 6.9 billion extra hours traveled and 3.1 billion additional gallons of fuel purchased [4]. This happens because the existing roadways cannot accommodate the increasing number of automobiles. To get rid of this unwanted congestion, a system is required that will overcome the problems of the existing system.

Controlling the traffic light with the combinations of the sensors is known as the smart traffic system. The proposed smart TMS measures traffic density by analyzing sensors data. It sets the timing for traffic signal light by traffic management algorithm. Traffic density is visualized graphically at Thing speak by sending data through ESP8266 Wi-Fi module. In case of emergency vehicles like ambulance, fire brigade, the system stops it's as usual task and changes the signal as green until that emergency vehicle passes to that intersection. This whole approach will cost less than other approaches. Moreover, operating the proposed system is more comfortable than other existing systems.

The rest of this paper is structured as follows. Section II deliberates the literature reviews. The architecture of the proposed system is described in Section III while Section IV describes the methodology of the system. An experimental result is presented on in Section V.

2.LITERATURE REVIEW

The urban population is incredibly increasing in this modern era, and that affects everyday life very badly, especially in transportation. Cities like Delhi, Dhaka and many more developing countries are still using the traditional way of managing the vehicles for the intensely increasing population. According to United Nations report, in 2018, about 55% population of the world resides in an urban area that is anticipated to be 68% and increasing rate of Asia and Africa closed to be 90% by 2050 [5]. For this growing urban population, an effective smart traffic congestion avoiding system is a crying need for managing the significant number of vehicles.

As a developing country, India, in some province, uses MATLAB, KEIL (Microcontroller coding) based system and surveillance camera to control traffic

congestion. The system was cumbersome to install and costly so that some province uses shortest route detections, IR sensors to measure traffic density. But IR sensor is impacted by temperature and humidity. Consequently, the result which was produced by the IR sensor was not accurate. In Pakistan, traffic density is measured using camera and sensors. Based upon the sensors' data, Pakistan controls the traffic signaling. They also used a smoke sensor to detect the emergency, i.e. fire accident. Camera sensor may be affected by rain and fog. Moreover, it is not cost effective. In Nepal, wireless traffic data and CCTV live video are used in 35 traffic junctions. The system can modify signal policies and reroute drivers to prevent congestion.

Recently, closed-circuit cameras and car detection devices are used to handle the traffic congestion, and the system can calculate the number of vehicles on the road. But, in rainy and foggy environment cameras cannot detect vehicle accurately. To the best of our knowledge, we do not have any holistic model to monitor and control the whole traffic system.

3. SYSTEM ARCHITECTURE

In our proposed system, we are implementing a system to monitor and control the smart traffic signal control. Here we are using an ultrasonic sensor and IR sensor to calculate the distance covered by vehicle in the lane. This will be implemented in the both ways of the road and all the details will be monitored by the controller and if any sensor value reaches the threshold range then the controller will give command to the driver circuit to turn on the green light of the particular lane to clear the traffic density.

All the information collected by the zigbee from the controller and will be transmitted. In addition to that we are using RFID tag in each and every vehicle to calculate the number of vehicle in the lane and also when reader reads emergency vehicle tag then the controller will automatically open the signal of the lane to clear the traffic for the emergency vehicle. All the status will be displayed in the LCD.

By analyzing the sensors' data, micro-controller controls signals, processes and sends data to the cloud server through the ESP8266 Wi-Fi module.

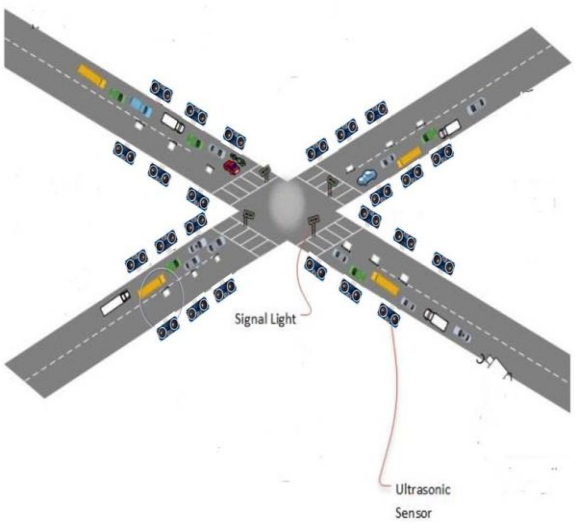


FIG 1: SYSTEM ARCHITECTURE

4. METHODOLOGY

There is research that have used several ways to detect traffic density consisting of different kind of sensors like surveillance cameras, ultrasonic sensors, RFIDs, the light beam that have merits as well as demerits. Ultrasonic sensors and IR sensors are suitable sources for our proposed system. The ultrasonic sensor is most used sensor to identify the traffic density level in TMS. It can calculate the distance up to 400 cm. The purpose of both Ultrasonic sensor and IR sensor is same here.

Let us consider a pair of sensors from sensor 1 to sensor x on both sides of the lane as a pair P1. Likewise, from sensor x to sensor y on both side of the lane will be pair P2 and from sensor y to sensor z will be P3. Here, Density is calculated by the following formulae:

$$\sum_{i=1}^{3} (Pi) = P1 + P2 + P3$$

If the value of the three pairs of sensors is high, that will be considered as high density, if two pairs are high and another pair is low, that will be medium and if one pair is high and another two pairs are low that will be low density. The sensors continuously send data to the microcontroller to detect traffic density. So, a density based, and dynamic traffic signal timing is essential instead of manual traffic signaling process. For that reason, traffic management algorithm was used.

Algorithm to calculate the interval time, Let A be the time given to each lane during low congestion of traffic, and if traffic congestion is medium then the

interval time given to that particular lane will be A+X, where X will be time given to get pass the traffic signal and so on.

Also, in case of an emergency vehicle like an ambulance, fire brigade it will stop its as usual task and changes the signal as green until that emergency vehicle passes to that intersection. All the data about traffic density, date and time are sent to the cloud server for further IoT analytics.

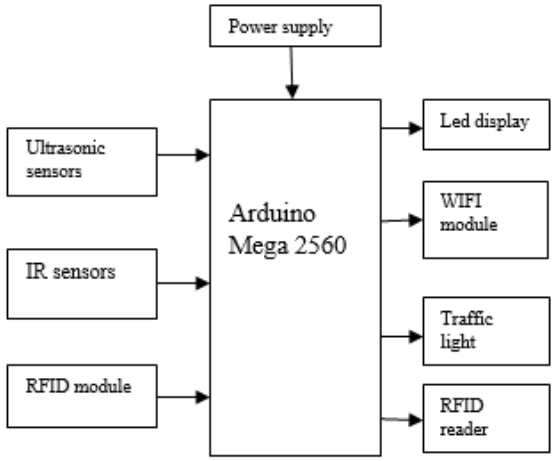


FIG 2: Block Diagram

In the Block diagram of the proposed framework, at the input side, Arduino Mega 2560 controller is accommodated with ultrasonic sensors, RFID module and at output side ESP8266 Wi-Fi module to transfer data at cloud server, LEDs as signal light.

The proposed system is classified into two main parts:

Hard wares: Following sections are used in our proposed system:

A. Series of HC-SR04 Ultrasonic Sensors: Ultrasonic Wave based, HC-SR04 ultrasonic sensor's head emits an ultrasonic wave and receives the reflected wave from the target. Measuring the taken time between the emission and reception it measures the distance to the target. In this system, HCSR04 ultrasonic sensors are used to measure traffic density at roads. At 40 KHz frequency, it can detect vehicles at range from 2cm to 400 cm.

B. Arduino Mega 2560 controller: The Arduino Mega 2560 is ATmega2560 based microcontroller that has 16 analogue inputs, 54 digital input/output pins, 4 UARTs, a 16 MHz crystal oscillator, an ICSP header, a USB connection, a reset button and a power jack which is useful for this system.

C. RFID module: MF RC-522 based RFID module uses Electromagnetic fields to automatically identify and track tags attached to objects. It is a low – cost, small size and non – contact card reader chip that is used in the system to detect a signal violation person by scanning his RFID tag

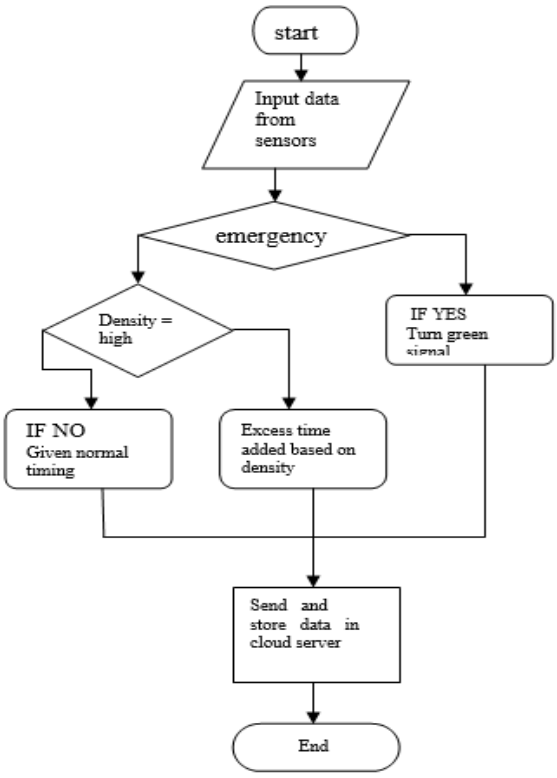
1. ESP8266 Wi-Fi module: TCP/IP protocol based ESP8266 Wi -Fi Module has a powerful enough processing capability that allows it to be integrated with the sensors with minimal loading during runtime, it transfer real - time data at the server side.
2. LEDs signal: LED's signals are used as a traffic signal

Soft wares:

By analyzing real – time traffic data, IOT analysis creates channels to plot real – time graphs. The uploaded code of the system is written in the Arduino language. ESP8266 Wi-Fi module transfer sensors data to the server through micro-controller.

Flowchart:

The flowchart of working module. The flowchart was followed to implement of the proposed system.



5. RESULT

Ultrasonic sensors based real – time traffic monitoring system can measure traffic density at roads. When the frequency is high, that route is in green signal, and a low dense route is in red signal. The system sent store the data at a cloud server for further analytics. Since we are using ultrasonic sensors and IR sensors and RFID module the accuracy of the result will be high comparing to other systems.

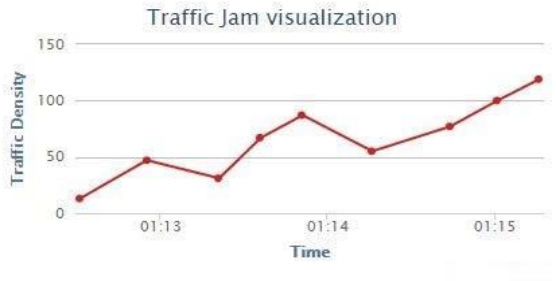


Fig 4: Traffic Level of A Lane

To describe our proposed system, a prototype was developed. All elements are tested before prototype implementation. In this part, Arduino Mega 2560 is accommodated with HC-SR04 ultrasonic sensors, RFID module, LEDs signal and ESP8266 Wi-Fi module shown.

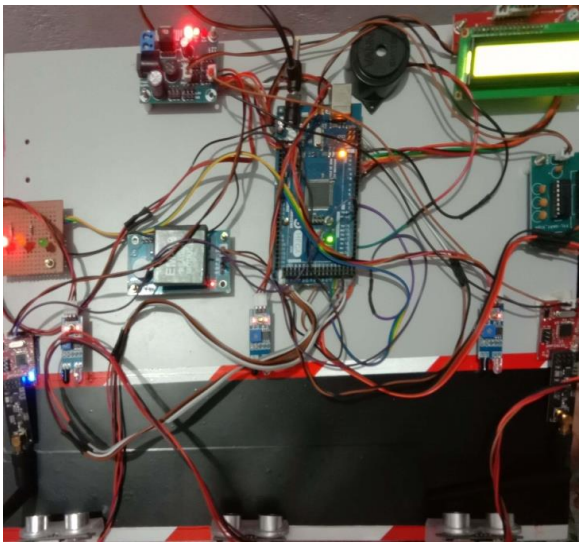


Fig 5: Proposed System Prototype

A table based on our proposed system,

Condition / Sensors	P1	P2	P3	Status
Condition 1	1	0	0	Low
Condition 2	1	1	0	Medium
Condition 3	1	1	1	High

Fig 6: Traffic Density States by Ultrasonic & Ir Sensors

6. CONCLUSION

Traditional system has many limitations to manage present increased traffic effectively. This paper proposed a smart TMS to control traffic situation more effectively and efficiently. By analyzing sensor data, it sets traffic signal time dynamically and sends the data to a cloud server through a Wi-Fi module that is stored for further data analytics. It also deals with emergency vehicle. The whole system is very cost effective than existing system in developing countries. But the security should be ensured for sensors as these are equipped at roadsides. The government can equip this proposed system immediately to change the current terrible scenario of the traffic congestion.

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