Car Wash Deterrent System

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***ABSTRACT*:**

The objective of the Car Wash Project is to prevent people from using self serve open wash bays for long periods of time without payment, which costs car wash owners considerable revenue. The solution proposed by the team is designing a universal car wash deterrent system that can be customized to multiple different car wash designs and bay layouts. The deliverable is an installation kit that can be shipped and self-installed. The packaged kit will include an ultrasonic vehicle-detection sensor, an LED strobe light, an LED display board, and a water solenoid valve. If customers stay too long without paying, the strobe light will light up, and after a set countdown, the water valve will open and the sprinklers will turn on.

Everything needed for the system will be included in the installation kit other than piping, cables, and wires. The team has successfully combined all the separate components into one operational circuit as well as getting the most suitable products for the device so it can run at optimal efficiency. We will display the installation kit, how the system operates, along with a schematic of electronics.

I. INTRODUCTION

A. Self Serve Car Wash Bays

Self serve car wash systems are a convenient method for people to wash their cars. They consist of bays where people may pay for time to use the bays at any time of the day. While this system is a helpful tool for many customers, it can sometimes be disadvantageous for self- serve car wash owners.

B. The Problem

The problem the carwash owner was facing is people using bays for long periods of time without payment. Some people would use the bay space to gut deer and some used it to work on their cars (change oil, parts, etc). This prevents customers from using the car wash for adequate purposes. Occasionally the police had to be summoned, placing a burden on community law enforcement as well. These issues kept the client from maximizing their earnings and profit from the establishment.

C. *Proposed Solution*

The solution proposed by the team is a universal car wash deterrent system that can be sold to car wash companies. This kit will contain all hardware necessary for customer installation, with the exception of wiring from the bay to the control console and water piping modifications to install the solenoid valve. These components will be customized based on the size of the bay and how far it is from the control room. The major components of the system are an ultrasonic vehicle detection sensor, a solenoid valve, an LED strobe light, and an Arduino control unit.

II. DESIGN PROCESS

A. Brainstorming

The team began with broad options to help keep an open mind as options were discussed to deter non-payment use of the bays. Many options were considered as constraints and customers' wants had to be factored into the team's ideas. Below is a diagram that displays the general brainstorming process.

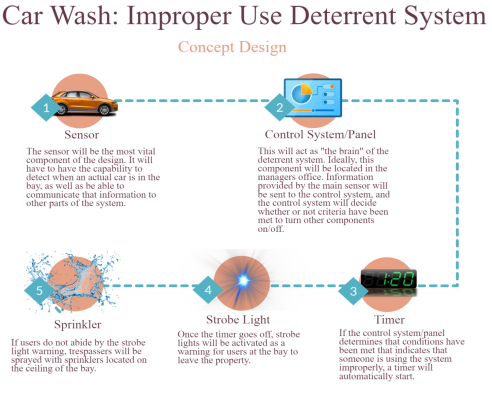

Figure 1: Brainstorming Process

B. Project Charter

Stage-Gate Project Management Tools were employed in this project. The essential elements are the establishment of a Project Charter, which details the customer's requirements, desires, goals and objectives for the specific project. The goals for the project were measurable, attainable, relevant, and timely; an assessment of risks and mitigation steps, and a preliminary timeline and milestones. Regular meetings were established with the customer to ensure project progress. The constraints were defined as weather, budget, and hard wiring the system. With all this information at hand, the team began building the prototype.

C. Sensor System Options

Two methods of sensing the presence of a vehicle in the bay area were considered: ultrasonic detection and image recognition. The benefits and drawbacks of each are described below.

- Ultrasonic sensor: The team considered using an ultrasonic sensor with an Arduino to record when a car is present in the bay. The way the ultrasonic vehicle detection sensor works is it uses either voltage or distance readings to determine if a vehicle/object is present. The output voltage reading increases when a vehicle is detected and the distance reading decreases when a vehicle is identified. By determining the threshold of the voltage or distance, the Arduino would be used to set timers and control following activities once a car is detected. Ultrasonic sensors' price ranges from $5 to over $200. This makes these sensors cost friendly and also of a wide variety with multiple functions and operations. They are mostly reliable, but are very sensitive so technicians have to be careful with the placement and maintenance of ultrasonic sensors.
- Tensorflow approach: Tensorflow is a machine learning and artificial intelligence software and its purpose for this project was to detect vehicles and control following activities such as turning on deterrent devices using a Raspberry Pi [1]. For the tensorflow system to work efficiently, the visual recognition requires a library of images. This makes tensorflow very fascinating and a multi-use software, but makes it complex to use. Tensorflow gets more intelligent based on the quality and number of images it is fed which leads to reliability issues.

D. Control System/Panel Options

The logic control system will be located in the manager's office/control room where it is protected from outside elements such as water and weather concerns and secured. It will only be accessible by car wash staff. It would act like the brain of the system. Information provided by the sensor will be sent to the control system, and the control system will decide whether or not the criteria has been met to turn other components on/off. The two types of control boards considered for this project are Arduino and Raspberry Pi.

- Arduino: It is an electronic board and a microcontroller for building digital devices and systems. It is able to read inputs and is able to turn them into outputs. These cost approximately $30.
- Raspberry Pi: It is a single-board computer which has its own operating system and runs on Linux. It reads command based code and can carry out more complex operations such as monitoring weather and robot control. These cost approximately $50.

E. Time

In order to set 'if' statements for the immediate action components of the system, multiple timers needed to be set. In order to do so, the team considered two methods; setting up analog timers and logic/digital timers.

- Analog Timers: The circuit would be built using potentiometers, diodes, and other necessary components. An analog timer system would be cheaper than a digital timer system but is more complex because if a component breaks, it would be hard to identify the cause. There are several parts in circuits for analog timer systems.

- Logic/Digital Timers: These require a control board (such as an Arduino or Raspberry Pi) to manage and execute commands. They are simpler to build and operate because they are programmed using code language and their cost varies depending on the function of the controller.

F. Deterrent Method

The client wanted two methods (a warning component and an engaging component) to deter people who do not pay for using bays. The client proposed using either a combination of a strobe light and sprinkler, or a buzzer and sprinkler system. For the strobe light and solenoid valve, the team was looking for both AC and DC options because a converter could be easily used to convert the AC signal to DC. For the strobe light, the team was specifically looking for an LED light for a longer life span and for the solenoid valve the team was exploring materials that would not quickly rust over time.

G. Selection of Control System

The Tensorflow system was able to detect cars but the data stored was inaccessible by the team. The Raspberry Pi displayed the ongoing data being collected but did not save the data within a library the team could access. This made it hard to program the Tensorflow system to execute commands. Because of time limitations, ability of gaining access, and the complexity of identifying the library to recover the data on the Raspberry Pi, the team decided to move forward with using the ultrasonic sensor with the Arduino. The ultrasonic sensor worked more efficiently than the tensorflow system. The initial sensor selection (MB8450) did not perform as expected so a different version of the sensor (MB8480) was used.

Finally, the team switched to another ultrasonic sensor, HC-SR04, to cut down on cost and for a more efficient and accurate sensing method. The HC-SR04 sensor converts time readings into distance readings. By determining the minimum height of a vehicle potential using a self-serve bay at the car wash, the team was able to use the threshold to set timers and following commands.

A touch screen or a different form of interactive screen for the control room was considered at the beginning. However, only three things really had to be known: whether a car was in the bay, whether the customer had paid, and whether the deterrent system needed to be engaged. This information could simply be conveyed with an LED display board.

III. SYSTEM DETAILS (RESULTS & DISCUSSIONS)

A. Integrated Final Design

Ultimately the team chose the Arduino Uno in combination with an ultrasonic sensor. The ultrasonic sensor was chosen based on simplicity, reliability, and cost factors. The Arduino was chosen because of its simplicity, lower cost, common use, and ease of implementation. Consultation with the client finalized the design. The ultrasonic vehicle detection sensor will be installed in the self-serve car wash bay to detect cars that have driven into the bays. This will initiate a timer in the Arduino that will be stopped if an incoming signal from the bay indicates that the customer has paid. Likewise, if the payment system indicates the payment has timed out, then the Arduino will re-initiate a timer until either the customer leaves the bay or inserts additional money.

If the driver chooses not to insert more money once the second timer runs out, if a car is still being detected by the system, then a sprinkler system will begin to dispense water into the bay. Both the sprinkler and strobe light were connected to relays for voltage regulation. The relays were suede to convert AC voltage to DC voltage [2]. The device will also have an analogue display board that will sit in a control room that will indicate what is going on in the bay. There are three LEDs on the display screen, the green LED indicates that a car is detected in the bay, the yellow LED indicates that the warning light turned on, and the red LED indicates that the solenoid valve turned on. Below is a diagram (Figure 2) of the general system design of the connections made in the circuit box in the control room as well as in the bay. Figure 3 is an image of the final installation kit.

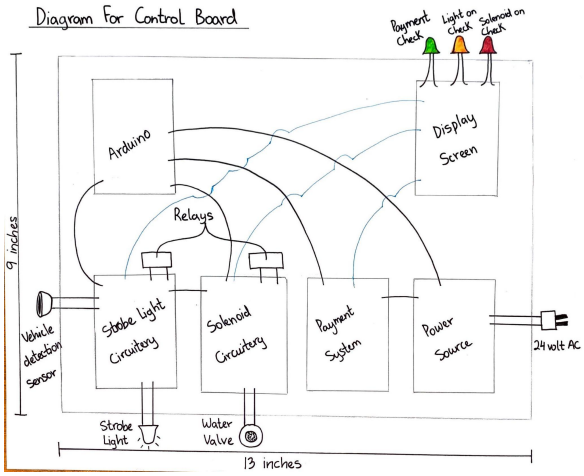

Figure 2: General System Design

Figure 3: Installation Kit

B. Detailed Circuitry

Below is a diagram (Figure 4) of the detailed circuitry that includes the light, valve, and payment system connected to Arduino. The pink wires highlight all connections made to the Arduino. Three 330 Ohms resistors were used for the display board LEDs. The 9 volt power supply is used to provide long-lasting power for the Arduino to function. The team decided to use this method instead of a battery because the battery would need to be changed frequently.

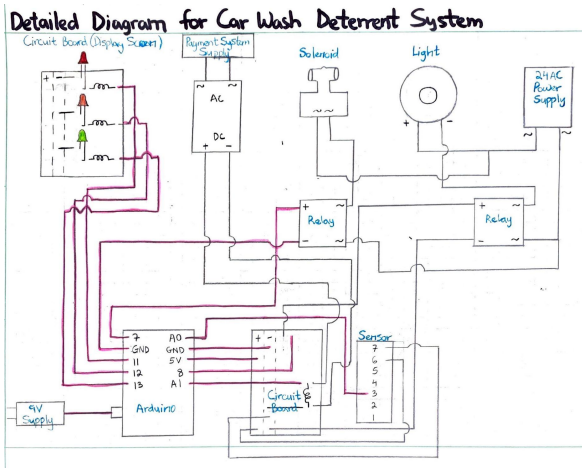

Figure 4: Detailed Circuitry

C. *Product Contents*

Below is a list of all the components in the installation kit. Piping for the water system in the bays, cables and wiring coming from the bay area to the control unit, and batteries are not included in the package.

- 1 HC-SR04 sensor
- 1 sensor mounting rack
- 1 Arduino Uno
- 1 LED Strobe Light
- 1 Water Solenoid Valve
- 1 LED Display Board
- 1 Circuitery Board (includes wiring and resistors)
- 2 AC/DC Voltage Relays
- 1 AC/DC Voltage Converter
- 1 24V AC Power Supply
- 1 9V DC Power Supply
- 1 User Manual

IV. FORWARD PLAN

The team plans on brainstorming ways and coming up with a system design that would cut costs of the deterrent system. The previous ultrasonic sensor being used was over $100 and the current sensor is less than $5. Other goals the team has is to determine a method for mass producing the installation kits and making more components of the

system customizable. Currently, the countdown time and length of cables and wiring is customizable.

V. ACKNOWLEDGMENTS

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VII. REFERENCES

[1] “Object Detection,” *TensorFlow*. https://www.tensorflow.org/hub/tutorials/object_detection (accessed Apr. 12, 2023).

[2] P. Evans, “How Relays Work,” *The Engineering Mindset*, Jan. 12, 2021. https://theengineeringmindset.com/how-relays-work/ (accessed Mar. 30, 2023).