ROBOTIC FINGERSPELLING HAND FOR THE AID OF THE DEAF AND BLIND

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EXECUTIVE SUMMARY

This quarter, work continued on the design and construction of a robotic fingerspelling hand. The hand is being designed to aid in communication for individuals who are both deaf and blind. In the winter quarter, research was centered on determining an effective method of actuation for the robotic hand. This spring 2008 quarter, time was spent designing the mechanisms needed to mimic the size and motions of a human hand. Several methods were used to determine a proper size for the robotic hand, including using the ManneQuinPro human modeling system to approximate the size of an average male human hand and using the golden ratio to approximate the length of bone sections within the hand. After a proper average hand size was determined, a finger mechanism was designed in the SolidWorks design program that could be built and used in the robotic hand.

INTRODUCTION

There are a large number of individuals who are unable to hear and unable to see. In the United Kingdom alone, there are over 20,000 (Sense, 2003). As one might imagine, it is very challenging for these individuals to communicate with others. These people are incredibly creative and adept at creating methods of communication. However, for normal speaking situations, they usually use sign language to form words for others to see. To listen to others, they usually feel the hands of someone spelling out words with the single-hand manual alphabet. These limitations obviously make it difficult for the deafblind to communicate with individuals who are not familiar with sign language.

To make communication easier for these individuals, the creation of a portable robotic hand will be developed, which will form sign language letters based on input from a keyboard, computerized text, and eventually voice. This would help persons unfamiliar with sign language to effectively communicate with persons who are affected by deafblindness, as well as serve as a valuable tool for young deafblind persons as they learn fingerspelling[1].

DESIGN

In designing a robotic fingerspelling hand that is easy for a deafblind individual to use, it is essential to design the device with dimensions similar to those of an average human hand. This will make it easier for deafblind users of the hand to effectively understand letter symbols made by the hand. The hand will be used to teach fingerspelling to deafblind users, and if its size is varied too much from a typical human hand, it will be difficult for a deafblind user who learned fingerspelling on the robotic hand to decipher letters formed on a human hand, and visa versa.

For these reasons, great care was taken to obtain typical hand dimensions to be used in the design of the robotic hand. These dimensions were obtained with the ManneQuin Pro Human Modeling System. The software contains a digital 3D model of an average human body. The dimensions for this model

1 In this text, "fingerspelling" will refer specifically to use of the single-hand manual alphabet for communication.)

were taken from 1988 US military measurements. Before the actual design of any mechanisms took place, dimensions were obtained from the 3D model and used as dimensions for the fingerspelling hand. This was done by measuring coordinates at the points on the 3D models below and finding the distance between these coordinates (Figure 1).

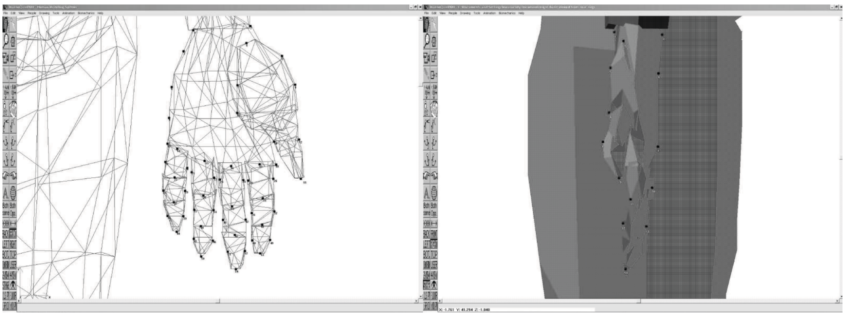

Figure 1 – Screen shots of ManneQuin Pro Human Modeling System software being used to find appropriate dimensions for a robotic hand.

As can be seen in Figure 1, it is difficult to determine the dimensions of linkages within individual fingers with the ManneQuin Pro Human Modeling System. It is almost impossible to tell from the model where the fingers bend. For this reason, the lengths of individual linkages were approximated numerically with a number known as the "golden ratio," a number which is often observed in natural phenomena and is said to be observed in the lengths of adjacent sections of human fingers (goldennumber.net).

To approximate the lengths of individual sections within each finger, it was assumed that adjacent sections of each finger had a length ratio approximately equal to the "golden ratio" or 1.61. Meaning the longer section is 1.61 times the length of the shorter section (Dunlap, 1997). The golden ratio isn't entirely accurate and it has never been scientifically proven that corresponding sections in the human body have lengths which follow the ratio exactly. However, measurements were taken of the student's hand who conducted this study, and the golden ratio was observed in the adjacent sections of the student's fingers with 94-97% accuracy, depending on which finger was measured.

In the design of the fingerspelling hand, it is crucial that the hand be able to mimic the motions of a human hand to the extent that a deafblind user will be able to interpret the symbols made by the robotic hand just as easily as they would be able to interpret a human hand. For this reason, the robotic fingerspelling hand should have close to the 22 degrees of freedom found in a human hand (Gilden, 1987). Initially, several finger mechanism designs were investigated that approximated the motion of one finger with a single movement by a single actuator. Namely, a design was investigated similar to that used in the Belgrade-USC hand discussed in Autonomous Mobile Robots (Bekey, 2005). A diagram of this mechanism can be seen in Figure 2 (Bekey, 2005). After some investigation, it has been determined that the finger motion produced by the BelgradeUSC hand is too simple and limited for use in a robotic fingerspelling hand. It was determined that a fingerspelling hand must have the ability to move individual sections of fingers without effecting the angular position of other fingers. The USC-Belgrade finger mechanism didn't have this ability, so it cannot be used in a fingerspelling hand design.

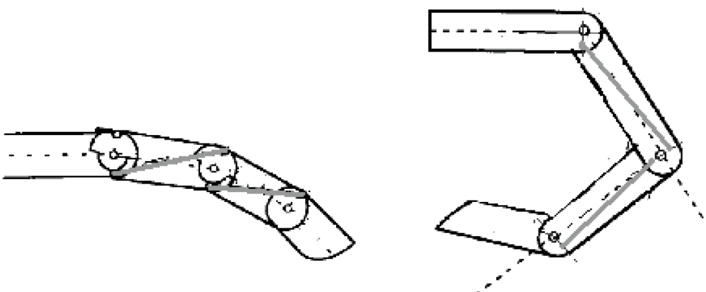

Figure 2 – Finger mechanism used in Belgrade-USC hand (Bekey, 2005). Internal linkages (red) create a realistic finger motion with only one degree of actuation. In this design each finger has one degree of freedom.

After the initial investigation of several designs used in robotic hands, a sketch was made of a finger design that would allow each individual section of a finger to move independently of the others. This design would be ideal for a fingerspelling hand, allowing a great deal of flexibility in hand motion (Figure 3). This design uses two wires to manipulate each individual section of a robotic finger. Each of these wires is extended down into the base of the hand, where it can be tensioned by a motor or other system of actuation. The

wires are arranged in such a way that actuation of any one of the wires will only affect the section of finger that the wire is attached to.

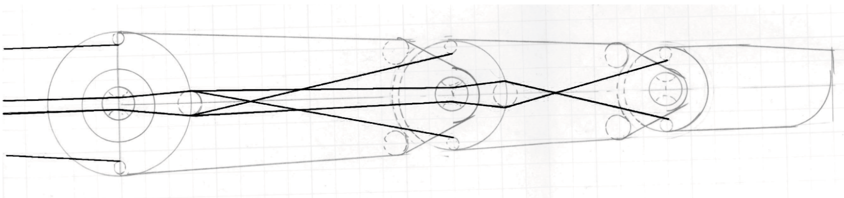

Figure 3 – Initial sketch of finger mechanism idea. In this design, each segment of the finger can rotate independently of the others by adjusting the tension in connecting wires (red). In this design, each finger has three degrees of freedom.

This design was developed into a 3D model using the SolidWorks computer drafting program (Figure 4). In this phase, many of the dimensional details left out of the sketch were determined. The creation of the robotic hand using CAD software is an important step, as the computer model can be used to create rapid prototyping models, as well as aid in final manufacturing of the hand. To create a finalized design of the robotic hand, five fingers must be designed and dimensioned completely. The dimensions of the single finger in Figure 4 can be adjusted easily in CAD software to create designs for the index, middle, ring, and pinky fingers. However, another finger mechanism must be designed to mimic the motions of the thumb, which is considerably more complex than the other fingers.

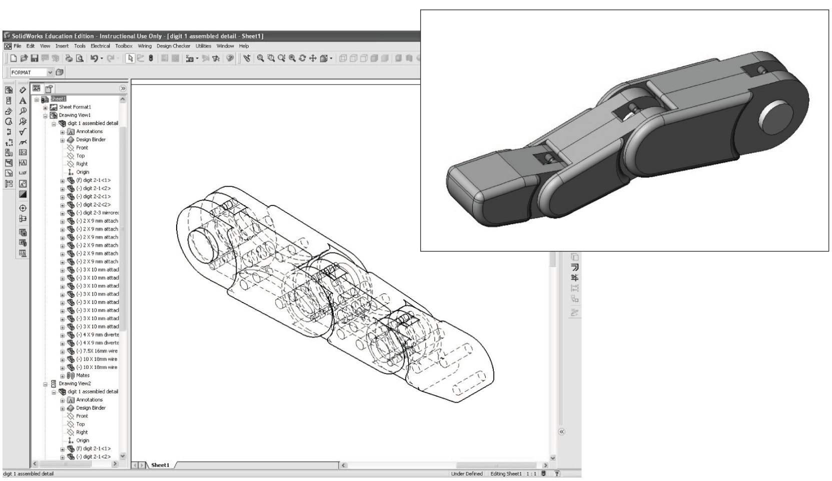

Figure 4 – SolidWorks assembly of a finger mechanism to be used in fingerspelling robotic hand (transparent view- left; solid view right).

CONCLUSION

Proper dimensions for a robotic fingerspelling hand were determined and an appropriate finger mechanism for the robotic hand was designed in SolidWorks. These are both important steps in the creation of a robotic fingerspelling hand to help individuals who are both deaf and blind communicate.

FUTURE WORK

There remains a great deal of work that must be done on the design of the robotic hand. The mechanisms for the center (palm) of the hand and the thumb have yet to be designed. Work will continue in these areas in the Fall quarter of 2007.

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