Animatronic Ghost Creature

A Major Qualifying Project Report

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Submitted By
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Abstract

Engineering can be used for many purposes, including artistic expression. The goal of this project was to create a cute ghost animatronic that could interact with an audience. The robot possessed a fully articulated pair of eyes, eyelids and eyebrows and a mouth that can spray water. An RFID reader detects the IDs of known RFID tags and triggers specific emotions and behaviors to activate. The animatronic was successfully able to receive commands and portray various emotions and actions through use of its articulated features during a live demonstration.

1.0 Introduction

Often in the world of engineering, we think about how to solve practical problems, such as designing robots to make manufacturing jobs easier, or perform complex medical procedures safely and reliably. However, we often overlook creative applications of robotics as entertainment. Robots have captured our imaginations in many ways and allowed us to create worlds, places, and creatures previously only partially expressible through traditional artistic mediums. Art does not have to be limited to the mediums of paint, pencils, or clay; anything can be considered a medium. Engineering is using the concepts taught in math and physics to create something new, and therefore can be considered a form of art.

For this project, I decided to take less of a typical engineering approach, than a more artistic approach instead, as that is what motivates me. I applied my artistic design skill to create an interactive animatronic cat-like ghost creature. The creature was designed to be able to react to a user input by expressing different emotions on its face and spraying water when prompted. I used my engineering knowledge and skills to create the animatronic, which possessed the ability to adjust its eyebrows, open and close its eyelids, and move its eyes both up and down and side to side. The animatronic used an RFID reader to detect a pre-programmed card representing a different facial expression or action, and then used the aforementioned subsystems to perform the given expression. After the animatronic was completed, I performed a live demonstration of the creature interacting and emoting.

1.1 History of Animatronics

Animatronics have a storied history that goes back millenia. The concept of animatronics was born out of automata, which humanity has been creating since at least the days of ancient

Greece. Automata are simple moving mechanical devices that often look like a living creature. Eventually, with the rise of electrical technology in the 20th century, automata started to evolve. In 1928, Westinghouse engineers developed a simple robot, named Herbert Televox, who had articulated arms, that took the basic form of a human. After developing several other 'humanoid' robots over the course of ten years, the engineers at Westinghouse debuted what is widely considered as the first animatronic, Elektro, at the 1939 New York World's Fair. Elektro was notable for several reasons, the primary one being that he was an interactive animatronic who did various tasks based on voice commands.[1]

The next great wave of animatronics happened in the 1950's. Around that time, Walt Disney took a trip to Europe and brought home with him an automaton of a little bird in a cage, that could chirp like a real bird. This bird would sit in his office and eventually inspired him to send his Imagineers to make their own little automata-like machines.[2] The Imagineers succeeded in this goal by creating The Enchanted Tiki Room which opened on June 23, 1963, in Disneyland's Adventureland. The show featured over 100 singing birds, flowers, and other features around the room.[3] The beloved tiki birds were soon followed up by another feathered friend in an animatronic first, that being the first animatronic featured in a major motion picture. In 1964 the Walt Disney Company released the film *Mary Poppins*, in which two animatronic american robins were featured. When Julie Andrews sings the song "A Spoonful of Sugar" she harmonizes with a robin and has one perched on her finger. Those effects were both produced with animatronic robins.[2]

In 1964 the Walt Disney Company produced the first truly human animatronics. Walt Disney collaborated with several companies to create many stunning animatronics for the 1964 New York World's Fair, including many dinosaurs for the Ford Magic Skyway, the children of

the world for Pepsico & UNICEF's it's a small world, the family of the past, present, and future in General Electric's Progressland (Carousel of Progress), and the 16th President of the United States of America for the State of Illinois' Great Moments with Mr. Lincoln.[4] Abraham Lincoln in particular was seen as a major technological advancement, as he could move his arms, legs, face, head and was able to get up from the sitting position.[5] WED Enterprises, currently known as Walt Disney Imagineering, and their artists and engineers continued to make many achievements in the world of animatronics throughout the following decades.

The next major instance of animatronics in pop culture, outside of the Disney parks, comes in the 1970's thriller *Jaws*. Several animatronics were created to portray the shark, however, they often failed and sank into the ocean. This ultimately resulted in the shark not appearing much on screen, which had a positive impact on the film.[6] The lack of the shark's presence added to the tension, and turned Jaws into a classic thriller. The next major animatronic in cinema was R2-D2 in the original *Star Wars* Trilogy. R2-D2 was primarily played by actor Kenny Baker, however the character was sometimes portrayed by remote controlled animatronic puppets.[7] The use of the animatronic puppet was not very important itself, however *Star Wars* plays several key roles in the history of animatronics in cinema. Also in the 1970's the Chuck E. Cheese restaurant chain was created, heavily featuring basic animatronic mascots that would define the brand.[8] The 1970's also introduced a major player in the world of puppetry and later animatronic puppetry, Jim Henson. Henson was the industry leader in the use of puppetry in the worlds of television and film, creating series such as *Sesame Street*, the *Muppet Show*, and *Fraggle Rock*, and movies such as *The Muppet Movie* and *The Dark Crystal*. [9]Notably, we see the first major use of animatronics in television history, with the TV series *Fraggle Rock*, which utilized animatronic puppetry to puppet the Doozers and the Gorgs, two of the three main types

of creatures featured.[10] Possibly the peak of animatronics in cinema was the *Jurassic Park* franchise. Special Effects Artist Stan Winston led a team to design several animatronic dinosaurs, including a full lifesize animatronic T-rex for the films. These dinosaurs are quite possibly some of the most iconic animatronics in cinema history.[11]

Unfortunately, the 1990's signified an end for the trend of animatronics in film in most respects. Jim Henson's untimely death in 1990 halted a lot of public interest in using puppetry in film. In 1999, George Lucas released *The Phantom Menace*, the start of the *Star Wars* prequel trilogy, which was created using almost entirely Computer Generated Imagery for the effects. George Lucas and Industrial Light and Magic inspired a new era of filmmaking using a heavy reliance on CGI. The *Star Wars* prequels were promptly followed up in 2009 by James Cameron's *Avatar*, which further pioneered the idea of CGI filmmaking.[12] For most of the 2000's and 2010's, CGI took over as the new way to make films. Surprisingly, a *Star Wars* movie would become a notable exception. In 2012, the Walt Disney Company acquired Lucasfilm from George Lucas, and immediately began working on creating a new trilogy of films. Since the previous trilogy of *Star Wars* films was poorly received upon release do to its heavy use of CGI, the filmmakers for the new trilogy decided that it would be best to merge the practical puppetry of the original trilogy and the modern advancements in both robotics and computer graphics technology to make a new yet very distinctly *Star Wars* style of effect for the films.[13][14] The films notably used practical animatronics for characters such as BB-8, D-O, and the adorable porgs.[15] Following the In the series *The Mandalorian*, Grogu, (also known as Baby Yoda), was a completely practical animatronic puppet that only needed to be touched up using CGI, instead of digitally inserted.[16] In many ways this improved the overall quality of the show, as it more easily allows Grogu to be held by various characters, and very easily placed into different

settings. Similarly, in the series *Andor*, B2EMO, the Andor family droid, is a completely animatronic puppet.[17] The resurgence of practical effects is a considerably newer trend however, and has not seen much impact outside of the world of Star *Wars*.

Returning to the world of theme parks, the 2000s saw some major achievements in the world of animatronics, yet again from the Walt Disney Company. In 2005, they debuted Lucky the Dinosaur, the first walk around audio animatronic. Following Lucky, in 2009, Disney demonstrated their first Autonomatronic figure, Otto, who was their first animatronic that could interact with its current surroundings, and interact with people in the room with it.[18] In 2014, Disney released their most complex examples of a unique method of creating animatronics. The animatronics created for the Seven Dwarfs Mine Train in Magic Kingdom created complex facial animations using projections on an animatronic figure, a technology they had been developing since the 1960's.[19] Over time, their standard humanoid animatronic figures kept getting better and better, allowing for them to look seemingly more realistic as time went by. The last major achievement seen in animatronic technology has been through the advent of Stuntronics, animatronics that are capable of performing complex stunts, which Disney has been working on since 2018.[20] They officially debuted this technology with the opening of the Avengers Campus area of Disney California Adventure Park in 2021, in a stage show that featured Spider-man doing a gravity defying flip, using an animatronic that could swing in the air, flip, and land safely on a trampoline.[21]

1.2 Brief History of Interactivity in Modern Theme Parks

Amusement parks and theme parks have always fundamentally had an element of interactivity, as the goal of theme parks is to immerse you into a world different than that of which we already occupy. There have always been a variety of interactive activities and

attractions, however they have often been limited by the technology of the time. Certain aspects of fantasy or far away worlds were not able to be recreated, in some cases, until the 2000's. An early example of this can be found in Epcot's Kim Possible World Showcase Adventure. This experience was based on the 2002 Disney Channel TV series *Kim Possible*, and had guests use Samsung cell phones to communicate with characters from the TV series and activate hidden in park effects throughout designated country pavilions in the park. The guests would help Kim and Ron defeat various villains from the series. In 2012, the experience was closed briefly and returned as Agent P's World Showcase Adventure, based on the Disney Channel television series *Phineas and Ferb*. In 2016, the experience was updated to allow guests to use their own cell phones to play the game, so they could experience the game at their own pace and own time.[22] In 2022 the experience was updated yet again, becoming the DuckTales World Showcase Adventure. Since then, the experience has only been available for guests via their own cell phones.[23] A major milestone in the world of immersive interactivity came in 2014, with the opening of the Wizarding World's Diagon Alley at Universal Studios. The land opened to critical acclaim, featuring incredible attention to detail in every aspect, and introducing guests to their very own working magic wands. The wands worked using infrared camera technology, where a reflective spot concealed on the tip of the wand is captured by an infrared camera while performing a given motion, which is displayed to the guest so that they can accurately 'cast a spell'.[24]

Around the same time, Disney also released their own form of interactive magic with the introduction of Magic Band technology. The Magic Band was a silicon wristband, roughly the size of a Fitbit or modern smart watch, with a built-in RFID chip. The Magic Band would serve as a park guest's hotel room key, park ticket, and could be connected to a credit card for in-park

purchases. The point of the band was to make it easier for a park guest to have access to those objects without the need to bring a wallet or purse with them whenever they left their hotel room. The technology was eventually implemented throughout the rest of the parks, integrated in dining and attraction reservations, and even connected to the Disability Access Service. The guest interacted with the bands through the My Disney Experience app, and used the bands in the parks and resorts at designated touchpoints. In 2022, after almost ten years of iterations on the first model of magic bands, Disney released the Magic Band+, which integrated Bluetooth and LED technology into the bands, to allow for more interactivity in the parks. Three interactive experiences launched almost immediately with the release of the new bands, the first being Walt Disney World 50 character statutes. Guests could find and wave at roughly 50 statues placed throughout the 4 parks which would cause the statues to respond by making a noise. The statue would then appear in the corresponding section of the Disney Play app, so that guests could track their progress. The second experience was ‘bounty hunting’. It was exclusive to Star Wars Galaxy’s Edge. Guests would go up to small terminals in doors in the land and be assigned a bounty, then they would have to use the Disney Play app and various vibrations and color changes on the Magic Band to find the location of the bounty. The game was initially very confusing and fairly buggy on release which could also be said for the first models of Magic Band+.[25] The last feature was fairly simple, the band would give haptic feedback, light up, and change color when used at a touch point or worn during a nighttime spectacular[26]. Similarly to the MagicBand+, Universal Studios recently released a ‘Power-Up Band’ which allows guests to connect to the newly opened Super Nintendo World at their California and Japan parks. The band uses almost the exact same technology as the magic band, and primarily allows the guest to interact with small games and fixtures around the land. [27]

1.3 Additional Research

For research, I got my hands on the most commonly available form of animatronic, a robotic toy. The model I focused on was the Build-a-Bear Workshop Bearlieve Bear. Bearlieve was released in late October 2023, as a tie-in with their feature film *Glisten and the Merry Mission*. The bear is the second animatronic bear released from the company.[28] The bear is only partially animatronic, with only the head containing robotic components and the rest being able to be stuffed by a customer. The bear itself has several servos, a microphone for sound input, and a speaker for sound output. Once the bear is 'woken up' Bearlieve bear will respond to any sounds it picks up, usually with an 'mmhhm' or an 'aahh'. While it responds, it will blink its eyes and wiggle its ears. The animatronic also has an on/off button located in the left paw, that, when held down, either wakes Bearlieve or puts it to sleep.

2.0 Objectives

When speaking about the creation of the Abraham Lincoln animatronic, Disney Legend Bob Gurr often brings up the issue of needing to fit the components needed to make Abe stand up inside the frame of a tall skinny man like Abe Lincoln, instead of a president similar in shape to "Grover Cleveland."[29] This sort of conundrum and design philosophy, of engineering to fit into an uncommon shape, greatly inspired this project. The main objective of this project was to build an animatronic with facial articulation, and all of the components fitting into the given design shape. Very early on in the design process, I also decided that I wanted this animatronic to have an element of interactivity. The animatronic needed to have the ability to express various emotions, including happiness, sadness, and anger. I also wanted its emotions to be tied into the interactivity, allowing someone to give the animatronic an object or command which could control its mood. All together, this could mean that if someone gave it a specific object, it could

become angry, shift its face into an angry expression, and then spray the offending person with water as a way of further expressing its anger.

3.0 Design

The Animatronic Ghost Cat, named Emquepea, is an interactive animatronic. Emquepea has articulated eyebrows that tilt up and down, articulated eyelids that can open, close, and stay partially open, and eyeballs that can move both from side to side and up and down. The animatronic also has a non-articulated mouth that sprays water, using a small water pump in the base. An RFID reader placed under the stylish hat on its head reads recycled MBTA Charlie Cards, which have been reprogrammed to call up certain emotions in the code, which have the eye subsystems move to form the corresponding emotion, and also trigger the water spraying function.

To start the design process, I first had to decide what I wanted the project to look like. Originally, I had the idea to design an animatronic version of a Pokémon, specifically the Pokémon Vaporeon. I had initially wanted it to have a degree of mobility, a fully articulated face, and the ability to spray water out of its mouth after being given a command to perform a certain move with RFID tags embedded in an object. This idea had to be scaled back however, because the requirements and time needed to create it would have been outside of the time and scope of an individual project. Unfortunately, the idea of recreating a Pokémon had to be scrapped, as Pokémon is a copyrighted and trademarked property. I decided I wanted to keep the major functionality of the Pokémon concept, but with a new exterior.

I started working on a quadrupedal ghost-like design, with a little top hat and a non-articulated mouth. I later decided to redesign the creature, changing it from quadrupedal to a bipedal sitting creature. To find a design, I studied a few living animals and the stuffed animals at Build-a-Bear Workshop. I ended up inspired by the Pastel Swirl Kitty, a popular mainstay model of stuffed cat available at Build-a-Bear, of which I had one at home. I realized I could borrow the shape language of the Pastel Swirl Kitty, but adapt it to look like a traditional sheet ghost, still wearing a top hat. To confirm this design, I took my personal Pastel Swirl Kitty, Connie, and took some fabric I had lying around, and worked to create a sort of live action reference model for use in my sketches. satisfied with the general shape and frame I needed to build into, I moved onto my facial feature design. In this stage of the design process, I knew I would need eyeballs that could move up and down and side to side, and that I would need eyelids that could open, close and stay partially open. I was stuck on whether or not I would need to give my animatronic eyebrows to help convey complex emotions. I again studied two animals, Parker, a small Cavapoo dog, and Sparky Figment Cohen, a five month old domestic shorthair tabby cat. I tried to see how they moved their faces and expressed themselves, as they do not have what we think of as ‘eyebrows’ in a traditional sense. My studies with them were somewhat inconclusive, as the animals became somewhat uncooperative. I also partially created an expression sheet for the animatronic, to get an idea of what each emotion might look like. I then spoke to Faith Drake, an experienced animation major at the Massachusetts College of Art and Design. I decided to speak to an animator, because this process was animation, but using robotic elements to create the illusion of life instead of a pencil and paper. We discussed the importance of eyebrows in animating expressions, and she convinced me that eyebrows would be important for the project.[30]

Once I had figured out what the exterior design would look like, and what major subsystems I would need to convey emotions, I needed to design the subsystems. The first thing I decided was what microcontroller I wanted to use. I decided on using an Arduino, as they are very maker friendly and easy to program, and add a variety of actuators and sensors to. I also wanted to use an Arduino as I am fairly familiar with its IDE and programming language are relatively simple and I am very familiar with them. After discussing this with the professor, I was provided with an Arduino Mega, which possessed a large number of pins to accommodate all of the various actuators I would need to attach to the robot. I also was advised to use a sensor shield and additional power source, to appropriately power and connect a large number of servos. For the servos, I chose a three pin FEETECH FS90 micro RC servo, and I was able to source a small 1 L/min water pump. For the RFID reader, I chose the Adafruit PN532 RFID/NFC reader shield. For further reference, please see Appendix Figure 23, for a wiring guide.

When it came down to the subsystems, I started with the eyeball itself. The first thing I created was a socket. The first prototype socket was crafted from a ping pong ball and paper clips, with 3 curved paper clip wires evenly spaced across the ball meeting at two poles on either side of the eye. I then attached a stalk to the back of the eyeball so that it could be moved from side to side and up and down by pulling the stalk to the inverse direction. I decided to keep going with this design, creating a new prototype, this time adding a structure to hold the servos and the socket. The servos were mounted perpendicular to each other, and then each was attached to the stalk of the eye via a rubber band attached to an arm on each servo. When the prototype yielded promising results, I moved onto working on the eyelid subsystem. The first thing I did was attach rods to the ends of each pole. I then crafted curved rims to create the rim of the eyelids and attached a rod to the middle of it to better define the shape of a lid, curving back around the eye.

The original idea was to have both the bottom and top lid controlled independently. This basic model allowed me to move the lids just as planned.

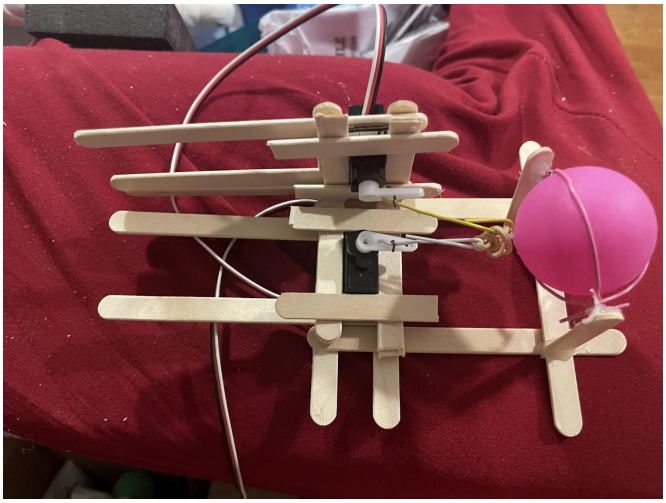


Figure 1. prototype eye socket, with two servos controlling the up and down and side to side motion of the eyeball.

I initially considered having two points of articulation on the eyebrows, but eventually I decided to change the design to include only one point of articulation, having them simply tilt up and down, directly attached to the servo. Once I had figured out the prototypes or designs for each of the eye subsystems, I started production on the final model. I first decided to 3d model a more precise version of the socket and servo holders for the eyeball. Upon printing I realized I had miscalculated the servo mounting locations in my initial model, so I fixed them and reprinted the models. I then inserted 2 light blue ping pong balls into each of the sockets.

For the next portion of design - the base and the rest of the understructure - I decided to take a trip to my local Home Depot. I spent a long while trying to figure out what my base would be made of and what my mounting system would look like. When I got there, I knew I wanted my base to simultaneously function as both a sturdy base and my water tank, which would prevent any excess framing I would need to create the shape of the animatronic from tipping it

over. I considered a two quart bucket and lid, though I did not know how I would attack mechanisms to it. In the outdoor and gardening section I discovered the HDX 56oz Handheld Multipurpose Pump Sprayer. The bottle base had three small legs for sturdy placement when not being held and a slim but large capacity for water, that, combined with the thick and sturdy plastic it was constructed out of, would make it a fantastic base. The other benefit was a threaded neck at the top, which could very easily be connected to a size cap and reducer for ½ inch PVC pipe spine. I also picked up some smaller pre-cut paint sticks, wood glue, screws, and some ½ inch pipe brackets meant for mounting pipes to a wall of flat surface. I also found some ⅜ inch vinyl tubing to attach to the water pump, to allow for the pump to sit at the bottom of the base and allow the water to travel to the mouth.

For the final construction of the animatronic, I started by assembling the base and the spine. After all of the PVC pipes that form the spine were attached, I created a wooden mounting bracket for the eye sockets. I used a small piece of vinyl tubing and attached each of the sockets at one end, and attached the tube in the middle to the bracket. This allowed me to adjust the height and angle of the eye sockets when creating the exterior. I then started assembly on the mouth, attaching the vinyl tubing to the pump and drilling a hole in the spine for it to exit through. For the eyelids, I recreated my previous design for the eyelid rims and the rods to hold the shape. I made a few changes, adding small rubber bands around the corners of the lids to provide tension to allow the lids to close, and creating a hole through the socket bracket so the rod for the top lid could fit through the bracket to reach the servo. I then created a second wooden mounting bracket for the servos for the eyelids, and attached the lids to the servos. Next I started assembling the eyeballs, attaching the arms, rubber bands and stem to the ball. The top

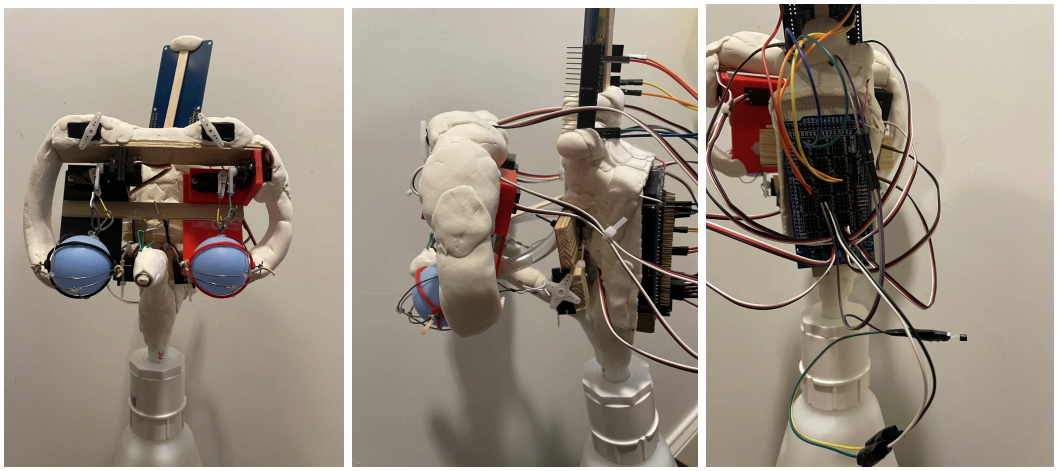
rod for the eyelid was preventing the stem from fully moving the eye side to side, so the rod had to be moved and angled towards the sides to allow for the largest range of movement.

Once the major subsystems were constructed, I began working on the structural components for the exterior and the electrical components. I used Model Magic air dry clay to first construct brackets for the RFID shield and the Arduino Mega, and then started on the eyebrows. I first took a paper clip wire, then tied the middle of the wire around a popsicle stick, leaving two long ends off of the back side of the stick. I then covered the stick in a layer of Model Magic, securing the wire to the stick and flattening out the edges. I had intended to sculpt an additional, more sculpted brow to sit on the brow supports, but ultimately decided that a straight line would be perfectly acceptable for a little ghost creature, and might give it an air of cartoonishness. After the brackets had dried for the Arduino and RFID shield, I added additional Model Magic around the spine, placed the Arduino bracket on the back of the spine, and placed the RFID shield on the top of the pvc pipe. I next moved to sculpting and working on the placement of the eyes and the mouth. I used some floral wire and a popsicle stick to prop up the eyes in the right position, so that they sat evenly on the face and looked straight forward. I then sculpted two rounded pieces to fit around the outward side of the servos and the socket bracket, so that when the skin sat on the animatronic, it wouldn't have a boxy and sharp look. When working on the mouth, I first tied a wire around the end of the tube, and then propped it up on a support bracket so that the tube was pointing outward and sitting around the area I wanted it to. I then covered the tubing and the rest of the PVC pipe in model magic.

Around this time, I realized that I needed to apply more pressure to the end of the tube to make the water spray far enough away from the animatronic to not saturate the creature. I first tested zip tying the top and bottom of the tube end together, but that resulted in a split stream and

a lot of leakage from the hole the zip tie went through. I then decided to create a nozzle insert for the end of the tube, which reduced the size of the hole on the end and added enough pressure to make the stream go farther.

Next came mounting the eyebrows. I simply glued two larger popsicle sticks together, then trimmed and glued them to the top of the socket bracket. I then applied a thick layer of Model Magic to the top, and pressed in the servos for the eyebrows. This allowed me to place them exactly at the angle and position I needed. I then covered the servos in Model Magic to secure them and smooth out the top profile.



Figures 2-4. The front, profile and back of the animatronic. Figures x and x demonstrate the eye mechanisms, and Figure x demonstrates the fixtures created for the Arduino mega to sit in. The figures also demonstrate the sculpting done to improve the shape of the animatronic.

Once the internal mechanisms of the animatronic were complete, I moved on to the exterior. I acquired a sheet of white cotton knit fabric with a good amount of elasticity and opacity. I laid the fabric out over the animatronic and traced a line for the RFID shield so that a thin slit could be cut and the shield could protrude through the top. The fabric was then sewed to the rfid shield, so that it could roughly cover the bottom of the shield, to help create the illusion

that the device wasn't there. I laid out the fabric over the bottom of the animatronic, and cut out the rough shape of a circle. I then added some general plush stuffing to pad out the shape of the head for the animatronic, and then I lined up the fabric to cut the holes for the mouth, eyebrows and eyelids. I started with a simple hole to put over the output of the eyebrow servo, then connected the servo arm with the eyebrows attached over the fabric. Next, I cut the mouth hole, pulled the mouth through, and sculpted a little bit around the tube to give it a better appearance and to secure it to the fabric. I then traced and cut the eyelid slits, and then sewed each side of the slit to the respective eyelid rim.

Once that was finished, I moved on to creating the hat. I used a ½ cup sauce cup from a salad jar container, sculpted a band and a brim onto it with Model Magic, and then painted it black with a light purple band. As for the ears and limbs of the ghost cat, I deconstructed a Build-a-Bear Pastel Swirl Kitty. I took the legs and ears, and attached the ears to the top of the head and strategically placed the legs to peek out from under the fabric at the base. I then painted six recycled Charlie Cards white, and drew on various cat emojis to represent the six actions the robot would be able to perform: be happy, be sad, be angry, be tired, blink, and spray water. Lastly, I crafted two pupils out of model magic to be placed on the robot's eyes once the optimal location was discovered. The pupils were painted a dark gray, with a grayish purple iris on the outside of it. The pupils were attached to the balls via a glue dot.

Finally, I started the programming. The basic flow of the program is exemplified by the flowchart below. The card is read by the RFID reader and each card's id is linked to an emotion. An if statement then processes which emotion has been read, and sends the code forward to a function that would tell the servos where to move to to display that emotion. This would change

the tilt of the eyebrows, the openness of the eyelids, the direction the eyes are looking and whether or not to trigger the pump to spray water.

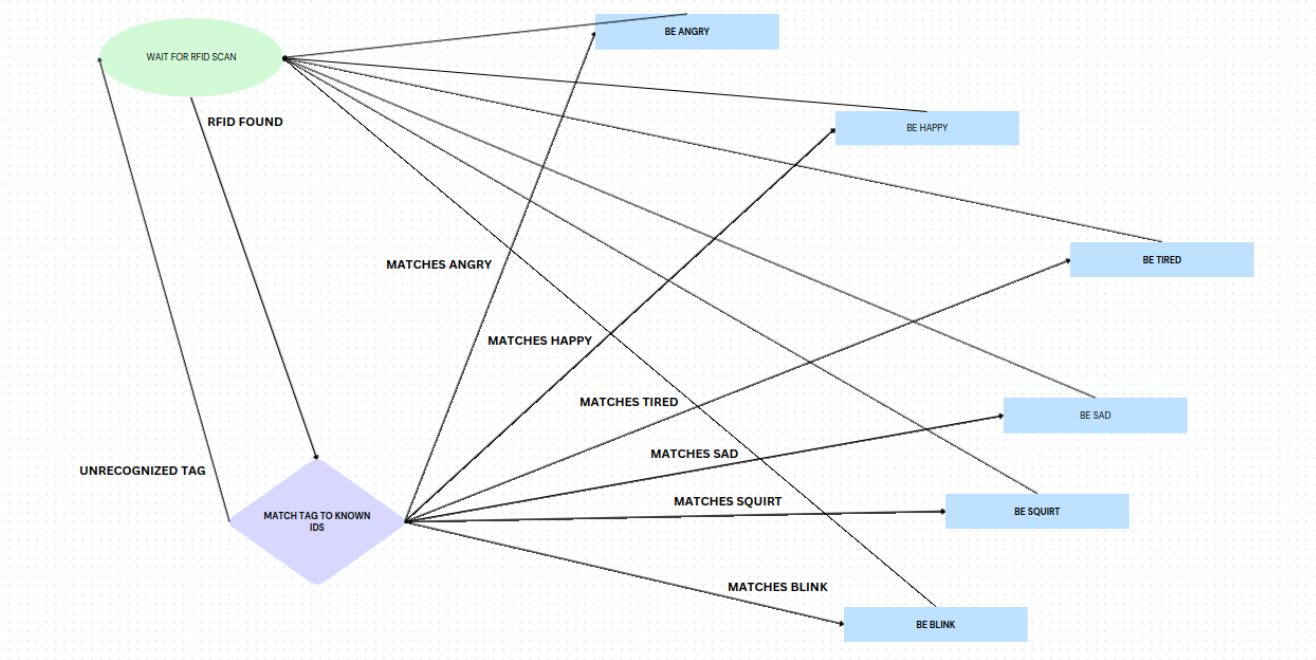


Figure 5. Flowchart of the program written to control the animatronic.

4.0 Results

Figures 6 & 7. The Animatronic Ghost Creature at project presentation day. Figure 6 demonstrates the creature in its "angry " state and Figure 7 demonstrates the creature in its "sad" state.

In the end, the robot was able to mostly complete the goals set for it. The visual appearance did not look precisely as I intended, however people that saw the robot agreed that it was rather cute. The articulation of each feature worked, albeit to various degrees. The eyebrows worked perfectly, as they were an incredibly simple design. The eyelids were not perfectly even regarding how well each closed. The reason could be boiled down to several points of human error, such as not having perfectly aligned and even lengths of rod attached to each lid. The lids did not close perfectly, though they did close, and when blinking, the discrepancy in their ability to close were mostly undetectable. The eyeballs themselves probably had the largest issues, as they didn't have the best range of motion, and were prone to slipping or getting stuck in the same positions. Part of this has to do with the pupils occasionally causing the eyes to get stuck on the lids. Another problem with the eyes was caused by the issue of the top rod from the top eyelid

physically getting in the way of motion. The eyes did still move, however their motion was relatively limited to moving from the right side to the middle, and up and down. The spraying feature worked pretty well. It did have some issues upon construction, such as needing to have a small transistor wired into the circuit to receive enough power from the Arduino. The spraying feature was still slightly less powerful than I had hoped, however it was still very effective. The RFID reader worked just as expected, however the base holding it up had a hard time supporting the weight of the hat, so it kept leaning backwards.This meant that I often had to leave the hat off of the animatronic, for fear of the hat tearing off the rfid shield.

The robot was demonstrated live before an audience at project presentation day. There were some minor flaws, like the robot not wanting to read one of the cards right away during my presentation, however, the results were generally positive. Several people interacted with the creature, each seemingly finding it interesting. The water spraying feature in particular would surprise people, which often brought a smile.

5.0 Discussion and Conclusion

Ultimately, this project was a success. It may not have been perfect, but it functioned as intended. There were several things I learned in the process, including several applications this type of robot could have. The original application this animatronic was intended for was for use in theme parks, where guests could be given an easy means of interaction via RFID, which is a technology already used in most major theme parks. This would allow for a more personal experience with the guests, and could also create new interactive experiences similar to the magic in the Wizarding World parks. Another initial use of this animatronic could be to create an

easy effect in a film. Instead of needing to model and insert a character digitally, there could be a figure that could be remotely puppeteered and interact with props on the set. There were two applications I previously hadn't considered in the field of education. The robot would make a fun and fairly simple to maintain interactive museum exhibit, so long as the parts are generally strengthened to withstand the forces of children, or if the animatronic was not physically accessible to the children.[31] The other great use for this would be in middle or high schools, as a means to get kids interested in robotics. Most of the parts I used in my project were either recycled, hand-me-down electronics, or inexpensive when bought new. The servos I used cost roughly $80 for eight of them, and the RFID reader cost roughly $45. The project could be a very cost effective way to introduce kids to robotics. The creativity in the design would allow kids to create their own engineering problem to solve, letting them fit their desired functionality in the form they have chosen. The code needed to produce results is also quite basic, and could be easily taught and replicated in a classroom. Once the students finish the project, it can be taken apart, and then recreated in future years, most of the costly pieces are one time purchases.

The project could be iterated on in the future in multiple ways. Future iterations of this project could develop a greater amount of articulation in the facial features or add a method of self conveyance. This project could also be iterated on further to develop a curriculum for school children based on the fundamentals ideas of artistic engineering put forth by the project. This project could also be adapted into an art or theater project focused on how to create a better outward appearance or interactivity ability.

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Appendix: Additional Images and Figures

Figure 8. Automata bird in a cage, from the offices of Walt Disney on display at the Disney 100 exhibition at the Franklin Institute. Automata like these inspired Disney to pursue the idea of animatronics

Figures 9 & 10. Various Animatronic Birds and Flowers from Walt Disney's Enchanted Tiki Room, in the Magic Kingdom. The attraction is a clone of the original in Disneyland

Figure 11. Original Abraham Lincoln Animatronic head from the 1964-1965 New York World's Fair, on display at the Disney 100 Exhibition at the Franklin Institute.

Figures 12 & 13. Abraham Lincoln animatronic standing up during Great Moments with Mr Lincoln at Disneyland

Figure 14. DuckTales World Showcase Adventure interactive app interface title screen on the Play Disney App.

Figures 15 & 16. A MagicBand v2 and a MagicBand+. The MagicBand+ is larger and thicker than the v2, and also possesses the ability to light up in the center.

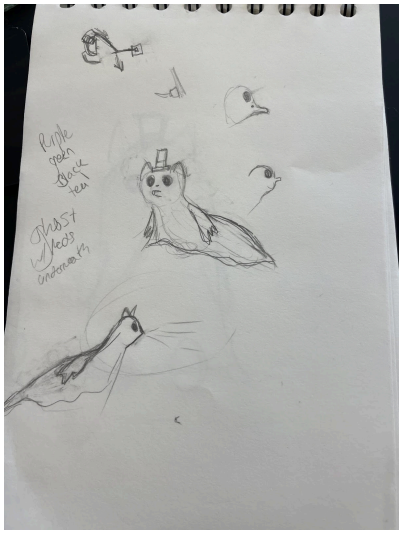


Figure 17. Early Design sketches of the quadrupedal version of ghost creature.

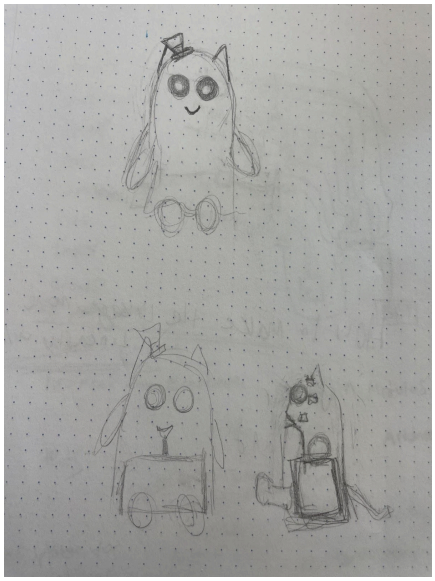
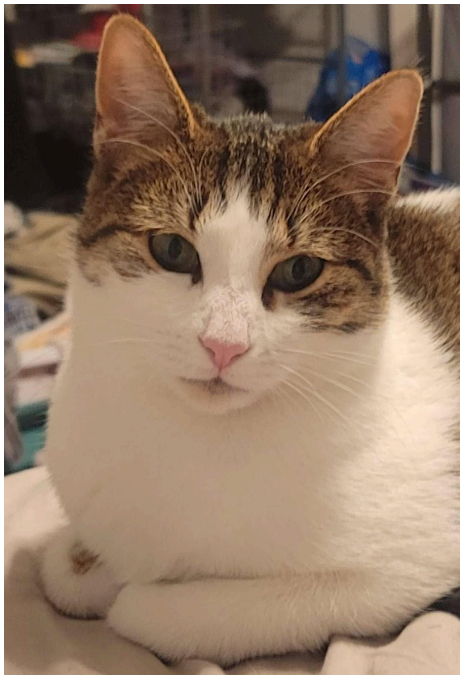


Figure 18. Sketches of the final design for the animatronic ghost creature.

Figure 19. Connie Candy, a build a bear workshop pastel swirl kitty that was used as a reference model for the final design



Figures 20 & 21. Parker and Sparky F Cohen, the dog and cat that were used as reference models.

Figure 22. reference model connie candy sporting eyebrows to help determine if eyebrows would be needed, and how they might look

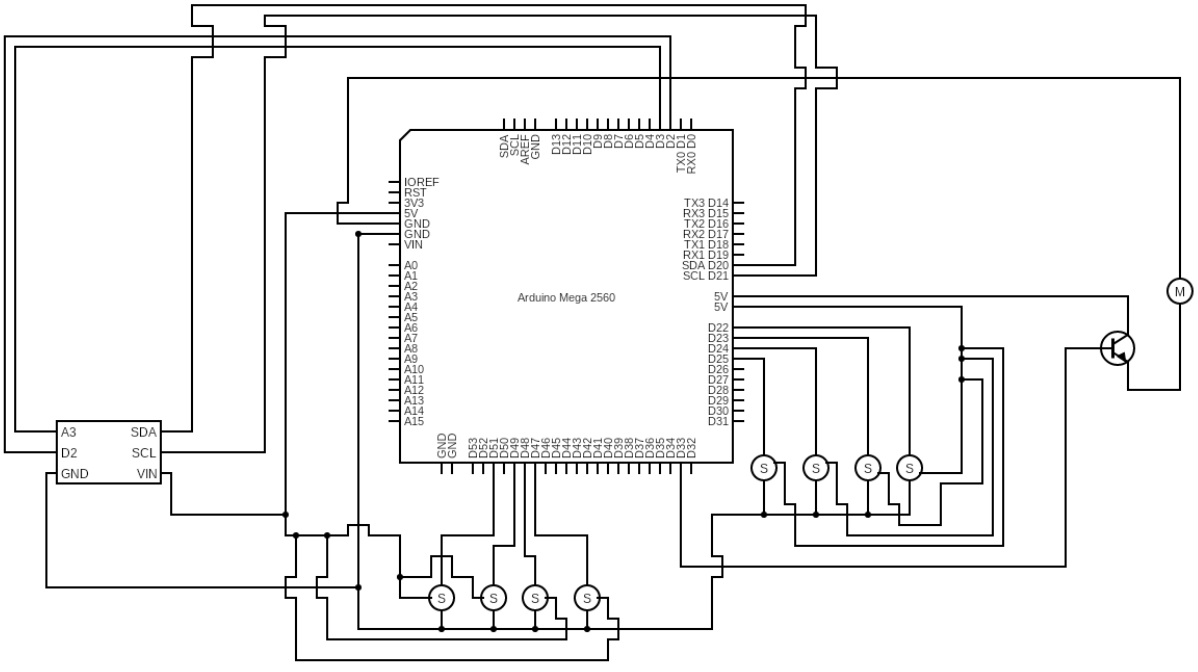


Figure 23. Circuit Diagram for the animatronic ghost cat. the unlabeled integrated circuit is the Adafruit PN532 RFID/NFC Shield

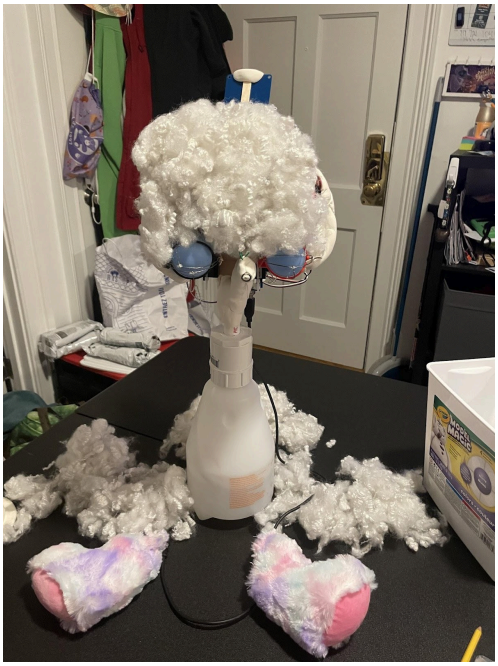


Figure 24. The animatronic during the process of shaping and attaching the skin. The stuffing was used to give the robot the desired shape while still allowing the servos to move without interference.

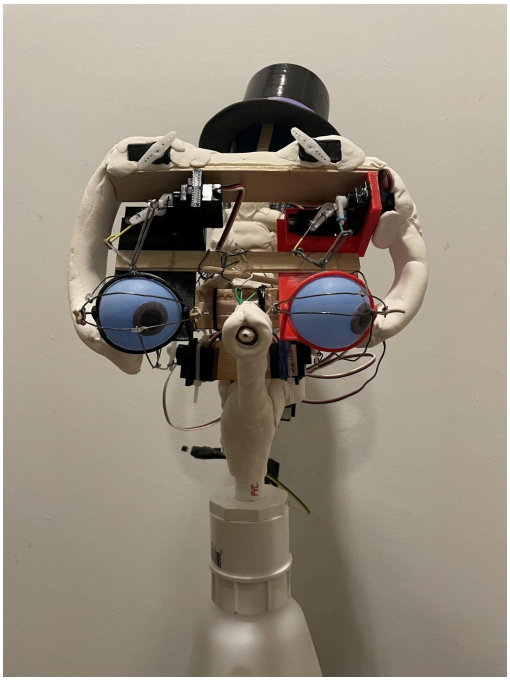


Figure 25. The internals of the animatronic with the pupils attached and the top hat placed on top of the rfid sensor, without the skin attached

Figure 26. The repurposed Charlie Cards used as the RFID cards for the project. from top left to bottom right, the cards cause the animatronic to do the following: be angry, be sad, squirt water, be happy, be tired, and blink/ be neutral.

Figure 27. The Animatronic demonstrating the blink expression, which resets the expression to neutral

Figure 28. The Animatronic demonstrating the squirt water response, while also demonstrating the neutral expression.

Figure 29. The Animatronic demonstrating its angry emotion. This includes an angry facial expression and squirting water.

Figure 30. The Animatronic demonstrating the sad expression.

Figure 31. The Animatronic demonstrating the happy expression.

Figure 32. The Animatronic demonstrating the tired expression.