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Smart Traffic Light Control System for Ambulance using IoT

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Abstract - *Time can either be a friend or a foe during an emergency condition. It thus becomes essential to save every second possible. With the recent increase in the number of vehicles, traffic congestion has seen a tremendous spike. As a result, many people have lost their lives because ambulances could not make it to their destination in time. Arriving at the destination safely and as quickly as possible is the fundamental requirement of any emergency vehicle. Each second stolen by red lights or the traffic blocking the route to the destination reduces the chances for survival. Thus it becomes essential that ambulances be provided with signal priority to enable them to get through the heavy traffic with the least delay. In this paper, a new system is proposed that uses IoT to aid in achieving this goal.*

Key Words: IoT, healthcare, ambulance, traffic signal, arduino nano, sensors, sound etc.

1. INTRODUCTION

Today's world is becoming enhanced day by day. Everyone requires everything to be automated and interconnected with each other. This interconnection ranges from sophisticated tasks like connecting a telephone stationed in America to one stationed in Australia to something as simple as a cooker that is being used in our kitchen to be connected with our smartphones. To aid in meeting this demand of the people, IoT promises to play a very significant role.

IoT is a growing industry that has the potential to cover all aspects and requirements of our lives. IoT is kind of a unique industry in the sense that it has the ability to incorporate all branches of Computer Science into one and use it for the betterment of people. So now a question arises, "What exactly is IoT?" IoT describes the network of physical objects - "Things" that make up the "Internet of Things" - that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet [1].

Time itself is a witness to the fact that the standard of living has increased with the passage of years. Fifteen to twenty years back where one could have hardly spotted a motorbike, the narrowest of the road are now flooded with cars. It has now become a common sight in cities to see every family owning at least one car. While this has helped people in becoming independent and provided them with the convenience of moving from place to place, it has also caused some serious problems that have resulted in the deaths of many without us even being aware of them.

Sometimes it so happens that whenever an ambulance is approaching a signal, it usually finds itself stuck at a red signal or in a traffic jam. Also, in many situations, the traffic jam is such that there might not be enough room to make way for the ambulance. Combining data taken from various statistics, it is estimated that an average of 30%-35% deaths in emergency cases happen due to traffic jams. In such conditions, it becomes essential that the traffic keeps flowing at a faster rate but in a smooth manner. In order to achieve this, an effort has been made to design a system that helps in regulating traffic whenever an ambulance approaches without causing much confusion.

2. LITERATURE SURVEY

The exponential growth in the amount of traffic every year has elevated the need for the design of an intelligent traffic control system. A lot of research is going around the world in order to invent novel approaches and innovative systems to solve this problem. Numerous models based on mathematical equations have been applied to estimate the number of cars in the waiting queue, the car waiting time at a junction, the extension of the waiting cars along the lane, the optimal timing slots for green, yellow, and red lights that best fit the real and veritable situation and the efficient combination of routing. As a result, various methodologies have been proposed and are being worked upon in the literature. In addition to this, the technological advances of microcomputers, sensors, and innovative algorithms modelling has made the practical implementation of such systems possible and affordable.

Authors have proposed various IoT based system models that are focused on identifying the traffic density. Models have also been proposed for clearing traffics to let emergency vehicles pass the dense traffic in order to reach the site of action quickly.

The system proposed in [2] focuses on calculating the traffic density using IR. It also provides a model to aid in clearing traffic for emergency vehicles. They propose to do this manually by giving a handheld device to the traffic officer that would enable the officer to control the traffic. The proposed system though has some drawbacks. There was a reason why traffic officers were replaced by traffic signals. Assigning additional officers just complicates the problem. It is not possible to place traffic officers at each and every junction in order to just use the handheld device. Though rare, it is also probable that when an emergency vehicle approaches a junction the officer might not be present at the scene.

The system [3] uses RFID technology to detect emergency vehicles. Each vehicle is proposed to have an RFID tag installed in them, including emergency vehicles. RFID readers are installed near traffic signals to detect RFID tags belonging to emergency vehicles. Once emergency vehicles are detected, signals are changed appropriately to help emergency vehicles to pass through the traffic.

Though the system is very efficient in detecting emergency vehicles and creating a path for them, it still has some major drawbacks. The RFID tags are required to be read by RFID readers installed near traffic signals and in order for this to happen the vehicle is required to be in the range of RFID readers. The problem here is that currently, the range of RFID readers is only a few meters. The maximum range that can be offered by RFID is 100 meters but the tags and readers to enable it are too expensive to be implemented at a large scale. In addition to this, the average length of traffic jams in metropolitan cities has increased to 150 to 250 meters. Even if we ignore the cost and are able to increase the range, we are faced with yet another difficulty. The range offered by the RFID is a 100-meter radius coverage. This means that the RFID readers will also detect ambulances that take a parallel route to the signal without having the need to cross the signal. To add to this, an ambulance can also be detected multiple times at the same signal by different RFID readers. All this adds up to thwart the smooth functioning of traffic near the signal.

Another system proposed in [4] makes use of GPS to achieve the same objective. The GPS helps in presenting all the possible paths available to the emergency vehicle to reach its destination. The driver selects the most appropriate path to the destination. During its journey, whenever the emergency vehicle comes in the vicinity of the traffic signal, it triggers a change in the traffic signal to suit its requirement. Though the system proposed works beautifully, there is a great chance that the emergency vehicle is just passing parallelly to the signal (while being in the vicinity of the signal), without actually having a need to cross the signal. This has the potential to destroy the smooth functioning of the traffic signal creating a lot of chaos.

Also, while developing the desired system the following regulations for ambulances as specified in AIS-125 [5] were kept in mind: "The main sound direction must be in driving direction. Permitted are wail and yelp signals that cycle between 10-18 respectively 150-250 per minute at a sound pressure level of 110dB(A) to 120dB(A). The sirens should be tested in accordance with IS 1884 (though not covered in the standard). The frequency range must be at least one octave and should be between 500Hz and 2.000Hz."

3. PROPOSED SYSTEM

After going through various studies and research, it was identified that a system was required that needs physical control while still making the process automatic. Physical control aids in the prevention of unwanted disturbances in the traffic flow while the automated system provides very high efficiency in getting the job at hand done.

The proposed Smart Traffic Control System is designed to enable ambulances to get through the crowded and congested traffic signals. It also helps the ambulances to get past a red signal that might block its path. This is especially important in a country like India where currently there are no special lanes or any buffer space system that can enable ambulances to get through the traffic.

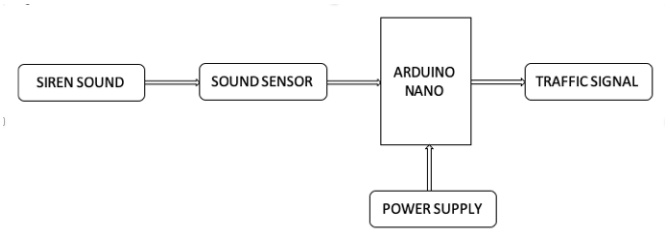

Fig -1: Block Diagram

The main components used in the proposed system are as follows:-

- Arduino Nano: It is a compact and breadboard-friendly microcontroller board based on the ATmega328 microcontroller. Arduino boards are open source and have a huge user community. They are widely used in robotics, embedded systems, and electronic projects where automation is an essential part of the system. The board can be connected with external shields and modules to expand its functionality. For example, a Wi-Fi module can be used to provide internet connectivity for future requirements and developments in the system.

Fig -2: Arduino Uno

- Unidirectional Siren: It is based on the technology of 'Directional Speakers'. Directional speakers produce ultrasounds that are very high frequencies of sound that rock back and forth in a laser beam-like fashion. Such sirens enable the propagation of the sound wave in a unidirectional fashion. It also helps in overcoming the

hindrance of sound propagation in areas with high levels of background noise as is common in traffic jams.

Fig -3: Unidirectional Siren

- Sound Sensor: These sensors are able to record noise levels and their frequency due to their integrated microphone. It collects and analyses the surrounding sound and gives out an appropriate output.
- GPS System: The GPS system aids in identifying the location of patients and identifying the best routes to the destination. It can also help in locating nearby hospitals that the driver may miss in a hurry. These characteristics contribute to a better ambulance service.

4. WORKING

The system is designed in a way that it can efficiently do the work expected from it while still keeping its design simple. The proposed system can be divided into two parts. The first part deals with the modification of the siren in the ambulance. On the other hand, the second part deals with the control of the traffic signal.

As per AIS-125, it's expected that the siren of an ambulance maintains a sound pressure level of 110dB to 120dB. It also requires that its frequency falls in the range of 500Hz to 2000Hz. All other vehicles use horns that have a sound pressure level of 80dB to 110dB with its frequency being in the range of 400Hz to 500Hz. Though these regulations are not universal, most countries have similar guidelines that can be used instead. The regulation in itself can differentiate ambulances from other vehicles without adding any extra devices like RFIDs, IR emitters, etc. for the detection of an ambulance. This reduces the cost and complexity of system implementation. The microcontroller is programmed to recognize the siren of an ambulance with the aid of sound sensors. The microcontroller used here is Arduino Nano due to its compact size, its ability to fit into small places, low cost, and its ability to increase its functionality, thus providing room for future enhancements.

Fig -4: Omnidirectional Sound vs Unidirectional (Shotgun) Sound Coverage

The big challenge in the system is the identification of the direction of the sound, and thus the direction from which the ambulance is coming. Sirens are usually omnidirectional (Fig 3) meaning that the sound emitted is spread out in all directions in a large circular pattern. In the proposed system, the traditional sirens are replaced by specialized unidirectional sirens. The specialty of this siren is its unidirectional behavior whose sound distribution follows the shotgun pattern (Fig 3) as compared to the traditional omnidirectional pattern. Hence, for the same intensity and frequency of sound emitted, the shotgun pattern covers only a specific area as compared to a big circular area covered in an omnidirectional pattern. This enables the ambulance to direct the sound of its siren to only one sound sensor present in the junction. In case an omnidirectional siren was used, its sound would spread to every sensor present in the signal, creating confusion in the microcontroller and chaos at the signal.

The working of the system is simple. A sound sensor is placed in every unidirectional lane along with the traffic lights at the junction to detect an “on-duty” ambulance through the unique siren proposed. The range of the sensor is set at 100m initially and can be expanded or reduced based on the observed traffic pattern. On normal conditions, i.e. when no ambulance is detected or the ambulance is “not on duty”, the microcontroller instructs the traffic signal to continue with its normal course of routine by activating the “default circuit”.

Whenever an ambulance is “on-duty”, the siren of the ambulance is to be turned on. The inbuilt GPS system helps the driver in locating the destination and identifying the best routes to reach it. It also helps in identifying nearby hospitals that the driver might miss in a hurry. As soon as the ambulance comes into the vicinity of the sensor while en route to the destination, the microcontroller detects the ambulance based on readings received from the sound sensor. The microcontroller then accordingly shifts the traffic control from the “default circuit” to a “special circuit” to change signals that facilitate the ambulance to get past the traffic signal. During this duration the microcontroller also enters into a lock state, i.e., it ignores the data received from other sensors. This aids in the prevention of multiple detections of the same signal by different sensors which might confuse the microcontroller. It also prevents the confusion that can occur when two or more ambulances pass

the signal at the same time. Thus it operates on the principle of "first come first serve". As soon as the ambulance passes the traffic signal, the microcontroller lifts the lock state and shifts the traffic control back to "default circuit".

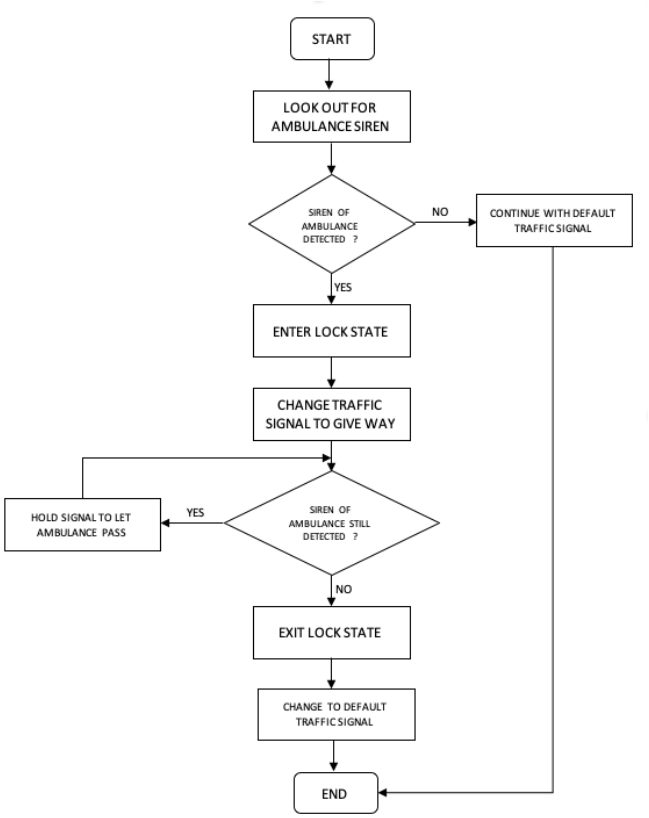

Fig -5: Flowchart of Traffic Control System

5. FUTURE SCOPE

The system proposed merely focuses on developing a way to let the ambulances pass traffic signals with minimum delay. As a result, many more areas can be explored to provide patients with high-quality ambulance service. The ambulance also can be equipped with a microcontroller that can monitor patients on a real-time basis and send the data to the destined hospital. This can assist the hospital to get prepared in the best possible way for when the patient arrives. The inclusion of microcontrollers in ambulances also opens doors to enable double authentication of ambulances at traffic signals. While the system proposed here merely focuses on providing traffic service only to ambulances, the system can be modified to provide similar assistance to other emergency vehicles like fire engines, rescue vehicles, etc. The scope of improvement is just limited to the imagination of the human mind.

6. CONCLUSION

In this system, real-time traffic assistance to ambulances is realized through maximum utilization of resources that IoT can offer while keeping the design as simple as possible. The proposed design aids in providing high-quality ambulance service to the patients, thus saving their lives. The proposed system has the potential to change how the services are offered to patients. It can flourish to be an integral part of city management by expanding its use to multiple aspects of challenges that might present themselves. The development and installation of the system are cost-efficient and can be easily relied upon.

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