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GNG2101[D] - Introduction to Product Development and Management

Prototype II

Project Deliverable F

Group 2.4
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Mike Sheppard, 300166172
Shambhavi Asthana, 300144663
Grace Buchardt, 300236838
Jacob Troop, 300186278

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1. Introduction

In Deliverable E, we presented our group's progress on the prototype and also spoke about what we intend to achieve as a group going forward and how we intend to meet those goals. After this presentation we received some great feedback from the professor, our TAs and some fellow classmates. We were able to use this feedback to help prepare for client meet 3. During client meet 3 the first prototype was shown to the client and we were provided with even more detailed feedback that related directly to the needs of the client and the user. After the client meeting, this design was modified to fit the client's needs better. The following deliverable will contain an updated prototype that has been modified accordingly and will be completed to the stage where additional parts contained in the bill of materials will be ready for purchase approval. In this deliverable client feedback will be summarised, also the critical assumptions used while creating the new prototype will be provided and prototype testing will be used to evaluate functionality of the prototype and show where there is still room for improvement.

2. Client Feedback

During the meeting, we showcased our prototype II along with explaining the improvements we have made since the previous prototype and explaining the mechanics we have added and future ones we plan to implement. The client was happy with what we had to show, and commented that the physical prototype was properly shaped in a way that allowed for a better representation of the final product. Both clients stated that the coding end of our project should be something we should focus towards, since it seems to be the more difficult part of our work. Another thing they mentioned was having two motors and rails on each side rather than just one in the middle, as our prototype II demonstrated. Another piece of information

the client gave us was to remember to not include sharp edges or little mechanisms on the outside of our product, as children will be dealing with it and we do not want them to be injured while using the tablet holder. Overall, the client was satisfied with our current progress for our project and gave us some good feedback and reminders to keep in mind while continuing with our work.

3. Critical Product Assumptions

Critical Assumption	Description
Material	All of the materials listed in the BOM are readily available and easily accessible (Possible use of MDF board as a cost and time saving measure which will only make a major difference regarding aesthetics)
Weight	All materials that are used to make the tablet holder have a total weight less than 7 lbs which will be within the functional range of our motors capabilities
Size	The tablet holder itself cannot be bigger than 21.83 x 11.7 x 1.24 inches
Usability	Must be usable by anyone in a wheelchair with basic motor skills
Range of motion hinge	Assume that hinges are able to open a minimum of 180 degrees (based on information given by the client the range from 0 to 60 degrees will be most important for the user and therefore the majority of presets should fall in this range)
Range of motion rail	Assume that the slide rail has a functioning range of at least 25 cm of its 30 cm length
Deterioration	Assume any minor damage that occurs to the prototype over time will have only a minor effect on its functionality
Tray type	Assume that the tray will have a grid like surface underneath up until client informs us of what tray we will actually be receiving
Safety	Assume that the majority of users will be children and place appropriate safety feature in

	place (no sharp edges, no loose wires, force upon closing of tablet holder is not large enough to cause harm to child, ect)
Motor damage	Assume all motors must run in synch with each other in order to prevent motor damage and overheating of prototype
Height change	Based if information provided by the client it can be assumed that any motion along the Z access is unnecessary due to the mobility range of the users and this form of motion will not need to be incorporated into further prototypes

4. Documentation of Latest Prototype

The latest prototype has 2 main functions, namely to open/close and to slide forwards/backwards from the user. The open/close function has been successfully implemented and works perfectly with a micro servo motor. The second function (sliding) has not yet been implemented on the tablet holder, but we have begun to understand the functionality and how it would work when we do implement it. The images of the circuits and their respective codes have been shown below.

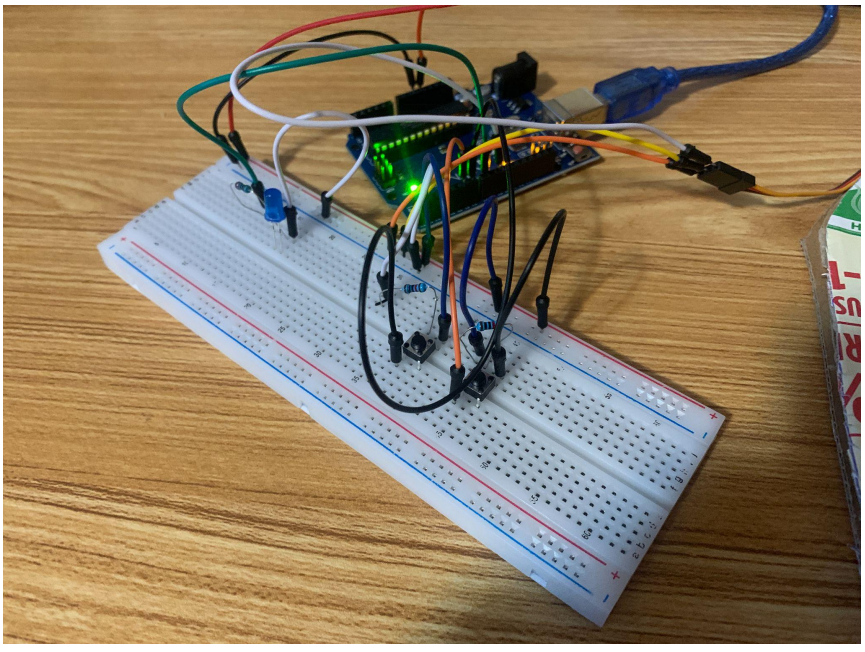

Figure 4.1: Arduino Circuit for Prototype II open/close functionality

Figure 4.2 & 4.3: Closed and open positions for Prototype II

prototype2

```
#define LED 8
#define sensor 7 //button 1 - to open tablet holder
#define off_sensor 6 //button 2 - to close tablet holder
#include <Servo.h> // include servo motor

Servo servo1; //initialize servo motor
int sensorState;
int off_sensorState;

int angle;

void setup() {
  Serial.begin(9600);
  pinMode(LED, OUTPUT);
  pinMode(sensor, INPUT);

  servo1.attach(10);
}

void loop() {
  sensorState = digitalRead(sensor); //sensorState reads state of button 1

  if (sensorState == HIGH) { //if button 1 is pressed
    digitalWrite(LED, HIGH); //turn LED on

    for (angle = 0; angle <= 180; angle += 1) { //0deg to 135deg in +1deg increments
      servo1.write(angle); //motor goes to the degree
      delay(15); //speed
    }
  }

  off_sensorState = digitalRead(off_sensor); //off_sensorState reads state of button 2

  if (off_sensorState == HIGH) { //if button 2 is pressed
    digitalWrite(LED, LOW); //turn LED off

    for (angle = 175; angle >= 0; angle -= 1) { //130deg to 0deg in -1deg increments
      servo1.write(angle); //motor goes to the degree
      delay(15); //speed
    }
  }
```

Figure 4.4: Arduino IDE (code for open/close function)

Figures 4.1 to 4.4 show a fully functional Prototype II with the open and close mechanism.

The Arduino Uno was used along with a micro servo motor which we attached to the

makeshift tablet holder through a cardboard hinge. As shown in the code, one button opens the tablet to a 135° and the other button simply returns the tablet to its default closed position.

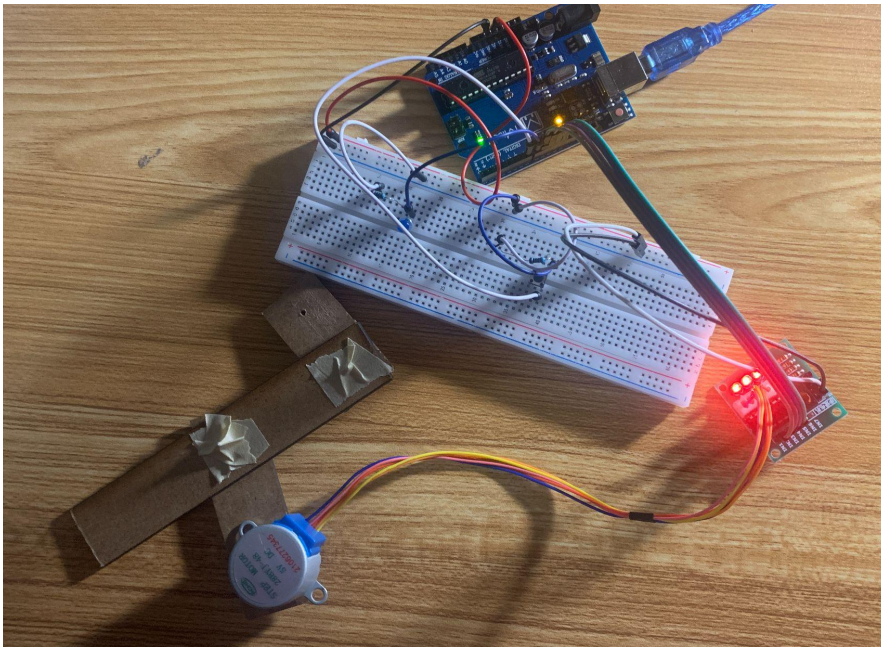

Figure 4.5: Arduino Circuit for new sliding mechanism

sketch_mar06c §

```
#define STEPPER_PIN_1 9
#define STEPPER_PIN_2 10
#define STEPPER_PIN_3 11
#define STEPPER_PIN_4 12
int step_number = 0;
void setup() {
pinMode(STEPPER_PIN_1, OUTPUT);
pinMode(STEPPER_PIN_2, OUTPUT);
pinMode(STEPPER_PIN_3, OUTPUT);
pinMode(STEPPER_PIN_4, OUTPUT);

}

void loop() {

  OneStep(false);
  delay(2);
}

void OneStep(bool dir){
    if(dir){
switch(step_number){
  case 0:
  digitalWrite(STEPPER_PIN_1, HIGH);
  digitalWrite(STEPPER_PIN_2, LOW);
  digitalWrite(STEPPER_PIN_3, LOW);
  digitalWrite(STEPPER_PIN_4, LOW);
  break;
  case 1:
  digitalWrite(STEPPER_PIN_1, LOW);
  digitalWrite(STEPPER_PIN_2, HIGH);
  digitalWrite(STEPPER_PIN_3, LOW);
  digitalWrite(STEPPER_PIN_4, LOW);
  break;
  case 2:
  digitalWrite(STEPPER_PIN_1, LOW);
  digitalWrite(STEPPER_PIN_2, LOW);
  digitalWrite(STEPPER_PIN_3, HIGH);
  digitalWrite(STEPPER_PIN_4, LOW);
  break;
  case 3:
  digitalWrite(STEPPER_PIN_1, LOW);
  digitalWrite(STEPPER_PIN_2, LOW);
  digitalWrite(STEPPER_PIN_3, LOW);
  digitalWrite(STEPPER_PIN_4, HIGH);
  break;
}
  }else{
    switch(step_number){
  case 0:
  digitalWrite(STEPPER_PIN_1, LOW);
  digitalWrite(STEPPER_PIN_2, LOW);
  digitalWrite(STEPPER_PIN_3, LOW);
  digitalWrite(STEPPER_PIN_4, HIGH);
  break;
  case 1:
  digitalWrite(STEPPER_PIN_1, LOW);
  digitalWrite(STEPPER_PIN_2, LOW);
  digitalWrite(STEPPER_PIN_3, HIGH);
  digitalWrite(STEPPER_PIN_4, LOW);
  break;
  case 2:
  digitalWrite(STEPPER_PIN_1, LOW);
  digitalWrite(STEPPER_PIN_2, HIGH);
  digitalWrite(STEPPER_PIN_3, LOW);
  digitalWrite(STEPPER_PIN_4, LOW);
  break;
  case 3:
  digitalWrite(STEPPER_PIN_1, HIGH);
  digitalWrite(STEPPER_PIN_2, LOW);
  digitalWrite(STEPPER_PIN_3, LOW);
  digitalWrite(STEPPER_PIN_4, LOW);
}
  }
step_number++;
  if(step_number > 3){
    step_number = 0;
  }
}
```

Figure 4.6 & 4.7: Arduino IDE (code for sliding mechanism)

Figures 4.5 to 4.7 show how the sliding mechanism will work once implemented on the tablet holder. An Arduino Uno is used along with a stepper motor, and this system is loosely based on a Scott-Russell linkage system.

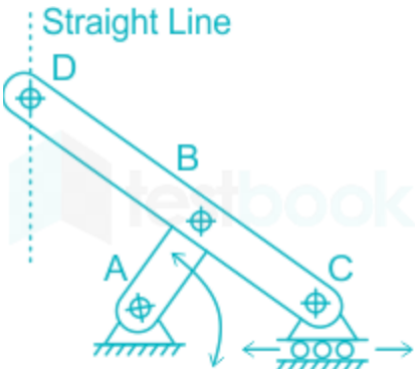

Figure 4.8: Scott-Russell Linkage

As seen in Figure 4.8, a Scott Russell linkage system is the ideal system for our sliding mechanism. The stepper motor will be attached at point A in the diagram, it will rotate clockwise and counterclockwise depending on the required direction of motion. This will assist point D in making a straight line. The initial subsystem that uses the micro servo motor to assist in opening and closing the tablet holder will be attached to the hinge and the entire mechanism will be sliding up and down line D once the new sliding mechanism is implemented. This way the tablet can open and close freely without impeding the user's motion and it can slide forwards and backwards, giving the user maximum flexibility.

5. Prototype Testing & Evaluation

Test	Description	Expected Results	Actual Results
Open	Must open tablet holder to 135 degrees	The expected result was that the tablet holder would open to a 135 degree angle and remain at this angle until told to close.	This test was successfully performed, as by a press of a button, the tablet holder is opened to a 135 degree angle
Close	Must close tablet holder back to original position	The expected result was that the tablet holder would close to the initial position and remain at this closed position until told otherwise	This test was successfully performed, as by a press of a button, the tablet holder is closed to the initial position

Extend (move forward)*	Must slide down the track towards the user	The initial expected result was that the hinge system will rotate clockwise with the stepper motor	The test was successful.
Retract (move backwards)*	Must slide up the track away from the user	The initial expected result was that the system would rotate counterclockwise	The test was unsuccessful. More programming and troubleshooting is required to rectify the problem

*More testing is required once this feature is implemented onto the prototype

6. Updated Project Plan

Updated Project Plan Link

7. Conclusion

In conclusion, our second prototype was a success and modified accordingly to match the expectations and critiques of our client. Our group has established critical product assumptions, including the heavy modification of our BOM to better suit the new information we have gathered and received related to our product, and we have managed to test our second prototype with success. In the future, our group plans to continue with our current line of thinking and take more time to work on physical results rather than written and theoretical work, taking what we have established within our deliverables and putting it into practice.