MAE 4630 Advanced Product Design Final Report

Long Distance Teddy Bear

Gabe Mitchell [gfm48]

Summary

1 Product Description Executive Summary

1.1 Team Name and Summary of Participants

The product is named The Long Distance Teddy Bear, addressing both the form and function of the product. The product prototype and market research was completed by Gabe Mitchell during the Spring 2022 semester as part of MAE 4630. Gabe had oversight from Professor Robert Shepherd and Teaching Assistant Jennifer Lee.

1.2 Problem Product Addresses

Individuals separated from their loved ones miss out on many interactions that are commonplace for people when together. Notably, people away from friends and family do not get to experience physical intimacy from their loved ones. The Long Distance Teddy Bear proposes a solution to this problem by giving customers a novel and physical way to interact with their friends and family while apart.

1.3 Basic Functions of Product to Solve Problem

The Long Distance Teddy Bear is a stuffed teddy bear that makes human motions, such as waving hello or giving a hug. Customers can control the bear over the internet with a mobile app. Users can give the bear to their loved ones, and the recipient can experience physical intimacy from the gift giver when he or she operates the Teddy Bear with the mobile app.

1.4 Special Features of Product

The Long Distance Teddy Bear will also include a speaker. Users can use the mobile app to record an audio message that is sent to the teddy bear. When the recipient of the teddy bear is ready, they can play the message from the speaker on the bear. Facilitating verbal messages is another way that the Long Distance Teddy Bear promotes intimacy between friends and family that are apart.

1.5 Service Environment Conditions

The actuation functions of the Long Distance Teddy Bear are best used while both the user with the bear and the user with the controlling app are on a video call. Audio features on the Long Distance Teddy Bear are designed such that audio messages can be sent by the app user at any time and then played at the convenience of the user with the bear.

1.6 Highest Level Product Refinement

The Long Distance Teddy Bear is currently in the prototyping phase. The most recent design includes a 3D printed mechatronic skeleton that has been integrated into a stuffed animal (a lion, as that was the best option available). The prototype can make simple motions, such as giving a hug, waving hello, or dancing. The mechatronic skeleton is pictured immediately below, and the skeleton integrated into the stuffed animal is shown in the following image.

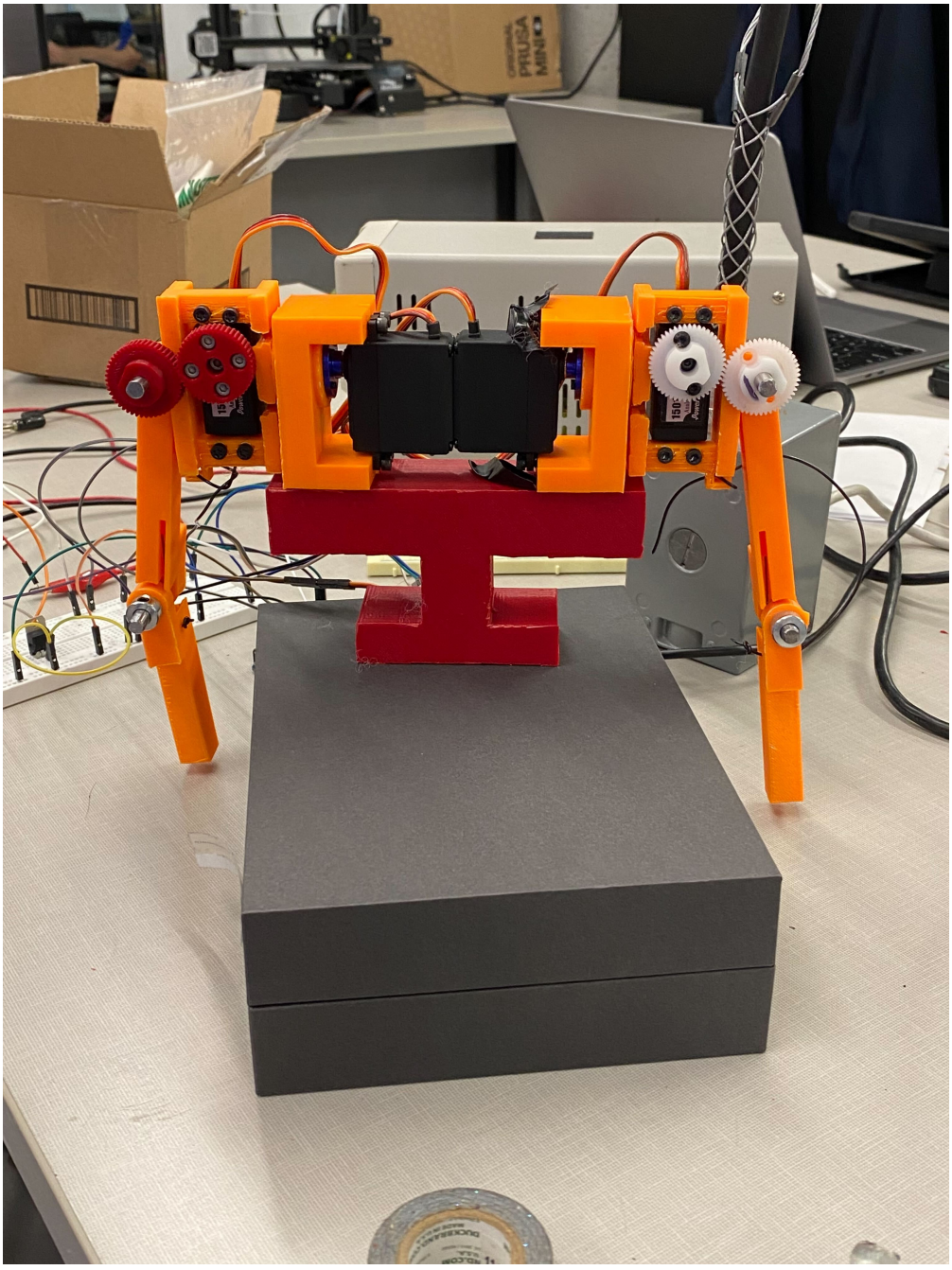

Figure 1: **Mechatronic Skeleton**

Figure 2: **Stuffed Animal and Skeleton**

2 Physical Description

2.1 List of Requirements from Customer

2.1.1 Stakeholder identification and contact summaries

The skate holder group includes anyone who is regularly separated from their loved ones. This includes people in long distance relationships, professionals who travel for work, and individuals at high risk of COVID-19, among others.

2.1.2 Conjoint Analysis

The conjoint analysis plots below show stakeholder preference for various product costs and features.

There was a clear preference for a larger iteration of the Long Distance Teddy Bear as opposed to a small one, and users of course preferred a cheaper product. Notably, there was a steady decline in the cost preference up to a $30, after which there was a much steeper decline. Lastly, of the potential additional features, a speaker with audio messaging was preferred.

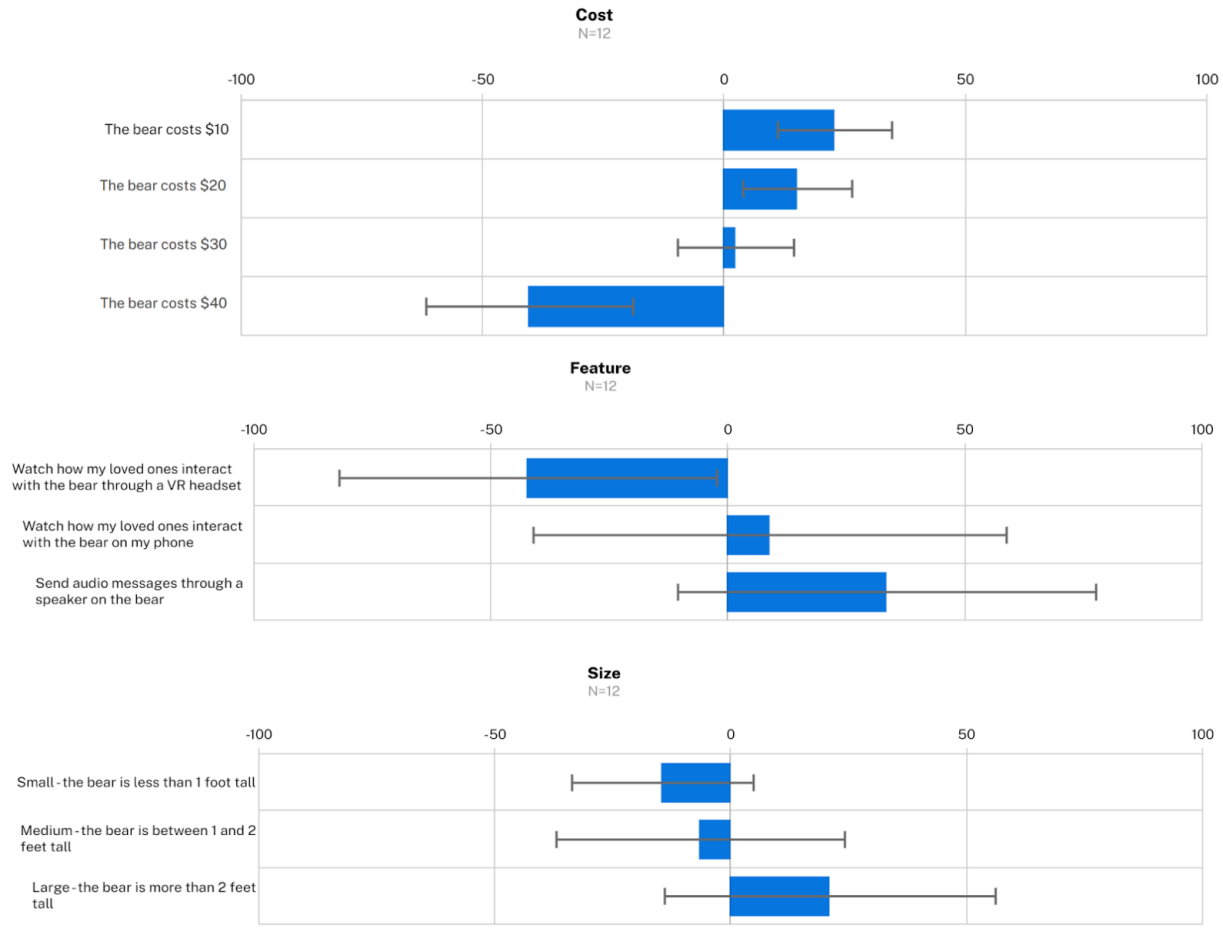

Figure 3: **Conjoint Analysis**

2.2 Engineering Characteristics of Concept

The Long Distance Teddy Bear consists of a skeleton and joints that are actuated with servo motors. The servo motors receive commands from a raspberry pi, and both the pi and the servos are powered by a battery. A regulator is used to reduce the battery's voltage output to a level appropriate for both the raspberry pi and the servos. The principle components of the mechatronic skeleton are the bear's two arms. The arms have two degrees of freedom dictated by the servo motors, as shown in the picture below.

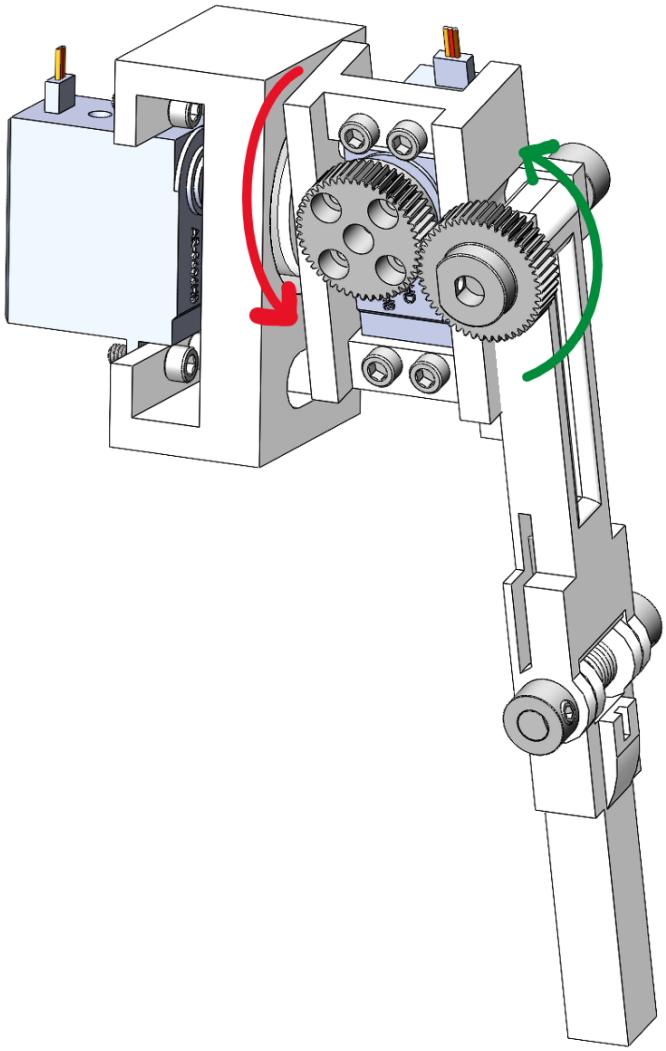

Figure 4: **Arm Degrees of Freedom**

2.2.1 Manufacturing and Assembly Considerations

Design iterations were primary based upon improving manufacturing quality and ease of assembly. To improve manufacturing quality, parts were made simpler, which reduced overhangs and supports on 3D printed parts. Features that require supports have a rougher finish, lower precision, and higher post processing time. Simpler parts also print quicker, which allowed for quicker testing and a more rapid design progress. To arrive at the desired simplicity, some parts that were originally one were split into two.

Making simpler parts was also the primary mode to improve ease of assembly. Originally, part geometries interfered with fastener installation. However, after several design iterations, arm assembly became a quick and easy process.

The most recent design updates optimized all parts for injection molding. To do so, all concealed overhangs were removed. Now, only the basic A side and B side mold are necessary for creating the entire mold of every part. This dramatically cuts down on the cost of manufacturing. To make this change, parts were simplified even more, often times by switching from fastened connections to press fits. An example of the design optimization is pictured below, where the previous part on the left is compared to the injection molding optimal part on the right.

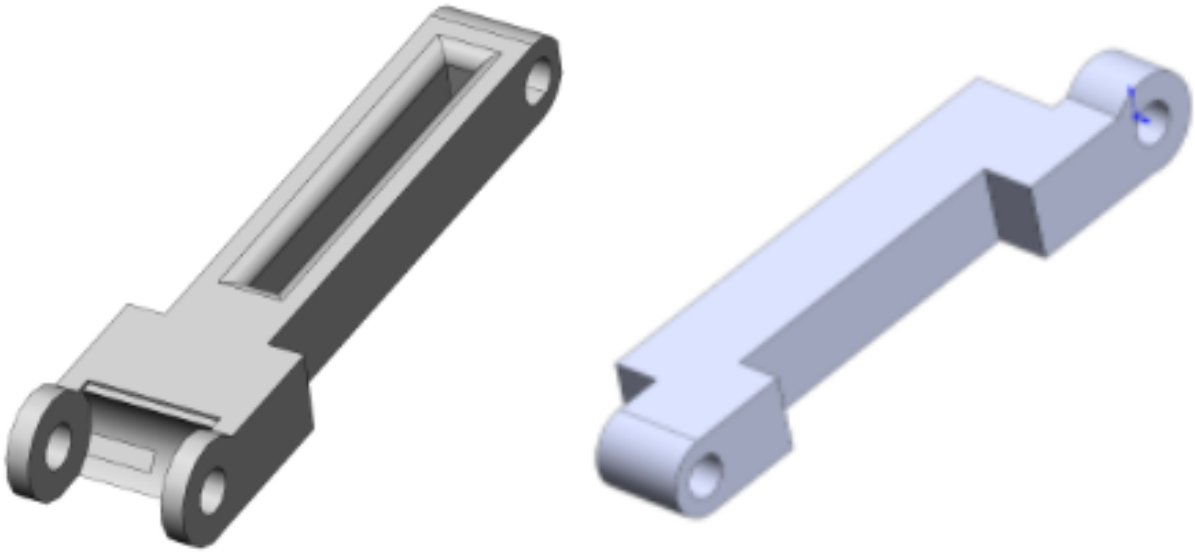

Figure 5: **Injection Molding Optimized Part Comparison**

2.3 House of Quality Diagram

Because there are no other products that have both a similar form and function to the Long Distance Teddy Bear, any products that aim to connect separated loved ones are considered competition and included in the house of quality.

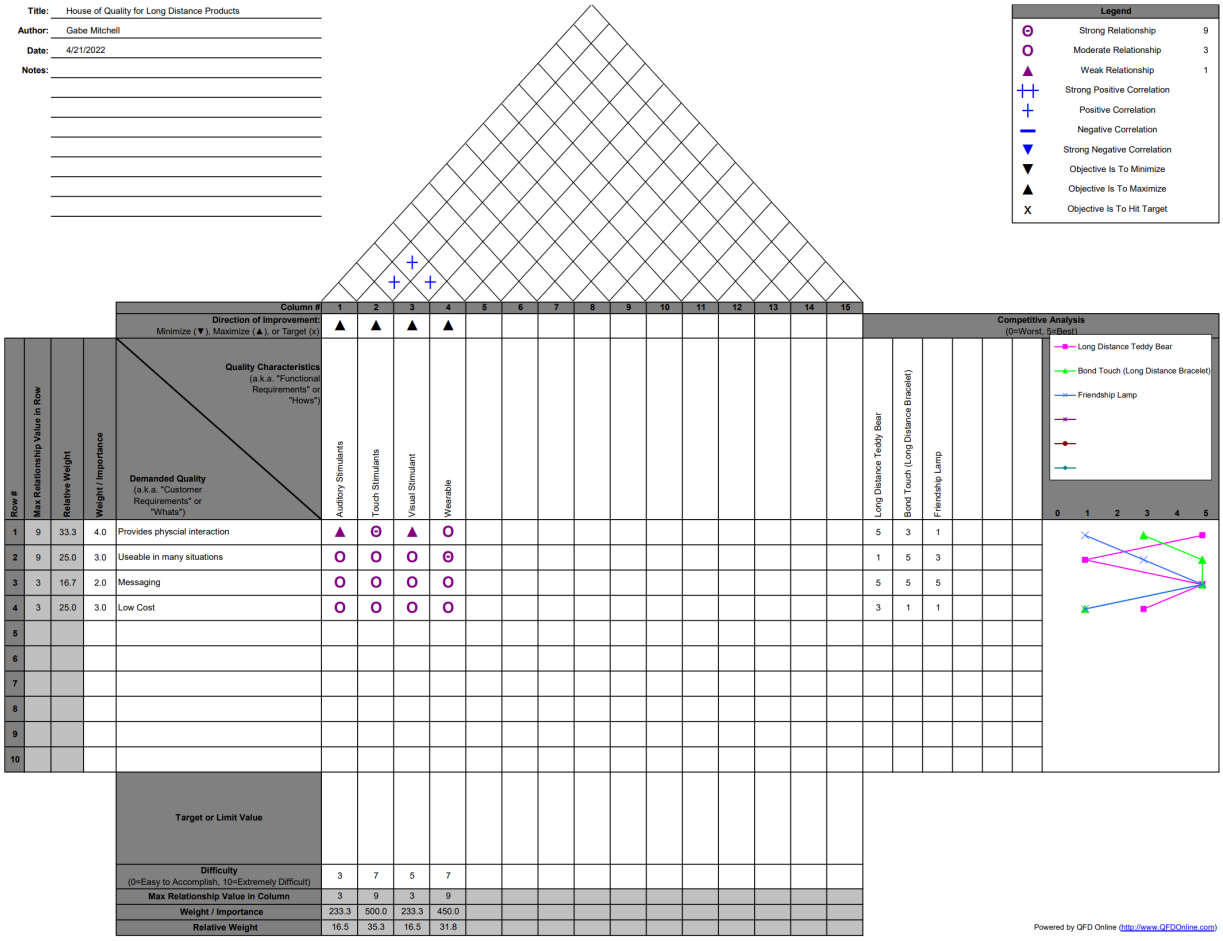

Figure 6: **House of Quality**

The main competitors to the Long Distance Teddy Bear are long distance bracelets and long distance lamps. The qualities desired by consumers are listed in the "Demanded Quality" section. They include low cost, the ability to send messages, usability in a variety of situations, and physical interaction. The Long Distance Teddy Bear and its competitors arrive at these characteristics in different ways, so only vary general attributes can be compared in the "Quality Characteristics" section. The characteristics include the nature of the stimulation that the product provides and whether or not it is wearable. The Long Distance Teddy Bear excels at providing physical interaction and messaging. The competition is either on par or worse than the Long Distance Teddy Bear with respect to these attributes. The Long Distance Teddy Bear's weakest attribute is usability, as its principle use case is only when customers and their loved ones are on a video call. The competition beats the Long Distance Teddy Bear in this respect. Lastly, the Long Distance

Teddy Bear is not yet at an appropriate price point due to the expensive actuators used in the prototype (four, $20 Servos). However, the competition is equally or more expensive, and the Long Distance Teddy Bear has plenty of room to cut costs, primarily by using cheaper servos.

2.4 Use of TRIZ

Improving the pressure created by the teddy bear's hugs while not increasing complexity was a contradiction TRIZ helped solve. The general solution that TRIZ proposed was a parameter change. When applied to the Long Distance Teddy Bear specifically, that entailed increasing the gear ratio between the servo and arm joint. This increased the torque applied to the system while also making movements less jerky. A higher gear ratio gear set is not yet included on the physical prototype, as the original gear set is already integrated.

2.4.1 Innovation

The Long Distance Teddy Bear is innovative because it applies existing technologies (mechatronics and internet communication) to a new use case - a stuffed animal designed for people separated from their loved ones).

2.5 What is the embodiment of your solution?

Mechatronics and internet communication came together in my solution to form a robotic teddy bear that people can use over the internet to interact with their loved ones.

2.5.1 Pictures of physical prototype Iterations

The first physical prototype was only part of the bear's arm. This prototype validated the wire and spring mechanism that actuates the bear's forearm once the entire arm has rotated a certain angle.

Figure 7: **First Prototype**

The second prototype was an entire arm. It was actuated by servos, but its movement was too quick, sudden, and unpredictable.

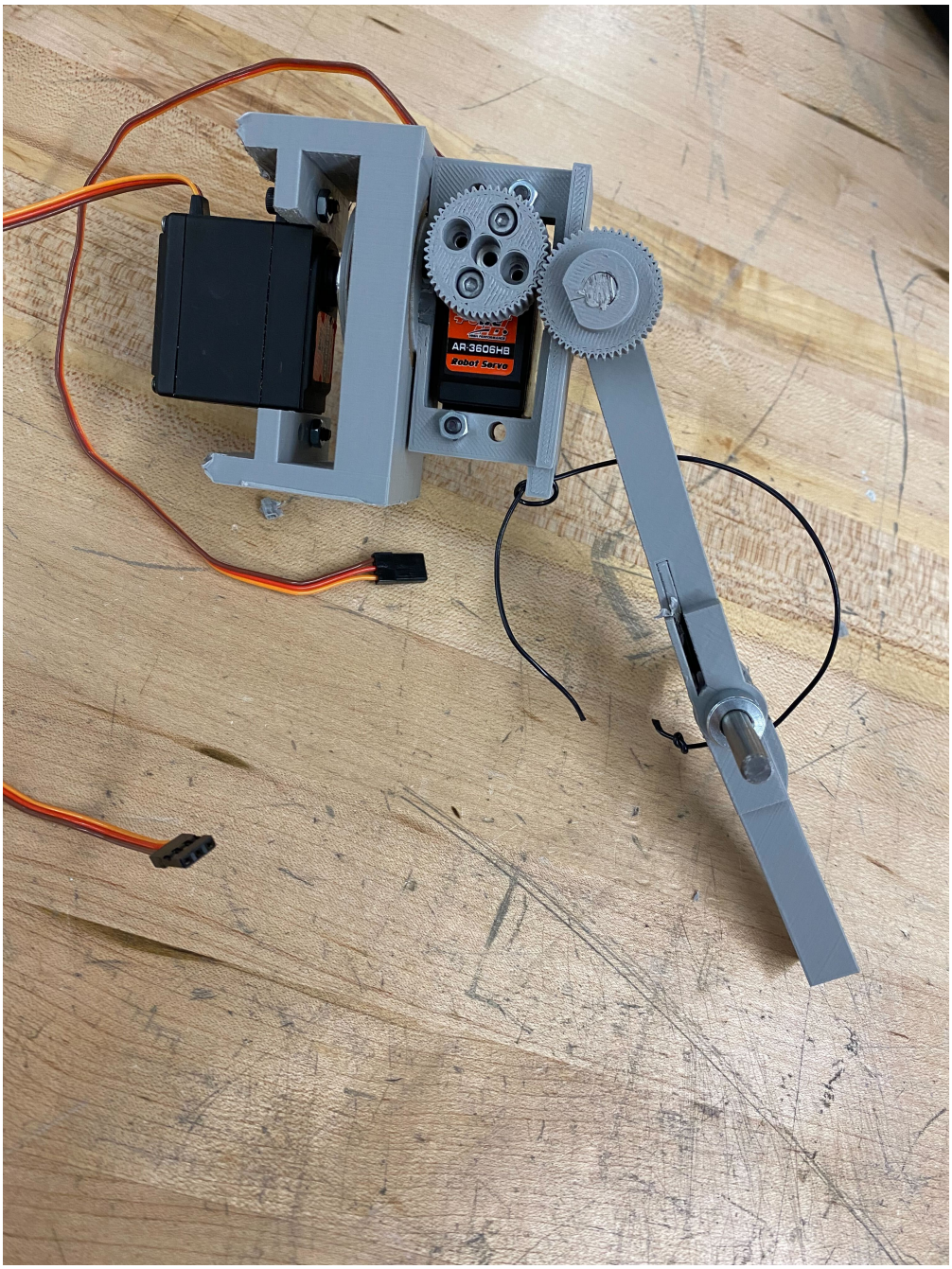

Figure 8: **Second Prototype**

The third prototype included several changes for ease of manufacturing and assembly. It also incorporates positional rotation servos and COTS gears, which dramatically improved the bear's motion.

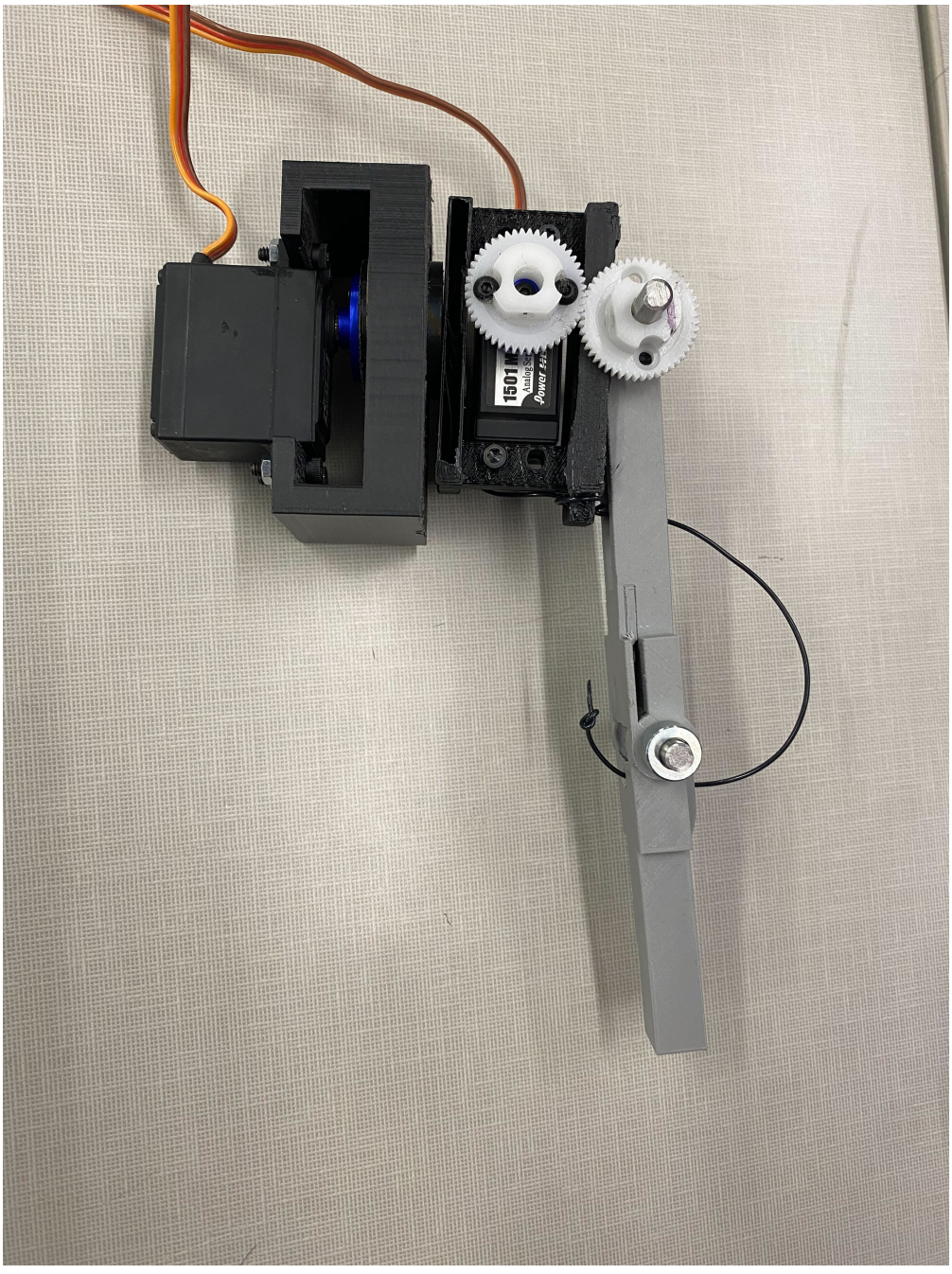

Figure 9: **Third Prototype**

As previously described, the most recent prototype included additional design changes for injection molding, prints for the entire mechatronic skeleton, and stuffed animal integration. The mechatronic skeleton and stuffed animal are again pictured below.

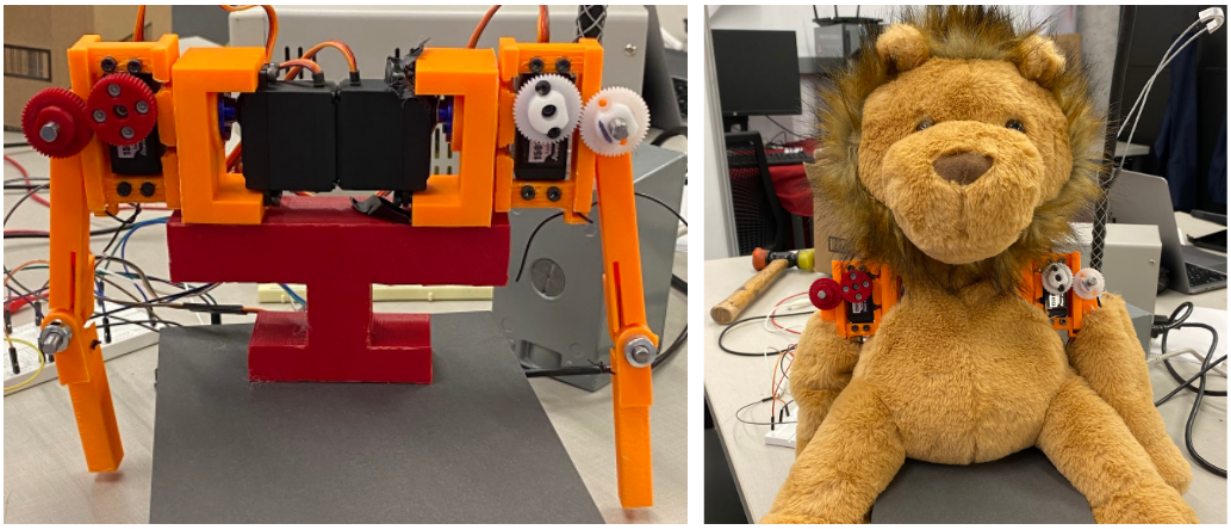

Figure 10: **Most Recent Prototype**

2.6 Project Deadlines

2.6.1 GANTT chart

The Gantt chart below shows how work was organized over the course of the semester. Projects were typically given two week time tables in between spring progress reports.

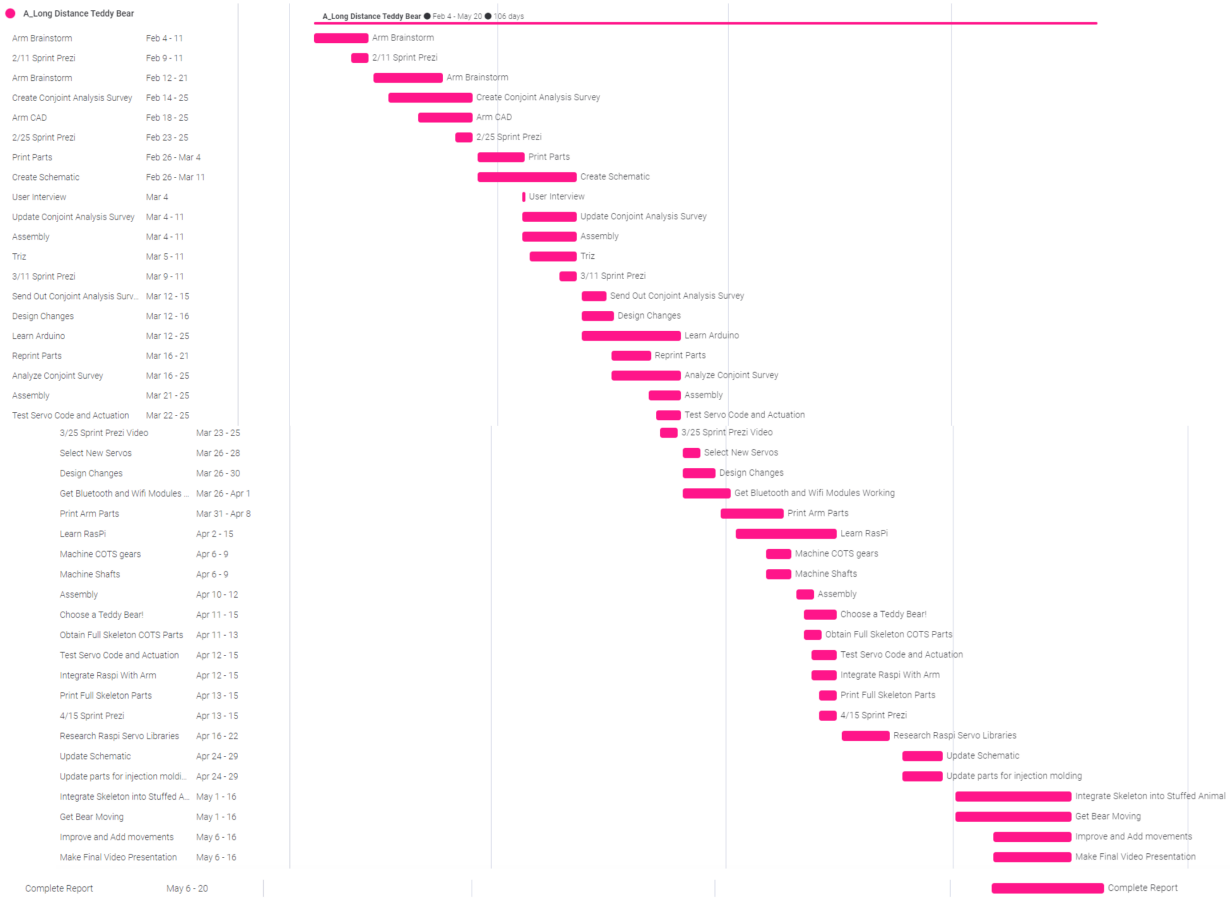

Figure 11: **Gantt Chart**

3 Market Identification

3.1 Target Market

The market for the Long Distance Teddy Bear is any person separated from their loved one. That could include traveling professionals, people at risk to COVID-19, individuals in long distance relationships, and others. Per Statistica [1], there are roughly 450 million domestic business trips in the United States each year. That is 450 million instances where the Long Distance Teddy Bear is relevant to customers. According to research done by KFF [2], based off information from the CDC, 4 in every 10 adults in the US are at high risk to COVID-19. That is 92.6 million people that could use the Long Distance Teddy Bear to more safely interact with their loved ones. Lastly, according to research done by a Long Distance Teddy Bear competitor, Friendship Lamps [3], there are 28 million people in the U.S. that are in long distance relationships. That is 28 million more people that are potential Long Distance Teddy Bear customers.

4 Legal Requirements

4.1 Patents

A utility patent is the correct pursuit for the Long Distance Teddy Bear, as opposed to a design patent. Utility patents are intended for products that innovate the way an article is used or works. Because the Long Distance Teddy Bear provides a novel use case for mechatronic stuffed animals, a utility patent is appropriate. However, because the Long Distance Teddy Bear appears to be nothing more than a stuffed animal, a design patent is not applicable.

Secondly, the Long Distance Teddy Bear name is novel, so pursuing a trademark is the correct decision.

References

[1] Statistica, 2022. *Number of domestic business and leisure trips in the United States from 2008 to 2019 with a forecast until 2024*. https://www.statista.com/statistics/207103/forecasted-number-of-domestic-trips-in-the-us/.

[2] Wyatt Koma, Tricia Neuman, Gary Claxton, Matthew Rae, Jennifer Kates, Josh Michaud. *How Many Adults Are at Risk of Serious Illness If Infected with Coronavirus? Updated Data*. KFF, 2020. https://www.kff.org/coronavirus-covid-19/issue-brief/how-many-adults-are-at-risk-of-serious-illness-if-infected-with-coronavirus/

[3] Friendship Lamps, 2022 *Long-distance Relationship Statistics 2020 - Backed by Research*. https://www.friendlamps.com/blogs/friendlamps/long-distance-relationship-statistics-research#:~:text=Overall%2C%2014%20million%20couples%20(28,and%20lack%20of%20travel%20freedom.