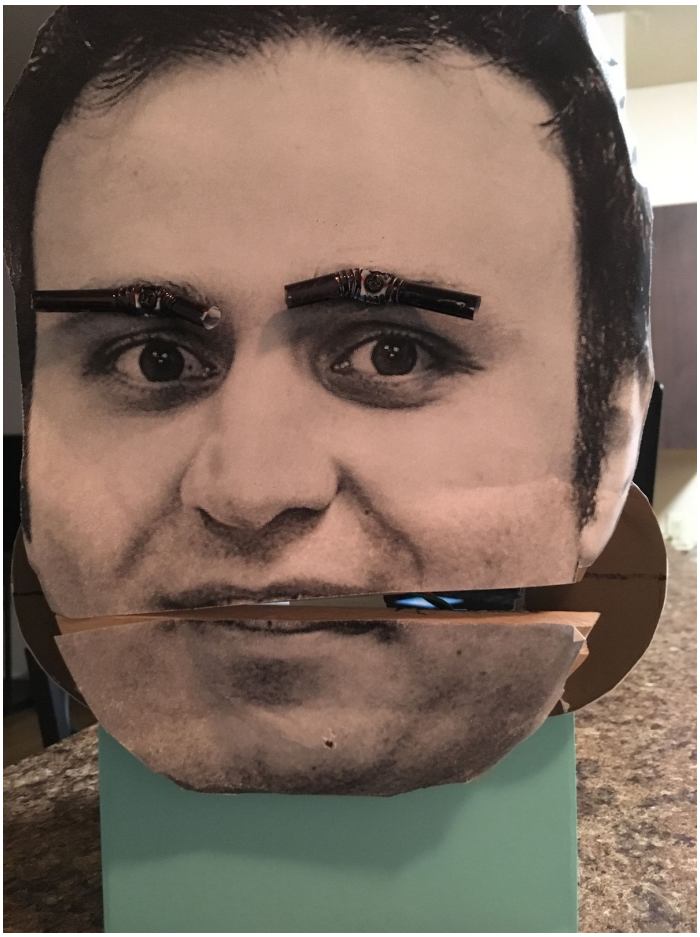
ANIMATRONICS FACE: PROFESSOR JAFARI



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ABSTRACT

An animatronic face modeled after the UTSA Mechanical Engineering Professor Dr. Amir Jafari was made from an Arduino Mega 2560 board, servo motors, sensors, and various construction materials. This face of Dr. Jafari has two different interaction modes activated by two separate sensors. There is a servo that moves each eyebrow when the capacitive touch sensor is activated and a single servo that moves the mouth open when an ultrasonic sensor detects a human within a certain distance. Once the mouth movement is triggered, a voice recording plays saying, “Hi I am Dr. Jafari!”

Section 1: Literature review

Talking Animatronic Robot Head

This Animatronic head concept is found on the instructables website by user “knife 141.” It is named Robot Head 2 and includes servos as the actuators which move the various parts of the face [1]. Plywood is mostly utilized for the material of the face itself with scrap metal, wire and extension cord for connections and fill in jobs. Wooden knobs were used for the eye body with “googly eyes” used as the eye itself. While this particular individual used a servo controller rather than an arduino, it can be switched out easily for the specified arduino mega. It is a relatively complex project because it involves multiple rotation mechanisms, uniquely shaped wood pieces, and a large selection of dialogues as seen in the video attached in the link. However, with a bit of modification, the project can be modeled towards our needs.

Figure 1: Robot Head

Servo Actuated Mouth

This is a more simplistic version of the animatronic face. It is referenced on pyroelectro.com by author “Chris.” There are two different ways to demonstrate the movement of the mouth shown on the webpage, however the more applicable version would be to use a servo motor for the articulated animatronic mouth [2]. The eyes and eyebrows are also controlled to convey different moods of the face [3], [4]. The eyes use a 2-axis movement gimbal system with 4 mini servo motors. A PIC microcontroller is used to control the eye and eyebrow movement. The form of the face would make it easier to depict the face of the UTSA professor.

Figure 2: Face with Moving Facial Features

Carrot Top Puppet

This is a simple design for a puppet head assembly designed by James Maynard [5]. Although it doesn't mention any sort of motors or electronics used, the physical components used make for a simple but complete project. As discussed during the presentation for the romobot, the physical aspect can get very tedious and sometimes more difficult than the actual programming. Here, the main frame of the head (eyes, mouth, teeth, etc.) is made out of wood. The wooden ball is a support which is what allows the head to rotate naturally. Black bungee cords are run through holes behind the teeth which connect to the opening and closing of the mouth. They also affect the opening and closing of the eyes. The material for the strings were 15 pound black nylon fishing line and 25 pound vinyl coated tip up line.

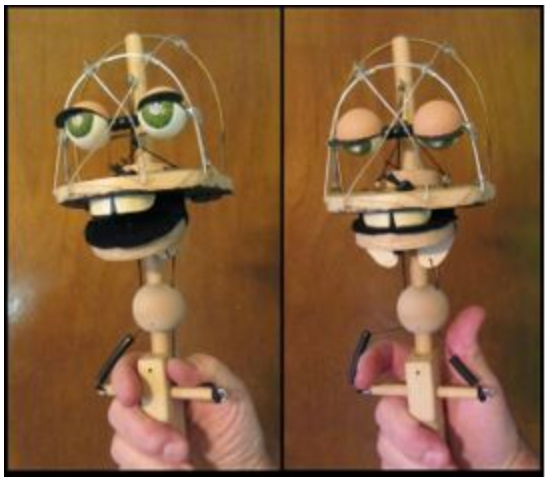


Figure 3: Top Puppet

Section 2: Brainstorming (Initial Planning)

The animatronic face will contain either 2 or 3 moving parts based on the potential difficulty in completing it. The ideal goal is 2 parts of the face moving: the eyebrows and mouth with the mouth synchronized with voice recordings. The eyebrows will be controlled directly through servo motors. The mouth will contain a two directional open-and-close motion powered by servo motors as well. This may need to be changed however, because the mouth may not move fast enough to sync with the audio file. The sensors we will use are a proximity-based ultrasonic sensor and a touch sensor. The ultrasonic sensor will launch the audio file once an object passing a particular distance is detected. The chassis will be formed mainly from plywood. Cardboard will be a supplementary material which can provide a less rigid material for construction. The audio file will be initialized with the mouth movement, so the two components work together in sync. Velcro will be used to attach the plywood platform to the back of the face. If not, then some other sort of adhesive which can stick well onto the wood. 9 Volt batteries will power the arduino, motors, and sensors all together as well as the soundtrack which will include, “Hi, I am Dr. Jafari!”

Section 3: Supporting structure

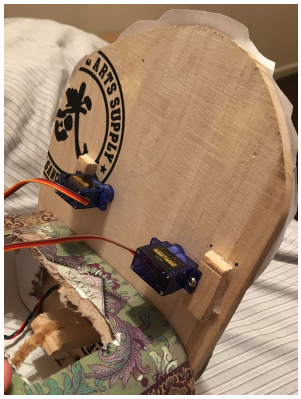
The face is made from a light type of wood, which is convenient for easily maneuvering the mouth different ways. Cardboard would not have enough strength and other stronger materials would have too much weight to move around. The face is mounted on a box which will contain contents of the circuitry, controls, and motors inside which will control the movement of the facial features. The servos for the eyebrows will be placed above the box. A dowel will be connected from the box to the back of the face shape to provide support. Velcro was used to attach the face to the box, so if the face needs the be taken off to connect the wires etc. it will not be difficult. The following figures show the fabrication and assembly process.

Edit: No dowel was used to support, rather the face was cut shorter and velcro was sufficient for support. Small pieces of would were cut and glued to the mouth to provide an easy method pushing from a closed to open position.

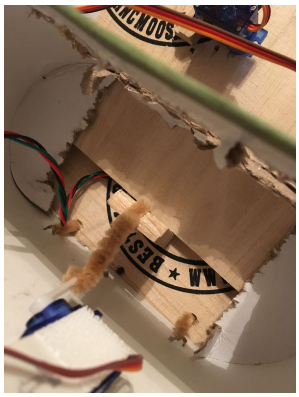
Figure 4: Carved Wooden Face

Section 4: Joints and motors

The motors and sensors interface to the eyebrows and mouth. The eyebrows are controlled by a servo motor on each one and are activated with a touch sensor which will cause the eyebrows to move in different variations to form emotions. For example, they will both point down when “angry”, or when “intrigued”, one will raise while the other will remain. The motors here act as the point of rotation for the eyebrows so that the different movements can be made. The mouth is controlled by another 2 servo motors with an ultrasonic sensor. The motors act as the jaw of a human and raise and lower the jaw. The voice recording will play simultaneously to show user interaction.




Figures 5 and 6: Eyebrow Joints/Motors




Figures 7 and 8: Mouth Joint/Motor

Section 5: Sensors

The sensors used in this animatronic face were a touch sensor and an ultrasonic sensor. The touch sensor was purchased at Intertex Electronics and the ultrasonic sensor was included in an Arduino Uno kit that was already owned by one of the group members. The ultrasonic sensor is connected to the breadboard, and the trigger and echo pins are inserted into digital pins 2 and 3 on the Arduino Mega board. The ultrasonic sensor pings out once code is initialized, and when a distance of 5 or less centimeters is returned to the sensor, the mouth begins moving. The touch sensor is connected to the eyebrow movements. Once the touch sensor is activated, the eyebrows rotate to display a different emotion. These sensors were chosen because they are interactive with the person and were the most convenient, readily-available items needed. The code is short for the sensors to be activated which makes it simple to configure with the other moving parts. Both sensors are quite interesting to learn about and form code with the various commands from the libraries.

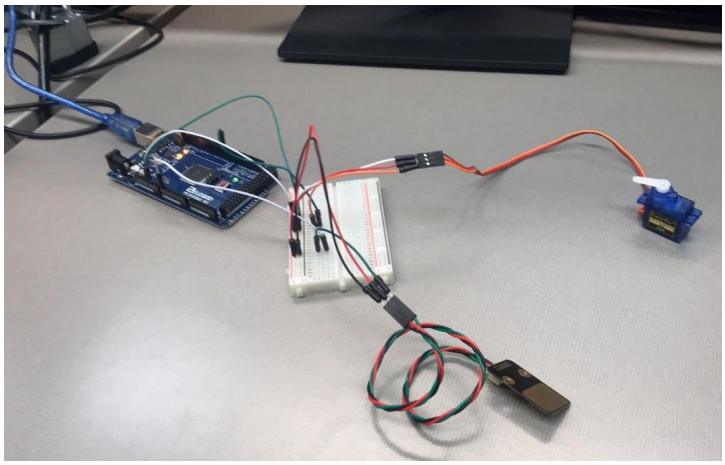


Figure 9: Touch Sensor

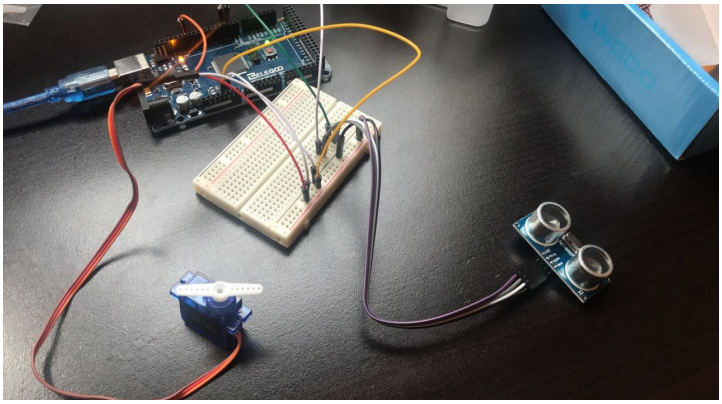


Figure 10: Ultrasonic Sensor

Section 6: Programming for interaction

Firstly, the “Servo” and “New Ping” libraries are included for commands for the servo motors and the ultrasonic sensor. Since the touch sensor is a relatively simple sensor, there is not a library for it. The power and ground pins all lead to the red and black rails of the breadboard, respectively. The echo and trigger pin variables of the ultrasonic sensor are initialized and connected to pins 2 and 3 on the Arduino Mega. Next, the servos are defined. Three servo motors are labeled as servo1, servo2, and servo3, where servo1 is the mouth servo, and servo2 and servo3 are the eyebrow servos. Then the servo motors are connected to digital pins 10, 11, and 12. In the loop section of the code, delays in terms of microseconds are needed for the digitalWrite function to stabilize the input ping values. We found that having a smaller delay increased the inputs displayed in the serial monitor which cause the servos to behave much more erratically. An if, else statement is introduced to show the distance. If the distance is pinged as greater than 10 cm then the code will print “Out of Range.” A for loop is written with the if else statement to essentially trigger the servo movement. The code writes to the servo to change position 130 degrees in steps of 3 degrees. While any speed (in terms of steps of degrees) is acceptable, we found that 3 degrees is a middle ground. A video showing its functionality is linked here: https://www.youtube.com/watch?v=xKePXTRKMSE

Section 7: Lessons learnt and suggestions

1. **Coding involves a lot of troubleshooting and errors.**

In the beginning stages of the project, for some reason I thought that the coding was going to be the simple part of the process. While that has some truth to it, the coding part took a lot longer than we anticipated and created many headaches. Part of the reason for this is because I have little experience with coding in general apart from the few arduino labs from the class itself. Even though those labs gave some insight on how the coding process works, writing the code for this animatronic face was completely different since it is completely from scratch. Knowledge of basic functions in the void loop section including if else and for statements is really beneficial for getting the motors to do exactly what you intend. Completing more projects including gradually more complex code is probably the fastest way to learn because I feel I have learned much more in this small period of time than in classes previously.

2. **Light wood as the chassis/structure makes for a slightly harder construction.**

When deciding on how the structure of the face would be made, we decided to use wood since it was readily available. With the idea that we had going, which was separating the mouth from the rest of the face, even though the wood was lightweight, it made a difference when we were trying to attach the wood onto the supporting base. The face was attached to the base using velcro strips, and because of how big the wood was, that extra weight would cause the wood to start tipping over since the velcro was attached at the bottom of the face. We realized that we had to cut the wood smaller in order to make it easier to stay attached. We didn't have the right tools readily available, so we had to make use of the machine shop. Although it was already towards the end of the semester, it would've been easier to have used cardboard to save on time and trouble as well as lightening the load on the servo motor. Another advantage of cardboard is easier connection to other components, since holes can be easily made.

3. **Simple designs are better.**

The method of how the mouth was going to open and close went through an evolution of ideas. Originally, we began with the idea of cutting a dowel to size and attach servo blades at either end. The servos would raise and lower the dowel which would laterally connect to the lower jaw. The problem with this design is that there are too many steps and extra parts which increases risk for error and wastes too much time to do a simple task. Additionally, the one servo must be coded in reverse of the other to raise and lower the dowel. It was a waste of time trying to make this design; instead the design ended up including one attached smaller wood piece using industrial strength adhesive. The wood was drilled into, leaving a hold for a pipe cleaner to attach and connect to the servo motor which pushes and pulls the lower jaw out and in.

4. **Research and understanding is crucial early on.**

Doing extensive research early on and building a solid knowledge foundation makes progressing through the project so much easier. We definitely hit bumps on the road due to confusion with the sensors, motors, the code, and how all of that functioned together. Due to our lack of experience with servos and motors, we had to do extra research which took away

productive time that could've been utilized somewhere else. If we had a better understanding early on, probably before even brainstorming about the project, then we wouldn't have hit as many bumps or had as much trouble bringing all the components together to work correctly.

5. **Given time, this project can be very creative.**

While we are satisfied with the finished product and have come a long way from knowing nothing, there are so many ways where there are opportunities for improvement in terms of creativity. Things like including a voice module to say whatever you want it to, or improving the design to make the interaction more immersive can be extremely funny and interesting. Presenting in the BSE where all the animatronic faces were on display showed a collection of the numerous ways one could create two interaction modes when constructing the face.

Section 8: Personnel and bill of materials
(a) Personnel

Task	Main Personnel	Secondary personnel
Gathering Materials	Talha	Alex
Buying Supplies	Alex	Talha
Cutting Wood	Alex	Talha
Overall Programming	Talha	Alex
Wiring Setup	Talha	Alex
Chassis Design	Talha	Alex
Integrating Sensors	Talha	Alex

(b) Bill of materials

No.	Description	Website/comment	Qty.	Unit $	Total $
1	Arduino MEGA 2560	Provided	1	0	0
2	Glue Adhesive	For wood sections	1	3.09	3.09
3	Sandisk 16 GB Card	For voice recording storage, output	1	10.99	10.99
4	Capacitive Touch Sensor	For detecting touch	1	5.85	5.85
5	PIR Sensor	For detecting motion	1	5.99	5.99
6	Digital Vibration Sensor	For detecting vibration	1	3.99	3.99
7	MP3 Voice Module	For storing voice inputs	1	7.99	7.99
8	Micro Servo Motor Mini 10x Pcs	For moving joints based on inputs	10	16.99	16.99
	TOTAL				**54.89**

The total price for this project was **$54.89**.

References :

[1] https://www.instructables.com/id/Talking-Animatronic-Robot-Head/

[2] http://www.pyroelectro.com/tutorials/animatronic_mouths/

[3] http://www.pyroelectro.com/tutorials/animatronic_eyes/

[4] http://www.pyroelectro.com/tutorials/robotic_eyebrows/

[5] http://jamesmaynardtheatricaldesigns.blogspot.com/2014_12_01_archive.html

Appendix A: Code

```
#include <Servo.h>
#include <NewPing.h>

//Ultrasonic Pins

const int TriggerPin = 3;
const int EchoPin = 2;
int pos = 0;

//Define Servos

//50 = max Distance
NewPing sonar(TriggerPin, EchoPin, 50);
Servo servo1; // Mouth Servo
Servo servo2; //Eyebrow 1
Servo servo3; // Eyebrow 2

//Define Servo Input Signals

void setup() {
  Serial.begin(9600);
  servo1.attach(10);
  servo2.attach(11);
  servo3.attach(12);
  pinMode(TriggerPin, OUTPUT);
  pinMode(EchoPin, INPUT);
  }

void loop() {

  long duration, distance;
  digitalWrite(TriggerPin, LOW);
  delayMicroseconds(2);
  digitalWrite(TriggerPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(TriggerPin, LOW);
  duration = pulseIn(EchoPin, HIGH);
  distance = (duration/2) / 29.1;

  if (distance <=10 ) {
  {
          for (pos = 0; pos <= 130; pos += 3) { // goes from 0 degrees to 120 degrees
          // in steps of 3 degree
          servo1.write(pos);                  // tell servo to go to position in variable 'pos'
          delay(15);                  // waits 15ms for the servo to reach the position
```

```
        for (pos = 130; pos >= 0; pos -= 3) { // goes from 120 degrees to 0 degrees
        servo1.write(pos);              // tell servo to go to position in variable 'pos'
        delay(15);                  // waits 15ms for the servo to reach the position
        }
        }
 }
 }
  else
  {
        Serial.print(distance);
        Serial.println("Out of range");
        servo1.write(0);
        servo2.write(0);
        servo3.write(0);
 }
 delay(500);

 int analogValue = analogRead(A0); // read the analog input
 Serial.println(analogValue);            // print it
}
```

The touch sensor code does not work fully, the working touch sensor code is below

```
#include <Servo.h>    // include the servo library

Servo servo1;            // creates an instance of the servo object to control a servo
Servo servo2;


void setup() {
 Serial.begin(9600);             // initialize serial communications
 servo1.attach(3);  // attaches the servo on pin 2 to the servo object
 servo2.attach(4);
}

void loop()
{
 int analogValue = analogRead(A0); // read the analog input
 Serial.println(analogValue);            // print it

 // if your sensor's range is less than 0 to 1023, you'll need to
 // modify the map() function to use the values you discovered:
 int servoAngle = map(analogValue, 0, 1023, 0, 30);

 // move the servo using the angle from the sensor:
 servo1.write(servoAngle);
 servo2.write(servoAngle);
```

```
}
```