BIOMECHANICS
-Hand Prostheses

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Overview

- Hands
- History of Prostheses
- Current Developments
- Need and Requirements
- Foreseeable Future
- Questions
What are considered Hands

- Appendages connected to the forearm
- Identifiable by opposable thumbs
- Only found in mammalian order of primates
  - Humans
  - Apes and Monkeys
Importance of Hands

- Primary organ for physical interaction
- Dense collection of nerve endings
- Dominate area for pressure perception
- Controlled by opposite side of the brain
Make up of the Hand

• Bones
  – 8 Carpus
  – 5 Metacarpus
  – 14 Phalanges
    • Distal
    • Middle
    • Proximal
Make up of the Hand

• 27 Degrees Of Freedom (D.O.F)
  – 21 in fingers and thumb
    • 4 for fingers
    • 5 for thumb
  – 6 in wrist
Control nerves

- Extrinsic control nerves
  - Radial
  - Deep radial
  - Ulnar
  - Median
- Intrinsic control nerves
  - Median
  - Ulnar
Make up of the Hand

- Muscles
  - Extrinsic
    - Flexor
      - Superficial anterior (4)
      - Deep anterior (2)
    - Extensor
      - Superficial Posterior (5)
      - Deep Posterior (4)
  - Intrinsic
    - Thenar (4)
    - Hypothenar (3)
    - Intermediate (3)
History

- Originally made of leather and wood
- Roman General had an iron hand
- Hook “hands”
- German Knight Gotz Von Berlichingen - “Robin Hood”
Advancements in History

• 1500’s Ambroise Pare - “father of prosthetics”
  – Artificial joint
• Improved Medicine
  – Drugs and anesthesia
• Wars
  – Civil War
  – WWI
  – WWII
Current hand prosthetics

• Mechanical
  – Cineplasty
  – Body-powered
  • Advantages
    – Decent Feedback
    – Durable
    – Cheaper
    – Weight
  • Disadvantages
    – Uncomfortable
    – Restrictive
    – Appearance
Current hand prosthetics

• Electrical
  – Prosthetic Control by an EEG-based Brain-Computer Interface
  – Myoelectric prostheses
    • Advantages
      – Functionality
      – Appearance
    • Disadvantages
      – Price
      – Weight
      – Recharge
Prosthetic users preference

• Survey results
  – Increase of functionality
    • Hand grasps
    • D.O.F
  – Reduced weight
  – Better cosmetic appearance
  – Tactile feedback system
    • Sensory feedback
Common hand grasps

- Cylindrical Grasp
- Precision grasp
- Lateral grasp
Importance of touch
Hydraulic Hand Prostheses

- Flexible fingers
- Fluidic actuators
- Light weight frame
- Microvalves
- Micropump
- Reservoir

- Controller / Interface
Hydraulic Hand Prostheses

- **Low power**
  - Increased surface area
  - Oil fluidic actuators
- **Light weight**
  - External Gear pumps
  - Center of gravity
- **Moveable thumb**
  - 3 D.O.F
- **Multiple hand grip**
Hydraulic Hand Prostheses

- Most used Hand grasps
  - Cylindrical Grasp
  - Precision grasp
  - Lateral grasp
  - Hook grasp
  - Index position

- 6 microvalves
  - 6 D.O.F
Hydraulic Hand Prostheses

• Advantages
  – Increase in functionality
  – Reduced weight
  – Better cosmetic appearance

• Disadvantages
  – Control issues
  – Not for hard work
  – Leakage of hydraulic fluid
Mechanomyography

- Mechanomyography (MMG)
  - Low frequency sound (5-50 Hz) vibration produced by contracting muscles
  - Mimics 2-site electromyograph (EMG)
    - Non specific
    - Lacks skin impedance
    - Cheaper
Mechanomyography

- Soft Silicone Socket
  - Embedded array of sensors
- Hard Socket
  - Battery pack
- EMG Emulator board
  - Reduced cost
- Otto-Bock
Mechanomyography

- Trial run
  - Two participants
  - Three 30min visits
    - Soft Silicon
    - Hard socket
    - Training
  - Success
    - Relative to previous prosthetic
    - 88% and 71%
Mechanomyography

• Advantages
  – Emulated electromyograph
  – Potential of multiple control
  – Heightened sensitivity

• Disadvantages
  – Extrinsic frequencies perceived
  – Lack of response under force
  – Use of emulator
Direct Neural Feedback

- Need for referred sensations of touch and joint movement
  - Appropriate, discrete and graded
- Avoiding
  - whole never stimulation
  - Unrelated motion control
- Phantom hand
  - 80\% of amputees
Direct Neural Feedback

• Solution
  – Peripheral nerve stump interface
  – Platinum-iridium wire
    • Teflon insulate (30 cm long)
  – Planted in Medial nerve
    • Fascicle
      • 1mm stimulus zone
  – Amplified and listened to
  – Computer interface
  – Robotic hand control
Direct Neural Feedback

- Future testing
  - Tactile and proprioceptive
    - Strain gauge
    - Flexion/Extension
  - Grip control and elbow position
    - Match forces
    - Match angles
  - No visual assistance
- Next would be Closed Loop
Conclusion

• Hand Prosthetic
  – Come a long way
  – May new advancements
    • D.O.F.
    • Control
    • Feedback
  – Problems
    • Not a high need
    • Funding
Questions?

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