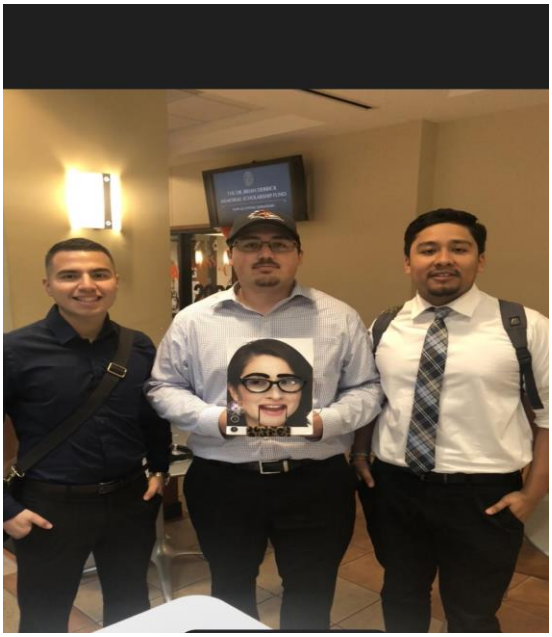
ANIMATRONICS FACE: DR. CASTILLO

https://youtu.be/SbG1tdgHUEk



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1. Abstract

The main goal of this Animatronics design was to be able to create an animatronics figure from scratch that would contain movement in at least three facial components, by the use of two different sensors and output two voice recordings. In this project it was decided to conduct movement of the eyes, mouth, and both eyebrows by the use of servo motors. The two sensors that were implemented in this animatronics design was one Ultrasonic Sensor that can detect motion from 2 cm up to 450 cm and a touch sensor “key switch button”. The ultrasonic sensor was used to trigger the mouth movement and the playing of the professor’s phases. Having the voice recording output from an SD card to a CQRobot Arduino Speaker was one of our bigger tasks due to having to implement programming in Arduino and having the right voltage to power the speaker. The push button was used to initiate the movement in the eyebrows and eyes simultaneously. The project had three moving human anatomy and spoke two different phrases which performed to the specifications of this project.

2. Literature Review

The Simple Animatronics Skull was created as shown in Figure 1. The purpose of the animatronics face is to use as a Halloween decoration. The skull itself was bought at a local Halloween store for less than five dollars. The components used to operate the system is considered to be economical, making this animatronic face easy and affordable to create.

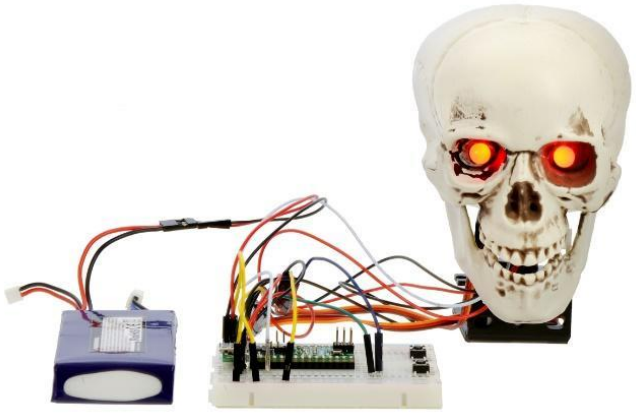

Figure 1. Simple Animatronic Skull

In order to create the movement of the skull, two high-speed mini servos were attached to the system. The servos were used to create the motions of the face, one for the jaw and the other for the neck. The skull eyes are lit up with the use of two RGB LEDs. The LEDs are attached in the eye socket of the skull for dramatic effects. The LEDs are connected to the breadboard using wires. To make the whole system operate, an A-Star Mini SV will control the servos and LEDs functions using a program code. The LEDs will be powered with 5 volt battery that is supplied by being connected to the A-Star's output. As shown in Figure 1, the 5 volt battery and A-Star will be connected together by using a breadboard and resistors.

The process of creating the animatronic face shown below in Figure 2, started by having a piece of plywood and cutting it to have a facial image that represented a person. This project has the ability of mouth, and eye movement. The required tools for this animatronics face, includes latex for the lips, and a server controller which in this case is the hearth of this face creation getting signals from the RAPU which is a single board computer. The RAPU has the ability of storing movements and audio portion which are uploaded to a compact flash card. All the power supplies and computer speakers were house in a black wooden box towards the back of the head. Aside from these parts the talking wood animatronic head needs a lot of wires, screws, eyes, various servos, soldering gun and other parts to be able to create this talking animatronic face.

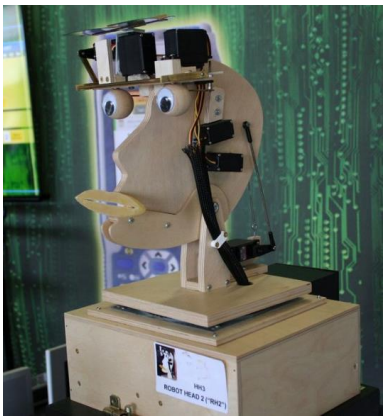

Figure 2. Talking Wood Animatronic Head

An animatronic head project was conducted using a coconut as the main support and skull in the Coconut Animatronic Head shown in Figure 3 below.

Figure 3. Coconut Animatronic Head

The main parts in this project was an Arduino, a coconut, three ultrasonic sensors, pre-manufactured eyes, a white ball for the nose, a servo, and many wires. The first step of this project was to form a concept drawing of the head. The coconut was first split in half, and on one of the half's two eye socket holes were cut. Premade eyes were used for the eyes in the project. One servo motor was used to move both eyes in the direction specified in the code. Three ultrasonic sensors were chosen to detect any motion in front of the head. The three ultrasonic sensors were placed in the front of the head. When an object passes in front of the three sensors the eyes follow the object in the direction that the object is moving. Also, a led is used to light up the nose of the head when any object passes in front of the ultrasonic sensors. An Arduino was incorporated to control and power the animatronic head. The main purpose of this project is to make a head that has eyes that follow any object/person that passes by the head, along with indicating an object is in front of the head by having the nose light up.

3. Brainstorming

After searching for different animatronics designs, we were able to put pieces together and come to a conclusion on how to build our own Animatronics figure. The apparatus will have lips, eyes, and eyebrow movements. In order to get the parts to move we have researched and found that servo motors are great, due to being small in size and having a built in circuitry to control their movement. The servo motors also have the advantage of being connected to an Arduino board. Furthermore, we will implement two different type of sensors to trigger the movement of the animatronic face. The two sensors that we chose are an ultrasonic sensor and a push button.

The fabrication structure of this project will consists of being able to create a face of our assigned professor. The face structure is formed from foam poster board that will have a picture of our assigned. The support structure will be formed from plywood that will be glued and stapled together. The eyes sections will be constructed from wooden beads that will be able to swivel to form the movement of the yes. We will create a soundtrack to synchronize with the movement of the lips by pitches of the soundtrack gathered. High voice and Low voice reading sensors will be able to depict when the mouth opens and closes as the voice recording is playing.

In addition, in order to power the Arduino, the servos and sensors a battery packet will be purchased. This will provide enough power to all the components for the animatronic project. Furthermore, the soundtrack we have in mind in collecting when meeting up with the professor is with our phones. Phones have a microphone which allows one to record someone's voice with great quality. The audio recorded can then be uploaded to a computer and then uploaded to a device that would best suit the animatronics figure such as an mp3 player. The mp3 player can then be connected to a speaker with an auxiliary cord. This method would be the simplest and economically affordable.

4. Supporting Structure

The support structure for the animatronic design project was constructed from four pieces of ⅜ inch plywood. The plywood pieces were cut to length and then connected together with 18 gauge pin nails and wood glue. The top deck piece is where the Arduino and both of the movable eyes will be attached. The poles that will guide the animatronic mouth of the face will be attached to the baseboard of the frame structure. To attach the Arduino to the top deck board two screws will be implemented. The servos and the other components will be attached using hot glue.

A foam poster board was bought from Walmart which would be used for the face of this project. A picture of the chosen professor was printed out and glued, using spray glue, to the foam poster board. The excess poster board was cut off following the guide of the outline of the picture. Then the mouth area was cut out to low the mouth to be separate from the rest of the face. Following the mouth, holes for the eyes were cut out of the face section. This is all displayed in the figure below.

Figure 4. Face Cut Out

5. Joints and Motors

A servo motor was glued using hot glue to the base of animatronic project to actuate the mouths movement. The mouth section that was cut from the foam board was glued to two straws. Two dowel rods were slid through the straws and were glued to the base of the project. The straws being plastic make it easy for the mouth to move up and down sliding on the wood dowel rods. The mouth joint section is displayed in the figure below.

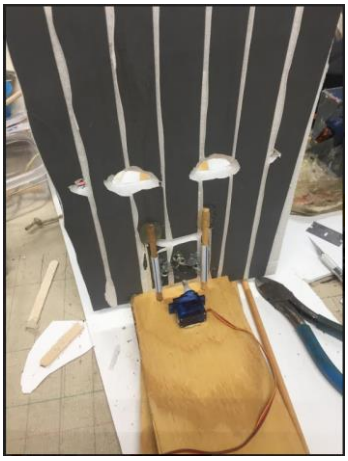

Figure 5. Base of Structure

The next thing constructed was the eye system. An old toy RC car front steering parts were used to make the swivel section of the eyes. The eyes themself are made from wood bead and doll replacement eyes that were purchased from Hobby Lobby. Two holes were drilled into each of the wood beads. One hole was to insert the doll eyes into the beads to make the eyes brown. The second hole is for a rod for the steering component to be inserted and glued to the wood eye. The wood beads were connected to one another using a dowel rod that has two eye hooks drilled into both ends. The eye hooks were placed over the poles from the car steering parts. This made is possible for both of the eyes to swivel at the same time. One servo motor will be used to control

the movement of both of the eyes. The eyes assembly with the working servo motor is displayed below.

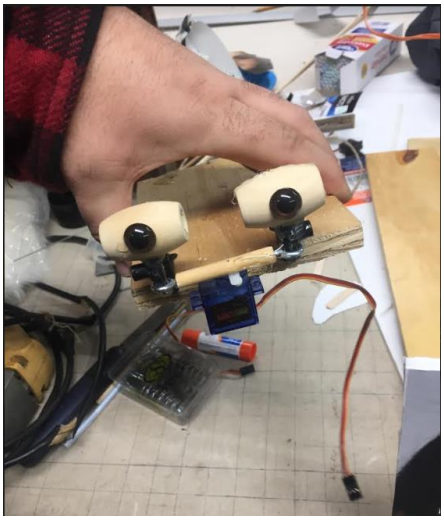

Figure 6. Eye Assembly

The wood that the eye assembly was placed on was then glued and stapled to the base of the whole project. This made an eye base platform that was large enough to hold the eye section and have the Arduino attached onto it. The eye section platform is shown in the figure below.

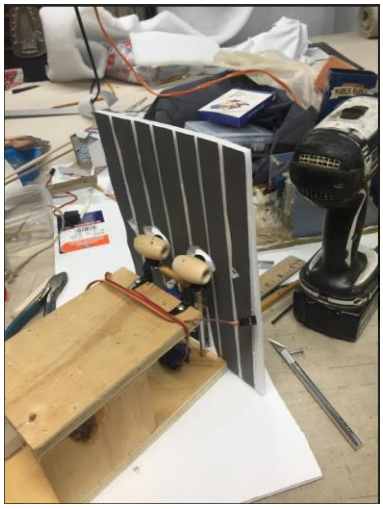

Figure 7. Eye Base Platform

The next parts that were applied to the structure is the Arduino. The Arduino was screwed using small Phillip's head screws to the eye base platform. After the Arduino was attached the next parts were the two servo motors to form the joints for the eye brows. Holes were drilled in the foam board face in the middle of the eye brows in the printed out face picture. The servos were pushed through the foam poster board from the back. The servos were hot glued on the back side of the project. The figure below displays the servo motors for the eye brows and the Arduino that were attached.

Figure 8. Backside of Project

After all the servos were attached for form the joints for the mouth, eyes, and eyebrows the front side of the face of the project must be finished to form a complete project. Eyebrows were constructed from stick on fake mustaches that were purchased from Walmart. A note card was used to draw the general shape of eyebrows and were cut out. The fake mustaches were stuck on the eyebrows and trimmed to form the correct shape. After the eyebrows were formed they were then hot glued to ends of the servo motors. To form additional details on the face of the project real glasses were hot glued to the face of the project. The glasses were just for aesthetics to give our project more detail. A light up earring was also added to the project for the same reasons. The finished front side of our project is displayed in the figure below.

Figure 9. Finished Face

For this project servo motors where used to form the movements for all of our joints. Servos were chosen because they are compatible with an Arduino and have a wide range of motion. The motion of the servos can be controlled to form the motion that is desired for this project. In this

project three different face features move which are the mouth, eyebrows and both eyes. Four servo motors were implemented in this project to form all of these features motions.

6. Sensors

The first sensor that will be implemented in this design is the ultrasonic sensor. This sensor will detect a motion is an object approaches our project. This sensor will then send a signal to initiate a certain set of servo motor to start a motion. The ultrasonic circuit is displayed in the figure below.

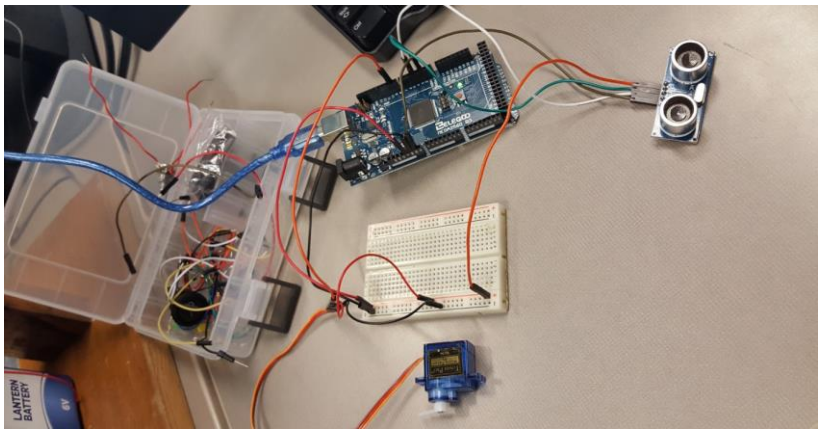

Figure 10. Ultrasonic Sensor Circuit

The ultrasonic sensor was glued to the back side of the face, but the two cone parts will stick through the front part of the foam poster board. The location of the sensor is under the ear ring of the right side of the face project. This sensor will activate the motion of the mouth and the audio of the professor. The image below shows the location of the sensor on the face project.

Figure 11. Ultrasonic Sensor Location

The second sensor that was chosen in this project is a push button. This push button will activate the motion of the eyes and the eye brows. This sensor works when a person pushes the

button it activates the motion of the projects. The button will be just attached to the wires so it can be located anywhere is it needed. The figure below shows the push button and is indicated by the blue arrow.

Figure 12. Push Button Sensor

7. Programming for Interaction

All programing for the Animatronic face was completed using Arduino IDE. Arduino Mega 2560 was the microcontroller used to operate the Animatronic face project Arduino. A DFPlayer module and a CQRobot Arduino Speaker allows for audio to play in coherence with Arduino. A power supply was placed at the end of the breadboard to supply the sufficient amount of power to the micro servos and DFPlayer module respectively.

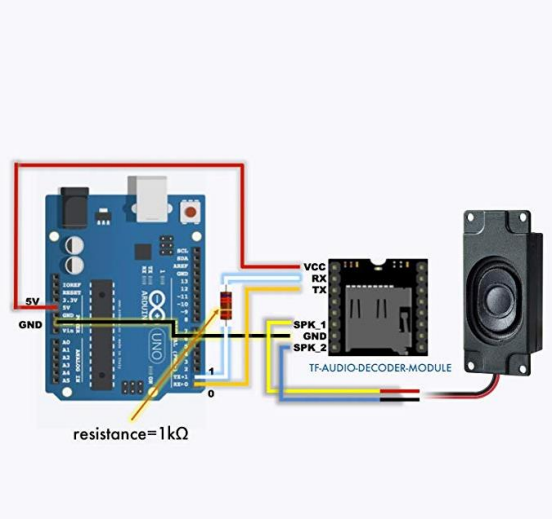

Figure 13. DFPlayer Diagram

The DFPlayer module allows the operator to insert a SD card. In order for the audio to play, it was necessary to save Dr. Castillo's voice as an mp3 file and import it onto an SD card.

The DFPlayer is positioned onto the breadboard, which then connects onto Mega 2560 and a speaker as shown in Figure 13. The coding that allowed the audio to play was downloaded from a website online. The file consisted of a zip file that allows the operator to then add the file to the Arduino library. Adding the sip file to the Arduino library is a necessity for the program code to operate. The downloaded file was modified to accustom the Animatronic face project. The code for the movement of the micro servo attached to the mouth of the project was added to the audio code. In order to make the audio play repeatedly a part of the code was placed into the Void Loop section. The servo code was also added to the Void Loop section which made the servo move simultaneously with the audio by using the delay command at 100 and 5. This task was achieved by using and *If Else* statement. If an object came 20 cm or less to the Ultrasonic Sensor the audio and mouth servo movement would be triggered simultaneously.

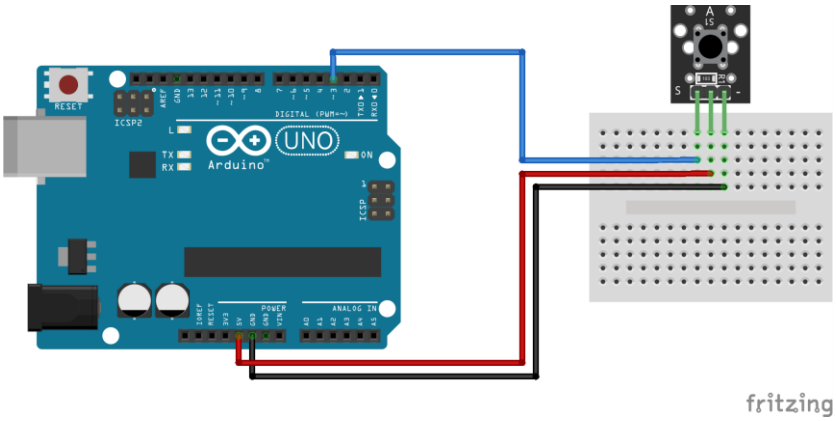

Figure 14. KY-004 Diagram

The next step was to have another sensor to trigger the movement of the eyes and eyebrows. A KY-004 push button was the second sensor that triggered the second set of movements. The key switch button was attached the breadboard which was connected to the Arduino Mega 2560 as shown in the figure above. The same layout for the code used to operate the Ultrasonic Sensor and servos was used to move the eyes and eyebrows with the key switch button. The servos codes also used an *If Else* statement placed in the Void Loop.

After both sensors were properly set up to operate each micro servos independently, the next step was to make them function together under one code. This was achieved by applying the key switch button code into the Ultrasonic Sensor code, since it was more complex and longer. The code was programmed into four sections. First, all sub-files used had to be uploaded through the Library on Arduino, *#attach*. The second section introduced the components that would be operated such as the sensors, micro servos, and audio played. The third section is where the Void Setup commands are placed. The Void Setup is a function that lets the operator set up the start of the program code like the micro servos and DFPlayer. The fourth section is where a majority of the coding was placed. The fourth section is also where the *If Else* statement was placed. This is because Void Loop is a terminal in which a function runs continuously with a combination of

coding and programming. For further inspection of the operational code see Appendix A: Code for further analysis on programming code used on Arduino IDE.

8. Lessons Learnt and Suggestions

1. One of the biggest lessons we learned throughout this project was being able to make the servo motors and speaker all function at the same time. This was one of the bigger challenges we as a team encounter throughout the length of this animatronics project. The trouble was at first trying to get the ultrasonic sensor to trigger both servo and the audio in the code. Since, majority of our classmates had the same problem there was no one to ask for help on this from our peers. Trial and error became the name of the game to synchronizing the motion of the mouth with the audio of the professor. We were able to get the voice and servos to function all simultaneously by combining both codes into one in Arduino. This was the portion of the project that gave us the hardest time, along with the hardest portion to accomplish on this project.
2. A problem we encounter during this Animatronics project was being able to power all the servos and speaker. We were able to fix this problem by purchasing a battery holder which holds 8 AA batteries. This battery pack combined all the voltage from the batteries to have a combined voltage of 12 volts. This battery power was connected to the breadboard to transmit the power to the speaker that would output both phrase recorded to a SD card, and the servo motors that will perform that projects motion. Aside from this power source we had to add an additional 9V battery to be able to power the Arduino Mega 2560. Figuring out the amount of power that was required to power this project by trial and error.
3. A lesson that we learned from this project was how hard it is to apply a flat picture to a three-dimensional mask. At the beginning of this project we chose to make this face from a mask. However, after we tried to apply the printed picture of the professor to the mask, we learned that it did not look very good. We learned from this failure that the best way to make the picture look better was to make the face flat. We chose to use a foam poster board as the structure of the face. The foam poster board was chosen because it will allow us to easily attach items needed to form the faces motions. The final product's appearance was a huge improvement from the first face structure that we had with the mask.
4. The motion of the mouth was another portion of the project that gave our team trouble. Our team wanted to have a mouth motion that moved with ease, since our chosen professor said the project phrases relatively fast. This meant that we had to have a way for the mouth to be able to move fast and not get stuck in the middle of performing the motion. Wood dowels were slid inside of drinking straws to solve this problem. The dowel rods were implemented to be the support for their face and the mouth's sliding section.

9. Personnel and Bill of Materials

(a) Personnel

Task	Main Personnel	Secondary Personnel
Structure/Chassis	Luke Story	Jose Alfredo Moreno
Overall Programming/Integration	Jose Alfredo Moreno	Jorge Delgado
Joints and Motor Interfacing	Jorge Delgado	Luke Story

(b) Bill of materials

No.	Description	Website/comment	Qty.	Unit $	Total $
1	Arduino MEGA 2560	Provided	1		
2	Small stepper motor	https://www.sparkfun.com/products/10551	1	6.95	6.95
3	Wood	Scrap			
4	Servo Motor	Amazon	4	10.99	10.99
5	Mask	Hobby Lobby	1	3.99	3.99
6	Eyes	Walmart	2	.98	1.96
7	Battery holder/cables	Altex	3	2.59	7.87
8	CQRobot Speaker	Amazon	1	7.87	7.87
9	Earring	Walmart	1	3.00	3.00
10	Wood Dowels	Walmart	1	.97	.97
11	Straws	Walmart	1	.98	.98
12	Batteries	Altex	1	11.95	11.95
13	Hot Glue Gun	UTSA Bookstore	1	15.00	15.00

Total Price of Project: $71.53

10. 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] Pololu - Simple Animatronics Face
https://www.pololu.com/blog/421/simple-animatronic-skull

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

[5] Coconut Animated Head
https://www.youtube.com/watch?v=CT9iG5XxCSw

[6] Hobby Lobby - White Female Full Mask Face
https://www.hobbylobby.com/Crafts-Hobbies/Basic-Crafts/Masks/White-Male-Full-Face-Mask--Small/p/23858

11. Appendix A: Code

```
//Mechatronics
//Jose Alfredo Moreno
//Luke Story //Jorge Delgado
#include <Ultrasonic.h>
#include <DFRobotDFPlayerMini.h>
#include <SoftwareSerial.h>
#include <Servo.h>
Ultrasonic ultrasonic(2,4);
Servo eyebrows;
Servo eyes;
Servo mouth;
int pos = 0;
int Key = 12;
int val;
int servo = 3;
int servoEyebrows = 6; SoftwareSerial mySoftwareSerial(10, 11); // RX, TX
DFRobotDFPlayerMini myDFPlayer; void printDetail(uint8_t type, int value);
void setup()
{
 pinMode (6, OUTPUT) ; // output pin  pinMode (3, OUTPUT) ; //  output pin
 eyes.attach(3);
 eyebrows.attach(6);
 mySoftwareSerial.begin(9600);
 Serial.begin(115200);
 if (!myDFPlayer.begin(mySoftwareSerial)) {  //Use softwareSerial to communicate
with mp3.
   while(true){
    delay(0); // Code to compatible with ESP8266 watch dog.
   }
 }
 myDFPlayer.volume(30);  //Set volume value. From 0 to 30
```

```
 mouth.attach(9);
}
void loop()
{
 Serial.print("Distance in CM: ");
 Serial.println(ultrasonic.distanceRead());
int k = ultrasonic.distanceRead();
 if(k <= 20){
  myDFPlayer.play(1);  //Play the first mp3
 delay(100);
 for(int w =0; w <= 4; w++){
 for ( pos = 0; pos <= 50; pos += 1) { // goes from 0 degrees to 180 degrees    // in steps of 1 degree
mouth.write(pos);              // tell servo to go to position in variable 'pos'    delay(5);                       // waits 15ms
for the servo to reach the position
 }
 for (pos = 50; pos >= 0; pos -= 1) { // goes from 180 degrees to 0 degrees    mouth.write(pos);              // tell
servo to go to position in variable 'pos'    delay(5);                       // waits 15ms for the servo to reach the position
 }
 }
myDFPlayer.play(2);
delay(800);
 for(int w =0; w <= 6; w++){
 for ( pos = 0; pos <= 50; pos += 1) { // goes from 0 degrees to 180 degrees    // in steps of 1 degree
mouth.write(pos);              // tell servo to go to position in variable 'pos'    delay(5);                       // waits 15ms
for the servo to reach the position
 }
 for (pos = 50; pos >= 0; pos -= 1) { // goes from 180 degrees to 0 degrees    mouth.write(pos);              // tell
servo to go to position in variable 'pos'    delay(5);                       // waits 15ms for the servo to reach the position
 }
 }
 }
 val = digitalRead (Key) ;
 if(val == LOW)
```

```
  {
  for ( pos = 55; pos <= 125; pos += 1) { // goes from 0 degrees to 180 degrees    // in steps of 1 degree
eyes.write(pos);              // tell servo to go to position in variable 'pos'    delay(5);                    // waits 15ms for
the servo to reach the position
  }
  for (pos = 125; pos >= 55; pos -= 1) { // goes from 180 degrees to 0 degrees    eyes.write(pos);              // tell
servo to go to position in variable 'pos'    delay(5);                    // waits 15ms for the servo to reach the position
  }
  {
  for ( pos = 0; pos <= 25; pos += 1) { // goes from 0 degrees to 180 degrees    // in steps of 1 degree
eyebrows.write(pos);              // tell servo to go to position in variable
'pos'    delay(5);                    // waits 15ms for the servo to reach the position
  }
  for (pos = 25; pos >= 0; pos -= 1) { // goes from 180 degrees to 0 degrees    eyebrows.write(pos);              // tell
servo to go to position in variable
'pos'    delay(5);                    // waits 15ms for the servo to reach the position
  }
  }
  }
}
```