ARM

(Actuation via Real-time Myoelectric signals)

ProsthEEsis

PROJECT PROPOSAL + OVERVIEW

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AGENDA

01 THE PROBLEM

02 THE SOLUTION

03 FEATURES

04 TECHNOLOGIES

05 ENGINEERING REQUIRED

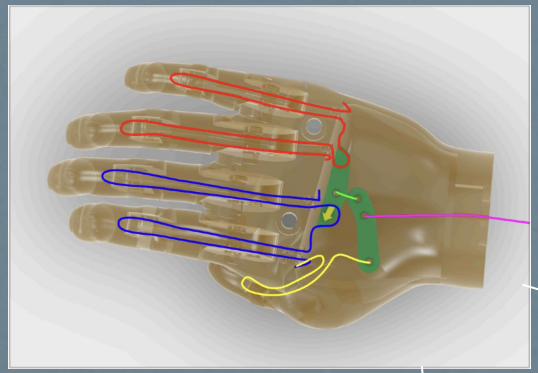
06 CONCLUSIONS

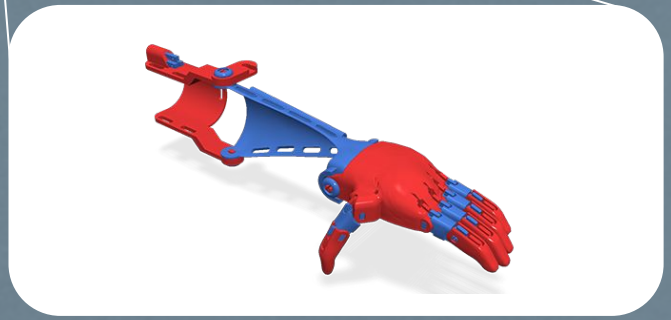
INTRODUCTION

e-NABLE is a global network of volunteers of which we have a chapter here on campus!

- 3D-Printed Hands + Sockets
- Open-Source Designs
- Low Production Cost
- Devices Given Free to Users

THE EXISTING DESIGNS





PURELY MECHANICAL

String through the fingers provides the tension for closing the hand.

WRIST OR ELBOW - ACTUATED

Two categories of devices, each specific to a type of limb difference.

THE PROBLEM

Market Challenges

Traditional prostheses are costly.

Body Powered Mechanism

Flexing a joint (elbow, wrist) to change hand position can often be counter-intuitive to performing tasks.

Energy Expenditure

These mechanical designs can require substantial effort to actuate and hold hand position, causing fatigue.

SOLUTION

Myoelectric Prosthesis

EMG Sensing

Existing technology that allows the use of a single muscle to control the device

Intuitive Motion

Using only one muscle allows simple operation that will not impede the natural movement.

Microcontroller & Servo Motor

These common devices will interpret the input and control the hand.

3D Printed Hand

This is e-NABLE's current standard prosthetic body.

Low Cost

These low-cost parts allow for many more users.

DEMO DAY FEATURES

Device Integrity

- Strong enough for simple household tasks

EMG Sensing

- Flexion of a target muscle will make the hand open or close

Locking Mechanism

- Switch to “lock” hand into position, minimizing fatigue

Calibration

- Simple, user-friendly process based on user’s strength at time of use

Battery Power

- Operate solely on battery power
- Safety will be a primary consideration

ENGINEERING REQUIRED

1. EMG Sensing
    - Sensor Placement
    - Signal Processing
2. Calibration Process
3. Hand Actuation
    - Grip Strength

ENGINEERING REQUIRED

3. Power and Charging Circuit
    - Safety
    - Operating Time
4. Physical Design
    - Weight

TECHNOLOGY AVAILABLE OVERVIEW

KEY PARTS	Sensors	Servo / Actuator	Microcontroller	Batteries
FACTOR 01	Cost	Weight & Size	Comms with Sensors & Actuator	Safety
FACTOR 02	Availability	Speed & Torque	Real Time Signal Processing	Run Time
FACTOR 03	Size	Mechanical complexity	Memory	Charging / Replacement Convenience

EMG Sensors

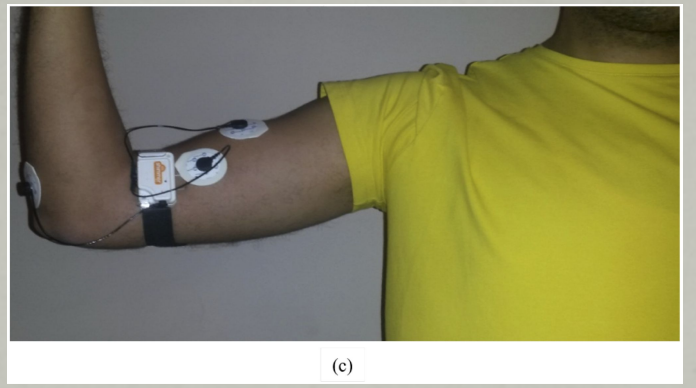
Function:
- Sense electrical activity in one or more target muscle
- Most electrodes are one time use

Availability:
- e-NABLE ND owns a few sensors
- In bulk from Bio-Medical.com or Amazon

Affordability:
- Electrodes cost <¢50 each

Accessibility:
- Existing Arduino compatible EMG sensor ecosystem (Advancer Electronics)

Size:
- Small size has minimal impact on user



https://www.mdpi.com/2076-3417/9/14/2795

Servo Motor

Function:
- Actuate grasping motion
- pull on strings that extend to the fingers

Availability:
- Common device, available at Adafruit, Digikey, etc.

Affordability:
- Price range $3-$30

Accessibility:
- e-NABLE ND is experienced at mechanically interfacing with servos

Potential alternative:
- Linear Actuator: could reduce mechanical complexity

Microcontroller

Availability:
- Widely available

Affordability:
- Many available for under $30

Accessibility:
- We have experience using microcontrollers to control various sensors and actuators

Considerations:
- ESP32 RTOS can simultaneously handle input and output
- After signal processing, ESP32 ADC can sample up to 2 MHz with WiFi off, well above myoelectric signal bandwidth (0-400 Hz)

Battery

Options

- Rechargeable: LiPo, NiMH, $LiFePO_4$
- Non-rechargeable

Availability, Affordability, and Accessibility

- All available from DigiKey in a variety of sizes
- Costs < 20 dollars
- Motor, sensors, microcontroller operate on <5V

Considerations

- LiPo has fantastic energy density, but higher risk of fire
- NiMH and $LiFePO_4$ offer more safety with energy density sacrifice
- Non-rechargeable battery offers quick re-energization if battery runs out during the day

CONCLUSIONS

01

MYOELECTRIC SIGNALS

Actuation using EMG sensors rather than mechanical components.

02

REPLICABLE + ADAPTABLE

Design considerations made so other e_NABLE groups can use and adapt to their clients.

03

DESIGNED WITH USER IN MIND

Careful consideration given to calibration and printing.

THANKS!

Questions?