Deliverable G

Prototype II and Customer Feedback

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1. Introduction

This document is intended as an overview of the work done since the submission of the first prototype: Deliverable J. This overview includes the actual work completed and the steps taken to reach that point. This document presents the decisions taken, why and how those decisions were made then the advantages and disadvantages of doing things in that particular manor. The deliverable separates the project into the two main subsystems: the hardware subsystem and the digital subsystem. The hardware covers every physical component for the system, essentially anything tangible. The software subsystem covers the user experience, including the dashboard, the digital signals managed by the source code for the arduino and the IP.

2. Hardware Subsystem

The second prototype saw the design and implementation of cases for the individual components of the system. Pieces were specifically designed in *Solidworks* to hold the Arducam, the motion sensor, the arduino board and protoboard; which would eventually be implemented. Throughout this process, the team overcame small issues and addressed larger issues that could arise further down the line.

First of all, the placement of the motion sensor and camera are both crucial for the overall system since the motion sensor is the only analog signal the system will receive and the camera is how the users will be able to see the printers. For the motion sensor, the team decided that it will be placed on one of the front corners, either left or right. The front of the printer was chosen, since people walking past the printers will not be detected by the printers long enough for it to affect the system. Additionally, since the printer nozzle never moves perfectly diagonally; it moves quickly up and down then left and right; this prevents the motion sensor from misjudging whether the nozzle arm is moving or not.

Next, the camera will be placed adjacent to the motion sensor but will be elevated above the edge and angled down towards the build plate. By doing this, the team accomplished two things: crucially, the camera will not obstruct the nozzle arm from printing; additionally this will provide a relatively good point of view for the camera. Ideally, the camera would be placed directly above the printer, however this would be unrealistic since it would either be in the path of the printer, or would be too tall to fit between the shelves inside the Makerspace.

Below both of these components, underneath the printer, a final box will be placed containing the hardware that runs the IP for the dashboard and converts all analog signals to digital. Underneath the printer there is adequate room to fit a box for these components and will also serve the use of being unobtrusive.

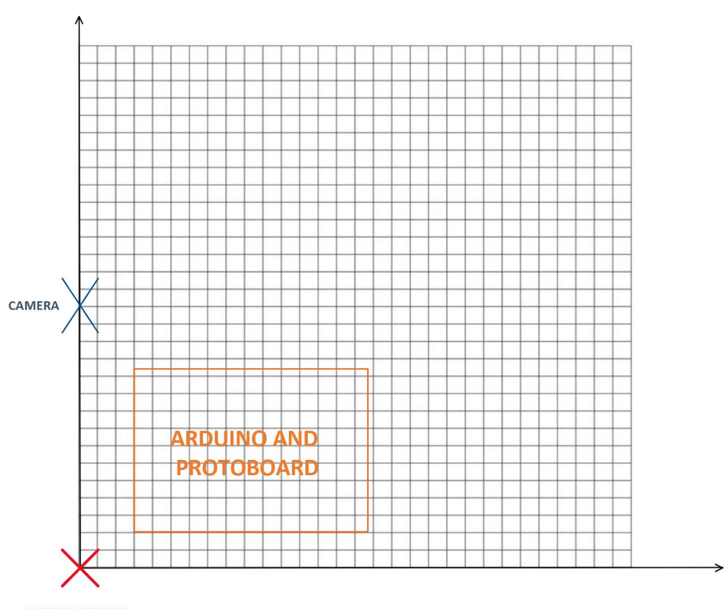

Figure 1: Placement of each component sketched onto graph (Representing the printer)

However, for all locations for the placement of all three parts, temperature is a huge factor. The cases designed for all parts have been made from PLA plastic, which is not resistant to high temperature, meaning it will melt if the temperature is too hot. As far as the camera and motion sensor are to be considered, the temperature at their locations is cool enough that the components will not be disturbed and the plastic cases should last over time. The temperature underneath the printers has not been measured, but if it becomes too warm during prints, then the team will move the box to a place adjacent or behind the printer in order to keep it cool.

While printing and designing these cases, the member tasked with this realized that making a box exactly to the measurements specified by the manufacturer would not be able to fit the component it was designed to fit. This was an easy solution, since they added approximately half a millimeter of space on each side of the measurements in order to easily for the components inside the cases. This member also learned more effective ways of keeping these cases shut in order to allow CEED staff to modify and maintain the system. Rather than printing an open top case then gluing a flat piece on top, they printed slits into the sides in order to be able to put the boxes together like puzzle pieces. These cases would not be able to be hung upside down since they would fall apart due to gravity, but they are extremely effective in all other orientations and allow for the modifications set out during the problem statement.

Figure 2: First edition of the case that will contain the Arducam

3. Digital Subsystem

The second prototype saw two significant changes to the system and progress towards the final prototype. The user interface was redesigned to emphasise the use of colour and symbolism as well as it being connected to the arduino via an IP. Finally, the camera began sending photos and live feed back to a local computer using another 3rd party software.

Following initial feedback from potential users, including the CEED staff and regular members of the public the user interface will be modified to feature more colours and use less words. When considering the use by CEED staff, the use of words is less important, but if the dashboard is to be used on a public HTTP address, then it would be ideal to use less words in english since the University of Ottawa is an ethnically diverse community of people who may be less comfortable reading words rather than understanding colours. The plan is, in the dashboard, for the working status of the printers to be represented by a border in order to condense the user interface and use less screen space. In the current stage of development there are two colours, green for working (printing), and red for not working (not printing).

The IP connection between the NodeMCU has been established after the team followed the lab manual available in brightspace. This IP connection enables the team to upload the dashboard to an HTTP address which enables its publication and availability to anyone from anywhere, The HTTP address is intended purely as a viewing platform and will not provide the user with any functionality, including reserving space in the Makerspace. Following a client meeting it was clearly stated that the customer is strongly against this idea. Unfortunately, in its current state the IP requires that the board constantly be working to update it, rather than it turning on when it receives a signal or when the address receives traffic. Aswell, the NodeMCU cannot normally send and receive data at the same time, however, with some modifications it is capable of this.

Finally, using a third party software the Arducam is recording data and sending it digitally to a computer. It does this by taking pictures at specific intervals of time and sending it through the arduino as a compressed file. It does this since the NodeMCU has an extremely limited amount of storage to buffer images through. So in order to prevent it from slowing down its processing, the system compresses still images, rather than raw video is minimize the amount of data needed for the photos.The primary focus for development is having the system autonomously take the data this software receives and send it to the dashboard, as well as researching a way to no longer require a computer in order to run the camera, and thus have a fully autonomous system.

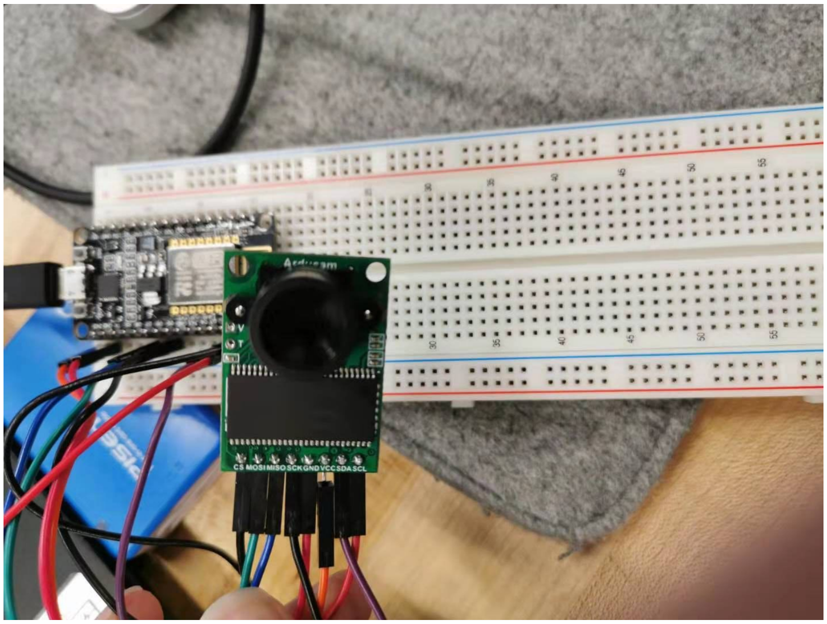

Figure 3. ArduinoCAM

The difficulty with the camera is that the code for it is very complex, unpredictable and extremely long. This results in the code being extremely difficult to shape and manipulate in a way that will benefit the system. In order to solve this, the team is researching further into learning about the ArduCam and looking for pre-existing code that satisfies the system requirements.

Conclusion

In summary, in order to progress successfully to the next prototype, the team has many tests and analyses to perform in order to best decide how to organize and optimize the prototype. The team needs to determine how much heat will be exerted on a case that is placed underneath the 3D printer, and whether or not this will cause the case to melt. Additionally the team will need to finalize and optimize the cases designed for the hardware. Specifically, the sizes, their appearance and where they will be placed. For software, the group will continue polishing the user experience by making a more symbolic user interface that will be easier to understand for users that have not been explained the functionality of the system, or that do not understand the language. Finally, the team will also polish to the connections between various components in order to create an extremely consistent system that does not produce unwanted results or outputs.