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Design and Development of a Pedestrian Controlled Stop Light

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ABSTRACT

Pedestrian safety should always be one of the priorities when implementing projects aimed at traffic. The vulnerability of pedestrians increases when they use the crossing roads, and it increases further during the nighttime since drivers have lower visibility of pedestrians on the road. This paper aims to reduce accidents relating to cars and pedestrians. Through the use of Arduino as microcontrollers and ultrasonic sensors, a smart pedestrian-controlled traffic light can be constructed to aid pedestrians crossing while causing a less negative impact on the traffic of the location. A control system will be utilized to analyze traffic and operate the traffic light depending on the data received by the sensors. The project is easy to produce and can be altered depending on the conditions of the location. The operation of the project aims to be useful for both pedestrians and drivers. However, the project cannot be applied to all traffic lights and must be strategically placed on specific situations to maximize the efficiency of the application of the project.

Key words: Pedestrian, traffic light, control systems, Arduino, ultrasonic sensor.

1. INTRODUCTION

The purpose of the study is to implement a low-cost pedestrian controlled traffic light using Arduino and PIR motion sensors to analyze traffic. The system will decide on a time interval for changing the lights to prepare upcoming cars for pedestrians that will try to safely cross the road. The system was created to be applied during the nighttime as fewer people are roaming around the streets and the system will prevent further accidents that may happen from no supervision from police officers usually supervising the intersections. The implementation of the system is to be done on streets with traffic lights for pedestrian crossings. This is usually seen in school districts and residential areas. A real and practical application of the system can be implemented on the roads in front of DLSU, which is a school district and a residential area for some students enrolled in the college.

As the study being conducted is only low cost and focuses on a specific target area, the system can be easily implemented and verified if it would be successful or not. Other countries have started implementing similar systems to their intersections and researchers are thinking of more ways to integrate the system so that not only are the roads safer, but so that energy conservation is achieved and emergency vehicles are no longer disrupted by red traffic lights when the vehicle needs to pass through. A better traffic management system also enables more people to save time going from place to place. This benefits society by enabling people to be able to get to work on time and still have time for their families when they decide to go home. If a road accident occurs, a delay in the flow of traffic is developed and someone may die which would lead to a lot of negative impacts.

2. BACKGROUND OF THE STUDY

The concept of a smart traffic light is an idea that is being expounded on by various other researchers but the difference with this study and the others is that this study is implemented on a smaller scale.

Knowledge of Arduino programming and sensors are required to understand how to implement a system like this. Basic understanding of the Arduino system is essential for the system to be able to operate simultaneously from input to output with the data that is varying. Although the system is fairly easy to recreate, one must have the proper understanding to ensure that the system will work as it is designed. The system works on the concept of interpreting real-time data being obtained by the sensors and a resulting time for the traffic lights will be implemented based on the result. This is essentially a feedback system wherein data is continuously returned to the circuit and varying codes are used depending on the situation analyzed by the sensors present on the road. The system can be implemented on a larger scale as done by other studies, but this study will only focus on small roads as to see if there will be any difficulties encountered and so that improvements can be continuously made throughout the initial phase of the system.

The basic understanding of how different sensors operate is a concept that the researcher must possess for this study as varying sensors would operate differently from one another. The main sensor used for the study is a PIR motion sensor, PIR stands for passive infrared. The PIR motion sensor is low power and low budget component that detects motion by

measuring infrared light emitted by objects within the field of view of the sensor. This is commonly used in security alarms and automatic light detectors and for this study, it will be used to detect either pedestrians or vehicles on the road.

3. STATEMENT OF THE PROBLEM

Road safety has been one of the Philippines' major issues [1]. The pedestrian's safety is one of the important criteria to consider when designing the streets. Pedestrians become vulnerable when crossing the streets. Although it is important to implement stoplights in intersections and some parts of the streets for crossing pedestrians. It is important to have efficient stop lights strategically placed to have an effective impact on traffic and ensure the safety of the pedestrians. Crossing pedestrians is one of the most dangerous factors in traffic [2]. Especially at nighttime, drivers not seeing pedestrians are one of the leading causes of accidents [3]. Currently, stoplights are timed and coordinated according to the car density and speed and it has been observed that at night, some stoplights are turned off, which makes the pedestrians crossing vulnerable and more prone to danger. To add up, drivers during yellow light tend to speed up rather than slow down [4]. This behavior calls for the importance of a strategically timed stoplight that is controlled by the pedestrian crossing to ensure their safety.

4. SIGNIFICANCE OF THE STUDY

The study is being done to ensure that people who live in areas that are not that busy can safely cross the road without the fear of getting involved in an accident from a vehicle late at night. This is achieved by the implementation of a more efficient traffic light system which results in no unnecessary stops from incoming vehicles due to sensors that will locate things near the vicinity and will ensure that a pedestrian will be able to cross the road safely. This results in safer roads and put everyone at ease. Though the study has been around for a long time there is minimal integration of the concept here in the Philippines.

As pedestrians are not a normal occurrence at night in these areas, the system aims to increase the mindfulness of drivers. This is achieved through the knowledge that the traffic lights now work through sensors and this would mean that the traffic light will turn red due to a pedestrian crossing and not just a time-based algorithm that drivers are used to. The system not only protects both the driver and pedestrian but also encourages both to be more aware of driving laws even at night when there are fewer cars present on the road.

5. DESCRIPTION OF THE SYSTEM

The system will only be applied during the nighttime, since during the daytime, guards are present to assist pedestrians, eradicating the need for a pedestrian controlled stoplight. Additionally, during the nighttime is where fewer regular pedestrians are meaning, fewer pedestrians are crossing rather there are only a few pedestrians at night.

The pedestrian controlled stoplight makes use of the Arduino Uno for its Data acquisition and control system. Two buttons will be placed on the poles on both sides of the crossroads. When one of the buttons is pressed the system will be activated. An ultrasonic sensor (HC-SR04) is used to detect upcoming cars. Two sensors will be set up at a distance of 50 m from the crossroad. These sensors will be connected to the Arduino microcontroller to analyze the obtained data. When the sensor detected that there are no upcoming cars, the system will set a short time for the orange light and a longer time for the red light. When the sensor detects cars upcoming, the system will set a longer time for the orange light and relatively shorter time for the red light.

6. METHODOLOGY

This system is applied only to non-busy roads that make use of stoplights for pedestrian purposes, the crossroad in front of the Velasco gate of DLSU, during the night. A button can be pressed on the poles on each side of the pedestrian crossing road. The ultrasonic sensors 50 m from the crossroads to measure and analyze the cars approaching.

The ultrasonic sensor detects the object in front of it by sound wave reflection [5]. When the pedestrian pushes the button, the ultrasonic will be triggered by connecting the push button to the trigger pin (pin 4) of the sensor. When an object is detected in front of the sensor, the echo pin (pin 3) will send a signal if a car is detected. Figures 1 to 4 shows the various pin configurations.

Figure 1: Pin configuration of an Ultrasonic Sensor

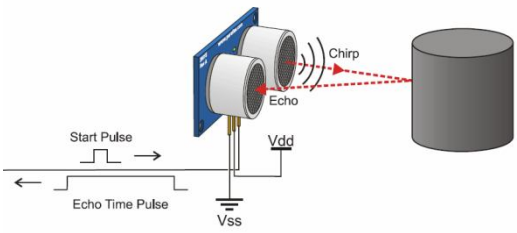

Figure 2: Mechanism of an Ultrasonic Sensor

The ultrasonic sensor will then be connected to the Arduino Uno. The Vcc pin of the sensor will be connected to the 5V power pin of the Arduino. The trigger pin and echo pin will be

connected to one of the Digital I/O pins, pin 12 and 13 respectively. The ground pin of the sensor will be connected to the ground pin of the Arduino.

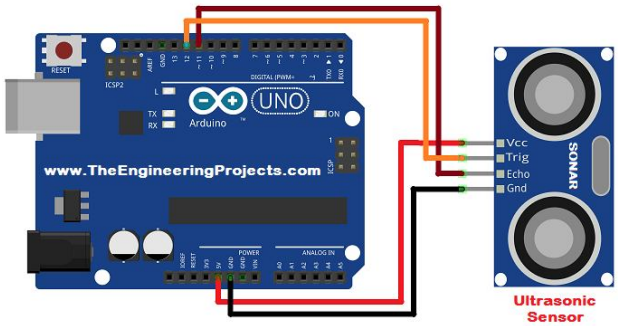

Figure 3: Ultrasonic Sensor Arduino Interfacing

The Arduino will also be connected to the two-car stoplights and the pedestrian stoplight. The LED lights will all be connected to the remaining Digital I/O pins.

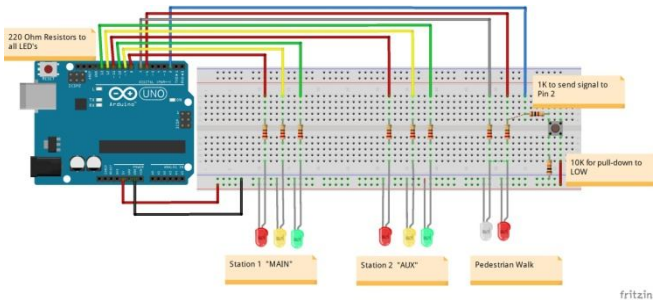

Figure 4: Stop Lights Arduino Interfacing

7. REVIEW OF RELATED LITERATURE

Previous studies, while not focusing on traffic lights, have successfully implemented Arduino and sensors to streetlights. This concept can be implemented and used on traffic lights as well. A group of researchers made a study on an adaptive streetlight that would make the streetlights adapt to the motion from cycles, cars, and pedestrians which would result in dimmer lights when no motion was detected [6]. The researchers had used Arduino and a few sensors namely the IR, LDR, LED, and PIR to achieve their goal. A similar study had created an Arduino based automation system for the streetlights wherein an LDR would detect if it was night or day and had a resulting dim effect for the light if it was night and with an IR implemented if the IR detected an object would set the light's intensity to high [7]. This idea was also used by another group of researchers but this time, the system worked by turning the lights on or off and only worked on a one-way road at a junction [8]. Another study tackled the same topic of using sensors to control streetlights but focused more on the reduction of energy consumption of the traffic lights to reduce CO2 emissions [9].

A study has also been done using PLC to create a smart traffic control light. The researchers implemented a feedback system to existing traffic lights and with the feedback, the traffic lights make a decision based on the density of traffic in the area and adjust the duration of the red and green lights accordingly [10]. An image processing algorithm was also used for the implementation of the smart traffic lights by another group of researchers [11]. The idea for the algorithm is the same as the feedback system wherein the traffic lights would change from green to red depending on the density of traffic per lane. Similar to this study, one researcher had used MATLAB [12] for image processing which would change the time the lights would change based on the traffic density and traffic count [13]. Fuzzy Logic can be used to improve image processing [14].

8. THEORETICAL CONSIDERATION

Push Button

At both poles located at the end of each crossroads. When the pedestrian wishes to cross the road, the button is to be pressed to request for a stoplight. The pushbuttons will trigger the system to be activated.

Ultrasonic Sensor

The ultrasonic sensor will detect any upcoming cars. The sensor will emit ultrasonic pulses and will bounce off an object and will go back and be received by the transducer. The ultrasonic sensor measures the distance from the object to the sensor [15]. It is given by the equation:

$$s = 0.5vt$$

Where ***s***is the distance in meters from the object to the sensor, v is the sound propagation speed, which is 344m/sec, and t is the traveling time in seconds.

The sensor will be placed in front of a column of the LRT train, and the fixed distance from the column will be the reference distance, approximately 6 m, which will signify that no cars detected. If the distance received by the sensor is less than the reference distance by 1.8 m, the regular width of a car, then it will signify that a car is detected.

Arduino Uno

The Arduino Uno will be the microprocessor of the system. It will receive data from the ultrasonic sensor. The activation of the sensor will trigger the stoplight to change to orange and then red. The Arduino analyzes the output of the ultrasonic sensor. If the distance received is more than 5 m, then Arduino will program the yellow light to last for 3 seconds then will turn the red light to 40 seconds. If the distance received is less than 5 meters, then the Arduino will program the yellow light to last for 5 seconds and the red light will last for 30 seconds. The time set for each light is decided by logic. When there are no cars present, there is less time for the yellow light since there are no cars to warn the crossing of pedestrians or cars are far enough to not rush and speed while the light is yellow, and more time for the red light since no car is waiting. When there are cars present, more time is allotted for the yellow light to warn them earlier and give more preparation time. The time for the red light is shorter since no cars are waiting.

9. DATA AND RESULTS

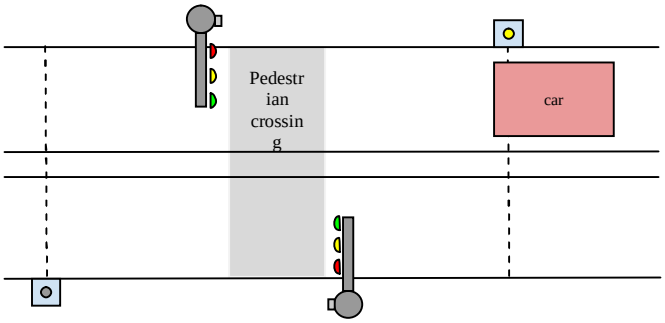

Figure 5: Applied System

When one of the buttons has been pushed by the pedestrian, the system will be activated as shown in Figure 5. The sensors will then detect the presence of a car and if one of the sensors has detected a car, an analysis will happen. If the countdown of the stoplight is less than 30 seconds, then the light will turn orange in 3 seconds and will last for 5 seconds and then will turn to the red light that will last for 40 seconds. If the countdown is more than 30 seconds, the system will wait until the countdown of the stoplight is at 29 seconds to turn the lights of the stoplight. If the sensor has not detected a car for 2 seconds, then the stoplight will turn orange in 3 seconds and will last for 3 seconds and then will turn red for 50 seconds.

10. ANALYSIS OF DATA

The sensors are placed 50 meters away from the edge of the pedestrian crossing. The average speed of a moving car is 50 kilometers per hour or approximately 14 meters per second. Upon activation through the push button, the sensor will detect the presence of cars for 5 seconds. 5 seconds for detection time was chosen since a car will take approximately 3.6 seconds to travel 50 meters. The 3.6 seconds was rounded up to ensure that the 50-meter distance is cleared during the allotted 5 second detection time for the sensor.

The time for a yellow light and red light varies depending on the data received from the sensor. When the sensor indicates that no car passed by the allotted 5-second detection lesser time will be allotted for the yellow light, but more time will be allotted for the red light. The reason for this is because since there is no car near enough to catch the yellow light there is no need for such a long time for the yellow light. The longer time for the red light is because there is no car waiting for pedestrians to cross. On the other hand, when the sensor detects there is an upcoming car present, there will be more time allotted for the yellow light and less time for the red light. Drivers tend to rush during yellow light rather than slow down. To ensure the pedestrians' safety, the yellow light is prolonged to give additional time for the drivers to slow down. The red light of the stoplight is reduced because in this situation, cars are now waiting for pedestrians to cross. Enough time will still be allotted as to not rush the pedestrians, but for the efficiency of traffic, the time allotted for the red light is minimized.

11. CONCLUSION

The priority of the project is to ensure the safety of pedestrians during nighttime while also considering its efficiency to the traffic. The project would be applied to non-busy roads wherein the possibility of people crossing the streets at night is low but is still plausible. These kinds of roads are especially dangerous for pedestrians to cross since it is not a busy road, meaning it is not a regular occurrence that pedestrians are crossing, so no guards are present to assist and cars may not be that careful to mind the pedestrians or simply see the pedestrians. Hence, the project aims to solve the problem with pedestrian safety to reduce accidents. The project is a smart stoplight that analyzes the traffic and pedestrians and operates according to the data it obtains. The system calls for pedestrian input and car presence input to set the efficient time for the yellow light and red light of the stoplights.

The project is projected to cost around Php 5,000.00 to Php 6, 000.00 for the addition of the sensors and microcontroller to the existing stoplights for two-way roads. The estimated cost for one-way roads would be Php 3,000.00 to Php 4, 000.00 since fewer sensors would be needed. Since the sensors are relatively small, with proper boxing and shell, the additional maintenance of the project would be relatively low.

The project is not to be implemented on all pedestrian crossing roads, but on specific roads that need extra care for pedestrians. A possible place for the installation of this project would be the pedestrian crossing in front of the Velasco gate. Although during the day, guards are present to assist the students crossing, at night there are none. There is also no stoplight to aid the pedestrian. It is not a busy road during the night, but there are still students living around the area and cross that road. To ensure their safety, the project may be implemented to assist the pedestrian during the night.

12. RECOMMENDATIONS

The project is aimed to be low-cost production and operation. Although this type of project ensures the safety of pedestrians while being efficient to traffic, there is a low chance for the government to implement such, since it focuses on specific roads. However, the project can be ideal to be implemented in big subdivisions rather than public roads, since subdivisions are greatly concerned about the residents' safety. It is recommended that the shell of the sensors is strong yet not a disturbance to the pedestrian sidewalks nor the roads. This project must be placed strategically for it to have its maximum efficiency. The roads must be usually free from traffic but are still being utilized by drivers and there must not be a large volume of pedestrians, as to not abuse the pedestrian controlled traffic light push button, but the pedestrian crossing also still be utilized by pedestrians.

The specifications of the project are heavily dependent on the usual situation of the roads the project is to be implemented on. The time of the traffic lights can also be changed

depending on the situation of the roads to be implemented. A busier road may mean a longer time for the yellow light. A wider road may need a longer time for the red light. The distance of the sensor and the time allocated for the detection may also be changed depending on the average speed of cars and the behavior of the drivers in that location. The alteration of the specifications is easily done by changing the codes programmed to the microcontroller.

The project is highly recommended for residential locations. Since pedestrians and cars can be both presents during the night. The project will help reduce accidents due to low visibility. The push button to control the traffic light must be visible and accessible for all, it can be low enough for children wanting to cross the road.

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