Mechanical Hand

Final Report

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by

Group 17

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Introduction

For our project we decided to make a mechanical hand because it is a worthwhile innovation that can potentially give someone, who may have an amputated arm, the ability to use a hand. The goal of this project was mainly to help assist those who have lost an arm because of a medical disease or occupational injury. Right now there are several options for those needing prosthetic limbs, but there are not a lot of options for hands with 5 fully functional fingers. For this reason we have designed and built a mechanical hand in the hopes that the technology we have designed could one day be used by those in need of a prosthetic limb. The current design may be better used just as an arm extension rather than as a prosthetic limb because of the design mechanism used to make the fingers move due to the minimal amounts of allotted time, a relatively low budget, and the lack of access to ideal materials. We began working on our project by thinking of possible designs and then trying to make prototypes of the different ideas to see which would be the best option.

Abstract

Our intention was to make a mechanical hand that could be used to assist anyone who has had an arm or hand amputated, and although that would be a very good use there are other possible uses, such as an arm extension, which would be helpful for those in wheelchairs or those of old age. This technology would be an innovation in the prosthetic community because of its similarity to an actual hand, in that it has and can control the movement of five fingers independently. We made our initial prototype of one finger using PVC pipe and string in order to make sure that our goal for the project would be possible to achieve. We then made a second prototype of a finger out of aluminum, which ensured that our hand would work. We made all of the segments of each finger and then continued to make the palm of the hand, which contains a separate plate for the thumb so that the movement would be more realistic. Each segment of every finger is connected by a hinge and the actual movement of the fingers is achieved by running a high tension steel cable through the fingers and then through the dual-plate design of the palm. The hand will be able to easily be strapped onto the users arm and then controlled with the movement of the users hands.

Methods

In the planning stages of the design of the mechanical hand we decided to make a simple prototype of our intended design to ensure that our idea would work. Rather than make a model of the entire hand we only made one finger since the design of all of the fingers, excluding the thumb, is the same apart from minor size differences. To make the initial design (Figure 1) we began by cutting PVC pipe into the three separate segments of the finger. We then designed a rudimentary hinge to connect the three segments. A string was run through the length of the hollow finger which allowed us to control the movement of the finger. (Figure 2) By designing this prototype we discovered several things that would need to be changed for the next design, some of which we had already foreseen during planning. We realized that we needed to use some sort of rubber along the back side of the finger so that it would remain erect when the string was not pulled. We also decided to use a different type of hinge so that the final product would not only function more accurately but also have a sleeker appearance. As we had originally suspected we also needed to use a material other than PVC pipe so that the design would look less sloppy and so the hand would be stronger and more durable.

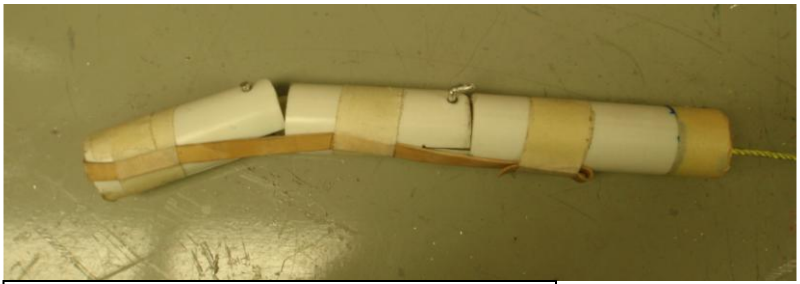

Figure 1: First prototype, three segments with hinge

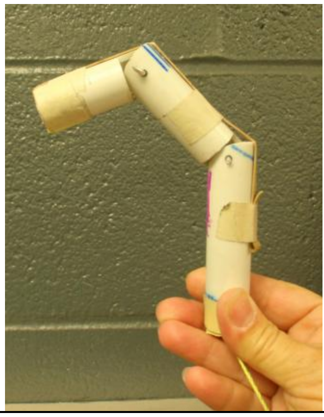

Figure 2: First prototype, string run through center to bend finger

Our second prototype was basically the same as our final design aside from being a different size. At this point we knew that we would have to make three different segments for each finger so it would look and work as much like an actual hand as possible. We used solid, ¾ inch aluminum to make the second finger. After producing the second model we came to the conclusion that it would be a good design because it was strong enough that it would not break but still light-weight enough for practical everyday use. For the final design we increased the size of the finger by using a lathe to cut down 1-inch aluminum to a diameter of .875 inches. The first step in making the finger was to mill a flat side onto the aluminum which, during production, would be used as a reference when placed in the mill but would later be the back the finger. Next we milled the male and female piece of the hinge (Figure 3) onto each of the segments that would join together to make an interlocking hinge, which would be the mechanical equivalent to the joint of a human finger. The two parts of the hinge were then joined by drilling a hole through the pieces and then placing a brass pin through that hole which would be the central pivot point for the joint. In order for the joint to be movable and fully bendable we then had to mill the aluminum at a 45 degree angle (Figure 4) on either side of the hinge.

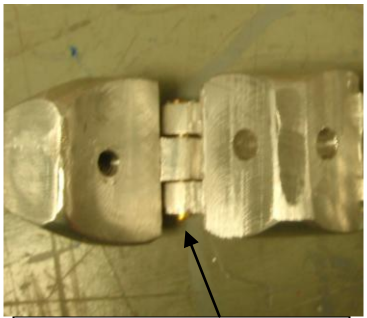

Figure 3: Interlocking hinge

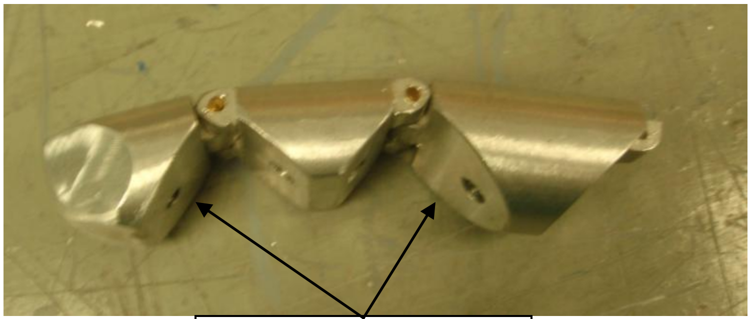

Figure 4: 45 degree angles

After that we decided to mill the tips of the fingers so that they looked more like fingers (Figure 5) and to make it possible for the hand to pick up smaller items with more accuracy. To do this we milled a 30 degree angle on the tip and 60 degree angles on the two sides of each finger. In order to make the fingers remain straight majority of the time we attached rubber strips to the back of each of the fingers. After doing so we realized that some of the fingers were bending backwards a little too far which would make it nearly impossible for them to be bent in towards the palm. To correct this we attached a metal plate (Figure 6) to the back of each finger to cover each joint and inhibit any backwards motion from occurring. The next step was to figure out a way to run a cable down the length of the finger so the cable could be pulled, which in turn would bend the finger. To make this possible we drilled a hole (Figure 7) through the middle of each of the segments, excluding the finger tips, so a plastic-coated steel cable could be run through the fingers and attached to the tip of each finger using a screw.

Figure 5: Angled finger tip

Figure 6: Metal plate to prevent backwards motion

Figure 7: Wire cable through finger

After all of the fingers were made we began working on the palm. We decided to use a dual plate system made up of two separate ½ inch aluminum plates, which would later be bolted together. The shape we wanted for our palm (Figure 8a) was drawn onto the aluminum and we then used a vertical band saw to cut the aluminum to the correct shape. The thumb (Figure 8b) needed to be designed differently since, like a human hand, the thumb bends a different way than the rest of the fingers. In order to achieve this we cut a piece out of the palm so it would be able to move towards the center of the palm. A rubber sheet was also attached across the gap that separated the thumb from the palm so that the movement would not be too broad and unrealistic.

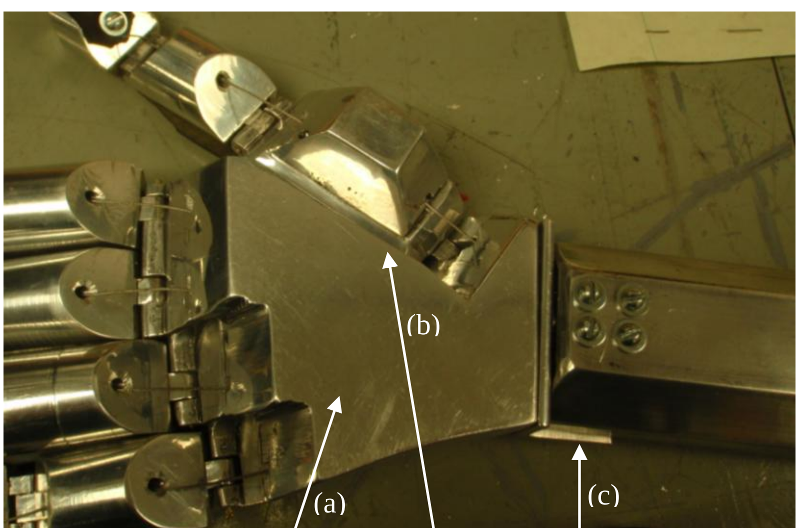

Figure 8: Palm design, thumb cut-out, arm attachment

The cables that go through each of the fingers needed to run past the palm and the best way to achieve this was to run the cables through the palm. To make this possible we milled five separate grooves, which were big enough to run the cable through, out of one of the metal plates. After the two halves of the palm were screwed together the cables were easily run through each of the grooves. In order for it to be possible to pull the cables and make the fingers bend the hand needed to be mounted and attached to the users arm. The hand was screwed onto a metal equivalent to a human arm (Figure 8c). We attached straps to the other end of the arm and then ran the cables through a metal plate, which was installed to keep the cables from moving too far from where the user's hand should end. Each cable was attached to a metal key ring (Figure 9) that the user will be able to pull and in turn bend the fingers.

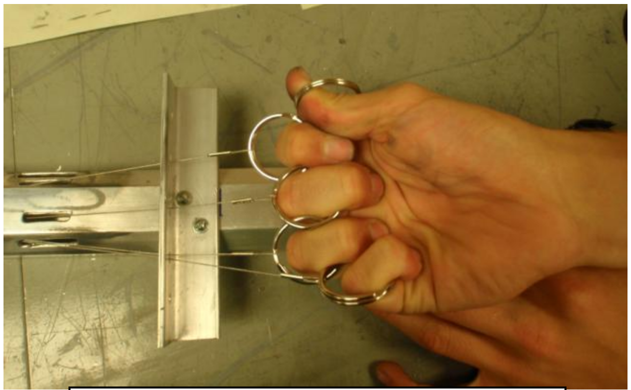

Figure 9: pulley system for finger movement

Analysis

In the production of the mechanical hand we were faced with many expected but unpredictable challenges, some of which we were able to fix easily, and some which would require a second prototype to fully overcome. One problem encountered was trying to figure out what would be the ideal material to use to make the hand. At first we considered using PVC pipe which was too sloppy and too hard to maneuver and work with. We also considered using steel, which has excellent strength but is also more difficult to machine. Another possibility was Delrin plastic, which is relatively weak and also is not very visually appealing. We finally decided to use aluminum which is stronger than Delrin but weaker than steel so it is much easier to work with than steel. Aluminum is also lighter than steel which makes it the optimal material to use.

There were also some problems with design such as what shape to make the palm and also how to make the thumb work more realistically. Even after the final palm was cut several changes were made to its shape after we realized that some of the cuts needed to be straighter so we could mount the hand onto the arm piece and so we could attach the fingers to the palm more easily. Not only was the shape changed multiple times, but an entire piece was removed and reattached using a hinge to give the thumb a wider range of motion. Initially the rubber strips we used to make the fingers remain straight were too strong, which was easily fixed by cutting the strips downs so that they were thinner. We also had problems with the plastic rubbing off of the steel cable, which we thought might weaken the cables. Each cable went through holes in the segments of the finger so we widened the ends of the holes so that the cables would stop scraping. Some small setbacks were encountered, such as a drill bit breaking inside a segment forcing us to remake that segment of the finger. As previously stated, at first the fingers overextended which made them very hard to bend. If we were to make another model of the hand we would line the hinges up before the hole was drilled for the brass pin. Overall, the problems we encountered were only minor setbacks, none of which made completion of the mechanical hand impossible.

Conclusion

The design and production of this mechanical hand is helpful in advancing the technology currently used in making prosthetic hands or robotic arms. There are many ways we could use our mechanical hand, some of which include using the hand as an arm extension for those limited to wheelchairs, or as a prosthetic limb. If we were to have time to make another hand we would consider making it out of Delrin plastic, which would have been faster to produce and assemble, as well as make sure that the joints moved more smoothly. We would also design a thumb that had a broader range of motion to act more like an opposable thumb. The hand, of course, needs some improvements and adjustments so that it acts more realistically and more like a human hand. All in all, the hand we made is a good basic model that, in the future, could become a more widespread and accessible by the majority of the population.