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Smart Ambulance Traffic Control System

SUREN KRISHNAN, RAJAN THANGAVELOO*, SHAPI-EE BIN ABD RAHMAN & SIVA RAJA SINDIRAMUTTY

Faculty of Computer Science and Information Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia
*Corresponding authors: trajan@unimas.my

ABSTRACT

The traffic lights control system is broadly implemented to track and control the flow of vehicles through the intersection of multiple roads. Nevertheless, the synchronization of traffic light system at adjacent junctions is an intricate issue given the different parameters involved. Existing traffic light control systems do not control many flows approaching the same junctions. This results in traffic jams and congestion at urban areas or major cities with high volume traffic consisting of various types of vehicles. This includes emergency ambulances travelling on the same traffic junction during peak hour traffic. Thus, an enhanced traffic light control system is imperative to provide a smooth and free flow for an ambulance on the way to its destination. The Smart Ambulance Traffic Control System proposed in this paper is an integrated system of traffic light control for emergency ambulance service. The traffic lights can be controlled in a timely and efficient manner every time an emergency ambulance is approaching. The Radio-Frequency Identification (RFID) is used as an instrument to communicate with traffic lights during traffic congestion. The emergency ambulance driver needs to activate the RFID tag to allow the detection of RFID readers to control the traffic light operation at the upcoming traffic light junctions. The traffic lights in the path of the ambulance are forced to be green to allow the emergency ambulance to pass through the junction with top priority. Immediately after the ambulance has passed the junction, the control system will reset and return to normal operations.

Keywords: GPS, IoT, RFID, smart ambulance, traffic signal

INTRODUCTION

Traffic lights, built since 1912, are a light signal system that regulates the flow of the road traffic at road junctions, between highways, pedestrian crossings, railway trains, and other areas. The traffic signals are comprised of three universal colours; the green light permits the traffic to continue in direction marked, the yellow light alerts cars to prepare for a short stop and the red signal denies any traffic from continuing (Kham & New, 2014). Many nations are suffering from traffic congestion issues that affect the transportation system. Despite the use of traffic controllers and programmed traffic light systems, the optimization of heavy traffic jams is still challenging, particularly with many road intersections (Isa, Shaari, Fayeez, & Azlin, 2014). The exponential growth in the number of vehicles and expansion of new roads and highways are not fully supported by efficient infrastructures to facilitate the easy flow of traffic. In some cases, partial solutions were proposed such as opening of new highways, building of flyovers or bypass roads, and creating rings. However, because of the presence of different variable, the traffic problem is very complicated.

Firstly, the traffic flow depends on the time of the day i.e., during peak hours, traffic in the morning and afternoon, during all working days and on weekend where there is usually less traffic on the road. There is usually dense traffic from cities to the outskirts and in the reverse direction for Mondays and Fridays respectively. Secondly, the traditional traffic light system is schemed with hard coded delayed where the lights changing interval time is fixed at a predetermined period of each direction of the traffic flow. It does not rely upon the ongoing volume of the traffic stream. Thirdly, the condition of a single light at a junction affects the traffic flow at the nearby junction. Likewise, the traditional traffic system does not consider various conditions such as accidents, roadworks, and vehicle breakdowns that contribute to a worsened traffic congestion, which then has a significant negative impact on emergency vehicles. This includes emergency vehicles of higher priorities such as ambulances, rescue vehicles, fire service and police cars. In addition to the above, pedestrians who are crossing the roads are likely to be a contributing factor too. A new traffic light control system is required so that high priority vehicles do not get stuck in severe traffic and are able to save lives during emergencies.

An ambulance is a highest priority vehicle when it is in service, but traffic congestion can result in patients not taken to the nearest hospital in time and this may lead to fatality. The Straits Times on 13th September 2019 reported that patients died as Manila traffic jams block ambulances (Anonymous, 2019). The cost of traffic congestion is high in some developed countries. For example, in the UK it reached USD20.5 billion in 2014 and it is predicted to reach 33.4 million USD by 2030, while in the US it was recoded as USD124 million in 2014 and predicted to reach USD186 million by 2030 (Davis, Joseph, Raina, & Jagannathan, 2017). Similar studies by Chakrabartty and Gupta (2015) in India's highly congested cities like Mumbai, New Delhi, and Kolkata showed an increase of 1.73 percent to 11 percent in terms of number of cars in these cities which caused the delay in arrival of the emergency services. Hence, there is a need to utilize a smart traffic control system targeted at emergency ambulance services, which will help to minimize the response time of the emergency ambulance services, and to take the patients to the nearest hospital as fast as possible. The proposed project attempts to ensure that traffic along the route taken by the ambulance is cleared and congestion is eased with the help of an integrated system between traffic lights and the ambulance. This can be achieved by signalling the nearby traffic light every time there is an emergency ambulance approaching.

Moreover, Radio Frequency Identification (RFID) tags will act as instruments placed in the ambulance and will communicate with traffic lights as it approaches the nearest traffic light in the congested area. RFID is a technology used for automatically recognizing an individual, package or item using radio signals. RFID tags are small transponders (using electromagnetic fields) which transfer identity data over a short distance when required. Hence, during an emergency, the driver of an ambulance only needs to activate an RFID tag that will be detected by RFID readers and the traffic signals are then switched (Mustapha & Nik Hashim, 2016).

Related works

Pol, Gupta, Rahatekar, and Patil (2016) proposed a Smart Ambulance System which is an application that gathers information about location using the Global Positioning System (GPS) hardware and uses Google Map Application Programming Interface (API) to plot the information of the ambulance on Google Maps. Moreover, similar function can be applied for the other module that allows user to find the hospitals with the number of services provided. Communication between the smartphone and the centralized database are coordinated using Representational State Transfer Application Programming Interface (REST APIs). The platforms utilized are capable of molding into different services that are applied. In fact, these technologies can produce a revolutionary work in public GPS if used correctly.

Ramani and Jeyakumar (2018) introduced a Smart Ambulance Guidance System using the concept of Internet of Things (IoT) and Arduino to implement a traffic signal controller. The Smart Ambulance Guidance System provides solutions to the traffic congestion problem by alerting or controlling the traffic signal before an ambulance reaches the traffic signal. This system utilizes a main server to monitor and control the traffic controllers. With the help of web applications, the ambulance driver requests the traffic controllers to force the traffic light to green following the route of the ambulance. The implemented system is capable to reduce the number of deaths due to traffic congestion at the traffic signal. Since web is accessible from any platform, this system will be useful in emergencies.

Similarly, Ahir, Bharade, Botre, Nagane and Shah (2018) proposed an Intelligent Traffic Control System for Smart Ambulance, where the traffic congestion is cleared by changing all the red lights to green along the path of the ambulance, and subsequently assisting in clearing the traffic and giving directions along the way to its destination. In this system, an Android application is developed to enrol the ambulance on its network. If an occurrence of crisis arises and ambulance is halted on its way, the application will send an emergency command to the traffic signal controlling server. In addition, it will direct the ambulance wherever it needs to go with the help of GPS. The system will identify nearby traffic signals and force the lights to green until after the ambulance passes by. Soon after, it regains its actual flow of traffic signal control. This system consists of two modules. The first module is an Android application. The ambulance driver will upload the patient's information in the Android application. The information of the patient is sent to the nearby hospital's server and thus the hospital staff will be able to prepare the requirements needed. This module operates on the principle of IoT with the help of REST APIs. This system also uses Arduino for the traffic signal controller. Wi-Fi modules are used to capture information from the server. Based on Wi-Fi modules, the Android application will directly be connected to the traffic signal controller.

Mukkawar, Rathod, Gawai, and Magar (2019) invented a Smart Ambulance with Traffic Ability using a combination of both hardware and software. The hardware is divided into two units of transmitter and receiver. The transmitter is comprised of node-MCU (micro controller unit), and the Arduino Uno consists of various health sensors such as temperature and heartbeat sensor. The sensors will sense the patient body parameters and will send the data to the cloud and thus the nearby hospital will prepare early for further treatment. When the ambulance reaches the location of an accident, the driver will get the basic information sent over the cloud. Hospital management will be able to assess the patient information through web applications to check the history of the patient. With the help of Google Maps API, the ambulance assembled with nod-MCU will transmit Wi-Fi signals continuously. The signal sensed by nod-MCU installed on the signal platform will turn green as soon as the ambulance reaches, and other signals turn red until the ambulance passes the signal.

Udawat, Tombare, Chauhan, Hadke, and Waghole (2017) proposed a smart ambulance system using IoT. As the vehicle reaches within 100m, the traffic light signal will change from red light to green; General Packet Radio Service (GPRS) will perform the communication between the vehicles and the cloud. By automatically monitoring traffic signals on the ambulance road, the system ensures a speedy response to emergency. Dunka and Sah (2020) introduced a Smart Ambulance Traffic Management System – a support for wearable and implantable medical device. It is a traffic management solution for ambulance using sensors and GPS technology. The data received from the sensors are sent to assigned stations. It is then processed, and modified information is sent to the ambulance system.

OUR PROPOSED METHOD

Our proposed Smart Ambulance Traffic Control System (SATCS) uses RFID as a main core of communication between the ambulance and the traffic light junction. The RFID consist of scanning antenna, RFID reader and RFID tag which contains the information of the traffic signal (Jagadeesan, Azhagiri, Maheshraj, Sanjay, & Srikanth, 2019). RFID Transmitter (Tx) in an ambulance will send a signal to RFID Receiver (Rx) placed at the nearest upcoming traffic lights junction. Once the signal is received at the traffic light junction, the Near Field Communication (NFC) module and microcontroller will perform a quick check first to identify the route of the upcoming ambulance and will freeze the current flow of traffic if the ambulance is on a red lane. Then, traffic control will change the traffic lights to green along the ambulance path. Figure 1 shows the communication process between traffic light and ambulance via RFID signal. Immediately after the ambulance has passed the traffic light junction, the control unit will restore the previous traffic flow according to their priority. Figure 2 shows the block diagram that forms a fundamental design of our proposed system.

Figure 3 illustrates the process flow of the oncoming ambulance route in our SATCS. The SATCs is activated by the oncoming ambulance RFID Tx to facilitate the traffic light control. Once the signal is received from the oncoming ambulance RFID Tx, the microcontroller at traffic light will perform a check on the oncoming ambulance lane. If the oncoming lane is red, the signal will then be forced to change from red to green to allow traffic flow in front of the ambulance to clear the path to give way to ambulance to pass through. All other lanes will be in red light to stop the traffic flow. Once the ambulance pass through the junction, the microcontroller then will reset to normal operations.

Figure 1. Ambulance and traffic light communication via RFID signal in SATCS.

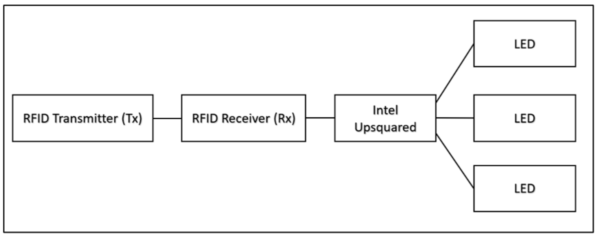

Figure 2. SATCS block diagram.

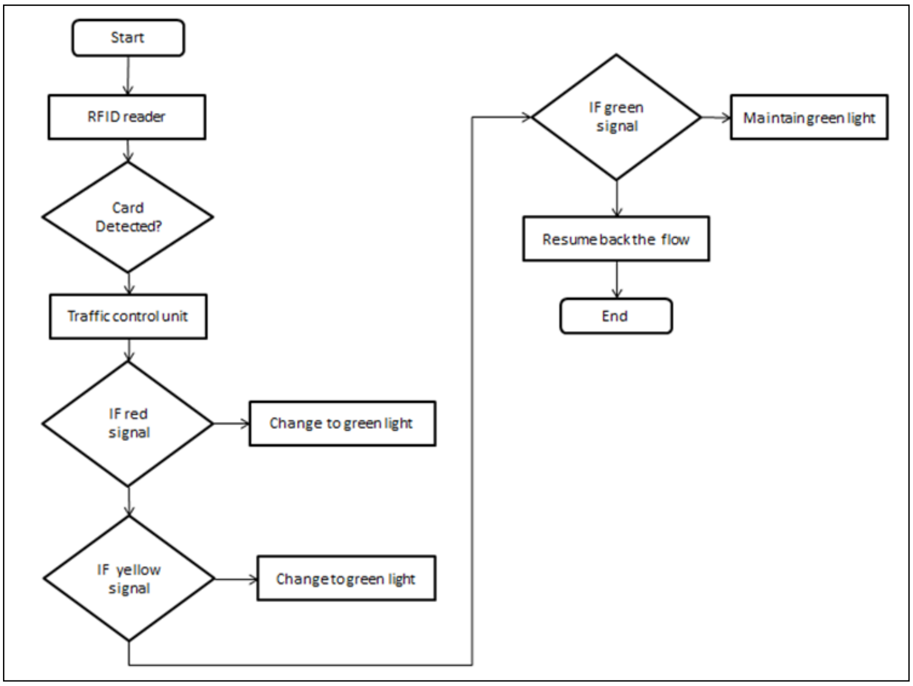

Figure 3. SATCS flow chart diagram.

Figure 4 shows the full-integrated SATCS prototype system that has been assembled. The grove NFC sensor is placed exactly 10 cm away from the traffic light. When the grove NFC module sends a Rx signal from the Tx of the oncoming ambulance, it will temporarily change the current lane signal into red and give priority to the oncoming ambulance by changing the ambulance lane to green. Once the ambulance has passed through the junction, it will change back to red and will resume the flow of the pre-set traffic signal.

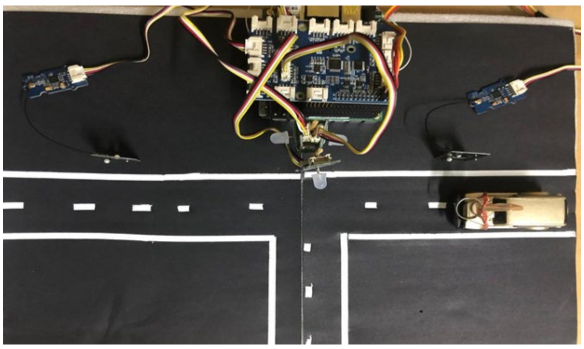

Figure 4. Top View of Proposed SATCS Prototype

RESULTS AND DISCUSSION

In this paper, the authors have reviewed four existing systems with traffic lights control specifically for ambulance and emergency services and compared them to our proposed system. Based on our review, Smart Ambulance System, Smart Ambulance Guiding System, Intelligent Traffic Control System for Smart Ambulance and Smart Ambulance with Traffic Control Ability have no offline availability, server-less deployment, and RFID technology. Our proposed system is designed to provide offline support and does not require a server to run the system. The proposed SATCS developed uses RFID technology so that the cost of implementation is relatively cheaper compared to similar existing systems. The proposed system also consumes less power than other existing system as shown in Table 1. This is important as the ambulance vehicle is equipped with plenty of medical tools and machines that already consume a lot of power. Thus, considering this factor, it is crucial to implement a proposed system with low power consumption.

The authors have conducted functional test namely Traffic flow test and RFID detection test as part of the testing phase. This is essential to ensure the proposed system complies with and satisfies all the specifications of the prototype and functional aspects as per its goal. Table 2 shows the testing of traffic flow at a busy traffic light junction. Table 3 shows the RFID detection test results at a busy traffic light junction. Based on the test results, our proposed SATCS able to detect the RFID signal from the oncoming emergency ambulance as it approaches the traffic light, and the RFID signal be able to communicate with our SATCS despite the busy traffic. The NFC communication module and microcontroller system assembled at the traffic lights junction then will enable the change of green light to red light at other junctions to halt the traffic flow while giving priority for the lane in which an emergency ambulance passes through. The test verified that our NFC communication module is working well.

Table 1. Comparison metrics of existing and proposed systems.

Metrics Existing System	Offline Availability	Server-less Deployment	RFID Technology	Cost	Power Consumption
Smart Ambulance System	No	No	No	High	High
Smart Ambulance Guidance System	No	No	No	High	High
Intelligent Traffic Control System for Smart Ambulance	No	No	No	High	High
Smart Ambulance with Traffic Control Ability	No	No	No	High	High
Our Proposed System	**Yes**	**Yes**	**Yes**	**Low**	**Low**

Table 2. Testing of traffic flow at busy traffic light junction.

Test case type:	Traffic Flow	
Test case description:	To test the flow of the traffic lights	
Test priority:	High	
Test Description	**Expected Result**	**Result**
Connect the grove chainable RGB led to grove pi+	Light up once connected	PASS
Follow the correct flow of the traffic lights	Follow the sequence of GREEN, YELLOW then RED light when changing from GREEN to RED	PASS
Follow the time interval of traffic lights	Successfully follow the time interval	PASS
Follow the correct phases or lane of the traffic lights	Successfully follow the phases of the traffic lights	PASS

Table 3. Testing of RFID detection at busy traffic light junction.

Test Case Type:	RFID Detection	
Test Case Description:	To check that the grove NFC module can detect the RFID signal	
Test Priority:	High	
Preconditions:	• Grove NFC module connected to the grove pi+. • Turn on the Intel Upsquared board. • Run the Python script.	
Test Description	**Expected Result**	**Result**
Detect the RFID signal	Successfully detect the RFID signal from the ambulance	PASS
Communicate with traffic signal	Successfully communicate or control the traffic flow at the busy/stall traffic light junction	PASS
Change the current GREEN signal to RED and give priority to ambulance lane.	Successfully change from GREEN to RED signal and give priority to ambulance lane	PASS

CONCLUSION AND FUTURE WORK

The proposed Smart Ambulance Traffic Control System has been designed and successfully tested. The prototype has achieved its functional test. The advantage of the proposed prototype is that it is not solely dependent on internet access but able to work on a standalone basis as well. The system can communicate with the oncoming emergency ambulance and traffic light using available Intel Upsquared and simple RFID technology. However, there is room for improvement. We propose that this work can be extended and tested at in the real-world environment. Since this is a Final Year Project and due to limitations, the authors developed this project as a proof of concept. Active RFID operating range is up to 100 meters or slightly more, and as such future works can focus on using cloud computing to test it in real traffic lights, for different distances between the ambulance and traffic lights, and for different ambulance speeds.

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