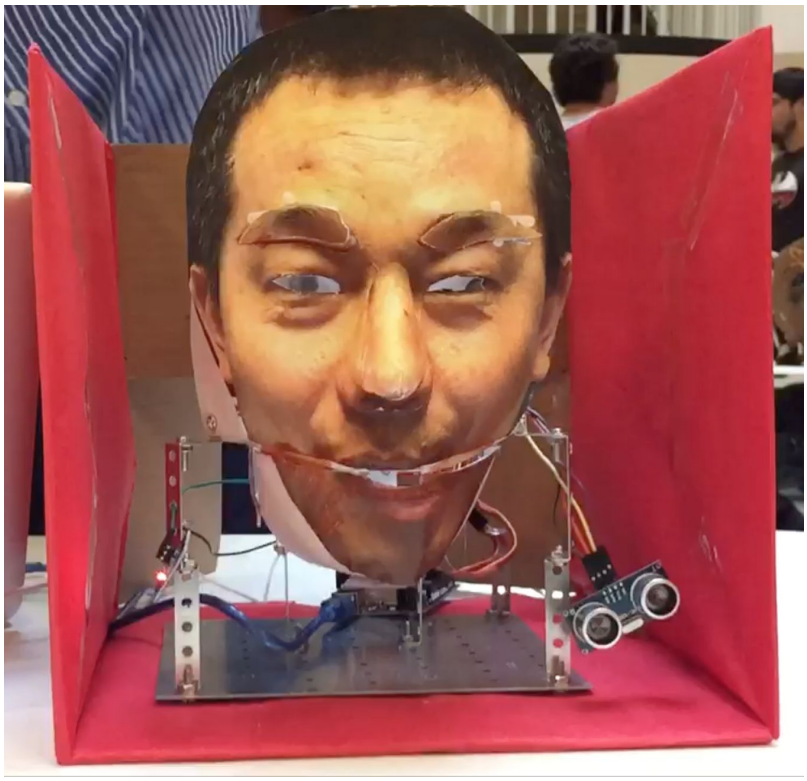
ANIMATRONICS FACE: PROFESSOR XIAOWEI ZENG, PH.D.



Raj Patel
Dept. of Mechanical Engineering
San Antonio, TX, USA 78249
hcf332@my.utsa.edu

Arbee Arceo
Dept. of Mechanical Engineering
San Antonio, TX, USA 78249
hob891@my.utsa.edu

Walter Slominski
Dept. of Mechanical Engineering
San Antonio, TX, USA 78249
atq183@my.utsa.edu

Submitted as part of project for ME4543 Mechatronics, Fall 2018

TABLE OF CONTENTS

ABSTRACT

The purpose of this report is to describe and explain the important aspects of the animatronics face structure of Dr. Xiaowei Zeng. It was inspired by the Fritz robotics project as mentioned in the literature review. The literature review describes previous animatronics projects that were completed to gauge the feasibility of what was required for the previous related work. The brainstorming involved the planning of what needs to be completed for the milestones which included factors such as how it was going to be built, ordering of materials & parts used, and how it was intended to function. The supporting structures for the project included using parts from multiple constructor kits and a plastic mask with precise cuts made to allow for the jaw movement & eyebrow placement. Servo motors were used for the movements of the jaw, eyebrows, and eyes while an ultrasonic motion sensor and a touch sensor were used as the initiators of the servo motor movements. Arduino MEGA was the main software/hardware that was utilized to control the motion of the servo motors. The programming for the project involved coding the movements of the servo motors with delays to move simultaneously with the recorded voice of Dr. Xiaowei Zeng. Lastly, the report includes what was learned from completing the project and what could have been done to improve the project as a whole.

Section 1: Literature review

Walter Slominski:

FRITZ - Animatronic Robotic Head by hackintoshlover12 (Instructables.com)

Figure 1: FRITZ

Fritz is a robotic head made that uses arduino system to control the facial expressions to mimic facial expressions of a human. These expressions include the movement of the mechanical eyes, eyelids, eyebrows, and the mouth. Fritz also rotates the neck as a human would. The instructions which are provided by the creator include 39 steps involving gathering the parts, building the face and electronic system with arduino, and the programming the movements to be controlled through a joystick. Most of the components of Fritz are made of plywood with the except of the eyes and eyelids being made of a plastic material. Some of the motors used in the arduino system are mini servo motor and a normal servo motor. Most of the components of Fritz were not mechanically fit together but rather they were glued together. [3]

Raj Patel:

"Robot Head 2- Instructables by knife141"

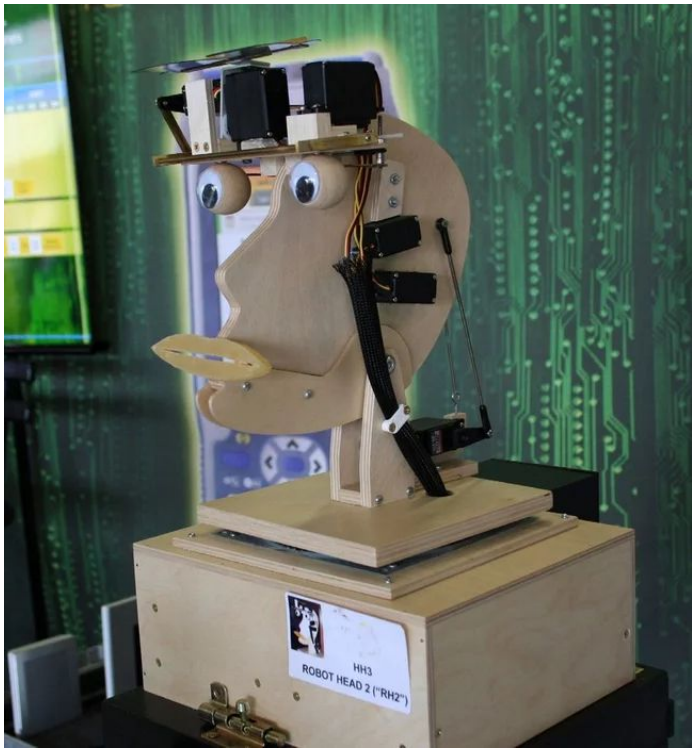


Figure 2: Robot Head

This specific projects consists of a robot head that swivels back and forth around the base, a mouth piece that opens to different angles to mimic speaking, a bar that that raises and drops above the eyes in order to represent blinking (as well as emotions), and up and down motion of the face itself to represent neck movement. It also consists of an audio box that the "lips" and eyebrows react to for the short comedy show that it puts on. The project is fairly complex as it requires a lot of assembling and programming. The main components of the Robot Head 2 are made plywood, eyes that are taken from dolls, latex for the lips, and hardware items to assemble it together. What robot is controlled by multiple servos (that are used model cars), a servo controller called MiniSSCII, a single-board computer called a RAPU (Remote Advanced Playback Unit) for the voice, and a lot of wiring. The heart of the project is the servo controller and the RAPU, the servo controller is what makes every component move while and the RAPU is what does the talking. The servo motors control the swivel of the head, the eyebrows, the neck movement, and the latex lips. The robot is powered externally as the head has a power cable attached to it. [2]

Arbee Arceo:

"Animatronic Head Capable of Human Motion using Face-Tracking Software"

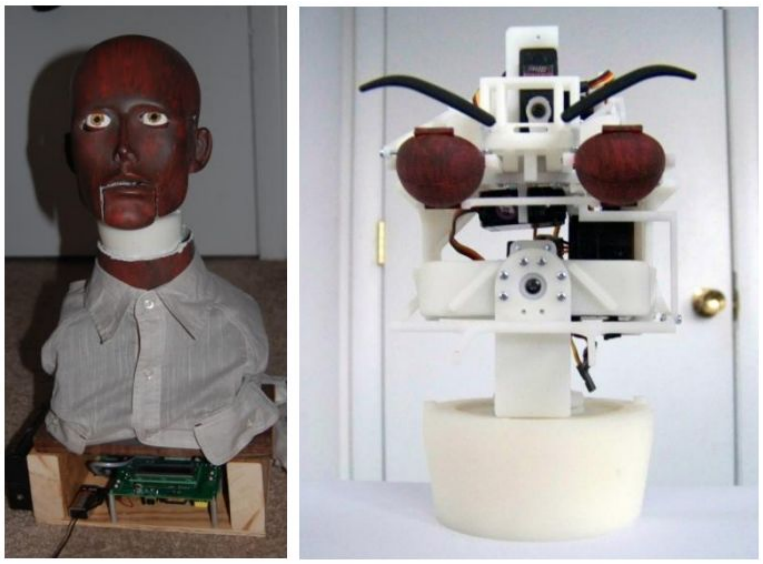


Figure 3: Animatronic Head

The purpose of creating this project was to construct a humanoid animatronic head that had sufficient degrees of freedom to mimic human facial expression as well as human head movement and could be animated using face-tracking software. There's eight degrees of freedom assigned to the robot's face and neck. For the design process, servo motors were used. Servo motors are rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. The mechanism movements for each part are listed as follows. The eye yaw and pitch are controlled by two actuators, for both eyes since they should be in unison. The eyelids are controlled by one actuator. The eyebrows were coupled together controlled by one actuator to perform rotationally and translationally. The mouth corresponds to one actuator which opens and closes it. Finally, the neck roll, pitch and yaw each correspond to an actuator in the neck. To mimic a human reaction, various face-tracking software such as FaceAPI and GazeTracker were utilized to analyze a prerecorded video of a human actor and map the actors neck, eyebrow, eye, and mouth motions. Additional feature that the robot must have is a human voice and this was created using a commercial software package called Visual Show Automation (VSA). The values gathered from the face-tracking software were converted into servo motor angles using MATLAB, that eventually fed into Visual Show Automation to generate a performance script that controls the audio and motion of the animatronic head. Other hardware that were utilized to successfully create an animatronic head are Mini SSCII motor controller and single board computer. [5]

Section 2: Brainstorming (initial planning)

For our project, we have been assigned Dr. Zeng for the animatronic face. The team, after considering the three projects that were researched for Section 1, we came to the conclusion of choosing to move his eyeballs, eyebrows, and mouth move. Our goal is also to add eyelid movements and neck movements. This project is heavily influenced by the FRITZ robotic head that was researched in the previous section.

- Eyebrows- They will be controlled by servo motors that raise and lower the eyebrows in order to show three emotions: surprised, angry, and content.

- Eyeballs- For the eyeballs, we are planning on cutting up ping pong balls in half and then drawing pupils onto them. Each of the ball halves, that will represent each eye, will be attached to servos in order to turn them to certain angles.

- Mouth- For the mouth, we are planning on using springs for the lips that are attached to servos on the corners. The servos will either rise or lower to show two emotions, a smile or a frown. The jaw part of the mouth will be a seperate part that will also be attached a servo motor that will make it swing to a certain angle and back to emulate the movement of a mouth. The bottom of the spring will be attached to the jaw piece so when he "speaks" it was replicate lip movement.

We are planning on putting a ultrasonic sensor so that if it senses a movement within about 6 inches from its face then it will start its reaction.

For the structure/chassis of the animatronic we are planning of making it mostly with wood, small slotted metal pieces, and using plastic face masks. To paste the face of the professor onto the robot, we may either print out copies of his picture and then cut it up to glue it onto the face masks, or we may try to paper mache it onto the mask. We may create some sort of box, such as the RomoBot, where the whole structure will be inside but what is only viewable to the audience is the face mask. The wiring, servos, and the powersource will be behind the mask/hidden in the compartment.

We will have a Arduino integrated MP3 shield that allows a microSD card to be attached with the MP4 voice recordings; which we will acquire from him with his consent. We will be programming the Arduino to sync a series of actions with the words that we have recorded.

The Arduino will be powered by an external battery pack, which will also power all of the servos. More battery packs may be attached to the wiring if the sole battery pack is not

enough or if it makes the animatronic face have a shorter lifespan. Everything will either move or be powered by the Arduino.

Section 3: Supporting Structure

For the structure we mostly created the framework from Constructor kits (that are similar to Erector sets) that we found at Five Below. The face substitute was made from a mask that can be found from any arts and crafts stores. The base was created from a metal plate that was found at a local Home Depot. Everything was put together using screw and nuts and a little bit of tape (which will be substituted in with better attachments later on).

The purpose of the frame was that the group can easily install the servo motors and the wires when the time is appropriate. There is room left in the structure behind the mouth for the servo motors to be installed so that when the motors turn, it will mimic the movement of a mouth. Refer to Figure 4 and Figure 5 which shows how the mouth will look open and closed . The team also built a support by the eyes where the eyes are planned on being installed, right below where the eyebrows will be. Overall, the structure may be changed in order to better fit the servos or wiring or if stability of the face needs to be increased.

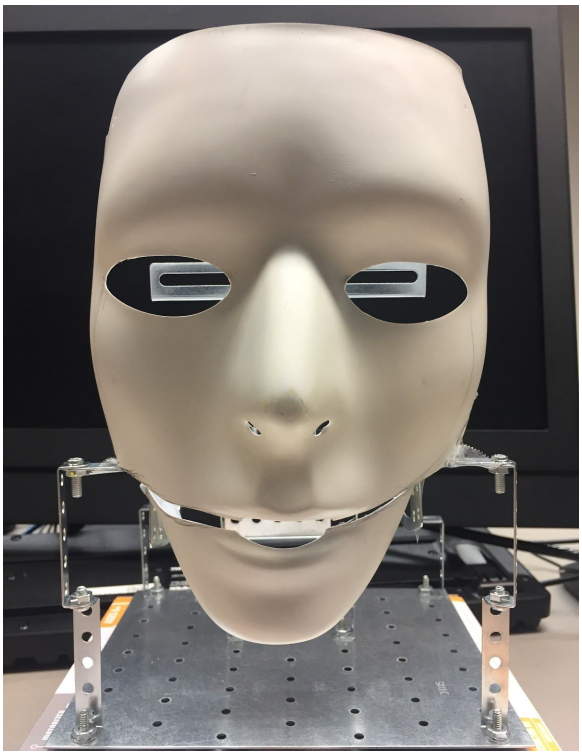


Figure 4: Jaw Closed

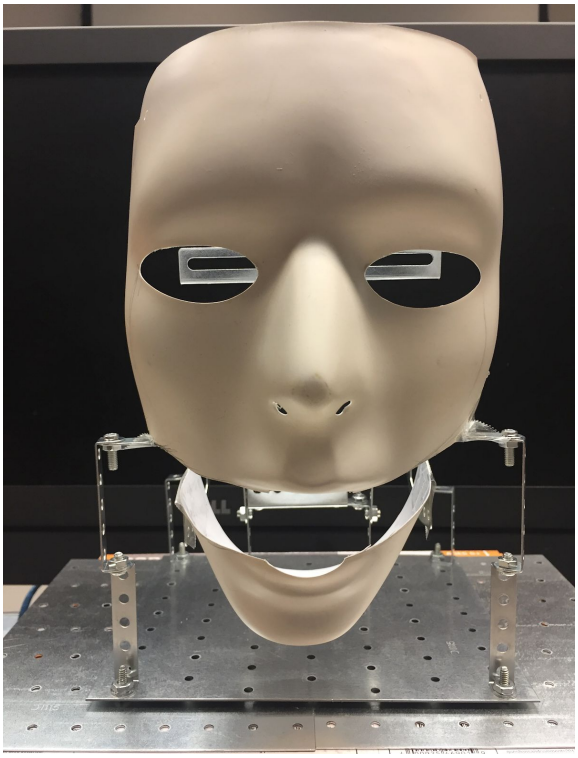


Figure 5: Jaw Opened

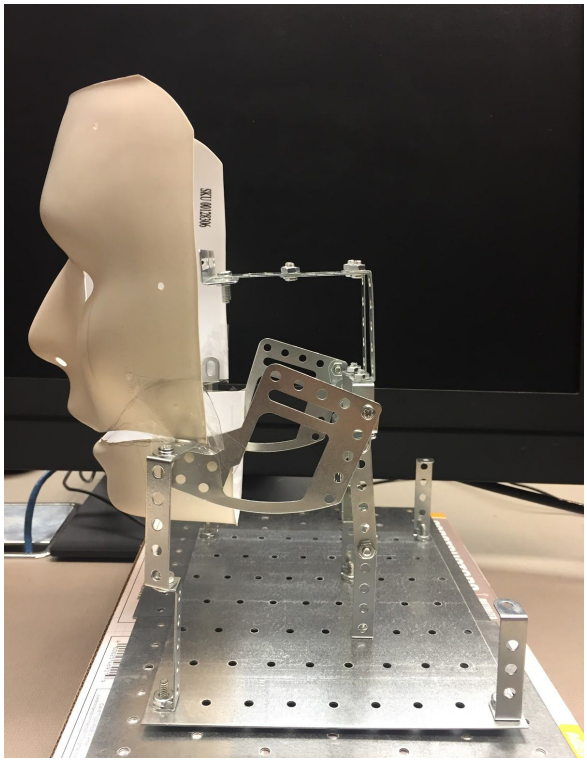


Figure 6: Side View (Right)

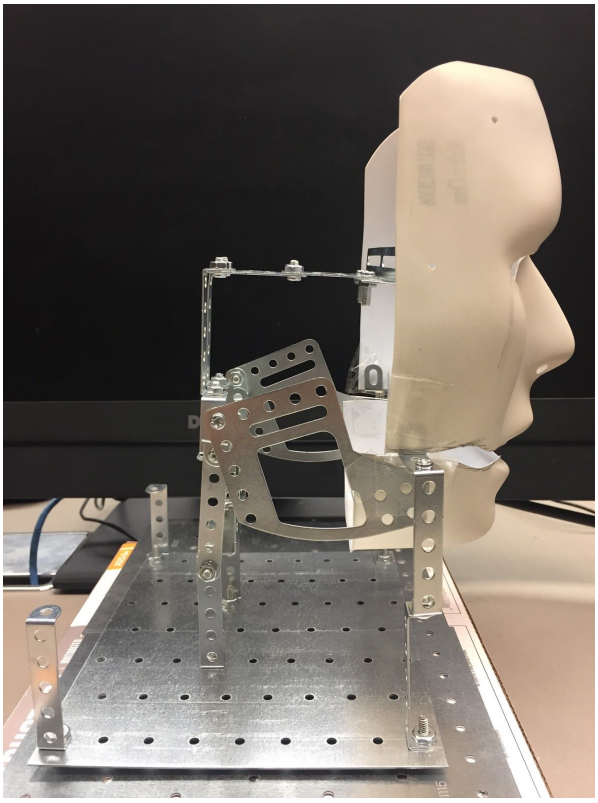


Figure 7: Side View (Left)

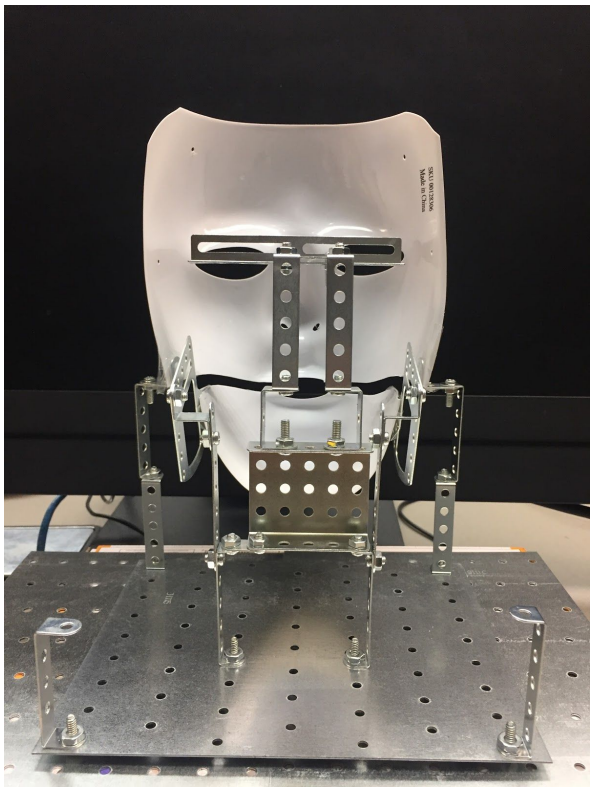


Figure 8: Back View

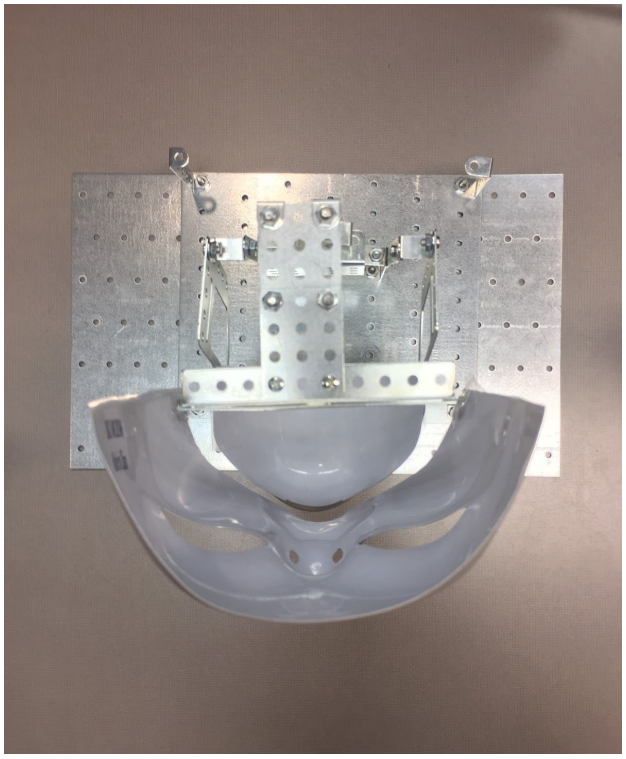


Figure 9: Top View

Section 4: Joints and Motors

For this face, we utilized a total of 5 servo motors in order to mimic mouth movement, eyeball movement, and eyebrow movement. The connections were made on a breadboard to the Arduino Mega. The servo motors begin to move once the sensors have been triggered. Upon the trigger, the servo motor placed by the mouth moves to a 45 degrees and back to reset in order to show mouth movement (Fig. 10). This setup will be used for the jaw structure to create an up and down movement. Another set of motors will be placed right above the eye socket holes in order to mimic eyebrows. Those servos will change about 30 degrees to the left and 30 degrees to the right in order to show an “angry” face and a “surprised” face (Fig. 12). Two servos will be placed on the backside of the eye sockets and attached to halves of ping pong balls in order to represent the eyeball movement (Fig. 11).

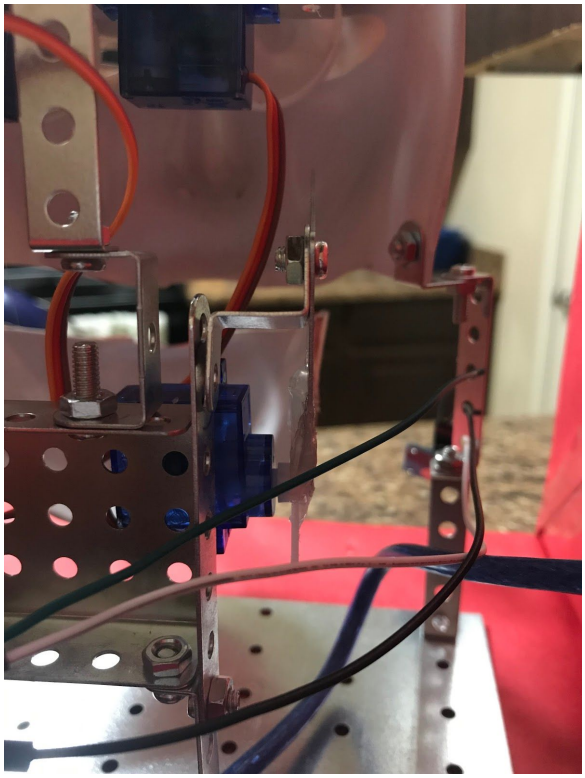


Figure 10: Mouth Joint Servo

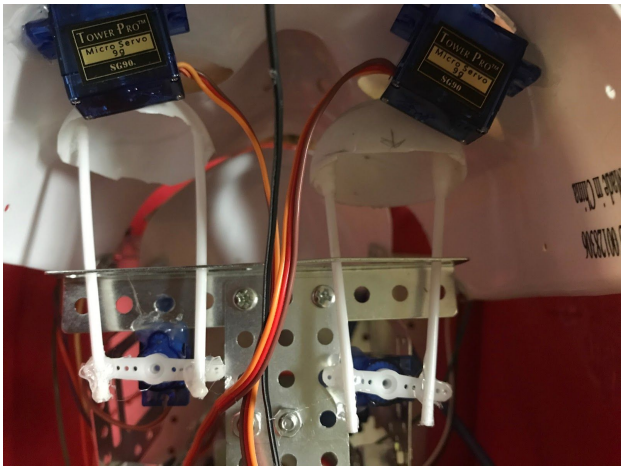


Figure 11: Eyeballs Servos

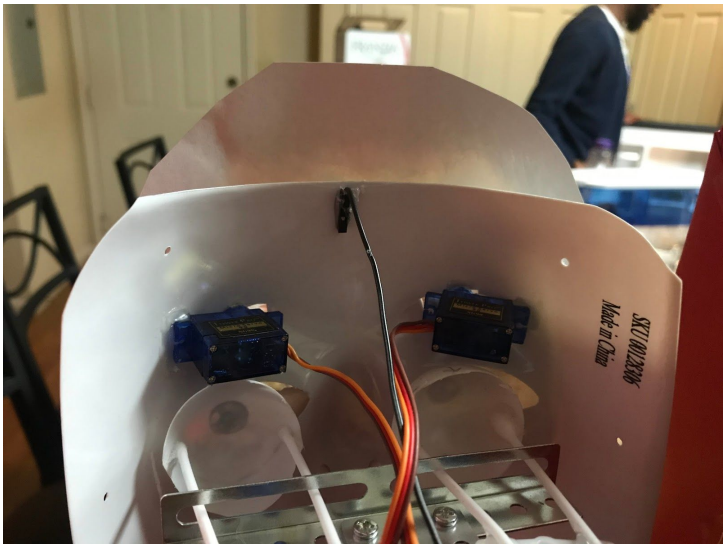


Figure 11: Eyebrow Servos

Section 5: Sensors

The two sensors that were used for the animatronic face were the ultrasonic sensor and the touch sensor. The reason we chose the ultrasonic sensor because we wanted the face to react to something whenever it was close enough. Whether that was somebody waving their hand in front of the face or a person passing by.

For the final product, the sensor was made so that you would put your hand out in front of the sensor close enough (about 20mm) to it in order to start off the act that the robot was programmed to do.

The reason we chose to do a touch sensor is because we took inspiration from the famous toy “Tickle-Me-Elmo” from the Sesame Street. When the touch sensor is touched or rubbed, the mouth section will move open and close in a laughing sort of manner.

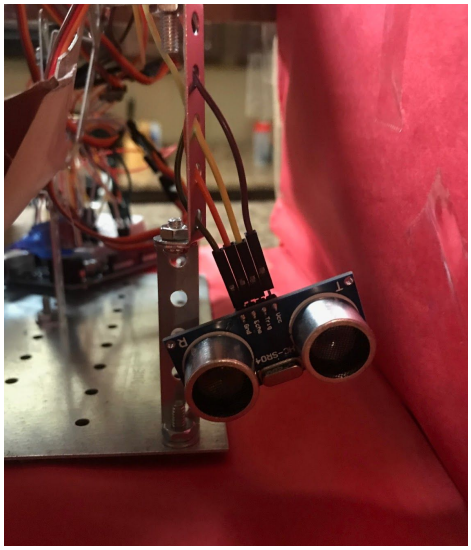


Figure 12: Ultrasonic Sensor

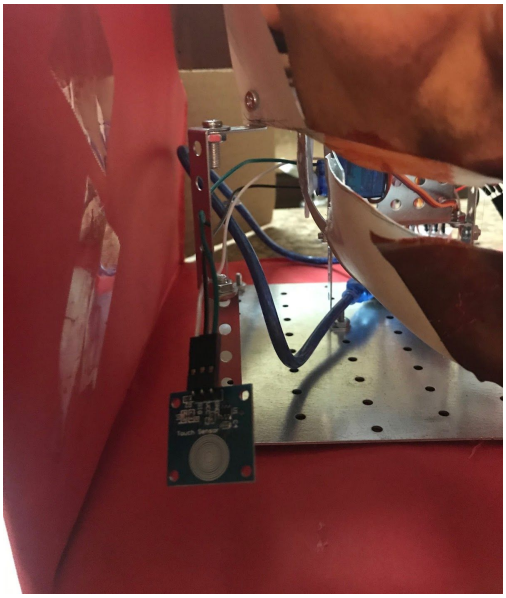


Figure 13: Touch Sensor

Section 6: Programming for Interaction

For the code, we made it so that once the ultrasonic sensor was activated, it initiated the rest of the movement. The first thing that it did was reset all the servo motors to their starting position. Then the "mouth" would open and close about 12 times at a rate of 150 milliseconds each in order to mimic the professor saying "Hello kids, would you like to see what I can do?"

Next, after a small delay, the mouth would open and close 4 times at the same rate in order to mimic him saying "look to the left." After a small delay, the servo motors for the left and the right eyeballs would shift about 30 from 0 degrees so the pupils looked to the left.

Further up, after a small delay, the mouth would open and close 4 times at the same rate in order to mimic him saying "look to the right." After a small delay, the servo motors for the left and the right eyeballs would shift about -30 from 0 degrees so the pupils looked to the right

Moreover, after a small delay, the mouth would open and close 4 times at the same rate in order to mimic him saying "be surprised." After a small delay, the servo motors for the left and the right eyebrows would shift about 30 degrees from 0 so the eyebrows point upwards.

Lastly, after a small delay, the mouth would open and close 4 times at the same rate in order to mimic him saying "be mad." After a small delay, the servo motors for the left and the right eyebrows would shift about -30 degrees from 0 so the eyebrows point downwards.

For the touch sensor, it was fairly simple. If the sensor was touched or rubbed, the mouth would open and close about 6 times in order to represent the professor going "hahahahaha."

Section 7: Lessons learnt and suggestions (1 page)

Raj

1. Wiring- For this project, in the beginning there was a good amount of time that the team had thought that the code created for the animatronic face was faulty even though Arduino compiled and verified it when running it. It was only until a day or two of messing with the program that the team decided to take apart the wiring only to find that there were some faulty wires involved that stopped the code from processing to the servo motors.
2. Coding- Being the primary coding person, there was a lot that I learned as to what commands did what; such as how if-else statements affect the ability of when the code is triggered. Not only that, new codes had to be learned in order to apply the sensors that we typically didn't use. An example being the touch sensor. The coding also had to deal a lot with timing in order to perfectly match the mouth movement with the audio recording.
3. Sound- The one thing that the group had trouble with was integrating the sound in combination with the rest of the code. The MP3 shield that was planned on being used didn't exactly have a simple code for integration. If we knew it would've gave us so much trouble, we would've started to work on that earlier rather than waiting for our professor to be free to finally get a voice recording. So instead, the team just started the audio on the laptop at the same time the sensors were triggered in order to create an illusion of integration.

Walter

1. Planning Ahead - For this project, we learned the importance of completing tasks early to stay on schedule with what was required with the project. This included making sure that the milestones were completed on time and also ordering the needed parts to complete the milestones that required for the structural setup for the project and the servo motors that were used for the movements of the jaw, eyebrows, and eyes.
2. Plan for structural design - Things we could have improved on was the plan for the structural design of the project. More research would have helped with making it easier on the design for the structure. The parts and tools that were used for the project were sufficient enough but it is possible that better parts could've been used for the design.
3. Knowledge on coding - my own knowledge on coding could be better than what it is now. Having better skills and more knowledge on coding and arduino could have significantly made it easier for the group to complete the project ahead of time instead of completing things at the last minute.

Arbee

1. Chassis Structure - Upon completing the base structure for the mask, the metal parts assembly using screws and nuts were not stable. There were instances during the jaw movement that the base holding it would move out of its position causing misalignment with the upper face structure. To resolve this issue, unstable areas were glued down to

prevent the structure from moving out of position. This will ensure that the body parts that are in motion will stay where they are without conflicting other moving parts.

2. Face Aesthetics - The animatronic face was built using an acrylic face mask. An issue the group encountered was how to properly apply the 2D printed face of the professor on to the 3D mask and maintain how his face looks. It was challenging because the face mask doesn't accurately match the face shape of Dr. Zeng. Although not completely perfect, the group was able to apply his face on to the mask by cutting two sections (top face and mouth). The nose which was one of the hardest parts to apply was resolved by using a paper mache technique to completely cover the nose. Since the cut out wasn't perfect, acrylic paint was utilized to cover up the white area that the face cut out didn't cover. It would have been easier if the group chose a flat surface to apply the face on, but I personally think that we were able to find a solution and did the best we can to execute a great structure.
3. Presentation - During the demo day presentation, there were some issues that affected on how guests were able to watch our project in motion. Since the table was low, guests had to squat a little to see the movement of the eyeballs moving left and right. It would have be more convenient for the viewers if the project was placed on top of a base/box or if the face is oriented up.

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

Task	Main Personnel	Secondary personnel
Coding/Arduino	Raj	Arbee
Structural	Walter	Raj
Materials & Supplies	Arbee	Walter

(b) Bill of materials

No.	Description	Website/comment	Qty.	Unit $	Total $
1	Arduino MEGA 2560	Provided	1		
8	Servo Motor Mini	10x Pcs SG90 Micro Servo (Amazon)	1	16.99	16.99
3	Constructor Kits	found at five below	3	5.00	15.00
4	Switchplate Screw	6/32 x 0.5” (home depot)	20	3.92	3.92
5	Tie Plate	4” x 7” Tie plates (home depot)	1	2.74	2.74
6	Mach Screw Nut	#6-32 (home depot)	20	1.18	1.18
7	Straight Snip	Metal cutter (home depot)	1	9.97	9.97

The total price for this project excluding the Arduino MEGA was **$50** ($49.80).

References:

[1] Animatronics Face of UTSA's President, Dr. Ricardo Romo, https://youtu.be/xkze1_hnam0

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

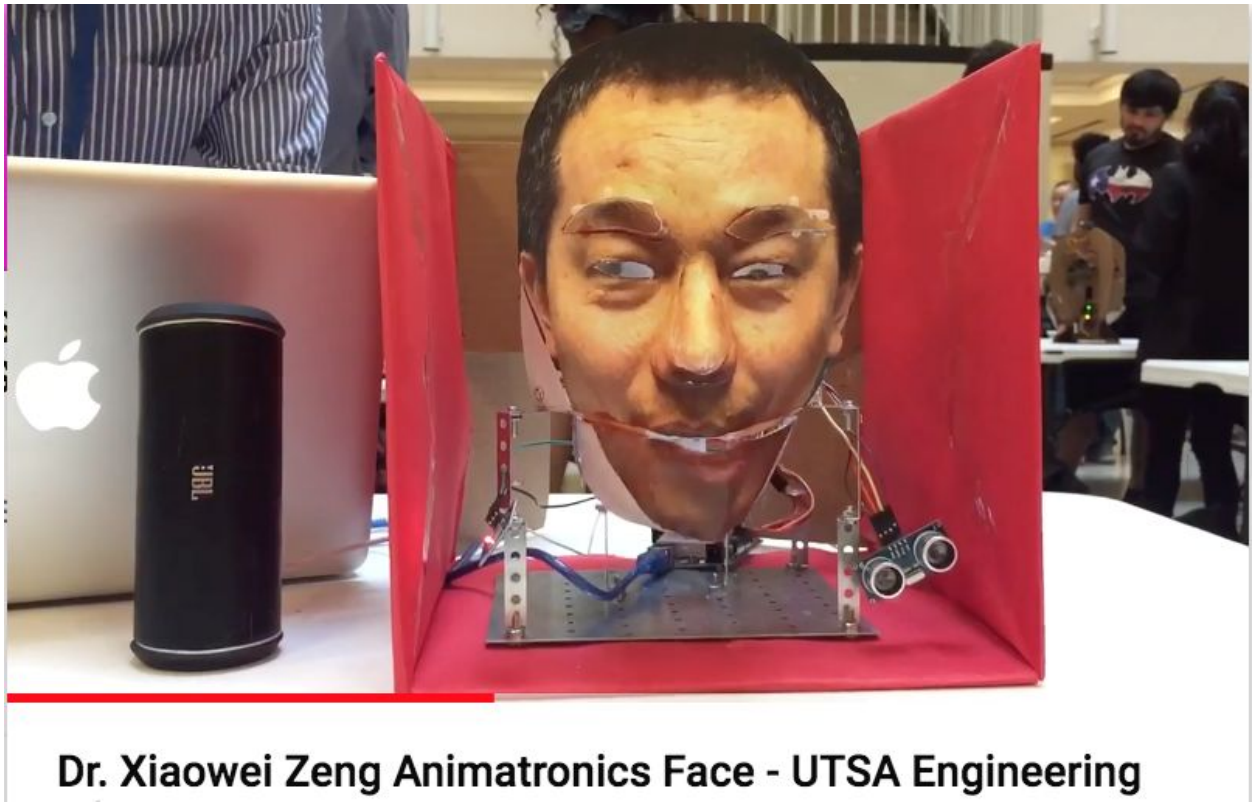
[3] Talking Animatronic Robot Head,
https://www.instructables.com/id/Talking-Animatronic-Robot-Head/

[4] FRITZ- Animatronic Robotic Heat
https://www.instructables.com/id/FRITZ-ANIMATRONIC-ROBOTIC-HEAD/

[5] "Animatronic Head Capable of Human Motion using Face-Tracking Software"
https://web.wpi.edu/Pubs/ETD/Available/etd-050112-072212/unrestricted/Fitzpatrick.pdf

[6] Animatronic Face of Professor Xiaowei Zeng, https://youtu.be/UytGr_9A1kM

Appendix A:



YouTube Video of Dr. Xiaowei Zeng Animatronics Face (https://youtu.be/UytGr_9A1kM)