THECOOPERUNION

# THE MYOELECTRIC HAND


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## INTRODUCTION

Prostheses were invented in early Egyptian times as a cosmetic solution to amputated limbs. Since then three forms of prostheses have evolved: cosmetic, body-powered, and myoelectrically controlled.

Myoelectric prostheses use live electrical signals from the nervous system to power a motorized mechanical prosthetic device. These electrical signals are read from the surface of the skin relatively close to the site of amputation and help restore the function of the lost limb to a greater extent.

## MOTIVATION

Existing myoelectric prostheses are capable of improving functionality, but are usually prohibitively expensive. Costs range from $70,000 – $100,000, not including recurring maintenance costs.

Myoelectric control has the potential for replicating fine motor functions, which are harder to restore.

## PROBLEM STATEMENT

To create a suitable myoelectric prostheses for use in developing countries which:

a) Establishes pattern/ frequency recognition as a trigger
b) Restores functionality to a suitable extent
c) Remains affordable (costs less than $ 500)

## EXISTING TECHNOLOGY

Cosmetic: Only aesthetic, not restorative, hard to clean

*Fig. A1: Body-powered device [1]*

Body-powered: Simple, hard to wear, strenuous to user, restorative for large scale motion. Approx cost: $ 30, 000

Myoelectric: One leading company in the field of myoelectric devices is Touch Bionics; their products include the i-Limb and Pro-digits. Approx cost: $70,000 - 100,000.

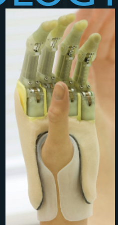

*Fig. A2: Myoelectric device [2]*

## PREVIOUS WORK

A previous ME 363 project group succeeded in making a prototype for under $160. This prototype is triggered by an arbitrary muscle and is threshold dependent. The disadvantages include limited functionality, only one degree of freedom, and susceptibility to electronic interference.

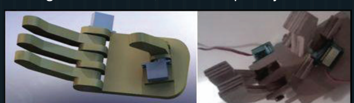

*Fig. A3: Independent study project prototype from Spring 2009*

# DESIGN GOALS

## ELECTRONICS

### FEEDBACK

In the current prototype, there is no feedback loop to sense the tightness of the grip once the motors have been actuated.

**Design Goal: Force sensitive resistors will be added to measure a feedback signal and use it to enhance the control mecha-**

### NOISE CONTROL

The current data acquisition system is susceptible to noise. Possible reasons include:

- exposed leads
- ambient electromagnetism.
- internal neurological signals.

In Fig. B1 on the right, EMG is the signal of interest.

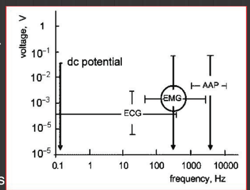


*Fig. B1*

Critical observation: ECG and AAP signals have similar frequency and amplitude ranges which interfere with data acquisition.

**Design Goal: Develop a more robust data acquisition and filtration system in order to eliminate as much interference as possible.**

## MECHANICAL

### DEGREES OF FREEDOM

The existing prototype has one only degree of freedom. In addition, the mechanical design of the fingers is limiting.

An important consideration is to minimize the weight of the entire assembly.

**Design goal: Add two more degrees of freedom to the existing design. Spring and cable system shown in Fig. 7 will be modified and adapted to the design.**

### GRIP PATTERNS

**Design Goal: Establish a pattern/frequency recognition that isolates signals dictating specific grip patterns.**

*These are two of the three grip patterns to be replicated in the prosthetic device.*

*TouchBionics i-Limb hand demonstrates the precision grip (**Fig. B2**, far left) and power grip (**Fig. B3**, immediate left). [4]*

# CURRENT STATUS

## ELECTRONICS

Research into the EMG signals was carried out via computer. The equipment used was:

- A National Instruments data acquisition device (NI 6009 DAQ)
- Triple shielded leads (Fig. C1)
- LabVIEW software.

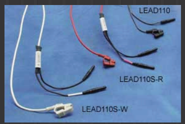


*Fig. C1: Triple Shielded Leads*

LabView was used to test various types of analogue and digital DSP techniques virtually. (Fig. C6)

**Observation:** A major noise source found at 60 Hz. May correspond to electromagnetic signals in the atmosphere.

A band stop filter has been placed to suppress the contribution of this major noise source.

**Noise control methods revealed that EMG's around 30 - 200 Hz correspond to muscle excitation.** When contracted, data shows greater amplitude in the 30 - 200Hz frequency range compared to when relaxed (**Fig. C7-8**). This behavior can be used to define a possible trigger to control the mechanism for the hand.

**Feedback Loop:** The force sensitive resistors [Fig. C2] will be attached to the middle digit of each finger and used to judge the tightness of the grip, and thereby the duration of motor activation.


*Fig. C2: Force-sensitive Resistor*

## MECHANICAL

A qualitative goal of 7 lbs was set for the weight of the entire mechanical device (not including the circuit as of yet).

A degree of freedom was added to the device by separating finger and thumb control.

Movement Resolution was added by incorporating a "finger curl" mechanism.

"Finger Curl" Mechanism: Movement will be driven by a motor which winds the cable in order to tighten or loosen the grip. A spring will the straightening force.

The motor is controlled by digitally processed EMG signals

The finger has been modeled in Solid Works (Fig. C5). This will be used to rapid prototype the parts.

*Fig. C3: Existing finger design on prototype*

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*Fig. C4: Proposed design modification to add degrees of freedom*

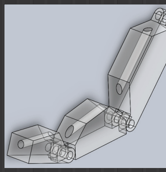


*Fig. C5: Solid Works design of finger*

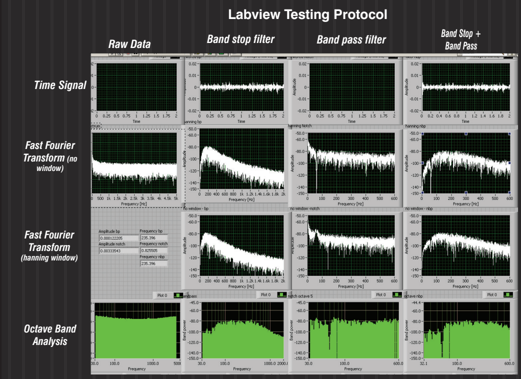



*Fig. C6 (above): Lab view VI used for signal analysis. Three different protocols were followed (columns). Four representations of the signal were shown (rows)*

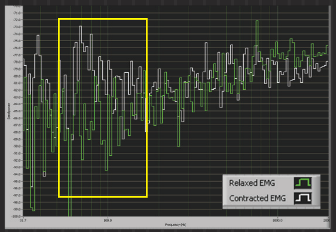
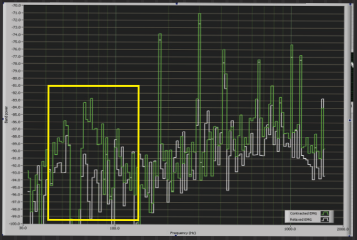



*Fig. C7 (left): Octave band analysis of the filtered signals shows a clear increase in activity in the indicated range. The white trace represents EMG's from a contracted muscle. The green trace represents the EMG's from a relaxed muscle. The activity being recorded was the opening and closing of a hand with periods of rest for control. Can be used to establish a triggering protocol.*

*Fig. C8 (left): Octave band analysis of two signals collected using shielded leads. Same protocol as Fig. C7 above. The reduction of noise in the signal shows that the behavior in the region greater than 100 Hz is irrelevant and may change depending on the noise in the environment. The change in behavior between 60 and 100 Hz correlates to the EMG signals, and not any electromagnetic noise in the environment.*



## FUTURE WORK

**Immediate:** Assemble the redesigned hand
Program the control mechanism build circuit.
Investigate possible triggering methods from the collected sample data.

**Long Term:** Add a functioning "wrist". Market the finished product in developing countries.

## REFERENCES


1] http://www.fidelityorthopedic.com/prostheticproducts.htm
[2] http://www.touchbionics.com/pro-digits
[3] http://www.touchbionics.com/i-LIMB/grip-patterns
[4] Mazumdar, A., Powered upper limb prostheses control, implementation and clinical application. Berlin, New York, Springer c 2004.
[5] Pan, T.-T.; Ping-Lin Fan; Chiang, H.K.; Rong-Seng Chang; Jiang, J.-A.; , "Mechatronic experiments course design: a myoelectric controlled partial-hand prosthesis project," Education, IEEE Transactions on, vol.47, no.3, pp. 348- 355, Aug. 2004 doi: 10.1109/TE.2004.825528