Project Deliverable H: Prototype III and Customer Feedback

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Introduction

The latest deliverable examined our second prototype's creation and analysis, feedback from an external personal acquaintance for our first prototype and the prototyping test plan for our third prototype. In this deliverable, we will address feedback received for prototype I from the client and for prototype II by another external person, create and test our third prototype and analyse the results of these new tests. Prototype III will be developed based on results yielded by our previous tests and using features implemented in prototype I and II, as well as newer features. This final prototype needs to be comprehensive and completely functional ahead of design day.

Client Feedback for Prototype I and External Prototype II Feedback

Since we did not get to present our prototype during client meeting 3 due to lack of time, we did not instantly get feedback for our product. However, we sent the client a recorded presentation after the meeting, for which he later provided us feedback. According to him, we had a good, logical understanding of the problem, but he suggested we add driver detection or car status recognition. Unfortunately, the best we could do with the allotted budget was to use a current detector to verify whether the car gets turned off by the caregiver. Moreover, the client mentioned he hopes we find a way to lower car windows if temperatures get too high inside the car and the caregiver does not return on time. While it would be possible to communicate commands from the Arduino to an automotive relay, testing it would not be possible for us, which means all we could do is develop the code necessary to accomplish the aforementioned task—this feature will not be considered a priority mostly since we will not be able to demonstrate it without modifying a car, and we have little to no time to implement it, the client feedback having been received only four days before design day.

Because client feedback could not be received at all for prototype II, we asked an individual who is not involved in this project for his opinion about our second prototype. The low-fidelity nature of our prototype unfortunately limited useful constructive feedback, the consulted individual saying he thought we were moving in the right direction. He thinks we need to make sure the PIR sensor detects movement on all backseats without detecting outside movement, so we will try lowering the range of motion at an adequate value and pay close attention to outside detection during testing for our last prototype.

Prototype III

For Our final prototype features most components from our final design—temperature and CO sensors, current detector, a buzzer and an LED strip—but important hardware changes had to be made. First, after discovering the SIM900 GSM Shield was only compatible with now-obsolete 2G cellular network service, we had to replace it with an ESP-8266 Wi-Fi module due to time constraints. Also, due to unforeseen circumstances occurring late in the present prototyping phase and low stock, we had to replace our PIR motion sensor with an HC-SR04 ultrasonic sensor to detect movement. Moreover, to build our circuits, we had to opt for a breadboard instead of a protoboard, as soldering could not be completed for reasons we still do not fully understand; thus, we created the final Arduino sketch and wired our circuit accordingly, acquired and tested the Wi-Fi module, as well as tested the purchased ultrasonic sensor, adjusting its delay on the go to ensure it truly detected human movement.

The casing was 3D printed for prototype III, but an error occurred while printing, and the inside of the rear wall had a rough texture compared to other faces, which were completely smooth. (Since time was running out for the project, we did not have the opportunity to reprint the casing.) Its color was chosen for its child-friendliness. We also did not manage to test the casing on a car seat, as was outlined in the prototyping test plan, since the car we intended to use was not available after printing the casing.

In all, for this prototype, we connected to the Arduino and used the HC-SR04 ultrasonic sensor, the DHT22 temperature sensor, the MQ-7 CO sensor, the buzzer, the LED strip and the 9V battery. The Wi-Fi module was tested independently, and the current sensor could not be tested due to lack of time. All the aforementioned physical components were then fitted inside the casing.

Figure 1: Finished Prototype Front View and LED Strip Detached

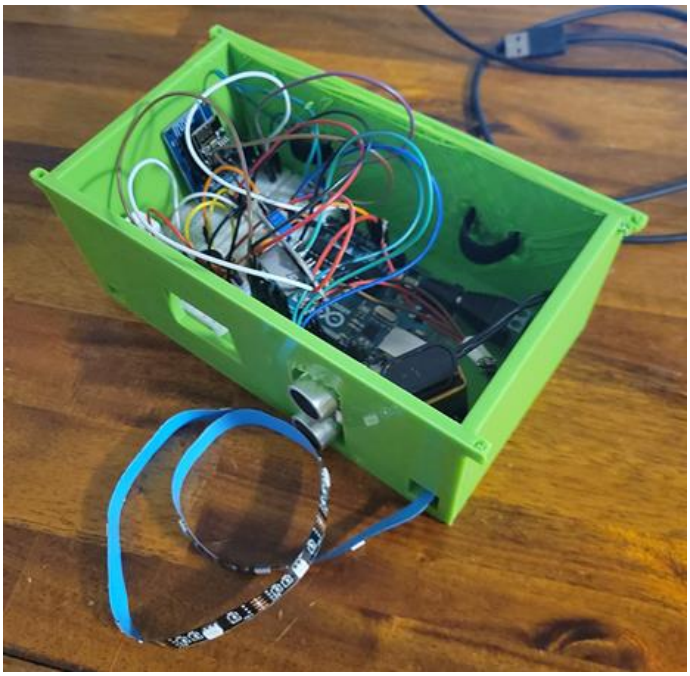

Figure 2: Prototype Components Internal View

The Velcro straps were fitted to the casing, as shown below. We rapidly tested the straps by pulling them with as much force as possible outwards (pushing on the casing wall), starting from a smaller force and gradually increasing it; the casing and the straps remained undamaged.

Figure 3: Prototype Velcro Straps

Finally, the sticker used to inform the passerby was created, as portrayed in the figure below, but not printed due to lack of time. It would have been applied on the inside of the car's backseat window on the same side as the product, more specifically the part of the window which cannot be moved.

Figure 4: Informative Passerby Sticker Design

Analysis and Final Design

With most of the components connected and the Arduino sketch prepared, we managed to detect human movement from about one meter of the ultrasonic sensor, though its accuracy was clearly a downgrade from a PIR sensor, and subsequently activate the buzzer and the LEDs while also accurately detecting temperature and carbon monoxide levels. We then disconnected the

Arduino from our computer and ran it on the 9V battery: the code remained consistent. The Velcro straps also proved to be sturdy enough for our product, as they did not snap when under a relatively high force. Therefore, we could have used this configuration for a fourth prototype, had time allowed it.

Unfortunately, time ran out for us to complete our product, as we had many hardware changes and complications with the Wi-Fi module's associated application, Blynk, which we had to use to send text messages and calls—the app simply could not reach any of our phones. We also spent much time on soldering, which did not yield compelling results. Taking more time to work on the project earlier would have been beneficial, but testing was necessarily delayed by some of our components' shipping.

However, if we had had time to complete our product, we would have configured it in the following manner: first the car loses power, which means no current passes through the current detector. At this instant, if movement is detected in the back seat—we would use a PIR sensor for motion detection instead of a lower-accuracy ultrasonic sensor—, the buzzer is activated once for 5 seconds and an SMS is sent to the user and any other configured phone number, if applicable. Then, if the user does not respond with "halt", in which case the alert system would cease all activity until the car is turned on again, more texts are sent at a rate of 1 per 3 minutes. If conditions become critical inside the car (temperature is not between 10 and 25°C or CO levels exceed 100ppm), a call is made to the user and any other configured phone number, and the LEDs are activated and flashing until the user responds with "halt". We would have also created a sketch to communicate with the car relay to lower the windows as an ultimate resort.

Conclusion

Feedback received for both prototype I and II drove design changes for the alert system and the motion detection system, and while multiple time delays have led us to achieve only part of our last prototype, we determined that the ultrasonic sensor is decently capable of recognizing movement, as we managed to activate a buzzer and an LED strip when relatively slight movement was done by a team member in front of the HC-SR04. The components all fit in the casing, which had its flaws and would have to be reprinted for a subsequent prototype. The Velcro straps also proved to be sturdy, but clear installation instructions in the user's manual for our product will be essential to ensure the device is well fastened to the backseat. Much has yet to be done in order to complete our product, but time has expired, and we now have all the content ready for our Design Day and final presentations; we can also carry on to the final deliverable, in which we will outline our user and product manuals.