ANIMATRONICS FACE: PROF PRANAV BHONSULE

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ABSTRACT

The project consisted on building an animatronics face for one of the faculty professors from the ground up. A supporting structure was required in order to simulate the face and the movement of at least two moving parts. The mouth and nose were selected to be the moving joints for this animatronics face. Servo motors were used to move the joints on the structure. An ultrasonic sensor was used to move the mouth up and down when an object would pass within 60 centimeters from the sensor. A 2-axis thumb joystick sensor was used to move the nose either up or down by moving the joystick to the chosen position. An Arduino was used to connect all servo motors and sensors together. The coding was elaborated to have both sensors work simultaneously as well as sending the signal to the servo motors, which will then react by moving the joints that were connected to the nose and mouth to move as desired. A short audio was recorded from the professor assigned (in this case that professor is Goldie Hood) to have a more realistic interaction with people and have the face “talk to you” when presenting it.

Section 1: Literature review

Worcester polytechnic institute built a very detailed animatronics face that is capable of moving eyes, eyelids, eyebrows and mouth as shown in reference [1]. The researchers first studied the motion of the eyes, the movement of the eyebrows, and the movement of the mouth. The researchers first studied the eyebrows motion to determine the largest angle that the eyebrows could move according to different face gestures. A servo motor and metal rods were used to move the eyebrows accordingly. The movement of the eyes and eyelids were done with a mechanism that consisted of links for yaw movement. The eyes had a universal joint to move freely at any command. Servo motors were also used to move eyes and eyelids. A jaw linkage and servo motors were used to move the mouth. The completed set is shown on figure 1. Figure 2 shows the completed animatronics face. The purpose for this animatronics face was to do further research on the face-tracking mechatronic field.

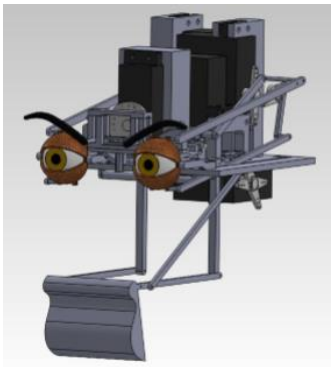

Figure 1 – Final inner assembly of animatronics face

Figure 2 – Final outer assembly of animatronics face

The following animatronic face has only two motions on it as shown on reference [2]. The first motion is on its eyebrow and the other is on its mouth. The eyebrow and the mouth will simply move up and down. The two motions are simple controlled by two servo motors. The rotational motion of the servo motor is transferred to linear motion that will move the desired part up and down. The main purpose of this animatronics is to simply understand the most basic motions and understand how to construct them. This animatronic is pretty simply and we will most likely go with something that is more complicated.

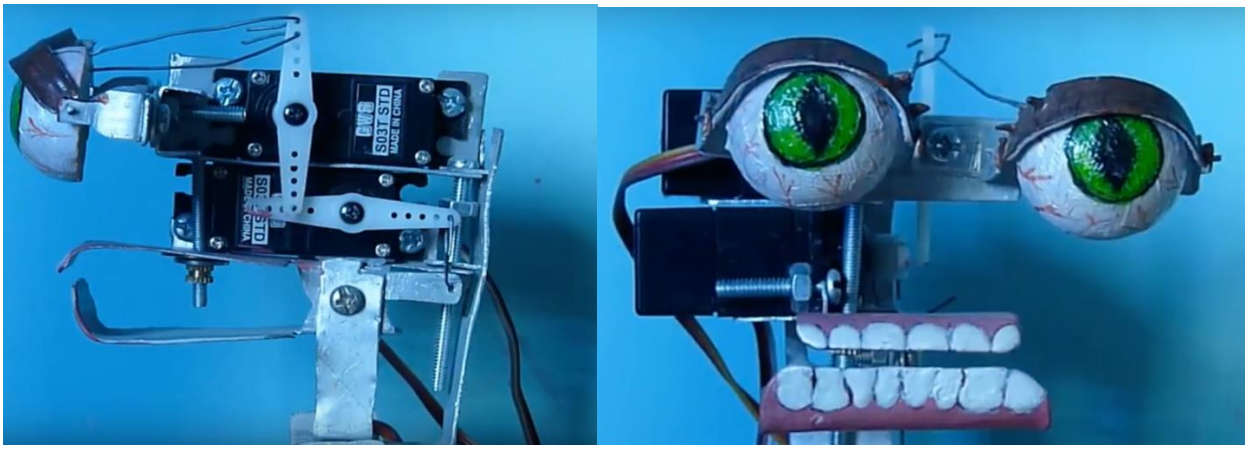

Figure 3 – Animatronics Face set-up

There is a DIY instructional video on YouTube depicting how to make an animatronic face constructed on a flat wall. The face is controlled by servo motors with the degrees of motion consisting of: eyes, mouth, and eyebrows. There is one servo for each eye so that they can move separately or in unison. Since this face is intended to be funny, the eyebrows move quickly and drastically. These components are connected to a Teensy 3.2 circuit board. [3]

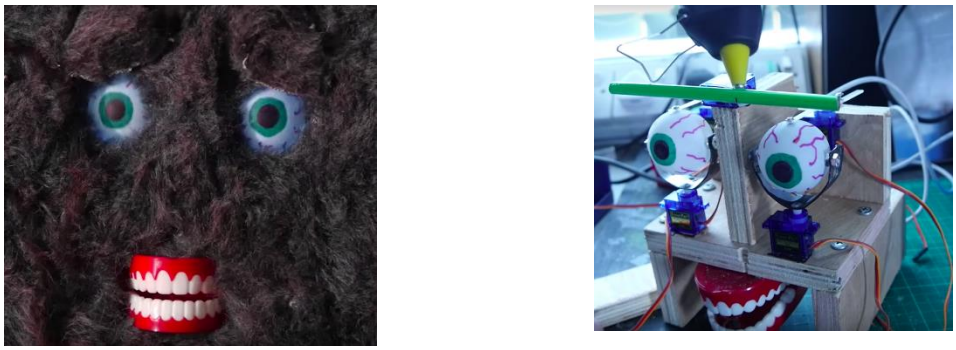

Figure 4 – Inner and outer finalized animatronics face

Section 2: Brainstorming (initial planning)

For the movement on the animatronic figure, the jaw and nose will be the primary movements. The jaw and nose will move using servo motors. The jaw will be moving up and down with the aid of linkage attached to servo motors. The nose will also move up and down with a different linkage set-up on the erector set. An ultrasonic sensor will be used and programmed to actuate the motion of the animatronics face if movement is detected within 60 centimeters of the ultrasonic sensor, also an analog 2-axis thumb joystick sensor will be used for the movement to be actuated either up or down. The structure and chassis will be made of cardboard and an erector set, the jaw showed on the front face will be cut out to show a more realistic jaw movement, the nose will have a connecting rod to another supporting rod where the servo motor will actuate to be able to move up and down when the analog 2-axis thumb joystick activates. The base of the animatronics face will be a box where the Arduino board, motors, linkages, and cables are going to be stored. As the ultrasonic and thumb joystick sensors trigger, they will send a command for the sound to play and motors to move the jaw and nose accordingly, this will be a calibration and programming activity in order to time the jaw/nose

movement with the sound. All electronics will be powered with either a 9V battery or from the computer USB port. The soundtracks that are going to be collected from professor Gold Hood will be:

1. Welcome to the design offices of old and evil, your first day in hell.
2. “Beneath this mask there is more than flesh, beneath this mask, Mr. Creedy there is an idea, and ideas are bulletproof” [3]

Section 3: Supporting structure

The supporting structure is made out of an erector set in order to hold on to the eyes, mouth, and nose. Copper cable and strings will be used to connect the servo motors to the nose and mouth to allow for movement. Copper cable will also be used to place both the ultrasonic sensor and 2-axis thumb joystick sensor. The base is made of cardboard in order to keep the erector structure balanced. Figure 5 and 6 show the structure made.

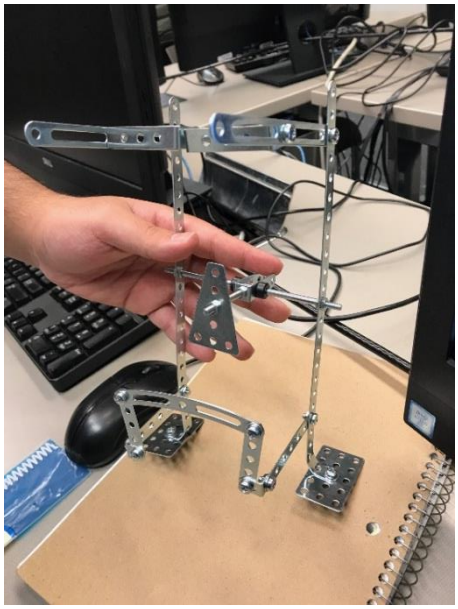

Figure 5 – Supporting structure

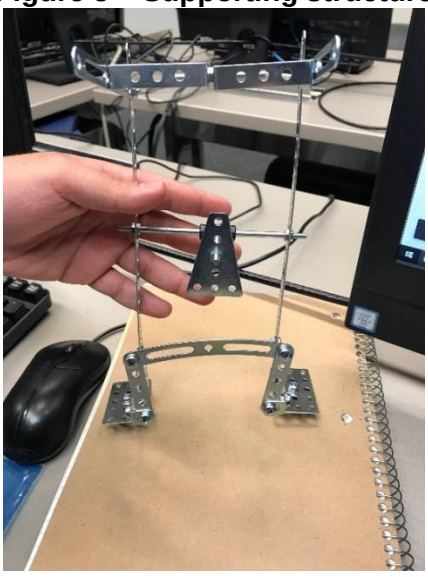

Figure 6 – Supporting structure second view

Section 4: Joints and motors
Servo motors will be used for the movement of the nose and mouth. Different angles on the servo motor (ranging from 10 to 180 degrees) will be tested to determine the perfect movement of the jaw and nose separately. The joints will be interconnected with rods in order to translate the servo motor circular movement into an up and down motion accordingly. The servo motors and joints will be connected with cooper wire to link both pieces together in order to allow for easier movement.

Section 5: Sensors
The sensors used for the animatronics face will be an ultrasonic sensor and a 2-axis thumb joystick sensor. The ultrasonic sensor will detect movement ranging from 0 to 60 centimeters, which will actuate the servo motor to jaw for movement. The ultrasonic sensor will be programmed to where it will actuate from 5 to 10 consecutive seconds when it senses one movement to be able to play the audio according to the jaw movement. The 2-axis thumb joystick sensor will be programmed to move either up or down depending on the direction that it is commanded. For example, when moving the joystick up, the nose will go up, when the joystick is down, the nose will move down.

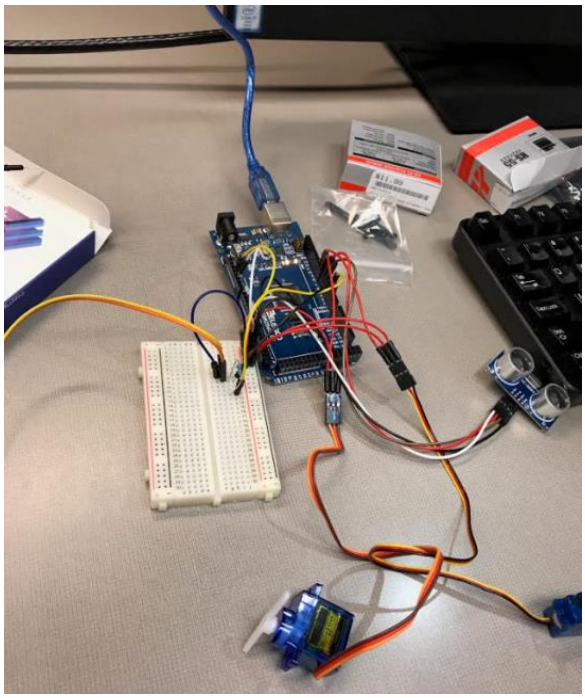

Figure 6 – Arduino connection with ultrasonic and 2-axis thumb joystick sensor.

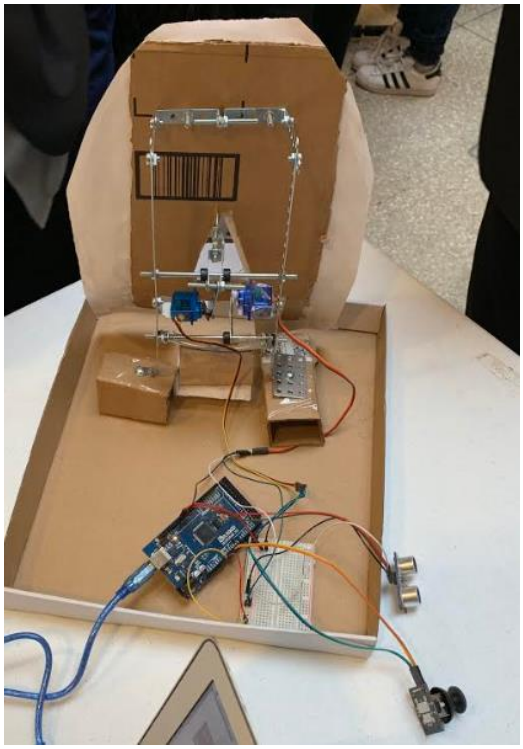

Figure 7 – Arduino connections and links to supporting structure

Section 6: Programming for interaction

The code as shown on the appendix took a significant amount of time and research to be able to perfection it. First the port names and values had to be defined by the sensors. Secondly, the two servos had to have a defined name. In the setup, ports needed to be identified with their corresponding servo. It was also important to define the values and to know if each pin was acting as an input output. Then the loop had a sequence of codes that identified the values of the sensors while creating printed outputs to display the statuses in the serial monitor. “If” statements were crated to program what would happen to the servos when the sensors reached certain input values. “Else” statements were also needed and created to identify what would happen when the “if” statements were false. Delays were added in order to “clean up” how the servo motors operated between commands. This loop ran continuously to check the input values of the ultrasonic and 2-axis thumb joystick which operated the output of the two servos controlling the nose and mouth accordingly. Three different videos of the animatronics face in action were uploaded to YouTube, links on appendices [5], [6], [7]

Section 7: Lessons learnt and suggestions

The animatronics face was a definite challenge. The following lessons and challenges we had to overcome are as follows:

1. The structural analysis and mechanism was a good hands-on experience for being able to figure out a way to convert the 180-degree rotation of a servo motor into another type of movement. Thinking of a way to put the structure together was a good exercise and using an erector set (as advised) saved some time and sweat in the long run due to the variety of link and rods that came with it (such as different lengths and shapes).
2. The Arduino complete set that was needed for this experiment was easy to use and even had some instructions on what the purpose of each sensor, switch and button was, and how it could be implemented for a variety of projects. The complete set has everything needed to complete this project (in the exception of the MP3 shield)
3. The coding and some sensors really caused a problem throughout the process of making the face. The team had initially wanted to do an ultrasonic sensor and a tilt switch sensor. The ultrasonic sensor worked very well throughout the whole time that the project was worked on, the tilt switch however became one of the biggest problems of the whole project. The tilt switch was initially to be activated as soon as there was any tilting in the switch, which will then send a command to the servo to activate. The coding programmed for this sent out the correct signal when checking the serial monitors on the software. It was recognizing when the tilt switch was being flipped 180 degrees. However, the servo motor wouldn't work all the time when tilting the switch. It was a very "random miss" most of the time. Which we then decided to buy another tilt switch to discard the possibility of a damaged tilt switch. A few days later when the new tilt switch arrived, the servo motor was doing the exact same thing. Considerable amount of time was spent on the coding, but the problem was still there.
4. A different approach needed to be taken to be able to have two different sensors to actuate the face. The team then decided to use a 2-axis thumb joystick sensor. The joystick sensor worked perfectly with the coding given. The up and down directions worked as expected to control the nose.
5. The MP3 shield bought needed soldering. Extensive amount of research to solder the shield and to learn how to code it was done by all members of the team. However, there was many problems with trying to sync the recording obtained from the professor, to the motion of the mouth and nose. Integrating it all on one Arduino became a very challenging task that became a step that, unfortunately just like many other teams, had to be skipped and an outside speaker was used instead to provide a sound to the animatronics face.

The two suggestions that the team recommends improving based on the experience with the project are:

1. Have more experience on projects that involve coding with Arduino that have to do with more than two servo motors and different types of switches. Since the coding plays a major role to make the animatronics face or any other project come alive with the correct movements and flow.
2. Do more research on how the MP3 shields work with the Arduino, and how it is automatically synced with an audio and motors.

Section 8: Personnel and bill of materials

(a) Personnel

Task	Main Personnel	Secondary Personnel
Structure/chassis design	Brandon Perez	Frank Garcia
Creating joints and motor interfacing	Naser Alajmi	Brandon Perez
Integrating sensors	All	All
Overall programming and integration	Frank Garcia	Naser Alajmi
Report Writing	All	All

(b) Bill of materials

No.	Description	Website/comment	Qty.	Unit $	Total $
1	Arduino MEGA 2560	Provided	1		
2	Erector Set	Build-you-own sailing boat erector set	1	29.65	29.65
3	Cardboard	Scrap material from home		0.00	0.00
4	Servo motors	Obtained one motor from Arduino complete set, another had to be bought separately	2	5.39	5.39
5	Copper wire	1.5 mm thick copper wire for attachment of servo motors (12 in. long)	1	1.99	1.99
6	Double-sided sticky tape	Tape to reinforce the servo motors in place (box of 2)	1	5.25	5.25
7	2-axis thumb joystick sensor	Obtained from Arduino complete set (see Arduino complete set for pricing)	1	0.00	0.00
8	Ultrasonic sensor	Obtained from Arduino complete set (see Arduino complete set for pricing)	1	0.00	0.00
9	Arduino complete set			30.99	30.99
10	Tape	Emergency material for last minute fixings	1	3.25	3.25
11	MP3 Shield	https://www.adafruit.com/product/1790	1	29.95	29.95

The total price for this project excluding the Arduino MEGA was **$106.47**

References

[1] Animatronics Face of Worcester Polytechnic Institute,
https://web.wpi.edu/Pubs/ETD/Available/etd-050112-072212/unrestricted/Fitzpatrick.pdf

[2] How to make your own Animatronics Robot at home
https://www.youtube.com/watch?v=2bN3ZSUr-QQ

[3] ROMOBOT - ANIMATRONIC FACE ROBOT
https://www.instructables.com/id/RomoBOT-Animatronic-Face-Robot/

[4] V for Vendetta – Famous Quotes
http://quotegeek.com/quotes-from-movies/v-for-vendetta/6646/

[5] Our animatronics face in action
https://www.youtube.com/watch?v=77ZEuJmpTPk&feature=youtu.be

[6] Our Animatronics face in even more action
https://www.youtube.com/watch?v=uv19dtCd484&feature=youtu.be

[7] Best animatronics face
https://www.youtube.com/watch?v=pHQUHfHmZOg&feature=youtu.be

Appendix A: Code

```
#include <Servo.h>
#define trigPin 7
#define echoPin 6
#define servoPin 9
#define groundJ A3
#define vOut A2
#define xJ A1

Servo servo;
Servo myservo;
int sound = 250;

void setup() {
Serial.begin (9600);
myservo.attach(9);
pinMode(vOut, OUTPUT);
pinMode(groundJ, OUTPUT);
digitalWrite(vOut, HIGH);
digitalWrite(groundJ, LOW);
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
servo.attach(8);
}
void loop() {
delay(10);
 int joystickXVal = analogRead(xJ) ;  //read joystick input on pin A1
 Serial.print(joystickXVal);               //print the value from A1
 Serial.println(" = input from joystick");  //print "=input from joystick" next to the value
 Serial.print((joystickXVal+520)/10);       //print a from A1 calculated, scaled value
 Serial.println(" = output to servo");      //print "=output to servo" next to the value
 Serial.println() ;                         //write the calculated value to the servo
 if (joystickXVal > 510){
 myservo.write((joystickXVal+520)/10);
 delay(5);
 }
 else {
    myservo.write(90);
  }

long duration, distance;
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance = (duration/2) / 29.1;
if (distance > 10) {
Serial.println("the distance is more than 10");
```

```
servo.write(90);
}
else {
{  for (int i=0; i<=90; i++){
    servo.write(i);
    delay(10);
  }
}
}
if (distance > 60 || distance <= 0){
Serial.println("The distance is more than 60");
}
else {
Serial.print(distance);
Serial.println(" cm");
}
delay(500);

  }
```

Appendix B: Arduino wiring

Created wiring diagram of the animatronics face using fritzing.org