Abstract

The purpose of this proposal is to obtain the necessary support to build a life-sized, fully functional mechanical hand. Research and design began in early December 2009 for a hand that has the dexterity of a normal human hand that can be controlled remotely by a glove and be operated by anyone. In this project, we will bring Electrical, Bio-Medical and Mechanical Engineering practices together in our quest for higher education and to provide a firm platform which will lead into advanced prosthetics. In the fall semester of 2009, we built a basic mechanical hand out of balsa wood and fishing line using a hard wired joystick controller (appendix A). While the purpose of the project was for an engineering course, the project itself became very captivating and inspired an un-ending wave of inspiration and imagination. We are advancing this project over the next year and a half which brings us to Phase II of the Mechanical Hand.

During the Spring 2010 semester, we intend to complete Phase II of our project, a working, wireless model of a mechanical hand. Our first goal is to finish design and manufacturing of a working model of a mechanical hand with a structurally sound, and efficient base. The base or forearm will contain the motors, gear boxes, and a microprocessor/receiver that will operate the hand. Second, we need to design a "glove" that will contain the various sensors and relays required in our design. Finally, we will be programming a microprocessor that will be installed in the glove which will collect data from the sensors on the glove and transmit organized data to the receiver in a form that can be recognized by the microprocessor in the mechanical hand. With the completion of these three goals, Phase II of our mechanical hand project will be successful.

Introduction

Some of the problems and challenges that this project faces include;

- Can a one to one ratio of movement be accomplished?
- By using a glove interface can we accomplish a more fluid movement?
- How much gripping power can we generate?

In many facets of life there is a growing demand for a flexible, dexterous mechanical device capable of performing the same tasks as the human hand. The impact that a dexterous, smooth operating, mechanical hand that is affordable could have in the prosthetic industry would be a huge leap towards helping injured people regain independence. They could gain the ability to do many tasks for themselves that are otherwise difficult to do single handed or with the crude pinchers that are widely used today. While other complex hands are being researched and prototyped, these projects are being developed with budgets ranging from $100,000 to $1,000,000 or more (Murph, 2007).

It is our goal to further our research in Engineering and also begin to include the Medical resources that are available through the WWAMI program here at UAA. By working with medical professors involving anatomy and neurology topics, we can prepare ourselves to take the biological classes necessary to take this project to the next level.

Research Design

We have split up the design process into three components. The first component is hand design. The second component is glove design, and the third component is the hand/glove interface. Steve is leading the hand design. Jens is leading the glove design, and Tim and Sarah are leading the interface design.

The hand is being designed in Pro Engineer, a 3-D mechanical modeling program, similar to Auto Cad. The finger joints will be outsourced to a stereolithography company. Stereolithography is a prototyping procedure using lasers to manufacture a component out of a liquid photopolymer material. (DPT, 2006) The machine uses the drawing files to manufacture the desired 3-D product. The other components will be manufactured using our own CNC machine here at UAA. The hand itself will be mounted to a frame work that will contain the motors and other components necessary in the project. The glove is being designed around a heavy leather/vinyl work glove that has the durability to have sensors, wires and other electrical components securely attached to it. By using flex sensors (Image 1) we can control

Image 1 - Flex Sensor

stepper motors by programming a degree of rotation to correspond with the resistance in the flex sensors. By using a microprocessor to translate this resistance from the flex sensor, and interfacing with the mechanical hand we can create a smooth power delivery and range of motion. Increasing the strength of the elastic being used on hand itself will create more griping power. A transmitter will be attached to the glove and a receiver and motor management system that will be hard wired to the mechanical hand. The final product will be a remotely operated mechanical hand that can be operated using a glove, plus the knowledge and experience necessary to bring us one step closer to developing an advanced prosthetic hand.

Anticipated Results

By the end of Phase II we have several outcomes that we expect to have completed. The following is a list of our anticipated results:

- Mechanical hand
    - Stepper motors implemented for hand actuation.
    - Wireless receiver implemented for communication with glove controller.
    - Motor Controller
- Glove
    - Implementation of flex sensors.
    - Wireless transmitter
    - Microprocessor

The goal of phase II in our project is to create a "glove" with sensors, a transmitter, and a microprocessor so that when a person wearing the glove moves his/her fingers, our mechanical hand will duplicate that movement. The purpose of the microprocessors is to take raw data from the movements of the sensors on the glove worn by a person, and to organize this data into recognizable signals that can be transmitted to our mechanical hand which can then receive the data causing it to move accordingly. The "distal", "intermediate", and "proximal phalanges" of our mechanical hand will be made out of a composite material used in the stereolithography process. These pieces will be joined together with the "palm" to complete the hand. The mechanical hand will be attached to the main motor structure and the motors will be installed and connected. These are the results that we expect to have completed.

Project Budget

Our budget consists of the hardware components and raw materials necessary to develop a new hand. The only part of the project that will be outsourced is the "phalanges", the four individual parts of the finger that are necessary to create a functioning finger. Since CNC manufacturing would cost thousands, we opted to use a process called stereolithography. This process is briefly explained in the Research Design portion of this proposal. The remaining hardware and structural parts will be manufactured in the UAA Design Lab.

	unit price		units		sub total
Mechanical Hand					
Stereolithography	$ 1,000.00		1		$ 1,000.00
Aluminum materials	$ 500.00		1		$ 500.00
Composite materials	$ 200.00		1		$ 200.00
Stepper Motors	$ 35.00		20		$ 700.00
Stepper Motor Controller	$ 200.00		2		$ 400.00
Human Interface					
Flex sensors	$ 12.00		25		$ 300.00
AXON II control board	$ 150.00		2		$ 300.00
XBEE transmitter/reciever	$ 100.00		2		$ 200.00
Shipping costs					$ 200.00
				Total =	$ 3,800.00

Budget Justification

- Stereolithography
  - Stereolithography is the cheapest way to prototype a product to exact specifications and the University does not have this capability.
- Aluminum Stock
  - Aluminum stock required to machine the structural components of our hand, and to secure the multiple motors that will be mounted in the "forearm" to control the hand itself. UAA does have the equipment necessary for us to machine these components.
- Raw Composite materials
  - We are using composites to create "pads" on the fingers and palm to provide grip.

- Stepper motors
  - These motors will control the fingers, thumb and hand and their various directions of motion.
- Stepper motor controller
  - These controllers are required to operate the stepper motors.
- Flex Sensors
  - Each flex sensor will generate a signal that will be computed and relayed to a corresponding motor.
- Axon II control board
  - These boards have microprocessors that can be programmed to receive the data from the sensors, and convert it to a signal that can be received by the motors.
- XBEE Transmitter/Receiver
  - The transmitter is wired to the control board so that is can transmit the signal from the microprocessor to the receiver that is mounted to the processor on the mechanical hand.
- Electrodes
  - The Bio-electrodes will be used to measure and map the electrical signals generated by the muscles in the forearm as we attempt to map the signals required to move fingers, thumbs and wrist.
- Electrode Lead Assembly
  - The lead assembly is used as a "hub" for the electrodes to connect to hardware for mapping and actuation purposes.

Project References

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Project Timeline

Task	Duration, days	Start	Finish
ProE hand design	25	2/1/2010	3/5/2010
Hand Manufacturing	20	3/8/2010	4/2/2010
Test motors w/ hand	10	4/5/2010	4/16/2010
Order parts	45	2/1/2010	3/15/2010
Test sensors	30	3/15/2010	4/15/2010
Test motor control	30	3/15/2010	4/15/2010
Build control glove	60	9/1/2010	11/1/2010
Interface glove to motors	60	9/1/2010	11/1/2010
Test motor control w/ glove	60	9/1/2010	11/1/2010
Install motors in new hand	10	1/15/2011	1/25/2011
Test glove/hand interface	60	1/25/2011	3/25/2011
Prepare presentation	10	3/26/2011	4/6/2011
Undergraduate Symposium	mid-April	4/6/2011	4/20/2011
Expenditure Deadline	31-May-11		
Final Report Deadline	15-Jun-11		

Appendix A

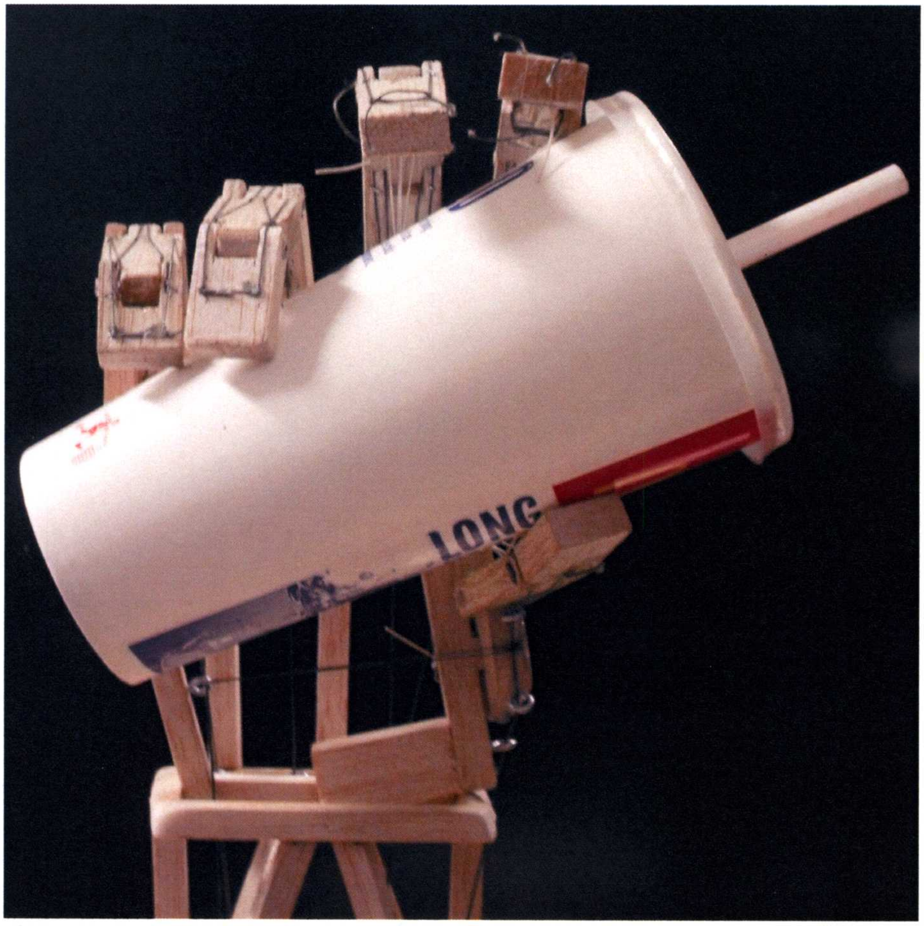

Figure 1 - Mechanical hand during phase I as of December 2009.

Appendix B

Figure 2 – From left to right, Sarah Aiken, Steve Sutton, Jens Jenson and Tim Eby presenting mechanical hand (Phase I) at the Engineering Design Competition Spring 2009.

Appendix C

Figure 3 – Mechanical hand Full view as of December 2009.