Memo

To: Dr. Kyle Winfree

From: Daniel Beckett

CC: N/A

Date: 11/20/19

Re: Prototype Findings

My team, AmpEd, decided to mostly work on 4 separate prototypes for the Augmented Power Mobility device (APM). The main reasons being our lack of shared free time and desire to get the most progress in as many directions as possible. Lauren primarily focused on the rangefinder. Taylor volunteered to research designing Graphics User Interfaces (GUI). Khaled was tasked with creating an adapter for our 12V batteries to power separate smaller systems. While I coded the joystick controls for a dual motor driver. For our final presentation, our 12V adapter was the only thing unfit of demonstration.

As requested, statistic by our client, the rangefinders will be implemented into the APM so that we can map average distances to obstacles over time as well as detect any collisions. Our initial plan was to use an Arduino to read analog inputs from an Infrared (IR) sensor and send them wirelessly over Bluetooth (BT) communications to a Processing.org script. Our biggest challenge being transmitting the results wirelessly as we collectively have no experience implementing half duplex BT communications. Code was written for BT communications, though without access to a BT enabling component for Arduino, that part of the prototype could not be tested and was abandoned in order to meet the deadline. In hindsight, we should have placed an order for the BT component sooner. The remaining prototype was successful in demonstrating our ability to implement an IR sensor. Most of the time spent on this prototype was towards BT communications, though was cut short as there would not be a testing phase. This allowed for Lauren to divert her attention to helping Taylor with the GUI.

Having a GUI that our client can interact with is one of our designated requirements. The ideal GUI should allow our client to easily understand data results and make changes to parameters concerning the APM, like maximum velocity. Since none of us had any experience using Processing.org, our initial objective was to implement functions into our GUI that would make changes to the APM. From there Taylor designed a circuit that would allow the user to toggle a motor on or off through a GUI on the Arduino's host PC. At this point in the process, we we're instructed to change direction and instead design a paper outline of how we want the GUI to look and what we want it to be able to do. It should be noted that we only first met with our actual client after the presentation, so our assumptions of what she would want were exactly that, assumptions. Moving forward we'll continue to remodel our GUI to further improve clarity as well as implementing the features our client expressed. Even though our prototype changed direction halfway through, I think the initial approach was still a learning experience in controlling the Arduino through a GUI. The advice on drawing GUI designs will save us time as making tweaks to an existing GUI is unnecessary.

The only prototype that was dropped entirely was designing a 12V adapter that could use the provided car batteries to power to possible smaller systems and sensors we plan to incorporate. As time went on we decided against using both an Arduino and a Raspberry Pi, one of which needing to be powered through the adapter, so the necessity for creating the adapter faded. Planning on presenting 4 prototypes allowed us to postpone the adapter prototype until we're confident it needs to be implemented.

Our last prototype was to program joystick controls for the APM through the use of a dual motor driver. This was unknown by the entire team and is vital for allowing the APM to move. The process started with reading the analog inputs from a joystick, which took little to no time. Though since the motor driver we plan on using in the APM would not arrive in time for the prototype, we instead used a L928 dual motor driver to control two 3V direct current (DC) motors. The 3V motors were unreliable as their 16,000 RPM made observations difficult and many burned out as the driver's minimum operation voltage required 12V and no additional measures were taking to protect the 3V motors. Afterwards the prototype would be changed to incorporate 12V DC motors that operated at 30 RPM, allowing for easier observations. This prototype was deemed a success as it allowed for movement forward and back, turning, and the ability to pivot. It took longer than expected due to the logic bit that allows motor A to reverse being undeclared as an output as well as needed ample time to distinguish direction of the 3V motors. Though needing to observe 16,000 RPM motors lead to a deeper understanding on how pulse width modulations (PWM) can be mapped to control motor speed. While the prototype allows for movement, the code likely lacks the fine tuning required for a comfortable user experience. Therefore, the next step is to optimize this experience once we can ride the APM ourselves

Overall, we had a successful prototype presentation of our range finder, GUI, and controls. We received insight as to how we might be going in the wrong direction. For example, we used an IR sensor to detect range, though IR sensors are dependent on the surface material, therefore we know to start researching other sensors, such as sonar or light. We were also advised to purchase higher end BT adaptors for the Arduino as they are more reliable. And where each prototype fell short of our original goal, we now have a clear direction as to what we need to continue researching.

Sincerely,

Daniel Beckett

NORTHERN ARIZONA UNIVERSITY | School of Informatics, Computing, and Cyber Systems

To: Dr. Kyle Winfree

From: Lauren May

Date: November 20, 2019

RE: Individual Prototype Findings

Dear Dr. Winfree,

This memo is to summarize the process and results of my team's performance while creating the three prototypes we presented last week. Furthermore, I will detail where we succeeded as a team and where improvements can be made in the future.

The three prototypes that we debuted during the presentation to our client were: two motors controlled by a simple joystick through a motor controller similar to the one we plan to use in the final product, a real-time graph on Processing using a proximity sensor, a paper outline of the plan of the implementation and goals of the GUI. These three prototypes represent three main objectives of the problem statement we were given. The connection of the motor driver circuit will give the child control of the device itself, eventually, the joystick will become force feedback and settings will determine how the force feedback will interact with the child. The sensors will then return different data on how well the child is driving and where there could be an improvement. The sensors will also give feedback to the joystick to help create muscle memory in the children learning to drive powered mobility chairs. The GUI is the main way the physical therapist will interact with the student so it must be well thought out. Since the target audience for this product is Physical therapists, the GUI must be intuitive to the human mind and the display of the data should be easy to comprehend.

Our overall goal was to be able to develop three main functions of the final product on a smaller more digestible scale. We expected to learn about how to implement some of the main functions of the project. We also expected to learn about connecting controls to a motor controller as well as learning more about using Processing.org for a user interface. We also chose these prototypes partially since we believed these three aspects of the project would be some of the most difficult. Both the sensor and GUI portions are aspects that no one on the team had experience working with, so we wanted to use the time while developing the prototype to learn how to implement these systems. One of the main struggles for our chosen prototypes is that they must be flexible designs so that they may be easily altered to work with the products that were ordered. For example, the motor driver that was used for the prototypes has different specifications than the one that has been ordered and on its way in. The prototype created for the graphical user interface (GUI) was actually portrayed on paper since the main functions are completely dependent on the client's needs and preferences which were not able to be clarified until the meeting this week. Now that the overall goals for the GUI have been established, we are able to move forward with fabricating code for each of the needed functions.

Unfortunately, the design and creation of each prototype did not go exactly as planned, there were a few hiccups that pushed progress back. Problems with the motor driver or the sensor module were code based so they were simple fixes but the GUI prototype needed to be altered so that it would be ready in time for the demonstration. We had originally planned to create a simple version of a GUI to control a motor but we decided to change directions since controlling the chair remotely will not be implemented in the final GUI. We then opted for a paper prototype of the GUI that details a visual representation of the user interface as well as the functions that are to be implemented represented by pseudocode. The sensor was the other prototype that needed to be changed so that it was ready to show for a demonstration to the client. Originally the goal was to develop a closed-loop system between the sensor and the motors so that if something were to get close to the sensor the motors would either stop or slow down.

To complete the prototypes we assigned each member a different problem but came together when that person encountered a problem. The work was divided in the following manner: Daniel worked on connecting a motor driver to an external joystick, Taylor worked mostly on GUI research and development, Khaled worked on several necessary aspects of the final project (i.e. the website), while I developed the sensor module. This allowed each person to focus on their prototype and if a problem arose a fresh set of eyes were there to look it over. The approach for each of the prototypes was to find projects that were similar to what each of us was working on and then use the information to create a template to work off of. Then using the well-defined goals we established for the prototypes, we created pseudocode which was then turned into functioning code.

The final prototype presentation was successful and did receive a pass from the client. Before each prototype was fully functional, the major challenges that we faced involved the fact that we didn't have the parts that are going to be used in the final design. We were worried about if our prototypes would not transfer when the new products are put into place. To address this we looked into projects that used the products that we ordered and keep them in mind while developing the prototypes in hopes that the transitions will be relatively seamless. If we had the ability to restart working on the prototypes, I would personally start on the proximity sensor module sooner so that we could implement the closed-loop system that was mentioned earlier. This was the one prototyped that actually took longer than originally anticipated which is why we ended up going with a more basic model.

Thinking about the different aspects that were explained above, I am very excited to continue progress on the this project. Although we experienced a few setbacks during the project, I feel we are currently on track to finish the final product on time. Overall, the experience gave me more confidence in my teams' ability to troubleshoot any issues that will arise during the remainder of the project. Anytime I felt I had reached a point where I was having difficulty completing the required task, there was a team member that was willing to help me work through it.

In conclusion, my team was able to successfully create three different prototypes that are integral to our capstone project. For the demonstration, we chose to create a motor driver module that would be able to take input from a joystick to control the direction on the motors. We also developed a GUI and a sensor module that was able to take data from a sensor that measures distance and be able to graph the data in real-time. Each of the described functions is important to the success of the final product and should be fairly easy to integrate into future designs. If there are any other questions about our plans or progress, please let us know.

Kindly,
Lauren May

NORTHERN ARIZONA UNIVERSITY | School of Informatics, Computing, and Cyber Systems

INDIVIDUAL PROTOTYPE MEMO

TO: DR. KYLE NATHAN WINFREE

FROM: KHALED ALBANI KHALED

SUBJECT: PROTOTYPES SELECTION

DATE: 19TH NOVEMBER, 2019

A prototype can be defined as a first preliminary model of a machine, from which other forms are developed or copied. In the Augmented Powered Mobility project, there are various factors that limited us in choosing of prototypes hence some successes and failures during the working on of the prototypes. The prototypes were supposed to ensure the perfection of the final product which is the goal of this project.

In the handling of the project, we chose the following prototypes; The motors with joystick/other controls, Baby GUI and Data processing and transfer from a single sensor. We chose a joystick to enable easy control of the final product. A joystick is easier to use in controlling rather than anything since our target is for kids not adults. We then chose a GUI because we wanted to allow the user to interact with program. This is from the fact that GUI replicates the features of elements so that we keep some kind of familiarity. We finally chose a data processing and transfer from a single sensor so as to allow ease access and control of the program. These three prototypes fit in the big picture in the sense that they will work in unison to make a functional object, when we have a joystick, it will get information from GUI. The data processing and transfer from a single sensor will be able to execute commands as required by the user hence enabling mobility of the final product.

The group chose these prototypes because it expected to learn how mechanics and software programming can be incorporated to work harmoniously. At first it seemed quite easy but when we started working on it, it came out to be a challenge to the group members hence it was an effort to try something that group members expected to be a challenge.

However, I can say that the everything went as planned. We therefore did not have to change prototypes to ensure the delivery. To ensure completion of this prototypes, we divided the work in per individual to ensure that everyone does enough research. After this, we would meet and discuss everything before we come into agreement with any step to be taken. Hence, all group members worked as an entire team, one prototype after the other.

Basing on the work we did; the prototype was a success. However, before it was a success there were challenges with materials and programming. At first, we did not have all materials. Our team leader Lauren wanted the team to reuse all the materials given from the past team members.

In concluding Secretary Khaled have researched on parts needed to control the motor. looking into the data/research, reusing all the materials given from the past team will lead for unperfect approach in the end. While discussing with team members, Secretary Khaled came with a video that controls DC motor using C and other programmers that will help us twist our needs and fulfill the task requirements.

Then came to programming errors, Team Leader Lauren and Treasurer Daniel was working together on programming to control the DC motor towards our aspect's goals. And Liaison Taylor working on GUI and how grapping data will accrues using our system. Looking into Team-Inventory Lauren, Daniel, and Taylor had more experience on program very well. So, team members had a clear picture on dividing parts on three prototypes that are handled by Lauren, Daniel, and Taylor. While Khaled is researching and working on the actual ways to connect the boards that are programmed for the prototype, to the original motors to have the final prototype ready for testing and to redraw the pseudocode to ensure that what was happening is in the required content.

If we were to do it again, I think we would adjust it to handle more things than just mobility, like to allow person to person communication and access to places that require wireless passage. One of the reasons me being an engineer, I love helping people in need. I'm thinking to create a new power mobility with advance programming that will collect data to ensure the perfection of upcoming designs will change the life of people in needed. The prototype took a longer period than we had expected, however, its completion was within the given time.

Thinking about the question about the prototype, my perception lies on the idea that augmented powered mobility can be made in different ways and various advancements made to it as long as there is enough time to ensure its functionality. The way we worked on the prototype, the programming we did and the final results of how the final product will work can definitely have an impact on the project plan.

In conclusion, I can say that the prototype though challenging in a manner, it was a success and this means that many people can benefit from the project. The project can bring about change to the lives of many hence a transformation to how things are done to many individuals.

Thank you in advance for looking into my individual prototype memo research.

Sincerely,

K.Khaled

NORTHERN ARIZONA UNIVERSITY | School of Informatics, Computing, and Cyber Systems

To : Dr. Kyle Winfree
From : Taylor Yee
Date : November 16, 2019
RE : Prototype Findings

Dear Dr. Winfree,

Attached below is the Prototype Findings document from Taylor Yee. In this assignment, I summarize the team's early efforts for the prototype demonstration given by Team AmpEd on November 15, 2019. The goal of this document is to analyze the team's effort, overall success, and how the prototypes will help the team moving forward.

The first prototype that we decided on was to demonstrate that we knew how to operate a DC motor with an Arduino and a joystick. This prototype idea was chosen because team AmpEd's final project is centered around being able to operate a powered wheelchair platform with a standard wheelchair joystick, as well as a force feedback one. The team decided to prototype a smaller version of the final product, in order to learn more about the interaction between joysticks and motors. The group expected this one to be slightly tricky, because none of us have any real background in robotics, but paramount due to its direct correlation to the final project. Some aspects that were unknown about this prototype included how to read values from the joystick, and how to connect those to motor speed and direction of rotation. Daniel took primary responsibility for this prototype, with assistance and input from the other members. The initial prototype consisted of an Arduino Uno, a single 6V DC motor, and a small analog joystick typically found in Arduino starter kits. The joystick was tested individually with the serial monitor to understand how it worked. Then the single motor and the joystick were brought together and tested, but it was determined by Daniel and Lauren that two 12V DC motors would be more suitable to work with, test, and demonstrate. Daniel wired up the final circuit and wrote most of the code required to make the motors run, but Lauren cleaned up the final version of the code for the prototype. She also came up with the idea of using spools of thread as emergency substitutes for the wheels, and a breadboard as the body of a car, to better demonstrate the functionality of the prototype. This prototype was demonstrated as a success, though it took a little bit more work and time than the team expected to work out some of the kinks. The biggest hurdle faced with this prototype was getting the motors to rotate in the correct direction and in sync with each other. If this were to be done again, the team would probably create a cleaner physical platform to run the entire system on, so that it would be easier to see the parts working. The experience of understanding how a joystick interfaces with DC motors will be important when building the platform and working with bigger voltages and motors, but the team will need to do more research to determine if a wheelchair joystick can be operated in the same manner as a simple Arduino analog stick.

The second prototype that we decided on was to demonstrate that we could use Arduino and Processing together to read sensor data and display it in real-time to a user in a closed-loop system. In the project description, the physical therapist (PT) specified that she would like user adjustable parameters on things such as object avoidance. In order to detect object avoidance from a computer's perspective, infrared (IR) or ultrasonic sensors are some of the most common. The team decided to prototype an IR sensor that would send data through a serial connection to an Arduino Uno, which would then forward this data to Processing, where it would be graphically displayed to the user. Since the team has never worked with Processing prior to capstone, it was both a challenge and an important goal to at least nail down some basic fundamentals that will be used in the future. Things went mostly as planned – the closed-loop system created by Lauren was able to detect objects in the 7cm-100cm range of the IR sensor, and output those to the Processing console as green lines, refreshing every second. I helped Lauren get started with working with Processing and showed her some very basic code, as well as directing her to Processing's page for downloads and more in-depth tutorials, but she definitely took charge of this prototype. She started by salvaging an IR sensor from the previous team's project, connecting it to an Arduino Uno, and then having it print readings to the serial console in Arduino to determine that both the sensor and her initial approach worked. After determining that it was reading correctly, the next step was connecting the Arduino and Processing together in order to display graphics that correlated to the sensor's readings. Before the demonstration, it was important (and a major hang-up until this realization was made) to understand that serial transfers, especially those between Arduino and Processing, only occur with strings, and not integers, floats, or doubles. This distinction is especially important because changes had to be made in order for the data to transfer over correctly. Additionally, a conversion to cm needed to be made so that the numbers and readings had value to them. This prototype was demonstrated as a success as well. If the prototype were to be redone, a nicer graphic could have been established, with labels and axes to give more weight to the readings displayed. The IR sensor could have also been tested against different surfaces and different colors as well to determine if it behaved the same across the board or was affected by these factors. The experience of understanding how sensors can communicate with Arduinos, as well as the Arduino and Processing IDEs respectively, will be important moving forward as the PT will want to be able to read data with zero knowledge of the electronics and workings. As such, this prototype has made the team reconsider how we will approach the physical display of results, and what we will need to prioritize.

The third prototype that we decided on was to demonstrate that we had a working understanding of what a graphical user interface (GUI) is, does, and how ours will tentatively look when it comes to the PT. In the project description, the PT specified that she would like a user PC side GUI for setting of parameters and assessment of driving skills. No one in the group has ever really designed user-end interfaces that are meant for people who are not engineers, so we were hoping to learn about how Processing displays and writes to the console, as well as begin to understand what aspects of the GUI are more important for the PT. Things went mostly as planned, though the team over-thought this prototype. I was primarily in charge of this prototype, with inputs and initial ideas from the rest of the team, as well as Dr. Winfree. I first created a rough GUI that allowed a user to communicate with an Arduino Uno, LEDs, and a 3V-6V DC motor with the Arduino IDE, a Processing console, and mouse clicks. Although this did not fit well into the scope of this prototype, especially after talking with Dr. Winfree, having a working understanding of Processing was helpful in what the prototype became. We ended up drawing an idea of what the GUI might look like, and I detailed some of the source and pseudocode that would drive each module in Processing in order to display things that we wanted to see happen. This prototype was demonstrated as a success, and though there was not much that had to be addressed before the prototype was functional, a lot of planning and thought went into breaking down the GUI before anything went on paper. This was probably the trickiest to prototype, simply because it was more theoretical in nature and mostly written only on paper, because this design will probably change drastically once we are able to talk to the PT and understand what she personally wants to see. However, it is good to start thinking about it now, because I have a feeling this part of the project will become the most labor-intensive part in the later stages of this production. If we were to do this prototype again, I would want to get in contact with the PT we will be working with, so that we could start tailoring our thoughts and ideas to meet her needs. Though the prototype itself did not take as long as I thought it would, it had the positive effect of personally opening my eyes to see that we need to think as designers and engineers who are meeting a client's needs. A client who is not an engineer and does not necessarily need all the details that we would fawn over, but instead needs something clean, easy to read, and easy to use.

In this memo, I analyzed and broke down each prototype that our team presented, and also made connections from what we accomplished and demonstrated, to the future of our project. Each of these has their own benefits and takeaways, and I am excited to continue working on the project and getting to work alongside the PT in the near future.

Very respectfully,

Taylor Yee