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Priority based Intelligent Traffic Control for Emergency Vehicles at Intersections using IoT

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Abstract - *Vehicular traffic is endlessly increasing everywhere in the world and can cause terrible traffic congestion at intersections. Traffic light controllers feature fixed sequences and durations of light signals, which do not consider dynamically changing traffic environments. Therefore, emergency vehicles such as ambulances, police cars, fire engines, etc. stuck in a traffic jam and delayed in reaching their destination can lead to loss of property and valuable lives. Traffic jams, especially those at intersections, not only increase delays for drivers but also increase fuel consumption and air pollution. We propose an Internet-of-Things-based platform for emergency vehicle priority and self-organised traffic control management at intersections. Our system is installed at traffic lights and collects emergency vehicle position information and vehicle density data at each road segment approaching an intersection. Then it adjusts the timings of traffic lights based on detected real-time traffic saving the valuable lives and property. The system minimises total delays, lane opening times and waiting times for both emergency and non-emergency vehicles reducing the fuel consumption and air pollution. In addition, the system prioritises all four approaches at intersections and determines the sequences and the durations of traffic light signals based on the density of vehicles on each approach. Ultrasonic sensors are installed to estimate the density of vehicles approaching the intersection. This information is then transmitted via Bluetooth to an android application which controls the traffic light duration based on the changing traffic environment.*

Key Words: **emergency vehicle priority, Internet-of Things, self-organised, traffic control management, traffic light**

1. INTRODUCTION

Traffic light controllers play a significant role in maintaining smooth traffic flows in city environments. The sequences and durations of traffic light signals are two key factors that must be considered when designing a traffic light controller. In many countries, most traffic light controllers feature fixed sequences and durations of light signals, which do not consider dynamically changing traffic environments. Such fixed traffic light control methods are only suitable for stable and regular traffic, and not for dynamic traffic situations. Therefore, traditional traffic light controllers are one of the main factors contributing to severe road congestion in urban areas. In addition, facilitating and prioritising the transit of emergency vehicles in urban areas comprises an important safety issue. However, in traditional traffic light controllers, light sequences are determined without considering the presence of emergency vehicles. Therefore, emergency vehicles such as ambulances, police cars, and fire engines must wait at intersections, which increases their delays and leads to the loss of lives and property.

Improving emergency response times is extremely critical, particularly for fire and health-related incidents. However, when the number of vehicles increases at an intersection, this not only increases the response times of emergency vehicles but also increases the likelihood of accidents occurring when emergency vehicles enter intersections at high speed. For example, in Ireland, an average of 700 fatalities are recorded every year because of late ambulance responses. The National Highway Traffic Safety Administration in the US released a report regarding accidents that involved emergency vehicles such as fire trucks, ambulances, and police cars. The agency studied the number of ambulance accidents over the 20-year period of 1992–2011 and estimated that an average of 1,500 accidents involving ambulances occurred each year, wherein 33 people were killed and 2,600 people were estimated to be injured. According to the report, fire engine accidents are the second leading cause of death for firefighters. There were roughly 31,600 accidents involving fire vehicles over a 10-year period in which 630 firefighters were killed. In addition, it is reported that there are approximately 300 fatalities in the US each year during police pursuits, where 30% of the fatalities comprise people not involved in pursuits. Therefore, reducing emergency response times by minutes or even seconds is crucial in emergency situations. An intelligent traffic management system is mandatory for effectively avoiding emergency vehicle accidents at intersections by presenting green and red signals to emergency vehicles and non-emergency vehicles, respectively, based on an intelligent priority algorithm.

We propose an emergency vehicle priority and self organised traffic control system, which prioritises the arrival of emergency vehicles at intersections to reduce their response times in emergency situations. In addition, it prioritises all four approaches at intersections and determines the sequences and the durations of traffic light signals based on the estimated arrival times of emergency vehicles and the density of vehicles on each approach.

Ultrasonic sensors are installed to count the number of vehicles approaching the intersection. This information is then transmitted via bluetooth to an android application which controls the traffic light duration based on the changing traffic environment.

2. RELATED WORKS

Accidents involving emergency vehicles represent a significant problem that is growing worldwide. Most emergency vehicle accidents occur at intersections because emergency vehicles travel at higher speeds in urgent situations, which can lead to severe injury or death. To prioritise the transit of emergency vehicles and organise traffic flows at intersections, a number of traffic management schemes have been proposed by researchers [1]. In [2]-[5], intelligent traffic control systems were proposed to provide priority to emergency vehicles. In [6], cameras were installed at intersections to measure traffic conditions, which were then utilised to estimate the sequences of traffic lights.

Shaikh and Chandak [7] utilised recent technologies, such as infrared cameras and GPS, to detect the presence of emergency vehicles and calculate the real-time traffic density. In [8], RFID tags were utilised to identify the presence of emergency vehicles and the inductive loop method was adopted to count vehicles.

Emergency vehicle pre-emption techniques were proposed in [9] and [10], where sensors were installed at each intersection to identify the presence of emergency vehicles. Then, the traffic light controller presented a green light in the direction of an emergency vehicle until it exited the intersection. An RFID- and GPS-based automatic lane clearance protocol for ambulances was proposed in [11]. The objective of this protocol was to minimise the travel times of ambulances by clearing lanes prior to an ambulance reaching an intersection.

3. PROPOSED METHODOLOGY

Traffic is a major concern for most of the metropolitan cities of the world. Efficient traffic management can have a major impact on the country's economy. Emergency vehicles such as ambulances are stuck in traffic junctions because of improper traffic management. Through this work, we will get an opportunity to learn the development of an embedded system, development of android application, and learn about IoT.

Major challenges identified are:

- Installation of sensors in a proper location in a traffic junction.
- Some modifications or changes are needed in Traffic junctions to use the proposed system.

Our system proposed to maximise traffic throughput and minimise average vehicle waiting times at intersections. This scheme accelerates emergency response operations, by facilitating the transit of emergency vehicles through intersections in urban areas. The system minimises total delays, lane opening times and waiting time for both emergency and non-emergency vehicles reducing the fuel consumption and air pollution In our system, an emergency vehicle can reach the scene of an accident with minimal delay in both light and heavy traffic conditions compared to conventional and virtual traffic light systems. The proposed system also assigns the highest priorities to high-density approaches, in order to avoid long queues of vehicles at intersections.

The proposed system deals with the systematic approach for traffic controlling. But this can be extended by accident detection and providing medication to the victims at the accident spot.

By increasing the technology, we can also avoid accidents by providing more authentic accident detection systems that can stop the vehicle to overcome the accidents. Traffic controlling systems can also be improvised using more fast and authorised systems.

Proposed system, which aims to reduce the average waiting times of both emergency and non-emergency vehicles at intersections by utilizing the following key features:

- Intersection Controller: The intersection controller manages the arrival of emergency and non-emergency vehicles. It priorities emergency vehicles at intersections and assigns the highest priorities to high-density roads or approaches.
- Ultrasonic Sensors: Sensors are installed at a distance of 25 m from an intersection controller via Bluetooth.
- Emergency Vehicle: An emergency vehicle approaching an intersection communicates with the intersection controller via Bluetooth for priority assignment.

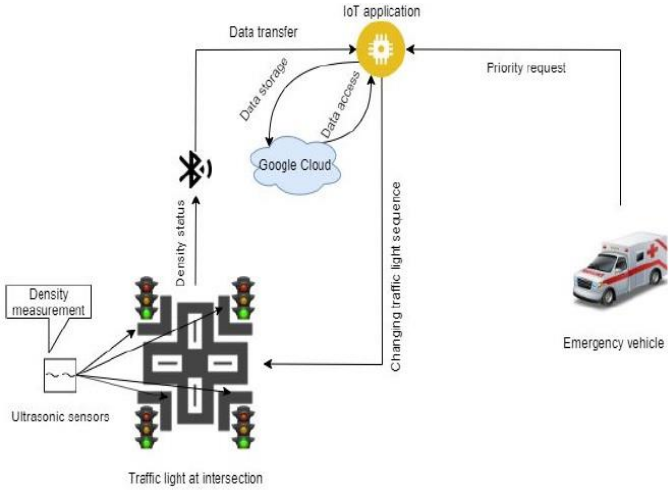

Fig -1: System Architecture

3.1 Density Based Traffic Light Controlling System

The system is composed of two units, Traffic density measuring unit Traffic light controlling unit. We are

presenting four sided junctions in north, east, west and south directions. The two ultrasonic sensors in each direction can classify the density into high, low and zero density. The ultrasonic sensor gives the distance to the object in front of it. The distance will reduce when the vehicle stops in front of it. If the distance is high in both ultrasonic sensors that means no vehicle is there, which is taken as zero density. If both the distances are low means high density and otherwise low density. This density status is then shared to the Google cloud using an android application. The data are transferred to the android application wirelessly through Bluetooth. Once the data is received to the Google cloud then it will be accessed anywhere under internet.

The traffic light is designed in such a way that each direction consists of 3 lights red, yellow and green. The timing of the light is controlled according to the density. The main attraction of the work is this traffic light can be controlled wirelessly through android application with the help of the internet. This application is designed for Ambulance, fire force and VIP vehicles. There is a separate login option and after login they can control the light by simply pressing the provided button in each direction.

3.2 Vehicle Detection System

The vehicle detection system includes ultrasonic sensors, a microcontroller, and a Bluetooth module. Each approach consists of two lanes and each lane is equipped with ultrasonic sensors. Ultrasonic sensors are utilized to detect vehicles at each approach. The microcontroller is utilized to transmit vehicle count information to the android application through a Bluetooth module. A predefined timer and count variable are initialized, and the microcontroller waits for an event to occur. When an event occurs, the controller will check the event type. If a vehicle is detected, then the count variable is incremented by one, and the microcontroller returns to the event detection state. However, if a 'timer expired' event is detected, then a message containing the vehicle count information is transmitted to the application.

4. CONCLUSION

Our proposed system aims to maximise traffic throughput and minimise average vehicle waiting times at intersections. This scheme accelerates emergency response operations, by facilitating the transit of emergency vehicles through intersections in urban areas. The system minimises total delays, lane opening times and waiting time for both emergency and non-emergency vehicles reducing the fuel consumption and air pollution In our system, an emergency vehicle can reach the scene of an accident with minimal delay in both light and heavy traffic conditions compared to conventional and virtual traffic light systems. The proposed system also assigns the highest priorities to high-density approaches, in order to avoid long queues of vehicles at intersections.

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