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Smart Traffic Light Monitoring System for Emergency using Arduino

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Abstract : The popularity of private cars has increased the number of vehicles on the road day by day, which has led to a dramatic increase in traffic. Hence, traffic congestion has become a common phenomenon nowadays. This can cause a lot of problems, especially in emergency situations where the traffic at intersections is always busy. Whether it is an ambulance, a fire engine or a police car, traffic jams and delays are often encountered during emergency operations or rescue. Accidents between emergency vehicles and other vehicles also often occur at busy intersections when there is no emergency route for emergency vehicles because other vehicles must be crowded to provide special routes for emergency vehicles. Therefore, there is a need for a traffic light system that prioritizes emergency vehicles and dynamically adapts changing traffic conditions. In this project, a prototype of a traffic light system that consider emergency vehicles as priority was created based on Internet of Things (IoT) technology. The traffic light prototype was implemented using Arduino Uno with radio frequency (RF) transmission with 433 MHz RF modules. The traffic light system works normally until it receives a signal from an emergency vehicle, the lights sequence will change to help emergency vehicles pass the busy traffic junction fast. To evaluate the significance of the system, a survey was made to evaluate the usability and usefulness of the prototype. The findings showed that the system can be useful to increase the efficiency of emergency vehicles during emergency operation. In future, this prototype system can be improved to adapt to the actual traffic conditions by studying its limitations. Different modules or equipment can be used in a real-life scenario to improve the prototype.

Keywords: Emergency Vehicle, IoT, Traffic Light System, Arduino

1. Introduction

Nowadays, congestion in traffic has become a frequent occurrence. Thus, emergency services, whether it is an ambulance, a fire truck, or a police car, often face traffic congestion and delays during the emergency operations or rescue process. Besides, accidents between emergency vehicles and other vehicles often occur at intersections with traffic lights due to other vehicles must be crowded to provide

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special routes for emergency vehicles when there is no emergency route for emergency vehicles. The emergency services such as the transferring of patients to the hospital by ambulance should be in a fast and safe manner to increase the rescue and survival rates of the patients. Hence, a traffic light monitoring system for emergency vehicles is required to adapt to traffics' changing conditions dynamically.

Emergency vehicle traffic signal control is the subject of several studies, such as [1]-[3]. Academic researchers investigated and analysed the strengths, design, and limits of several types of traffic control systems for emergency vehicles in [1]. Based on cost, utility, and maintenance considerations, this research study proposed the optimum traffic management method for emergency vehicles. Wireless network sensors, image processing, and radio frequency identification (RFID) are some of the common ways to managing traffic congestion addressed in the article. Wireless network sensors, image processing, and RFID are some of the common ways to managing traffic congestion addressed in the article. According to the conclusions of this research, RFID is often the best technology for regulating traffic signals for emergency vehicles.

Using a peripheral interface controller (PIC), the researchers built an automated traffic light controller for emergency vehicles in [2]. In this system, the PIC and 315MHz RF transmitter and receiver modules were used to programme a priority-based traffic light controller for an emergency vehicle. The traffic light circuit is linked to an RF receiver and controlled by the PIC16F877 microcontroller. To make clearance for its path, emergency vehicles can use the PIC to cause the traffic light to turn green. When the emergency vehicle has gone across the junction, the traffic signal will resume regular operation. When the traffic light is already green, the time period for the green traffic light will be lengthened until the emergency vehicle safely passes through the junction.

The researchers in [3] used sound sensors to manage a traffic system for emergency vehicles. The system made use of two sound sensors as well as the Xbee communication protocol. Both sound sensors measure the frequency of the emergency vehicle as it approaches the traffic signal. Sound sensor 1 is connected to the Arduino Uno 1, while sound sensor 2 is connected to the Arduino Uno 2. A connection was established between sound sensors 1 and 2 using the wireless Xbee protocol. Sensor 1 is placed 100 metres distant from the traffic light, whereas Sensor 2 is placed close to the traffic light. Regular traffic operations resume when none of the sensors identifies an emergency vehicle. When sensor 1 detects an emergency vehicle, the driving lane goes green for 120 seconds, and the remaining lanes turn red until the emergency vehicle approaches sensor 2. If sensor 2 identifies an emergency vehicle, it will proceed with a 2-second delay to let the emergency vehicle fully pass through that lane and green light in each lane.

The main concept of this study is to help emergency vehicles to control the traffic light when it is arriving at the intersections to provide effective services. As a result, a prototype for a smart traffic light monitoring system was created for emergency vehicles in this study. This paper introduces the use of Arduino Uno and 433 MHz RF module to develop a low-cost traffic light system prototype that considers emergency vehicles as a priority. The Arduino Uno will be used as a microcontroller in the prototype. Arduino is an open-source platform. The circuit board and software are easy to obtain, and the circuit board can be modified and optimized to improve its functionality. The Arduino IDE is the programme that is used to programme Arduino devices. It requires some basic skills to learn and free to use. C and C++ languages are used in the Arduino IDE [4].

The following section of the paper is formatted as follows. Section 2 describes the materials and methods. Section 3 explains the results and discussion. Then, continued with Section 4 that explained the conclusion.

2. Materials and Methods

2.1 Materials

Materials that are used for the usability evaluation are Google Form and Microsoft Excel. Google Form was used to create the questionnaire to collect participants opinions toward the prototype. The recruitment approach of participants is finding people who hold driving license between the ages of 16-46 and feel panic easily when an emergency vehicle is behind his/her vehicle to watch the demonstration video of the prototype and answer the evaluation form through Google Form. After the data is collected from the participants, Microsoft Excel is used to analyse the data received from the Google Form.

2.2 Methods

This paper was conducted by adopting the Waterfall methodology. The waterfall methodology phases are shown in **Figure 1**. It includes six phases which are requirement analysis, system design, implementing or developing, testing, deployment, and maintenance. In this paper, the system requirements were gathered from previous studies on the Internet. Then, the low-fidelity prototype system was designed based on the requirement specifications. Next, the prototype was developed using the Arduino IDE. C and C++ languages are used in the Arduino IDE. The prototype was continued with the testing process to verify that it was met with the requirement specification. A usability evaluation was conducted on 30 participants to test the usability and usefulness of the prototype. The errors and bugs can be found out through the evaluation process and these can be fixed before the final system is released. The feedback from participants will consider improving the prototype in future work.

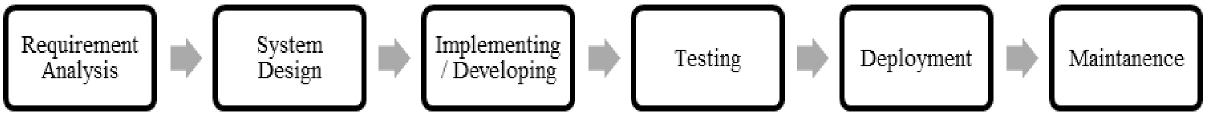

Figure 1: The phases of waterfall methodology

3. Results and Discussion

A usability evaluation was conducted on 30 participants. People who hold driving license between the ages of 16-46 and feel panic easily when an emergency vehicle is behind his/her vehicle are considered potential participants to this usability evaluation. The recruitment approach is finding people who hold driving license between the ages of 16-46 and feel panic easily when an emergency vehicle is behind his/her vehicle online to watch the demonstration video of the prototype and answer the post-task questionnaire through Google Form.

The instruments used for the usability evaluation were the video demonstration of the prototype and a post-task questionnaire. The video demonstration showed the complete flow of the prototype to be triggered under specific circumstances which is the ambulance vehicle arrived at the traffic light intersection. The participants should watch the video demonstration of the prototype before starting to answer the post-task questionnaire. Section A asked the participants' demography and background information while Section B asked the participants to complete some given tasks to ensure the prototype is working properly. The following section asked participants opinion on a five-point Likert scale where one represents strongly disagree, and five represents strongly agree. Section C asked participants opinion about the ease of use of the prototype. Section D asked participants opinion about the usefulness of the prototype. Section E asked participants opinion about the performance of the prototype. Section F asked participants opinion about the satisfaction of the prototype. The participants performed the following step-by-step procedure for the usability evaluation: (1) read and signed a consent form, (2) watch the video demonstration of the prototype, and (3) answered the post-task questionnaire.

The findings for demography and background showed that the participants' gender consists of 76.67% female and 23.33% male. 86.67% of the participants are from the age 21-25, followed by 10% of participants in the age group 16-20 and the rest 3.33% is the age group 26-30. 56.67% of the participants held their driving license for 1-5 years, followed by 30% of the participants who held their driving license for more than 5 years and the rest 13.33% of the participants held their driving license for less than 1 year. 76.7% of the participants feel panic easily when an emergency vehicle is behind their vehicle, 16.7% will not panic easily when an emergency vehicle is behind their vehicle, and 6.7% of the participants maybe will feel panic when an emergency vehicle is behind their vehicle. For the question of whether participants have heard about Smart Traffic Light Monitoring System (STLMS), 73.3% of the participants do not hear about STLMS, 23.3% of the participants had heard about STLMS, and 3.3% of the participants may be heard about STLMS.

The outcomes of the usability evaluation stated that the prototype was easy to use and useful. In addition, participants expressed that they are satisfied with the functionality of the prototype. **Table 1** reports the frequency and average value of participants' responses to system satisfaction. Overall, most participants are satisfied with the system. On the question of whether they were satisfied with the STLMS, a total of 17 participants were rated as strongly agree 56.7%, while 12 participants were rated as agree 40%, and the remaining 1 participant was rated as neutral with 3.3%. The next question is about how the system works in the way that participants expect. Most of the 18 participants strongly agreed with 60%, while 11 participants agreed with 36.7%, and the remaining 1 participant gave a neutral rating of 3.3%. No participants rated as strongly disagree and disagree. Only a few participants considered it neutral.

Table 1: The participants' response on the satisfaction of the sytem

Post-task questionnaire	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	Average
Overall, I am satisfied with this system.	0(0.0)	0(0.0)	1(3.33)	12(40.00)	17(56.70)	4.53
This system does the things I would expect it to do.	0(0.0)	0(0.0)	1(3.33)	11(36.70)	18(60.00)	4.57

The prototype for Smart Traffic Light Monitoring System for Emergency using Arduino was separated into two parts. The first part is the emergency vehicle part that includes the Arduino Uno, RF transmitter and 4 control buttons. It was assembled as shown in **Figure 2**. While **Figure 3** showed the second part for the traffic light part that includes the Arduino Uno, RF receiver and 4 traffic lights. The control button can be pressed to indicate the RF transmitter to transmit the signal from the emergency vehicle part to the traffic light part. The Arduino Uno will trigger the traffic light to turn green for the emergency vehicle when the RF receiver receives the signal. After 20 seconds for the emergency vehicle to pass the intersection, the traffic light operation will back to normal.

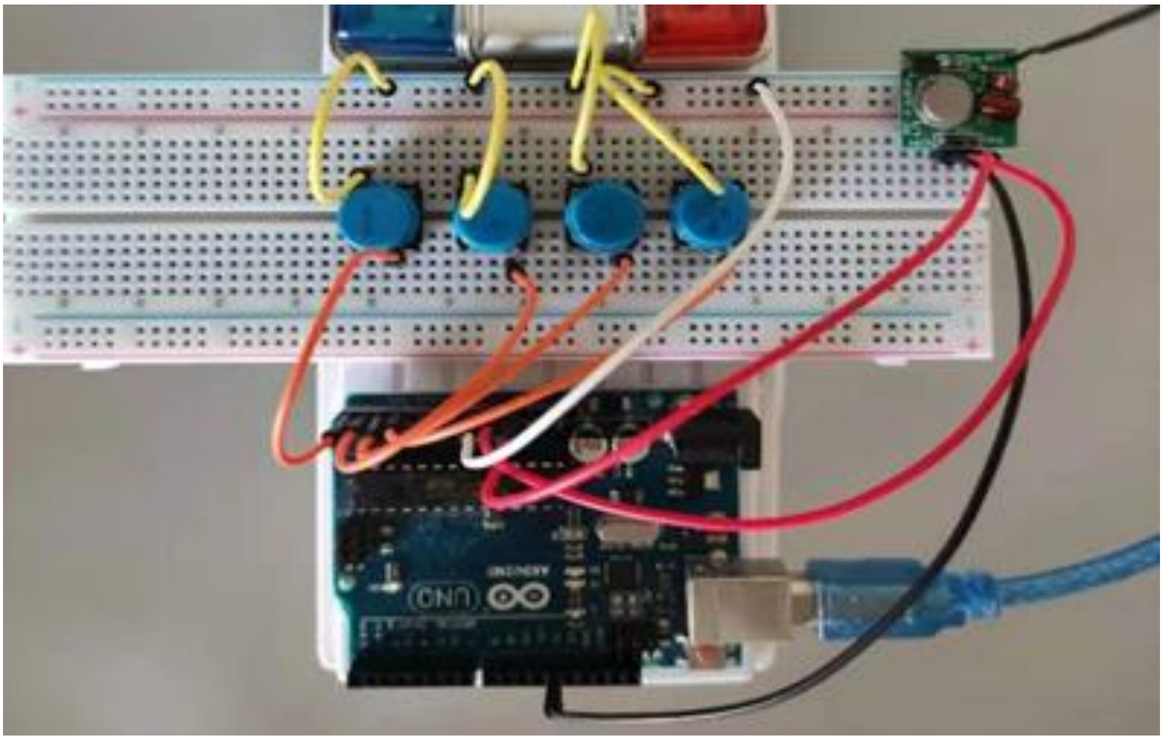

Figure 2: Assembled of emergency vehicle part

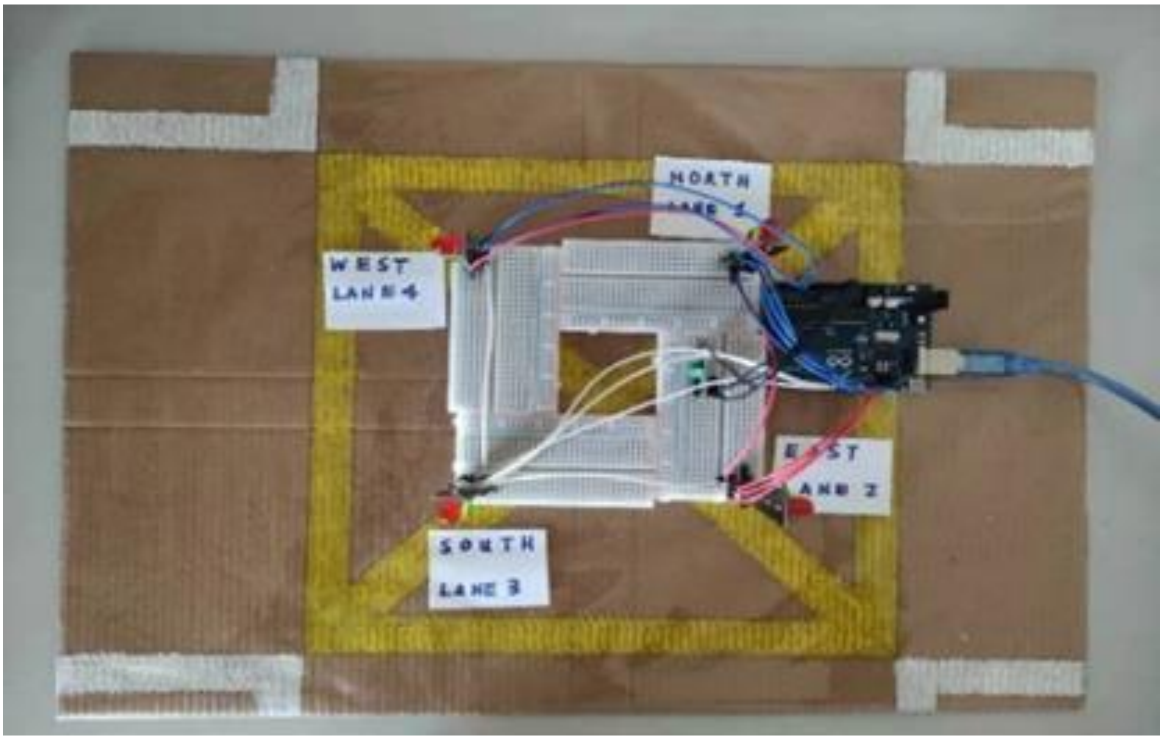

Figure 3: Assembled of traffic light part

The functionality of the prototype had been successfully achieved which is implementing an emergency mode of traffic light system at an intersection when the emergency vehicle is involved.

4. Conclusion

Based on the Internet of Things, a prototype of a traffic light system that prioritises emergency vehicles was built in this study. The microprocessor for the traffic light is Arduino Uno, and 433MHz

RF modules are utilised to facilitate communication between emergency vehicles and traffic signals. During an emergency, the prototype can be operated utilising radio frequency communication. The prototype's performance has been validated. The basic idea behind this prototype is to assist emergency vehicles in controlling the traffic signal as they approach the intersection. The prototype can increase the efficiency of emergency vehicles during emergency operations. Different forms of wireless technology might be substituted in the prototype in the future to adapt to actual traffic circumstances by analysing its limits with the communication method between the emergency vehicle and traffic light. On the other hand, various modules and equipment can be utilised in real-life settings to enhance the prototype.

References

[1] W. M. H. B. Wan Hussin, M. M. Rosli, and R. Nordin, “Review of traffic control techniques for emergency vehicles,” Indones. j. electr. eng. comput. sci., vol. 13, no. 3, p. 1243, 2019.

[2] N. Hashim, F. Idris, A. F. Kadmin, and S. S. J. Sidek, “Automatic traffic light controller for emergency vehicle using peripheral interface controller,” Int. J. Electr. Comput. Eng. (IJECE), vol. 9, no. 3, p. 1788, 2019.

[3] G. Iswarya, H Bharath, VV Reddy, “Sound sensors to control traffic system for emergency vehicles,”, International Journal of Applied Engineering Research, vol. 13, no. 7, pp. 184-186, 2018;13(7).

[4] A. Aqeel, "Introduction to Arduino Uno - The Engineering Projects", The Engineering Projects, 2021. [Online]. Available: https://www.theengineeringprojects.com/2018/06/introduction-to-arduino-uno.html.