ANIMATRONICS FACE: DR. KRYSTEL CASTILLO

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ABSTRACT

We created an animatronic face of Dr. Krystel Castillo from the UTSA department of mechanical engineering. Every week a milestone was to be met (e.g. research in week 1, brainstorming in week 2, creating the chassis in week 3, and so on) which led to the final presentation of the project. A wooden base, as in the platform the project stands on as well as the structures designed to hold the facial features was used. This provided us with a sturdy support and allowed for larger and heavier components to be used if needed. All other parts of the design were made from simple items people may have laying around the house (ping pong balls, a plastic mask, etc.) and motors were purchased to provide movement of the mouth and eyes. We recorded a simple audio track of "Hello, I am Dr. Krystel Castillo. Go Roadrunners!" spoken by the professor and wired both an infrared and ultrasonic sensor to an Arduino board so that the audio will be played when an object triggers the sensors. Arduino coding was used to write a program sothe animatronic face's parts would cooperate with each other. For a power source that would allow everything to run smoothly, we opted to use external and very portable batteries which will let the face go places and function even without a computer present. A printout of the professors face was placed onto a mask and the chin/lower lip area was cut out so that in could move freely, giving the illusion of speech when the audio track is playing. The end result is of this project is basically a human-like robot that will talk to you when in its presence.

Section 1: Literature review

As a rudimentary introduction into the development and creation of animatronic heads, the website allscare.com as shown in reference [1], offers some baseline products that perform small actions in order to mimic a real face. Their product, which is a plastic shell in the shape of a head fixed over a base assembly, serves more as a novelty than a project. There is a small frame built onto the base assembly that connects to the mouth of the animatronic face and allows for the illusion of speech. This uses a single motor to control the upward and downward motion of the bottom jaw. Additionally, the site offers a mounting for the base assembly that would allow the head to rotate, although that is more a matter of external aesthetics than internal operations. Lastly, they offer a set of LED eyes that blink in accordance with a program. Overall, the build doesn't incorporate sensors for anything.

Figure 1A: Allscare Face

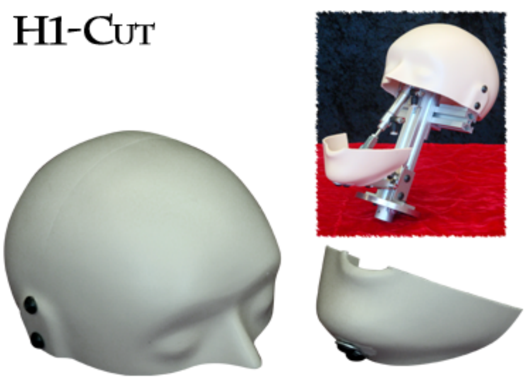

Figure 1B: Open Allscare Face

Another approach to the development of the animatronic head was done by the author of the instructables page, Knife141 [2]. This approach is vastly different than the previous one. This build incorporated plywood as the main staple of the framework, including the head. As opposed to the 3 dimensional appearance, this creation is more of a silhouette of a head when seen from the side, with the facial features extruding from the edges when seen from the front; the eyes and mouth to be exact. There is a servo that controls the eyes, and another that controls the lower mandible to mimic speech. The animatronic face reacts to preprogrammed inputs from an onboard chip programmed in RAPU. It doesn't use sensors to gather anything externally, instead relying on commands from the chip.

Figure 1C: Knife141 Face and Structure

Lastly there is an animatronic faced being developed by KM Design. The scope of this project [3] is quite immense, and it involves 3D printing pieces of the build in order to achieve accuracy on a scale that the other projects can't achieve. The project seems to be ongoing as of today, seeing that the motion test for the neck was performed in September of 2018. This particular project allows the head to move on 2 separate axes to mimic neck movements. On top of that, the eyes move independently from the eyelids, and the jaw moves as well. This project still forgoes sensors to gather data external to the animatronic head, instead opting to use two Hitec Transmitter radios to control the eyes, jaw, and neck.

Figure 1D: Initial Supporting Structure

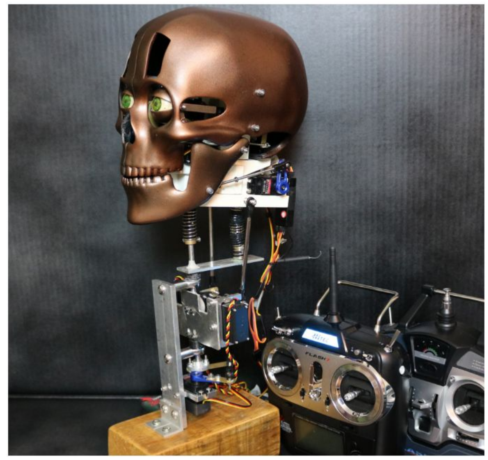

Figure 1E: Initial Supporting Structure

Section 2: Brainstorming (initial planning)

We would like the animatronic face to display movement in a few different locations including the eyelids and mouth, as well as the neck and eyes themselves if time and the scope of the project allow. We would wire a single actuator to control the eyelids, since both usually move together for the majority of the time. The same would then be true for the eyes, as they also tend to move in tandem with one another. A separate actuator would be wired to control the movement of the jaw in order to mimic the movement of the lower mandible during speech. Lastly, a stepper motor could be wired to control a swivel motion of the neck to appear as though the head was looking around. In short, the necessary joints will be in the locations of the upper eyelids and the lower jaw. Due to timing of the build, and the magnitude of wiring and coding, use of sensors will be the last addition to the project. An ultrasonic or infrared sensor could be set up to detect objects in close range to the eyes and trigger the eyelids to shut, giving the impression of blinking when an object is too close. In addition, we would attempt to wire a sensor to detect motion, causing the head to swivel before delivering a line of dialogue.

A simple base made of a cardboard or plywood frame will be used to support the face surface and components when finished. If the animatronic face is light enough, a hard piece of cardboard will likely be easier to work with. The chassis can be fabricated from individual wooden pieces or stiff cardboard making up the face (including the forehead, nose, and chin all in one piece), mouth, and neck. Those pieces will then be held together by various plastic and/or metal brackets, rods, nuts and bolts placed in the necessary locations. A generic plastic mask will be used to provide the look of an actual face. We could then utilize body filler to achieve the features we desire. A picture printed on paper will be overlaid onto the mask and will provide the look we hope to achieve of an actual face. It will have cutouts in the mouth and eye/eyelid areas to allow for movement of the structure to be seen. There are other methods of creating a face that would look more realistic such as silicon or a mold. However, given the time constraints and budget of this build, we believe paper will provide enough function in our current situation without sacrificing too much in form. All the electronics including the Arduino board, motors, and sensors will be powered by 18650 batteries (as much as is needed) that put out a range of 3.6 to 4.2 volts and have a max continuous discharge of 20 amps. The batteries will be connected with the appropriate hardware to a voltage regulator which is attached to the system in order to maintain a steady power supply.

Use of a recording device, likely a phone or a laptop, will allow for the acquisition of specific dialogue from the professor, which will then be used during the construction and subsequent display of the animatronic face. The audio will be captured in a .wav file format and likely converted to .mp3 in order to utilize an mp3 shield, which will be attached to the Arduino board controlling the face. Playback of the file will be synchronized to coincide with movement of the mouth. We plan on acquiring a sound file that portrays school spirit and engineering pride, and is to the point, such as “Welcome to the department of engineering” or “Hello UTSA, go Roadrunners”, as well as any other phrase the professor is known to commonly say.

Section 3: Supporting structure

We chose to use a completely wooden base and supporting structure that were made of different pieces and cut in various ways to meet the requirements of the design (Figure 3A). They were then all put together with multiple screws, nuts, and bolts. Two hemispherical pieces of wood were used for the mouth structure, with the lower piece able to move down and back up again. Wood proved to be a good material for us to use given our access to it as well as methods of shaping it, it is great for making a strong and sturdy foundation for the project. Ping pong balls with dots colored in by a marker were used as eyes (Figure 3B). Pill bottles with the ends cut off were used as eye sockets and were attached to a few popsicle sticks bunched together and finally secured onto the support structure, as shown in Figure 3C. The bottles ended up not being long enough to reach the rest of the facial features so a longer set was attached to the existing parts using fasteners. As far as the face goes, a simple picture cut into the correct shape was formed onto a plastic mask. The chin area was cut away from the mask and attached to the lower wooden jaw, while the rest of the face was stationary and place on the upper wooden jaw. This is demonstrated by the picture on the cover page.

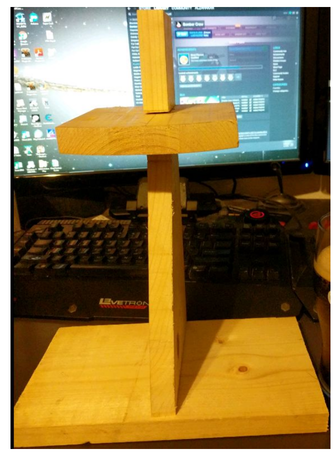

Figure 3A: Initial Supporting Structure

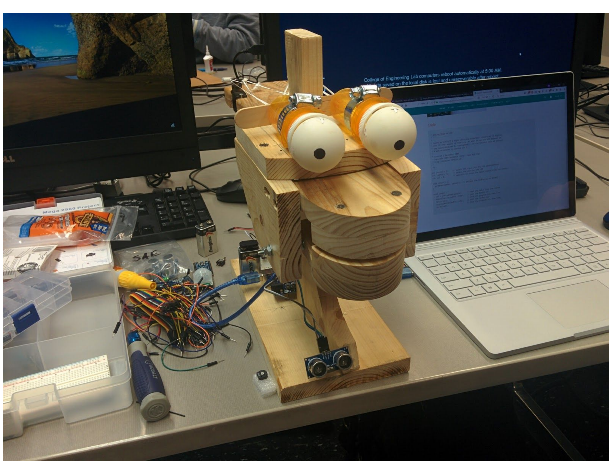

Figure 3B: Main View of Structure

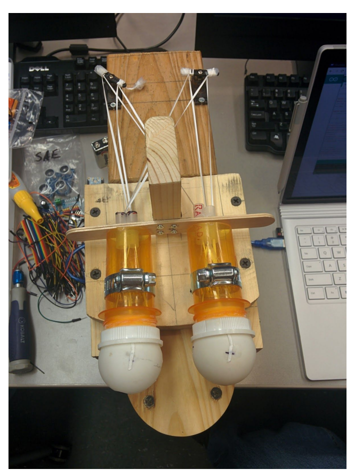

Figure 3C: Top View of Structure

Section 4: Joints and motors

We used a total of three joints for our animatronic face, two that were connected together to allow for simultaneous eye movement (Figure 4A), and one for the mouth (Figure 4B). A stepper motor was used to control jaw movement and the joint used allowed for angular rotation instead of straight up and down movement. Stepper motors were also used for eye movement, with fishing line connecting the sides of the ping pong balls on the x-axis to one motor and the sides on the y-axis to the other. Since having both directions of movement for the eyes was not crucial at the time, we only used the motor for eye movement on the x-axis.

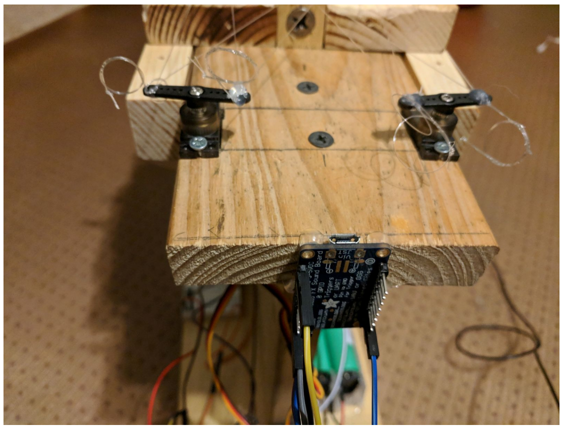

Figure 4A: Eye Motors

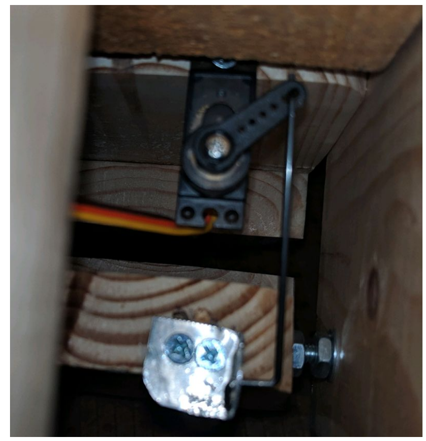

Figure 4B: Mouth Motor

Section 5: Sensors

One of the sensors used for this application was an ultrasonic sensor that sensed movement up to three feet away and actuated the movement of the jaw to create the illusion of speech when synced with the audio track that was used (Figure 5A, Left). The other sensor that was used was an infrared sensor directly beside the ultrasonic sensor which also sensed movement in the same locations (Figure 5A, Right). This sensor was wired to the eyes and when triggered, caused the eyes to scan their surroundings, as demonstrated on the day of project presentations.

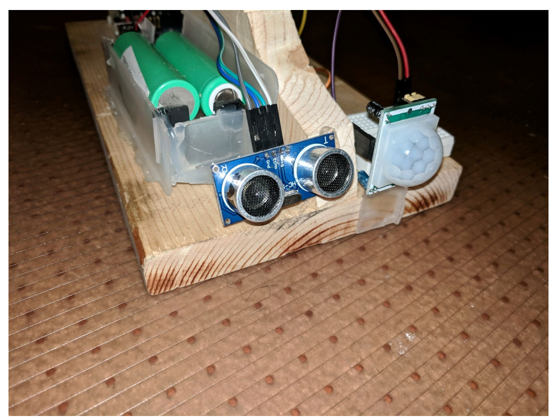

Figure 5A: Sensors

Section 6: Programming for interaction

We wanted to keep the project simple overall while still creating a unique design. With there only being two sensors placed side by side our project was very reliable. We wanted it to work even when away from a power source, so we ran our code through the Arduino and used rechargeable 18650 batteries (Figure 6A) to power all the components. The wiring (Figure 6B), while messy at first glance, provides for a direct correlation of a sensor to its respective motor and joint. If we took our project with us while traveling and didn't have an external power source available, it would still work due to the emphasis placed on its function. A link to a YouTube video demonstrating our project is given in reference [4].

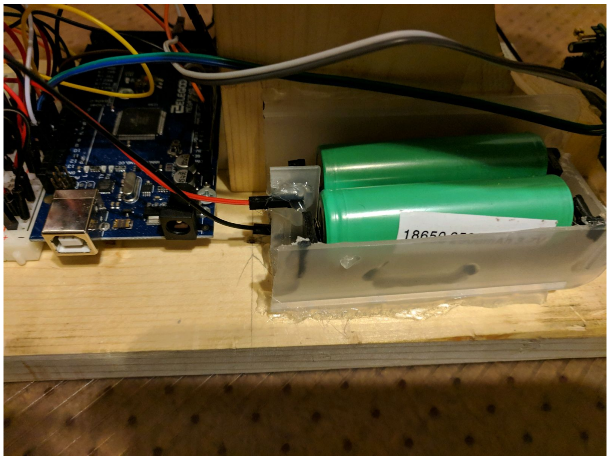

Figure 6A: Batteries

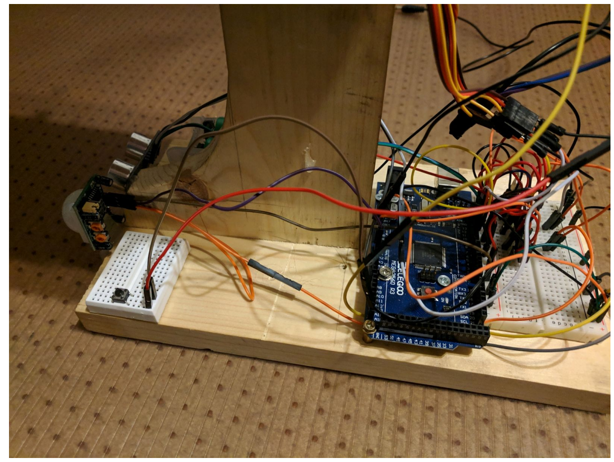

Figure 6B: Wiring

Section 7: Lessons learned and suggestions (1 page)

Lessons Learned:

1. Strings controlling eye movement began to fray and break; This was caused because we initially used floss to connect the eyes and motors. They were under constant tensile load and rubbed together when moving. We fixed this by replacing the floss with 20 lb fishing line.
2. The first structure broke; Epoxy was used to mold the supporting structure together, however it was accidentally dropped and all the epoxy connections broke. This was fixed later on by using the aforementioned screws, nuts, and bolts for connecting the structural parts together.
3. Larger battery source; As nice as it was to not require a computer to power the project, it would have been beneficial to have a power source with more charge than simple batteries. Although they didn't lose all power, we could tell they were starting to slowly die down and a bigger single battery would alleviate that.
4. Start everything earlier than you would like to; as obvious as it may sound, starting the project earlier would have helped greatly with time and stress management. Although stated in the project description, we now realize that things will inherently go smoother the earlier you begin things with a deadline, and will definitely apply that knowledge to future major assignments.

Suggestions:

1. Start earlier as a group, so there are less problems in the final moments

2. Work together in the same room so if a problem arises, another member may know how to solve it and can do so instantly.

Section 8: Personnel and bill of materials

(a) Personnel

Task	Main Personnel	Secondary personnel
Structure, Joints, Motor	Robin	Lance, Ryan
Coding	Lance	Robin, Ryan
Sensors	Ryan	Robin, Lance

(b) Bill of materials*

No.	Description	Website/comment	Qty.	Unit $	Total $
1	Arduino MEGA 2560	Provided	1		
2	Small stepper motors	https://www.sparkfun.com/products/10551	3	6.95	6.95
3	Wood	Scrap			
4	Arduino Kit (Wires, Sensors, Regulators, etc.)	Already in possession of	1		
5	Ping Pong Balls	Already in possession of	2		
	Plastic Mask	Already in possession of	1		
	Pill Bottles	Already in possession of	2		
6	Finishing Hardware (Joints, String, Fasteners, etc.)	Available for use in PDSL			

*Receipts have been submitted

References:

[1] Allscare.com
http://www.allscare.com/heads.html

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

[3] Animatronic Project
http://kieranmeadows.co.uk/project_animatronic.html

[4] Animatronics Face of Mechanical Engineering Professor at UTSA, Dr. Krystel Castillo,
https://www.youtube.com/watch?v=mga7RrRHAS4&feature=youtu.be

Appendix A: Code

```
/*
Animatronic Face Project

*/

#include <Servo.h>
#include <SD.h>
#include <SPI.h>
#include <Audio.h>
const int trigPin = 11; //Check to make sure that the ultrasonic sensor is connected to this pin.
const int echoPin = 12; //Check to make sure that the ultrasonic sensor is connected to this pin.
long duration;
int distance;
Servo JawServo;
Servo EyeServo;
int pos = 0;
int inputPin = 2;
int pirState = LOW;
int val = 0;

void setup() {
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
pinMode(inputPin, INPUT);
Serial.begin(9600);
JawServo.attach(13); //See if you can connect the Jaw Servo to this pin, or change the number to the corresponding pin.
EyeServo.attach(10); //Right now, the code only controls 1 servo for the eyes. I would connect the horizontal movement here, so that the face looks as though it's scanning the room.
Audio.begin(88200, 100);
}

void loop() {
for (pos = 0; pos <= 60; pos += 1) {
	EyeServo.write(pos);
	delay(15);
}
for (pos = 60; pos >= 0; pos -= 1) {
	EyeServo.write(pos);
	delay(15);
}
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance = duration*0.034/2;
int audio = 0;
int count = 0;
while(distance < 60){
```

```
  audio++;
  while(audio = 1){
          File myFile = SD.open("test.wav"); //This refers to "test.wave", but should be changed to
the name of the audio file.
          const int S = 1024;
          short buffer[S];
          while (myFile.available()) {
          myFile.read(buffer, sizeof(buffer));
          int volume = 1024;
          Audio.prepare(buffer, S, volume);
          count++;
          for (pos = 0; pos <= 45; pos += 1) { //Starting here, the jaw should move to mimic speech.
          JawServo.write(pos);
          delay(15);
  }
          for (pos = 45; pos >= 0; pos -= 1) {
          JawServo.write(pos);
          delay(15);
  }
          if (count == 100) {
          Serial.print(".");
          count = 0;
          }
  }
  myFile.close();
  audio = 0;
}
  val = digitalRead(inputPin);
  if (val == HIGH) {
          if (pirState == LOW) {
          EyeServo.write(0); //The eyes should stop moving when motion is detected.
          delay(15);
          pirState = HIGH;
          }
  } else {
          if (pirState == HIGH){
          EyeServo.write(0); //The eyes should start moving again once motion has stopped.
          for (pos = 0; pos <= 60; pos += 1) {
          EyeServo.write(pos);
          delay(15);
}
          for (pos = 60; pos >= 0; pos -= 1) {
          EyeServo.write(pos);
          delay(15);
}
          pirState = LOW;
          }
  }
}
}
```