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Commentary
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Engineering Reports

Project Design Report (PDR) for Proximity-Based Alarm System using an Arduino Board and other Devices

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Abstract

This report outlines the design process used to create a proximity-based alarm system using an Arduino board as well as additional instruments that work with the Arduino. Throughout the development of the alarm system, several key methodologies are emphasized; specifically, the use of incremental testing to ensure that everything in the alarm system works properly. The final design of the alarm system is capable of detecting objects within a one-hundred-and-fifty-degree angle and setting off an alarm and LED if something is detected. Some key insights throughout the development of the alarm system are related to the structural integrity of the design. Issues arose with the wiring limiting the rotating ability of the servo in the design. The importance of a strong structural base is emphasized here. The proximity-based alarm system has great potential in various uses as well as further development. The alarm system could be used for uses such as home security and traps as well as even parking assistance. Further improvements to the design can be made by integrating Bluetooth or internet connectivity capability. As of now this project only contains instruments that work if connected directly to the Arduino board.

KEYWORDS

Alarm, Arduino, Buzzer, LED, Proximity, Radar, Sensor, Servo, Ultrasonic

ABBREVIATIONS

PDR – Project Design Report
LED – Light Emitting Diode
FBI – Federal Bureau of Investigation

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INTRODUCTION

This report goes into detail about the proximity-based alarm system using an Arduino board. The motivation for the project began due to peers and classmates at the University of Tennessee, Knoxville, ho are worried about crime. This fear contradicts the statistics released by the Federal Bureau of Investigation (FBI) released for the year of 2023 display a decrease in national violent crime by 3.0% [1]. It is also estimated that murder and rape saw an estimated 11.6% and 9.4% decrease, respectively, when compared to 2022. It is also estimated that murder and rape saw an estimated 11.6% and 9.4% decrease, respectively when compared to 2022 This contradiction of most violent crimes decreasing and a sustaining or even in some cases, rising fear of crimes occurring could be due to many different environmental factors. One of the main catalysts of this fear would be the spread of social media and its effect on information gathering.

There have been many studies completed throughout social medias relatively short life span that have linked social media with crime. A group of scholars in 2020 collected data from Twitter (now known as X) from the "18 largest Spanish speaking countries in Latin America over the period of 70 days." They found that around 15 out of every 1000 tweets were "related to a crime, or fear of crime." From this data they were able to conclude that "social media is shown not to be highly useful for detecting trends in crime itself, but what they do demonstrate is rather a reflection of the level of the fear of crime" [2]. This is most likely the reason for fear of crime sustaining while crime itself is decreasing. The average person spends 2 hours and 24 minutes per day on social media which means that each person is likely seeing multiple posts per day about some form of crime which increases general fear of crime [3]. Since social media is not going to disappear anytime soon, there must be better ways to make people feel safe even while constantly seeing crime on social media every day. The is the goal of this project is to help people feel more comfortable and safer even with the powerful reach of crime spread through social media.

Many crimes occur out of the victims' control entirely, but there are a few ways to help deter any attempts of crime in a controlled system. Many peoples most controlled system is their house/home. Home security is something that people have desired and is likely required to live a comfortable and less stressful life. This is a field that has historically been very expensive to get into, but recent developments have allowed for many people who would not have had the opportunity of a security system in the past to have it today. For example, the ring doorbell has been spreading rapidly throughout the United States and the world since its release. This is great for everyone involved, but we would like to continue those developments and make an option for people who have simple components and can make it themselves. This could, of course, be upscaled and use better materials in the future so that it can truly be implemented in peoples' homes around the world.

Specifically for the project we made a system of Arduino components that utilized a rotating ultrasonic sensor, a speaker, and a light to simulate an alarm going off. This simple design can be completed by any person with an Arduino kit within approximately an hour if necessary. Our product successfully completed the task of finding an "intruder" and alerting the user while maintaining its simplicity for ease of use. The future of this design can be furthered to make it more effective at detecting "intruders" and alerting the user which could be turned into an alert on the user's phone with the correct components.

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MATERIALS AND METHODS

2.1 MATERIALS

The design for the proximity-based alarm system detailed in this report makes use of several different instruments as well as materials. Many of the instruments for the alarm system are simple and made to work with an Arduino board. The materials used for the alarm system are primarily used to structurally support the alarm system and allow for the movement needed for it to properly perform its task. Instruments and materials and their respective costs are listed below.

- Arduino UNO Mini Board ($8.98)
- Ultrasonic Distance Measuring Module ($6.89)
- Micro Servo Motor ($6.99)
- Active Buzzer ($5.99)
- Colored LED ($4.99)
- Male Wires ($6.99)
- Cardboard ($6.99)
- Duct Tape ($4.98)

The Arduino UNO Mini board serves as the microcontroller that receives and interprets inputs and creates outputs accordingly. The Arduino UNO connects the software side with the hardware side, allowing for code to be created to change the results of the system as desired.
The Ultrasonic Distance Measuring Module makes use of high frequency ultrasonic waves to measure the distance between the sensor and whatever object is at the end of the distance being measured. It works by sending out the ultrasonic wave and waiting for the echo to return. The time it takes to return informs the distance away the object is.
The Micro Servo Motor is a small lightweight motor that allows for precise, controlled movements, either angular or positional. In the case of this alarm system, the servo is used for angular movements. The servo moves the Ultrasonic Distance Measuring Module so that it sees and rotates in one-hundred-and-fifty degrees.
The active buzzer makes use of a built-in oscillating circuit, meaning that sound can be generated directly when powered, and no external signal is needed. The active buzzer in this situation is supposed to alert the user that something has been detected by the Ultrasonic Distance Measuring Module. Once something is detected by the module, the active buzzer will go off and begin making noise, alerting the user.
The colored LED serves a similar purpose as the active buzzer, but for a different sense. When power is supplied to the LED, it lights up, alerting the user to some activity. In the alarm system, when something is detected by the Ultrasonic Distance Measuring Module, LED is supplied power, alerting the user that something has been detected.
The instruments and devices listed above work together to create the hardware making up the Proximity-Based Alarm System. Inputs are provided by the Ultrasonic Distance Measuring Module, outputs are provided by the colored LED as well as the active buzzer, and the Micro Servo Motor receives a constant input from the Arduino UNO Mini microcontroller. The Arduino UNO Mini microcontroller provides the correct inputs for the active buzzer and the LED based on the outputs received from the Ultrasonic Distance Measuring Module. Besides the instruments comprising the hardware in the system, other materials are used to provide an infrastructure for the hardware to work on.

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The alarm system makes use of both cardboard as well as tape. The cardboard provides a surface for both the Micro Servo Moter and Ultrasonic Distance Measuring Module to sit on top of. The cardboard is folded into a shape capable of supporting some of the hardware of the system, and then duct tape is used to ensure that the infrastructure stays in the shape best for supporting the servo motor. The cardboard is a temporary material, as the Proximity-Based Alarm System built is a prototype. If more of these alarm systems were to be made, a 3D printed infrastructure would likely be more suitable for the task at hand.

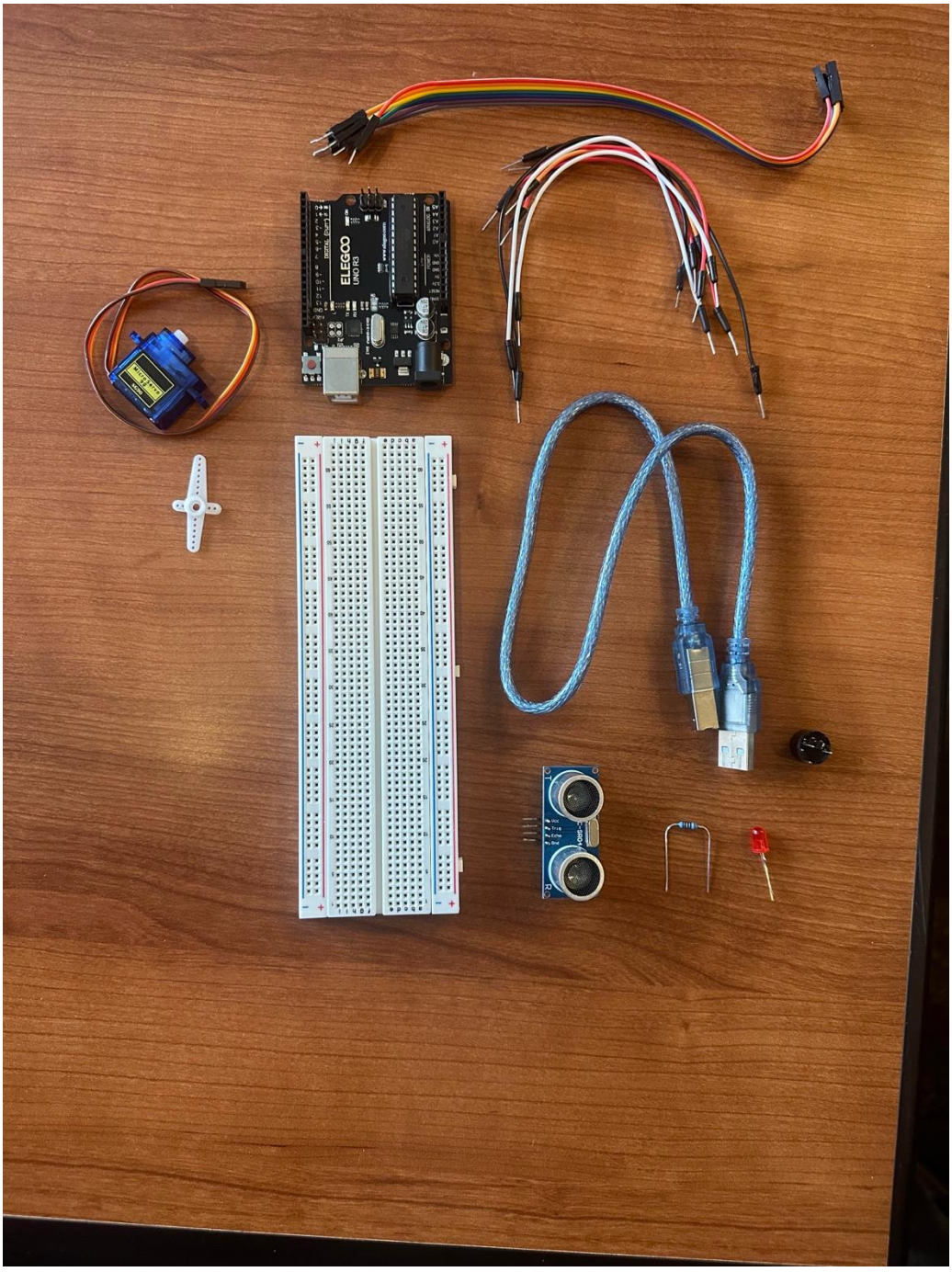

Figure 1. Hardware Materials of Alarm System

The cost of the Proximity-Based Alarm System gets significantly lower as more are built. If only one was to be built, like the prototype for example, it could end up costing fifty-two dollars and eighty cents just to build the prototype. However, many of these purchases cost so

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much because several parts are included in the purchase price. If the parts are bought efficiently in bulk, the cost of the alarm system can be widdled down to fourteen dollars and seven cents, much less expensive than the prototype.

2.2 METHODS

This project employs an iterative design methodology to ensure the the quality of the project is adequate, and that all parts making up the alarm system correctly work together to achieve the goal at hand. An iterative design methodology consists of continually building upon something that has been proven to work prior. For example, after confirming that the Micro Servo Motor and the Ultrasonic Distance Measuring Module can accurately measure a one-hundred-and-fifty-degree arc, other components can be added afterwards, such as devices that activate depending on what the Ultrasonic Distance Measuring Module measures.

The first thing done for this project is the identification of the problem at hand. The identified problem is to create a Proximity-Based Alarm System that alerts the user of the system if anything is detected by the ultrasonic module. The goal at hand is to have a system that can both reliably detect when objects fall within its range as well as adequately inform the user if something is detected.

Once the problem and goal are identified, the next step is to think up how that goal could be accomplished. The reliability of measurements has been confirmed in a previous project already, so the only other goal to solve is how to appropriately alert the user of a detection. For a better user experience, it is decided that both audio and visual cues should be implemented to ensure that the user is aware of the alert. For the audio cue, an active buzzer is deemed to be the best instrument for the scale of this system. For the visual cue, a simple colored LED is deemed to be the best instrument for the scale of the system. Louder audio cues are ruled out because of the relatively small scale of the project. If the system were larger and more powerful, than a speaker may be better, and the same applies for visual cues. If the system were more powerful, it might be more beneficial to use large LED strips or larger lights.

Once the concepts and devices that would best work for the goals of the project are decided upon, the next step is to design and build the prototype. The design of the system is then done online before any building takes place.

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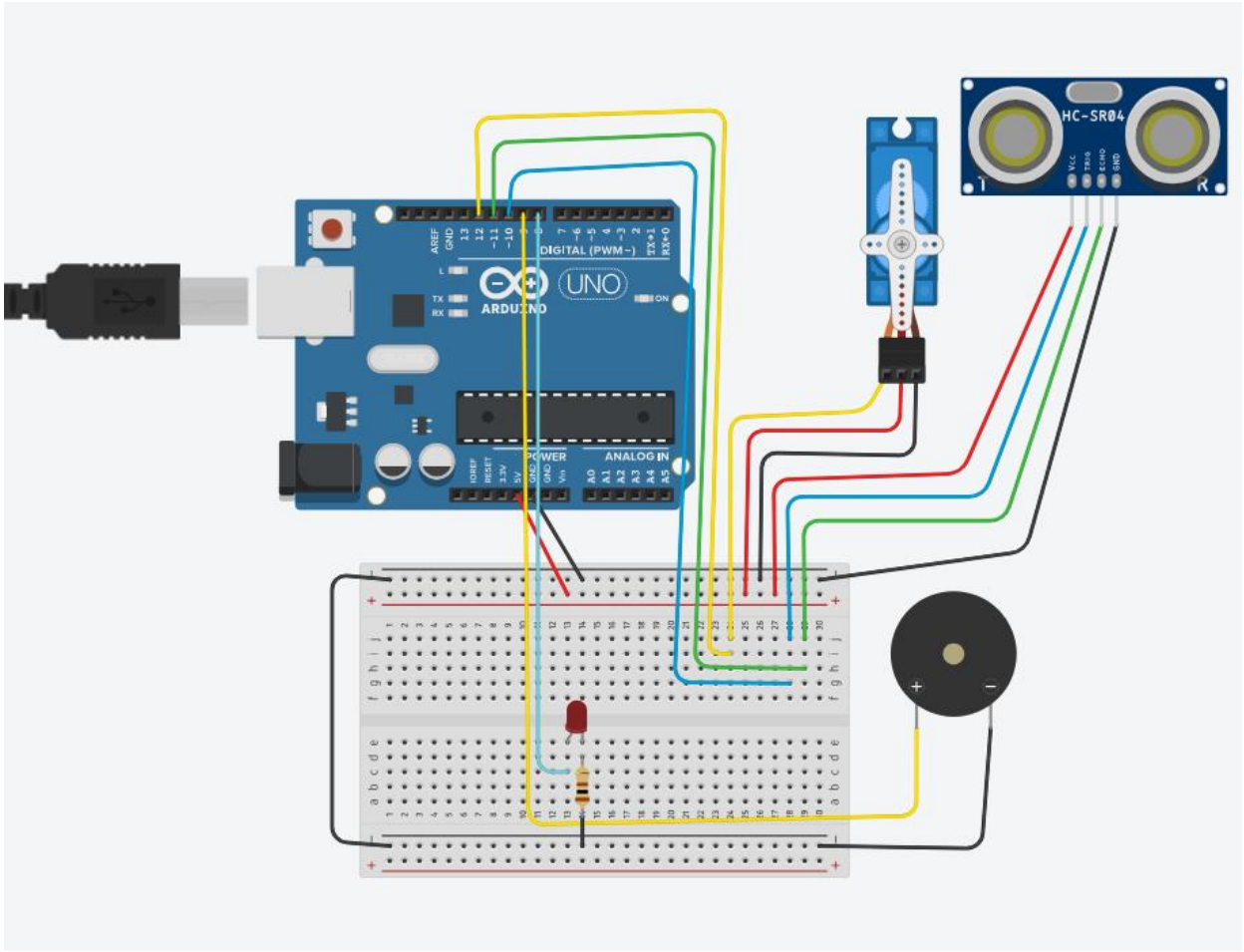

Figure 2. Diagram of Proximity-Based Alert System

Once a working diagram is created, it is then time to start building the prototype. The hardware of the device is then put together without any infrastructure. After the assembly of the prototype, the prototype is tested. Things are placed in front of the sensor while it is running. If the sensor detects something, it would be expected that active buzzer then makes a noise and the colored LED lights up. If both of those things occur when something is placed in front of the sensor, then it can be said that the prototype works adequately. If neither condition occurs, then it would be time to go back and reassess what went wrong with the design of the system.

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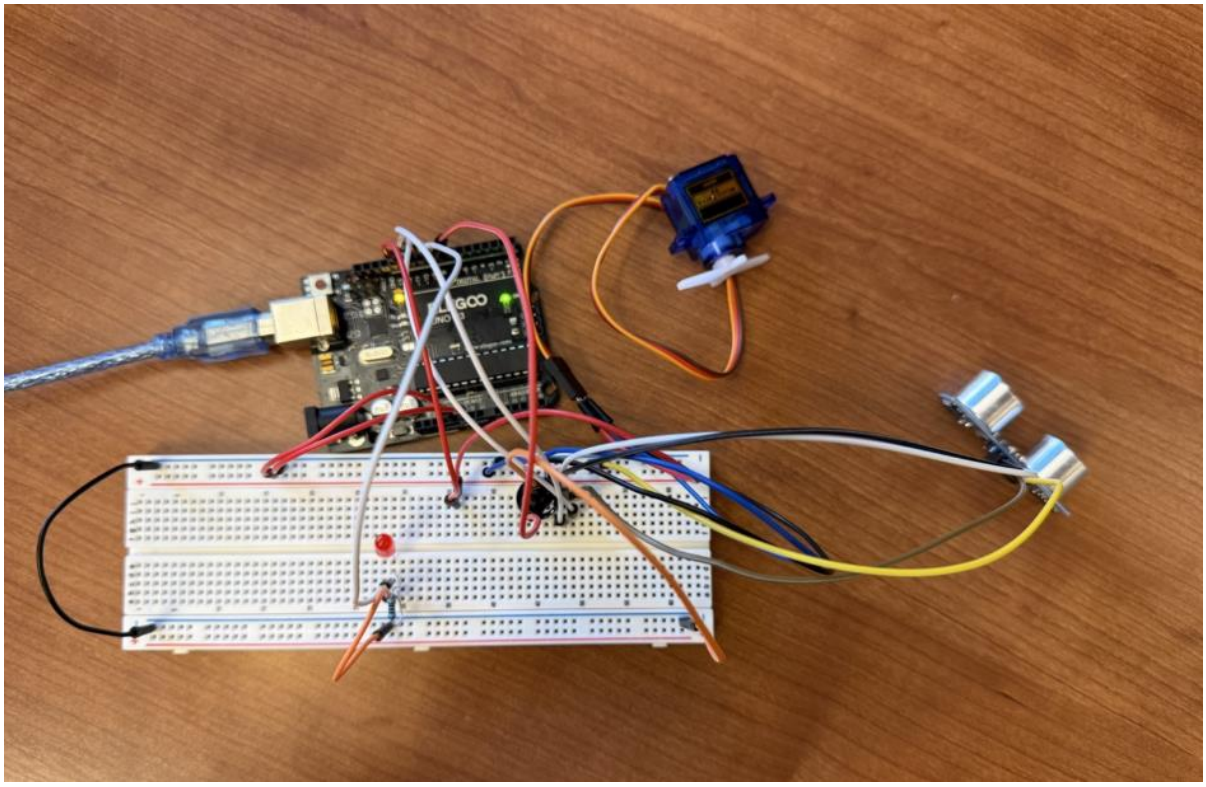

Figure 3. Prototype has nothing in front of sensor; therefore, light is off

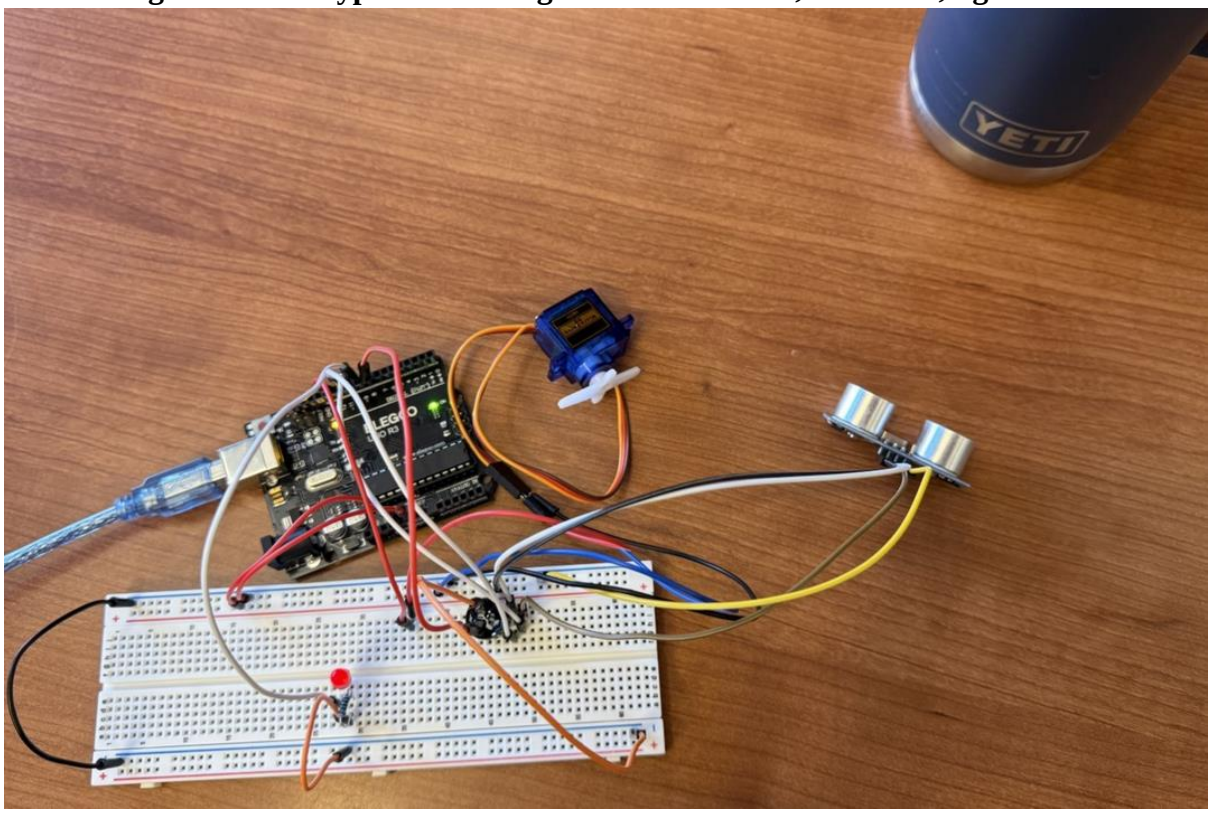

Figure 4. Prototype has something in front of sensor; therefore, light is on

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After testing has proved the prototype to work it is then time to assemble the entire system. The stand for the Micro Servo Motor and the Ultrasonic Distance Measuring Module is added for final touch ups.

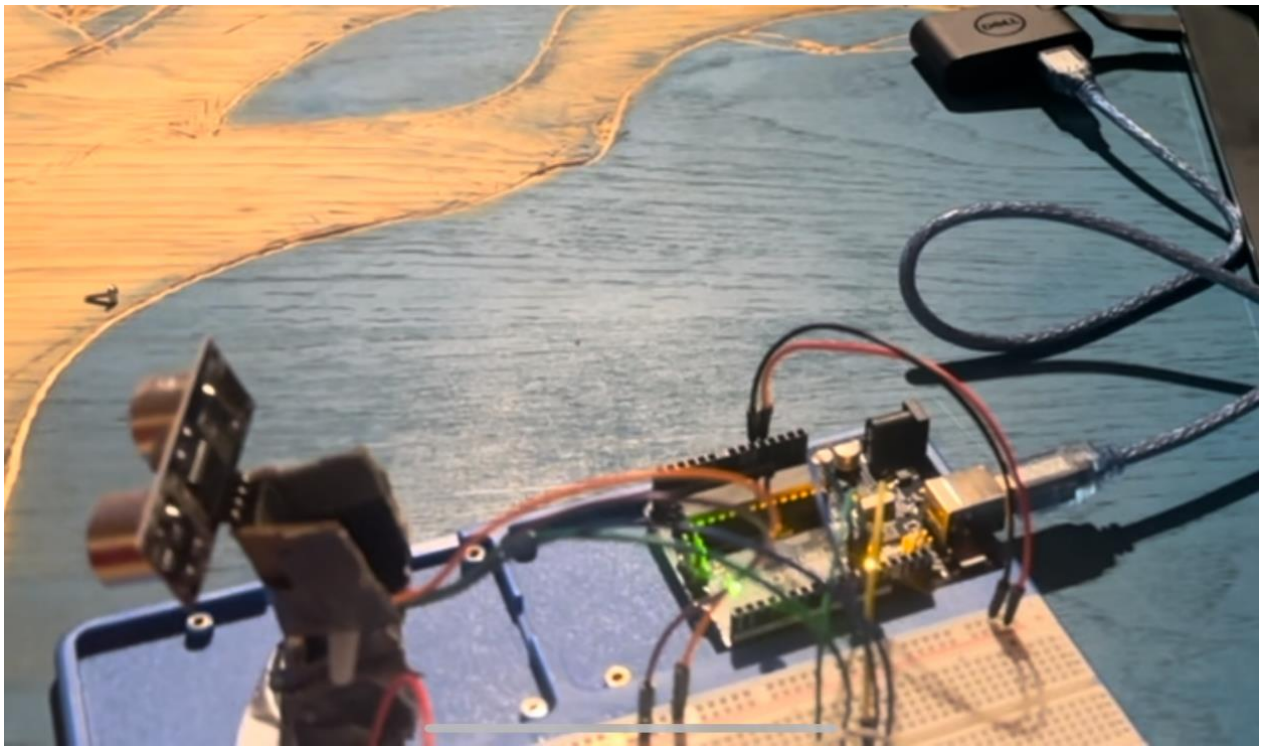

Figure 5. Infrastructure in action

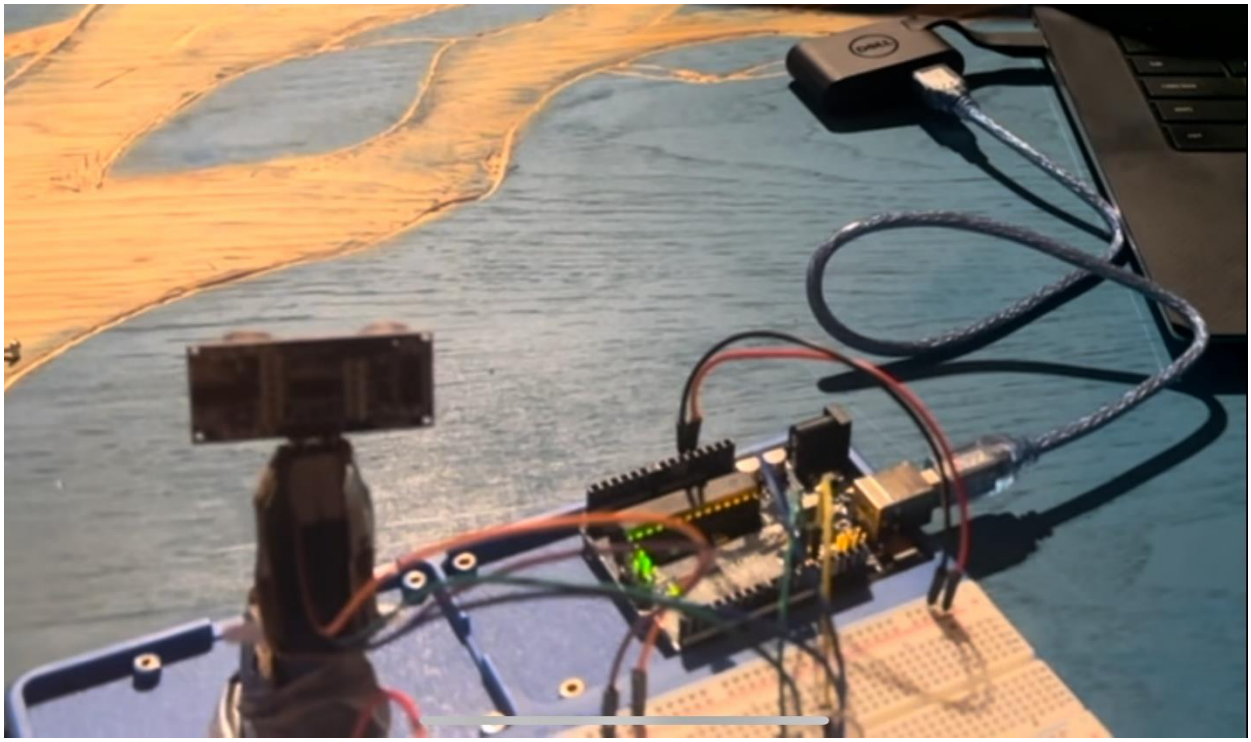

Figure 6. Infrastructure in action (moved)

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RESULTS AND DISCUSSION

3.1 RESULTS

The final design of the Proximity-Based Alert System produced a working system that can detect if objects are in front of it in a one-hundred-and-fifty-degree arc in front of the sensors. If an object is in front of the sensors, an LED will light up and active buzzer will sound. Calling back to the initial objectives and goals of this project, the system should be able to adequately detect when something is placed within its vision and alert the user if something is detected. Both objectives have been accomplished; therefore, the system is successful at completing project goals.

3.2 DISCUSSION

The results of this project are about as expected. It was expected that the project would be able to accomplish both goals, and it does. One of the biggest strengths of this project's design is the simplicity of it. Adding on any accessories or fixing any bugs that occur is relatively easy. There are limitless applications of the Proximity-Based Alert System. It could be used for home security, detecting if anybody appears in front of sensors, or it could be used to alert a driver before their car hits something, whether it be another car or a wall.

Some current limitations on our system are related to the scale of it. The current design does not detect objects at larger distances away from it, so it currently only works well for a couple meters. Another limitation is that the system only works locally. It makes noise and lights up, so the only way it would alert you is if you are near the system.

Some future improvements of the system relate to getting rid of those limitations. The easiest improvement would be to improve upon the sensor used and scale up on the LED and buzzer. These improvements would improve the range and dependability of the system, as well as better alert the user if something is detected. Another improvement of the system would be adding Bluetooth and wife capability to the system. This improvement would allow the system to alert the user even when they are not with the system.

CONCLUSION

The goal of this project was to create a Proximity-Based Alarm System. The system should be able to reliably detect if something is in front of its sensor as well as alert the user if something is detected by the sensor. The final prototype was successful in both objectives. The methodology used to design the system was an iterative process as well as user centric. Small improvements were made throughout the design process to the system, and the user being alerted to the system detecting something was prioritized. The Proximity-Based Alarm System has the potential to greatly improve the safety of individuals. People using the system would be made aware of break ins or any other scenario where someone is in some place they should not be. There are a couple limitations of the system in this project, most regarding the scale of the system. These limitations could easily be done away with by improving the quality of sensors and getting larger devices for both the audio cues and the visual cues. Network capability could be added to extend the range of the alerts to near anywhere instead of having to be directly next to the device to be alerted. In conclusion, this project demonstrates the use and capability of ultrasonic sensors, and with further refinement, it can contribute significantly to improving safety for individuals across the world.

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