Biomechanics
The Bionic Arm

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Presentation Outline

● The Human Arm
  - Structure
  - Movements
  - Nerve Stimulation

● Prosthesis
  - Internally and Externally Powered
  - Terminal Devices
Presentation Outline Continued

- Bionic Arm
  - The Team
  - Specifications
  - Control Systems
    - Myoelectric Control
    - TMR
  - Building Blocks and Flexibility
  - Power Supply
- Research Horizons
Motivation

“The human [upper extremity] is capable of literally an infinite number of movement patterns….Regrettably, even the most sophisticated of available prosthetic terminal devices cannot [satisfy the] number of grasp patterns, and none offer direct sensory feedback.” [1]
Upper Limb Amputations

Mainly a result of:
- Congenital Deficiency
- A tumor
- Trauma

Types of amputations
- Shoulder disarticulation
- Above- or below- elbow
The Human Arm

- Scapula
- Clavicle
- Humerus
- Ulna
- Radius
- Deltoid
- Pectoralis Major
- Biceps Brachii
- Triceps Brachii
- Brachioradialis
The Human Arm: Movement

- Weight bearing of human arm
- Degrees of freedom
- Purpose of Movement
  - End-effector
- Determination of Movements
  - Minimal cost function
The Human Arm: Nerve Stimulation

- Travels from brain to arm
- Action potential makes arm move
The Human Arm: Nerve Stimulation
Upper Limb Prosthesis
### Upper Limb Prosthesis: Internally Powered

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
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<tr>
<td>● Lightweight, inexpensive, and easy to repair</td>
<td>● Relies on ability to make movements</td>
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<tr>
<td>● Cosmetic appearance achieved</td>
<td>● Cables and harness can restrict movement</td>
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- Lightweight, inexpensive, and easy to repair
- Cosmetic appearance achieved
- Simple design
- Relies on ability to make movements
- Cables and harness can restrict movement
Upper Limb Prosthesis: Externally Powered

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<tr>
<td>• Eliminates harnesses and cables</td>
<td>• More expensive</td>
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<tr>
<td>• Minimizes essential body movements</td>
<td>• Difficult to repair</td>
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<td>• Battery power needs to be replaced periodically</td>
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<td>• Cosmetic appearance harder to obtain</td>
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Upper Limb Prosthesis: Terminal Devices – 4 Main Types

Functional Terminal Device

Mechanical Hands
Upper Limb Prosthesis: Terminal Devices – 4 Main Types

Specialized Terminal Devices

Passive or Cosmetic Terminal Devices
Bionic Arm: The Team

- Government Agencies, Universities, and Private Firms
- United States, Canada, and European Countries
- Defense Advanced Research Projects Agency (DARPA)
  - $55 Million Grant
- DEKA Research and Development Corporation
  - Dean Kramer
- John Hopkins University
  - Applied Physics Laboratory (ALP)
- Rehabilitation Institute in Chicago (RIC)
The Bionic Arm: Specifications
Targeted Muscle Reinnervation (TMR)

Surgical Process

- Deinnervate spare muscle
  - Ex – pectoral muscle for lateral shoulder disarticulations

- Reinnervate with appropriate nerves
  - Takes approx. 3 months for nerves to be fully functional
Targeted Muscle Reinnervation (TMR)
Bionic Arm: Control System

- Myoelectric signaling - the natural electric impulse producing muscle contraction
- EMG – electromyography
  - Records myoelectric signal and passes it on
- Acts as the inputs to the microprocessors controlling the motorized arm
  - Progression
Sensory Feedback

- Mapping of sensory nerves
- Can react to temperature and pressure
Bionic Arm: Structure

- Modular Construction
- Secular Arrangement
  - Power System
  - Control System
  - Joints
- Lightweight
- 14 degrees of freedom
- Strength
Bionic Arm: Structure Modular
Bionic Arm: Structure
Degrees of Freedom
Bionic Arm: Power Supply

- Miniaturized monopropellant rocket motor system
- Hydrogen peroxide canisters
- Heat produced
  - Plastic sealant around power supply
  - Porous surface for steam to evaporate through
  - “Sweats”
• IMES
  - Injectable MyoElectric Signaling
  - wireless
  - Measure muscle activity at the source

• Chronic Brain Implants
  - Very futuristic
  - Record signals directly from the motor cortex

• Biocompatibility problems
Fluid Joints

- Developing mesofluidics
  - Movement of smaller joints
  - Pump driven by electric motor controlling flow of fluid
  - Same energy efficiency of human muscle (21% of energy input)
Research Horizons

FILMskin
- flexible, integrated, lightweight, multifunctional film
- Allows feelings of heat, cold and touch (pressure)
- Vertically aligned nanotubes (VANTA’s)
  - Conduct heat quickly
  - Working on nanocomposite responsive to pressure
Questions
Bibliography

1. BOOK
5. His slides
Bibliography

Bibliography

17. http://www.biomed.drexel.edu/labs/biomechanics/emg_analy.htm