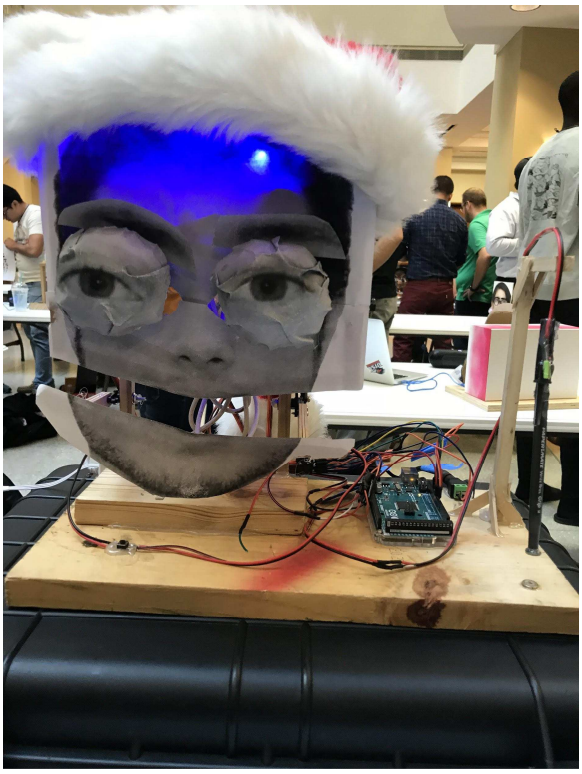
ANIMATRONICS FACE: DR FRANCISCO HERBERT

Link: https://youtu.be/W-wmTqZ3ZHU



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ABSTRACT

The goal of this project was to learn to interface mechanical systems with electronic controllers and components. The students looked into similar projects to get a basic understanding of how to tackle the project, then made this specific project to the constraints given. While it may seem simple and straightforward to build a mechatronic face, there are very fine details that need to be addressed and solved. This project illustrated things like the range of movement from a circular servo to a linear motion of the mouth. Interfacing the servos with the arduino controller was another large issue that had small details that could not be overlooked. Mounting the servos and sensors in a manner that allowed them to function properly as well as be positively aesthetic to the overall build was crucial to the final outcome of the project.

Section 1: Literature review

Robot Head 2 is an animatronic head made by knife141 on Autodesk [1]. This used wood as a base structure, servos to animate pieces and various household pieces to create this project. The controller for the system is a RAPU that takes serial signals and turns them into servo controls, it uses a CF card to store the function file. It uses Microsoft text to speech system to reinforce the robotic aspect of the project. The setup was mounted and staged in a trunk for travel and display very easily.

Figure 1. Robot Head 2

The image shows that the eyes are mounted directly to the wooden eyeballs, this gives them a left right movement but locks them in the vertical axis. Pushrods and rod ends are used to actuate the entire head movement upwards and downwards and two servos actuate the mouth. This face was created to take to trade shows and to bring along to elementary schools to preview what a project in the STEM field can do.

This next animatronic head uses a face tracking software to add a more real-life aspect to the project. The goal of the project was to have the head incorporate many degrees of freedom in movement. Robert Fitzpatrick wanted to have the same range and speed of movement of a human head [1]. The movements trying to be achieved were eye pitch and yaw, eyelid open and closing, eyebrow movement, mouth movement, neck roll pitch and yaw.

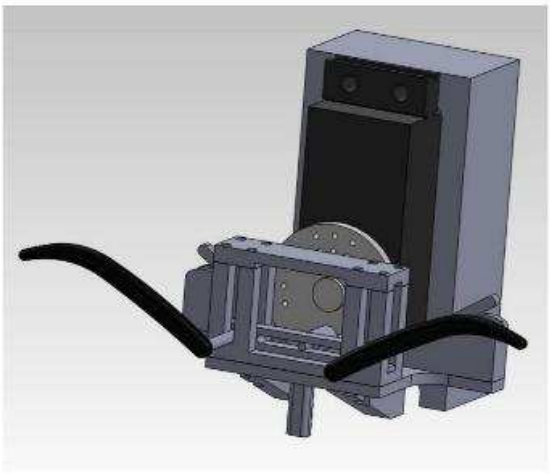


Figure 2. Robert Fitzpatrick's Creation

The CAD model of the eyebrow system shows a unique way to move the eyebrows. They rotate about the outer most point of the eyebrow which is fixed to a pivot, the insides of the eyebrows actuate together to give a symmetric motional movement of the brows for the robotic face. This method is feasible if users have access to a 3D printer, however, custom building a structure like this would be very difficult and likely fall out of tolerance and have a very slim chance of working effectively. The modeling in this instance had very complex designs to keep the system compact and make it look as realistic as possible. This system also used a RAPU to control the servos, in total 8 servos were used to control this face. The goal of the project was to make the face track movement to follow and respond. The animatronic face project that was assigned for ME4543 does not need to be this complex, however the mechanism movements are important and helpful to study.

MiRAE is an animatronic robot project aimed to be a minimalist design that can recreate human like facial expressions. The primary objective of the project was to answer basic science questions about the best way to design a robotic human face and recreate human like facial expressions. Casey Bennett used an Arduino Uno, prototyping shield, 10 micro servos and a few brackets [3]. To construct the internal support structure, a metal prototyping kit was used because of its diverse arranging ability. joints and pivots were added in to make the movement possible. many different servo horns were attached to achieve different goals from linear movement of the mouth, eyes and brows. The Arduino prototyping board was used to connect and hold all the pins in place to attach directly as a shield do the Arduino.

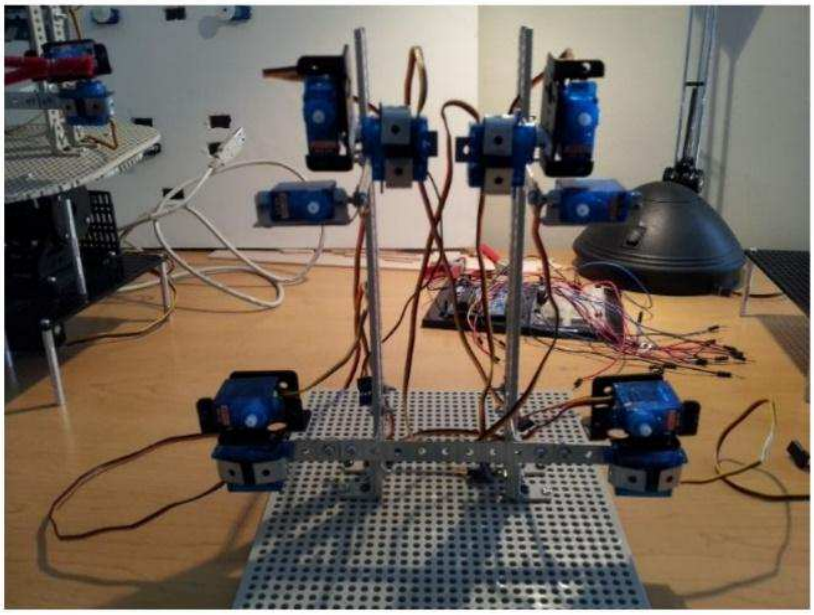


Figure 3. Casey Bennett's MiRAE

The MiRAE project used a mounting plate that has many holes for a multitude of setup designs. This project used numerous 9g mini servos to actuate the different facial features. For this project, full sized high torque metal gear RC airplane and car servos were used. The extra available torque will help to overcome any production imperfections that would otherwise bind or be too great for micro servos. Aluminum prototyping bracketry was used to hold together and stand up the structure of the face. A similar style of building will be used for the animatronic face of Dr Herbert.

Section 2: Brainstorming (initial planning)

The animatronics face will have yaw and pitch in the eyes, a moving mouth with a tongue that also moves while talking. We plan on having a touch sensor on a "hand" that when you shake it, will activate one interaction mode. A capacitive touch sensor will be used and programmed that once it is disturbed, will activate the interaction mode, this will most likely be an introduction of the professor. The second activation mode is pull my finger to tell a joke. We will make a hand that will be on a spring switch that once moved, will tell a joke from the professor. Universal joints have been purchased for the eyes, one side will be rigid mounted to the inner frame of the robot. The use of the universal joint will allow movement in any direction for the eyes depending on which actuator is moved a certain amount.

The jaw and mouth will be vertically moved using an electromagnetic servo so that quick actuation can be achieved to mimic quick movement of the jaw like a laugh. The actuator has a 5 volt signal power which will be pulsed to get the jaw to move.
The servo actuators used will be connected via RC car rod ends that will allow for 135 degrees of pivot movement.

An erector or K'NEX set will be used for the structure. Super glue and hot glue will be used to fasten plastic pieces if needed. All connections will be fastened mechanically if possible using the erector set, screws and Loctite if possible. A circular form will be aimed at achieving so that the humanoid robot looks as realistic as possible.

An Arduino mega will be used for the controller as it has many input ports.

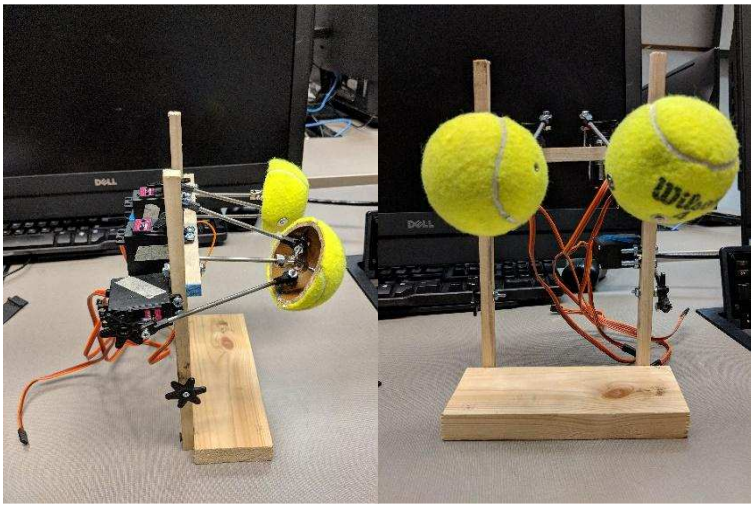
An adafruit wave shield was purchased which goes on top of the Arduino and covers half of the mega inputs which is why a mega need to be used. The adafruit shield has a 3.5mm audio output jack and a potentiometer to control the sound output. It will be hooked up to a speaker put on the desk. The soundtrack will be recorded using a digital microphone, in an improvised acoustic sound booth. An introduction of the professor will be recorded as well as a joke and laugh will be recorded for the audio playback.

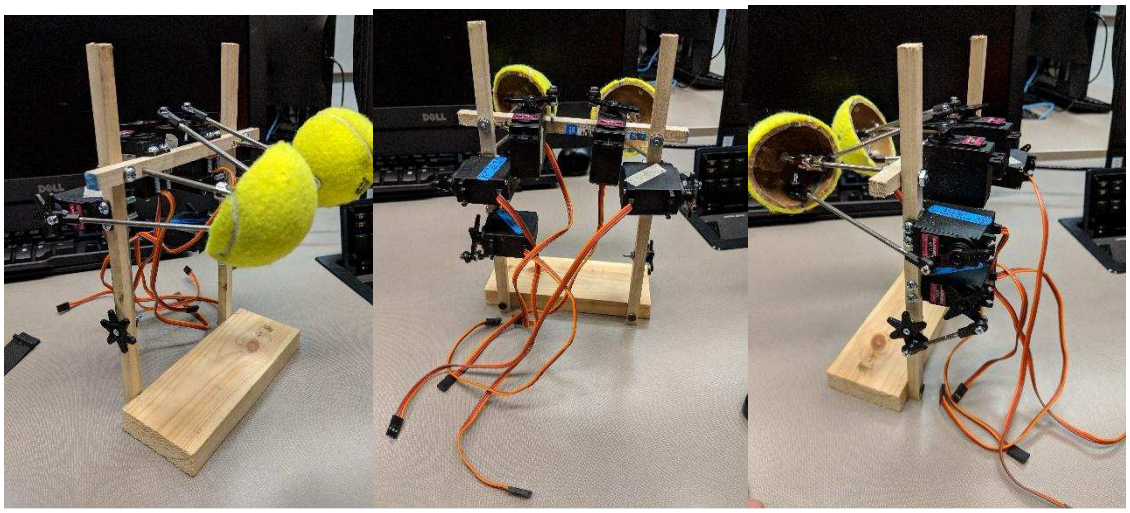
This structure will be a stand-alone bust that can be covered to look as human as possible a 5 volt 10 amp power supply will be plugged into the Arduino mega to ensure that there is no shortage of current in the system to ensure optimal performance of all parts.

The head will be oversized about 25-50% bigger than a regular human head. This will give more of a comedic appearance and atmosphere. The other benefit is that it will allow for more room to mount things and give open motion. The face will be made of a plastic mask for the general human shape, then a paper printout of the professor will be printed. The paper will be resin infused style onto the mask so that the paper can give the coloring and detail, but also contour to the cheeks, forehead and chin. This would allow the mask to look realistic and give realistic contouring of the face.

Section 3: Supporting structure

The face was constructed out of 3/8” x 36” long square dowel rod. The main screws were held to the base 1”x4” using 1-3/8” drywall screws. A basic H frame was constructed to mount all the servos to. This project was created using the most simplistic method possible. An interior structure system was used so that the skin could be put on top over it like a helmet and removed for easy adjustment. The simple frame, allows for easy prototyping and open spacing to get hands and tools in to work on it. The finalized frame will have wood glue to make sure all pieces are permanently in place. #6 1” screws hold the cross members of the frame together using washers and Loctite to make sure they don’t back out.





Figures 4-7. Various Views of the Structure

Section 4: Joints and motors

The eye joints of the system consist of RC hobby universal joints. This allows the movement in both directions up to 180 degrees each way. The linkages from the servo horn use traxxas rod end ball joints. This is used so that perfect inline mounting can be skipped. If there is a slight misalignment than the rod ends will still work and allow rotation and movement. Using a bolt and it direct connection only allows 2 degrees of freedom whereas the rod ends allow 3 degrees of freedom.

The jaw joint is just a rotational servo horn connected to the chassis that pivots via a push rod and rod end. This allows the circular motion of the servo to be converted to a linear push then back to a circular motion at the jaw joint. The motors chosen were servos because we needed to control movement.

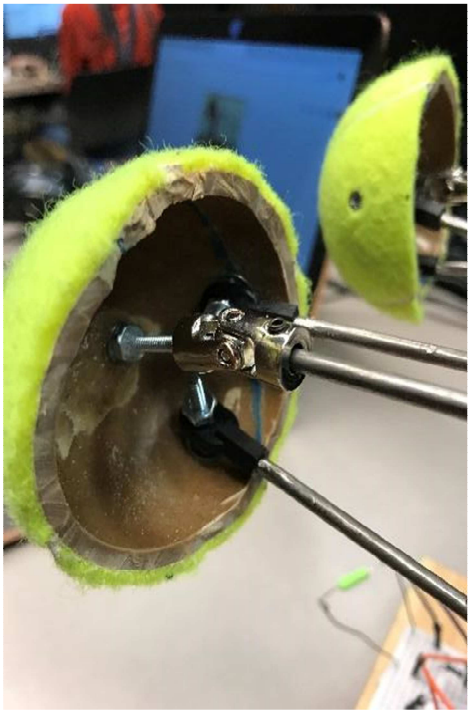


Figure 8. Eye Joint

Figure 9. Mouth Joint

Section 5: Sensors

The 2 sensors we incorporated are a push button sensor and a tilt sensor. The push button sensor uses a circuit that, when a button is pushed, will play an animation of the eyes moving, then returning to the starting position. The tilt sensor is type of motion sensor that reacts to when a the sensor rotates fully an a small metal ball completes the circuit. When this is activated a jaw will move up and down and return to its starting position. A tilt switch was used because we incorporated a pen that when activated will move the jaw. A push button was used to facilitate the interaction between the sensor and eye movement.

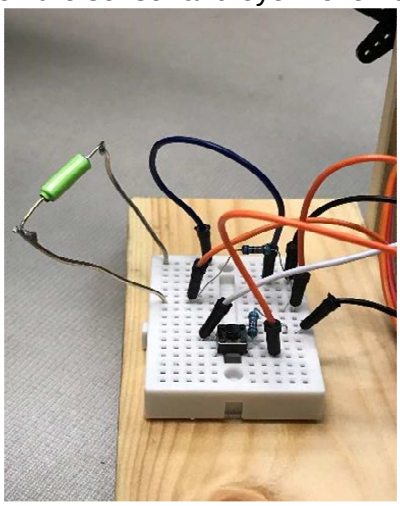


Figure 10. Tilt Switch and Push Button

Section 6: Programming for interaction

The theory behind the programming of this project was relatively simple. The theory was if a sensor is activated, however that may be, then the face should respond with a specific action. In our case, these sensors are a push button and a tilt switch. As far as the code, this means that when the push button is returning a signal of “high” then it should perform an action. We programmed this statement using an if/else loop. If the push button equals high, then perform action 1. Action 1 is the movement of the eyes, the code counts from 0 to 75 in steps of 1 degree, until it hits 75 degrees and then reverses the direction back down to 0, this moves the eyes in a certain direction and then returns them to the starting location. As for the mouth, this was done using a tilt switch, this is the same exact principal except you have to tilt the sensor to get a signal return of “high”. The code is the exact same, except there is only 1 servo controlling the mouth, so it only moves up and down.

Link: https://youtu.be/W-wmTqZ3ZHU

Section 7: Lessons learnt and suggestions

1) Removing any interference in the power supply. The 5 volt 10 amp power supply originally used was plugged into a multi-plug during construction that also had a hot glue gun, solder iron, computer and the power supply for the arduino. This caused interference and noise to be generated in the electrical components which caused the arduino to not react to the interface inputs.
    a) After isolating the power supply for the arduino and motor from everything else, the arduino worked.
2) Power supply rating issues. The arduino did not like a 10 amp power supply even though it never drew that kind of current. It just never worked.
    a) Use a 1 amp 5 volt power supply for the arduino and not a large 10 amp power supply
3) Check the USB cable. There were communication issues with the arduino and the serial read monitor. It was very laggy and latent, changing all the hardware out and re-wiring didn’t work.
    a) Changing the USB cable cleared up communication issues with the arduino which fixed the response of the arduino.
4) The breadboard sometimes did not make solid connections with the jumper pins that made it difficult to track where the problems came from.
    a) Once the system was proven to work by holding all the wires to make positive connection between jumpers, the wires were soldered together to eliminate the variable of loose connections.
5) The tactile momentary push button has a specific orientation that we were not aware of. The coding was done properly and theoretically should have worked, but for a while was not. Rotating the orientation of the push button 180 degrees instantly fixed the problem.
    a) Rotate the push button 180 degrees from original position
6) Keep the project simple. We were going to make a papier-mâché head, but it proved to be too difficult to get contours and coloring right. Aim to make a simple structure and don't be too difficult.
7) The use of rod ends from RC truck steering made the movement from servos to the various parts very simple. Go to Home Depot and get 36” ⅛” diameter steel rod for the linkage and just put the rod end on the wire. I would highly recommend anyone else to use them for future projects.

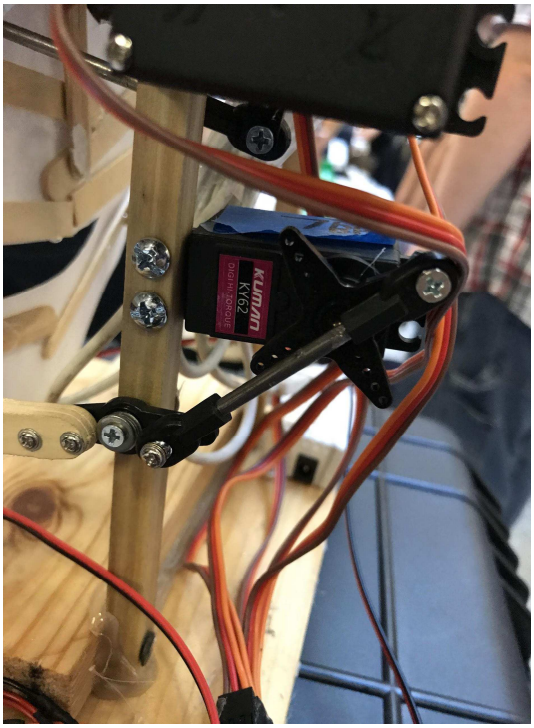


Figure 11. Push Rod with rod ends

8) Make a power adapter to power all the servos with 5 volts. We made an adapter to separately power all 5 servos.
9) Make a bus of all the servo plugs to keep things organized and neat.

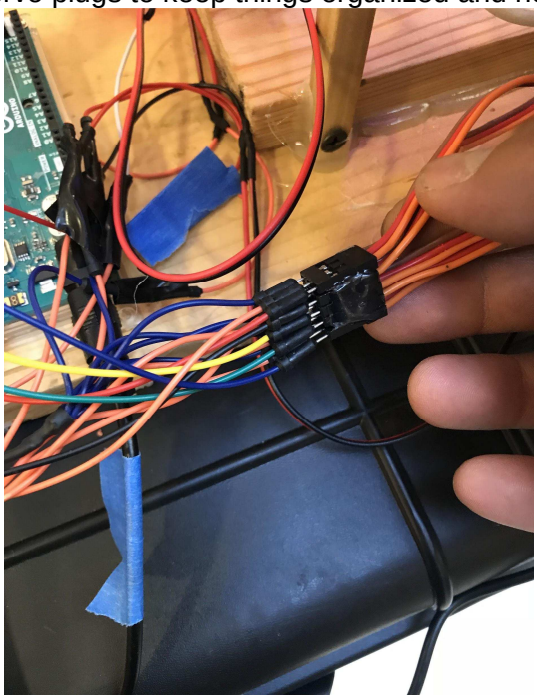


Figure 12. Hub of servo power and control pins

Section 8: Personnel and bill of materials

(a) Personnel

Task	Main Personnel	Secondary personnel
Structure/chassis design	Daniel Tran	David Bolerjack
Programming and integration	David Bolerjack	Daniel Tran
Aesthetics and Face	Karen Aradillaz	David Bolerjack
Integrating sensors	Daniel Tran	David Bolerjack
Joint/Motor interfacing	Daniel Tran	David Bolerjack
Wiring	Daniel Tran	Karen Aradillaz
Decoration	Karen Aradillaz	Daniel Tran
Report	Daniel Tran	David Bolerjack Karen Aradillaz

(b) Bill of materials

No.	Description	Website/comment	Qty.	Unit $	Total $
1	Arduino MEGA 2560	Amazon	1	$33.00	$33.00
2	Traxxas 1942 Rod end set	Amazon	1	$9.00	$9.00
3	Adafruit Wave Shield	Amazon – adds 3.5mm audio to Arduino	1	$22.96	$22.96
4	Universal Joint RC Car	Amazon	1	$7.99	$7.99
5	Servomotor Kuman 10 pack	Amazon – high torque metal gear KY62	1	$42.99	$42.99
6	195pc breadboard jumpers	Amazon	1	$7.39	$7.39
7	5V micro solenoid	Amazon – 5mm 40g pull	1	$7.99	$7.99
8	⅜” Square Dowel	Home Depot	2	$2.49	$4.98
Total			9	$133.81	$136.30

The total price for the project was $136.30

Acknowledgements
We would like to thank Dr. Francisco Herbert for letting us use his voice and image to complete the project.

References:

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