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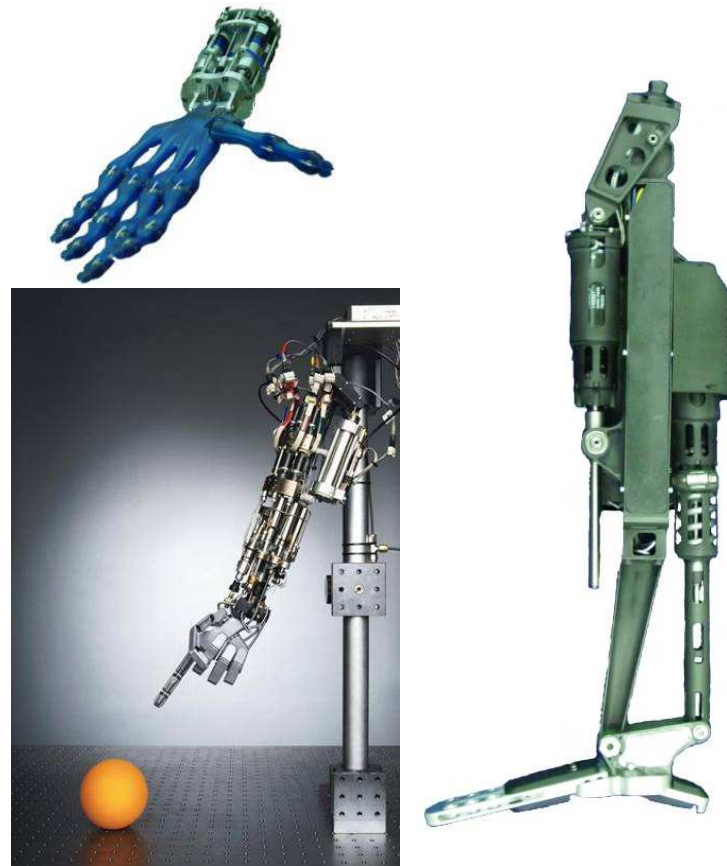
<http://research.vuse.vanderbilt.edu/cim>



Research Interests

- Design, modeling, and control of electromechanical devices and systems
- Design and control of advanced prosthetic limbs
- FES gait restoration
- High power density actuation
- Haptic interfaces and telemanipulator systems

Research Highlights



Honors

- Vanderbilt Chancellor's Research Award, 2008
- ICORR Best Paper, 2007
- ASME FPST Best Paper, 2003
- Vanderbilt Engineering Best Paper Award 1997

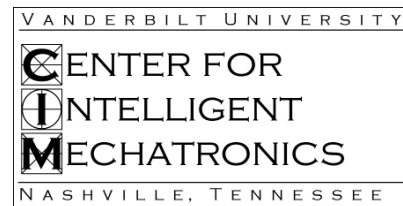
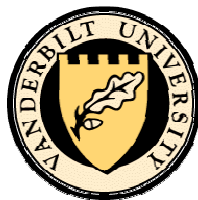
Professional Activities

- ASME DSC Robotics TC
- ASME DSC Mechatronic TC
- Associate Editor, *ASME JDSMC*, 2001-2004
- Chair, ASME DSC Robotics TP, 1998-2000
- ASME DSC Fluid Control Panel, 2003-present

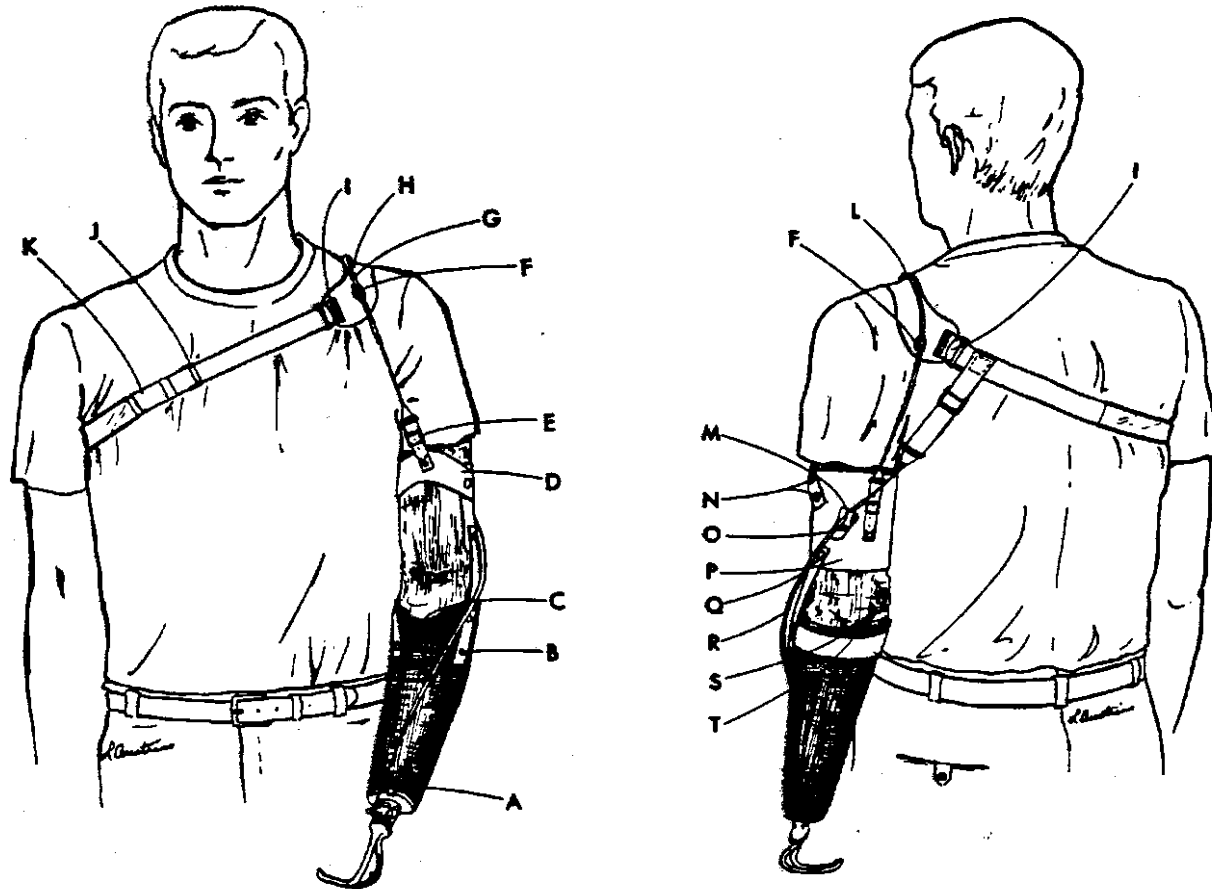
Frontiers in Prosthetic Limb Technology

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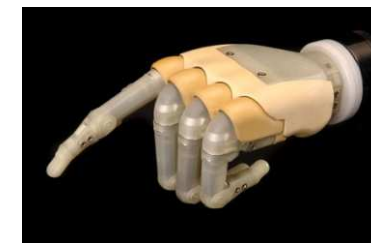
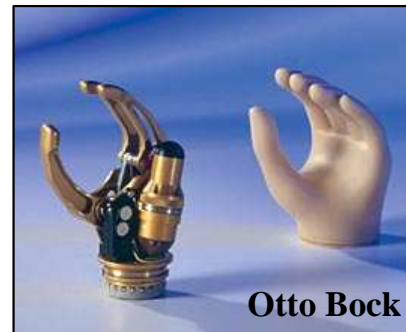
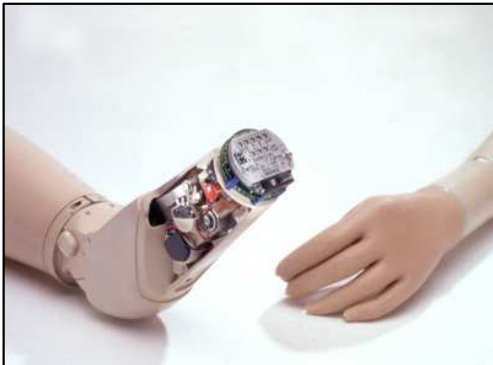
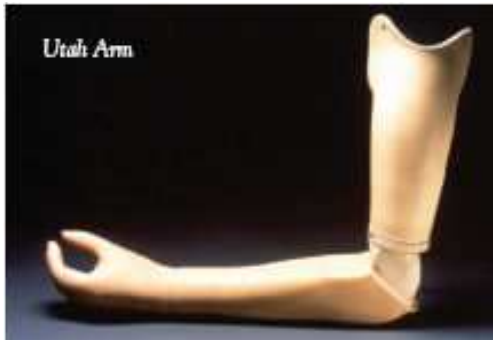
State-of-the-Art I: Body-Powered Prostheses



State-of-the-Art II: Myoelectric Prostheses



- State-of-the-art myoelectric upper extremity prostheses utilize electrical signals from muscles to drive electric motors
- Myoelectric approach provides a single input signal, which must be multiplexed between DOF's
- Lack of sensory feedback to user limits functionality



Touch Bionics

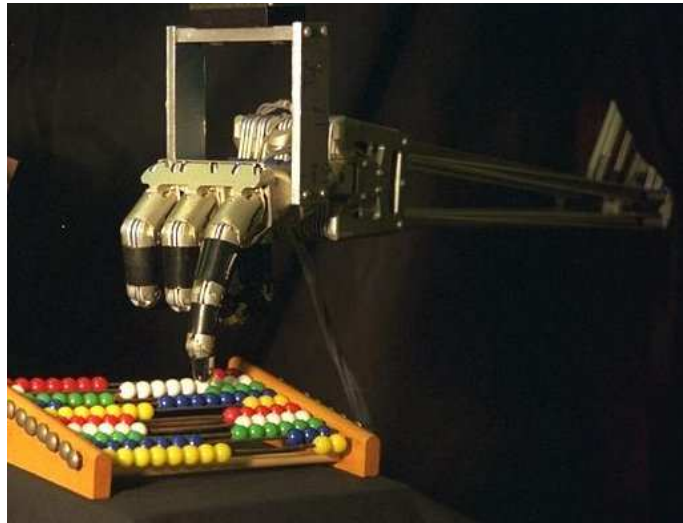
1 DOF Hands



Anthropomorphic Robot Hands



14 DOF NASA Robohand



16 DOF Utah/MIT Dexterous Hand



23 DOF Shadow Hand



Why the Disparity?

Number of Control Channels:

- Robots: essentially unlimited number of control channels and force, motion, and touch sensory information
- Current active upper extremity prostheses have single efferent control channel multiplexed between the elbow and hand

Space and Weight Constraints:

- Robots are high-tech marionettes: Most actuation and all power off-board (i.e., outside volume of a typical arm)
- Upper extremity prostheses must have no strings attached: all power and actuation must fit within volumetric confines of typical arm.



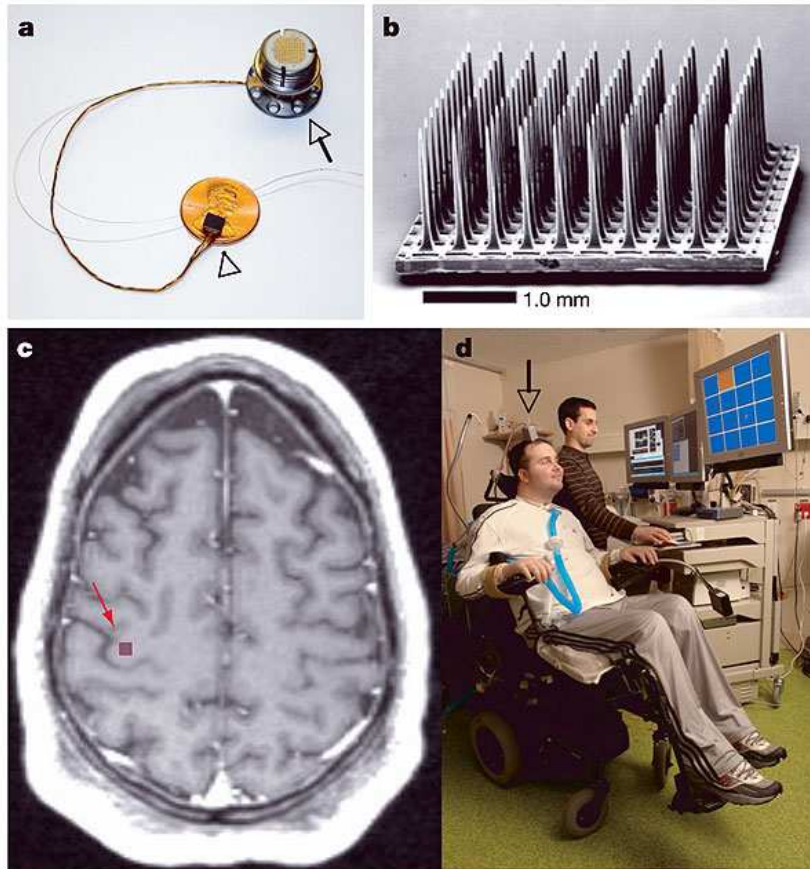
23 DOF



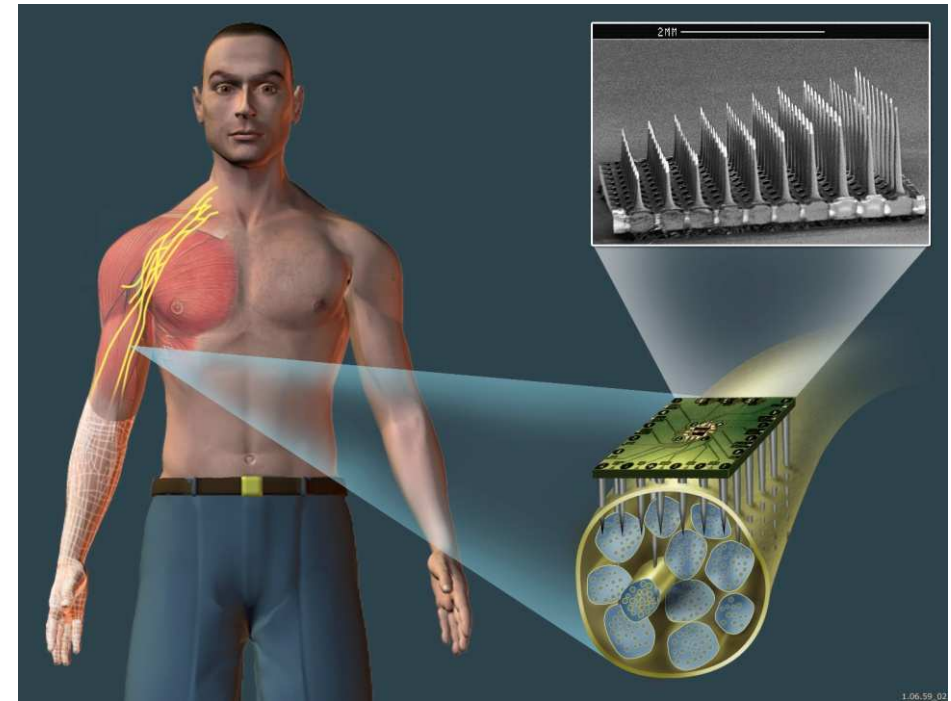
One DOF



Neural Approaches to Neural Interfacing



Cortical Electrode Implants (Cyberkinetics)

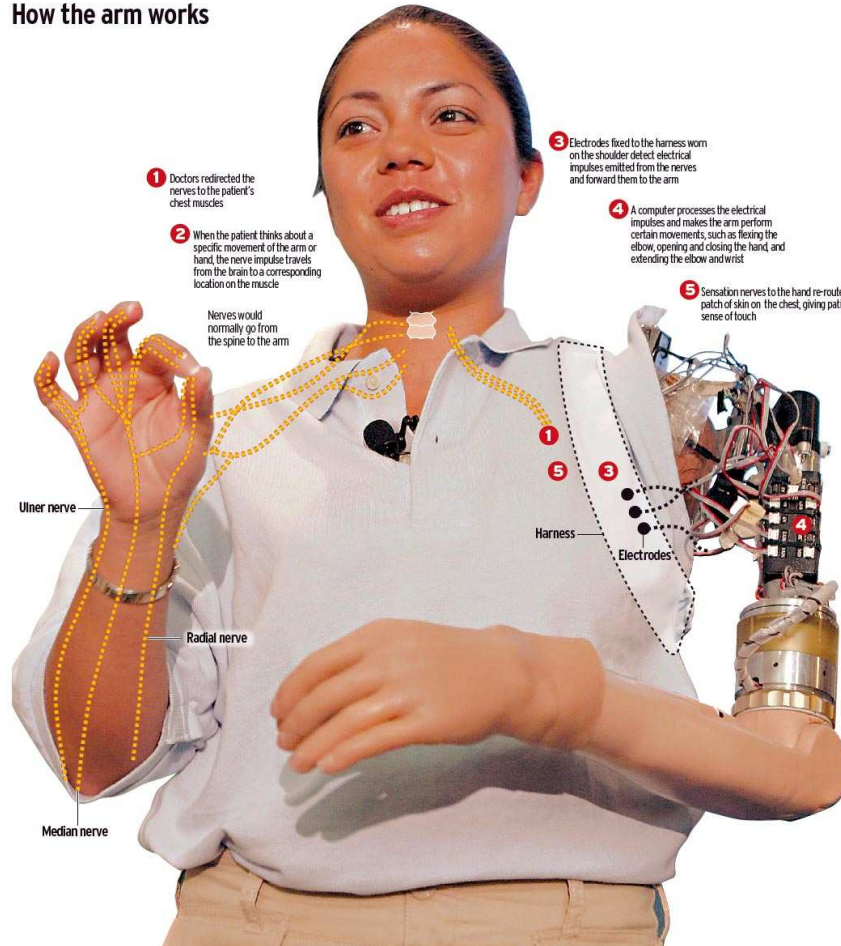


Peripheral Electrode Implants (Univ of Utah)

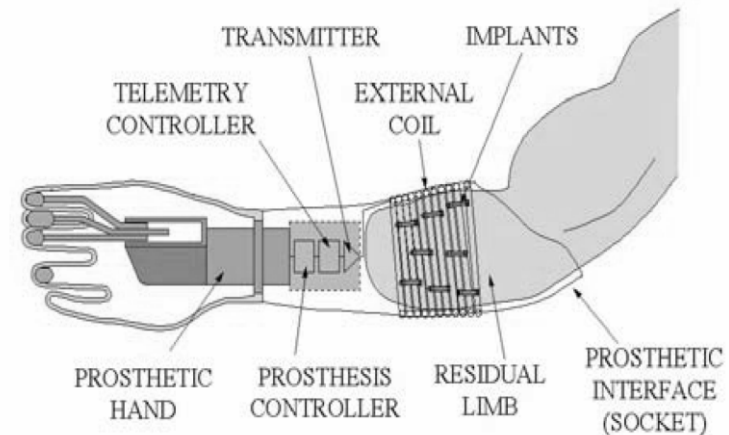
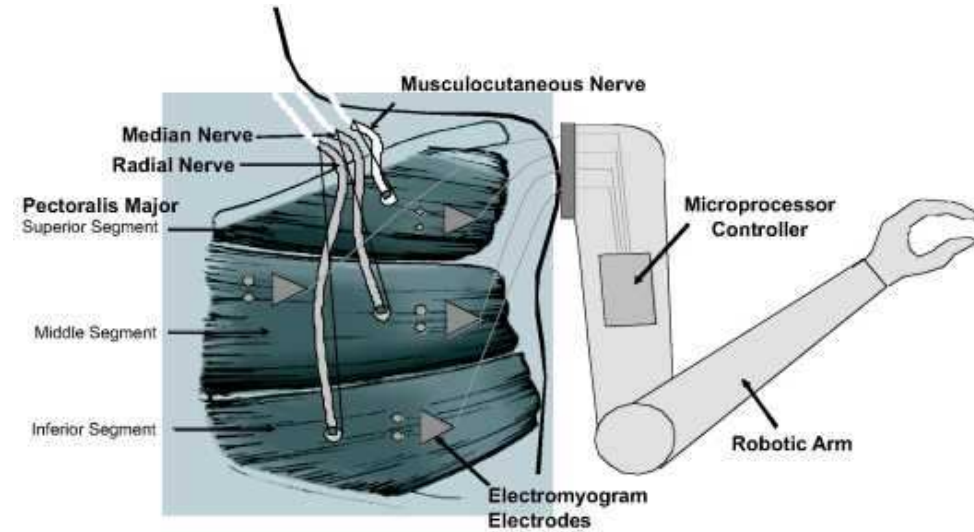


Muscular Approaches to Neural Interfacing

How the arm works



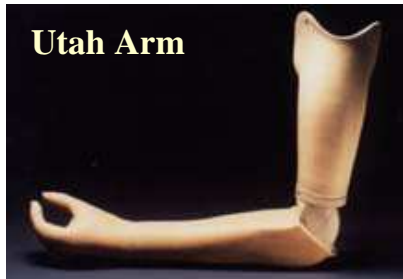
Targeted Reinnervation (RIC)



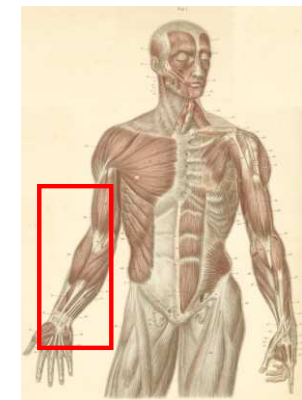
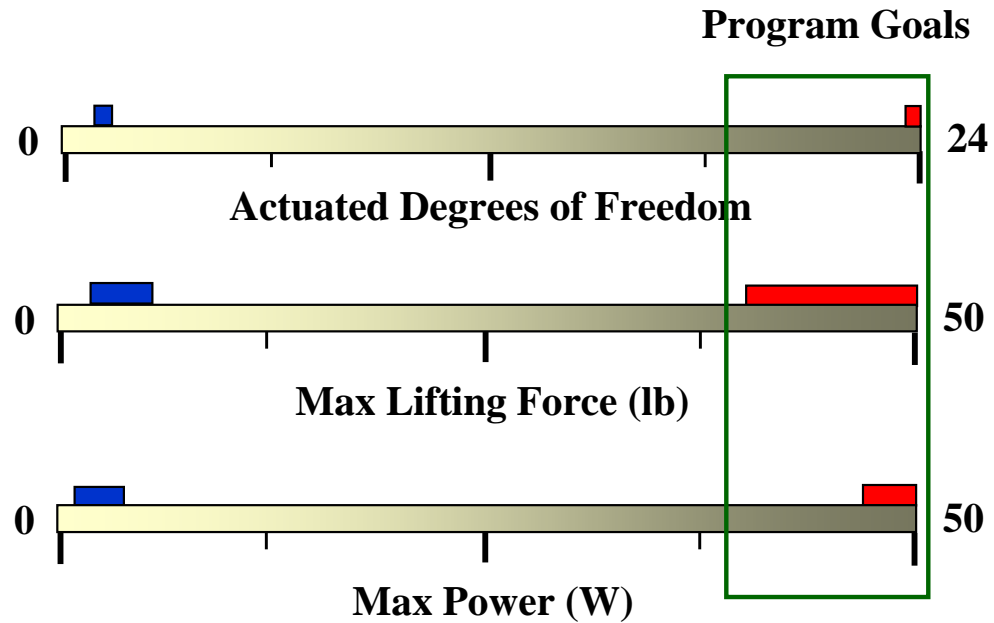
IMES (RIC/Sigenics)



Disparity in Power and Actuation



State-of-the-Art
Myoelectric Prosthesis
(composite of Utah Arm
and LTI Boston Arm)



Human



Vanderbilt Anthropomorphic Upper Extremity Prostheses

Arm Video #1

Arm Video #2



State-of-the-Art in Lower Limb Prostheses

State-of-the-art lower extremity prostheses are energetically passive



Otto Bock C-Leg



Ossur Rheo Knee

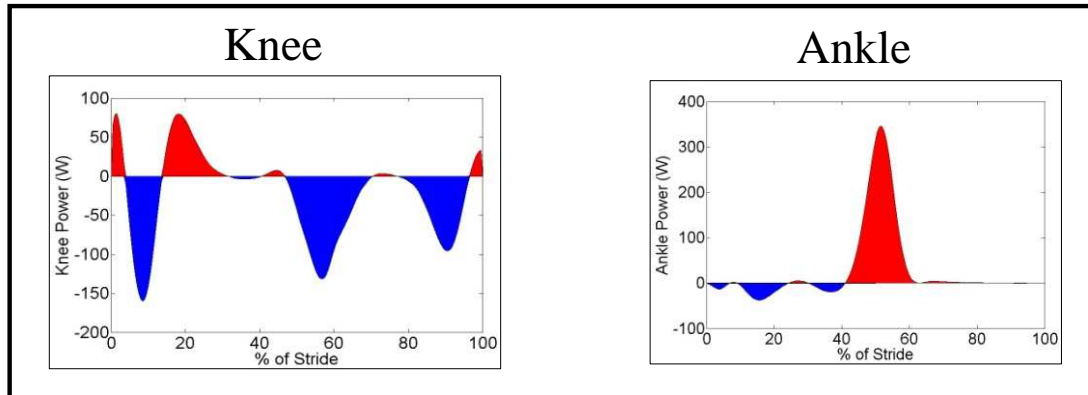


Otto Bock Trias Foot



The Need for Power

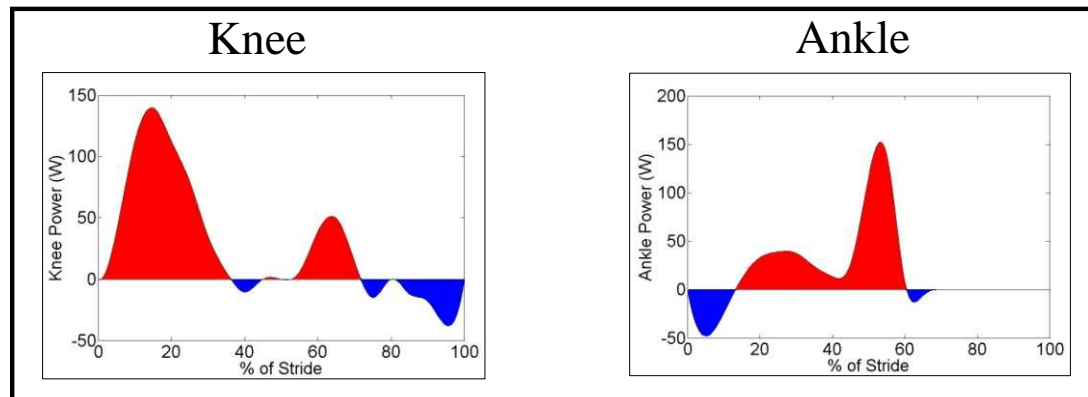
Joint Power during Level Walking



Absence of power in lower limb:

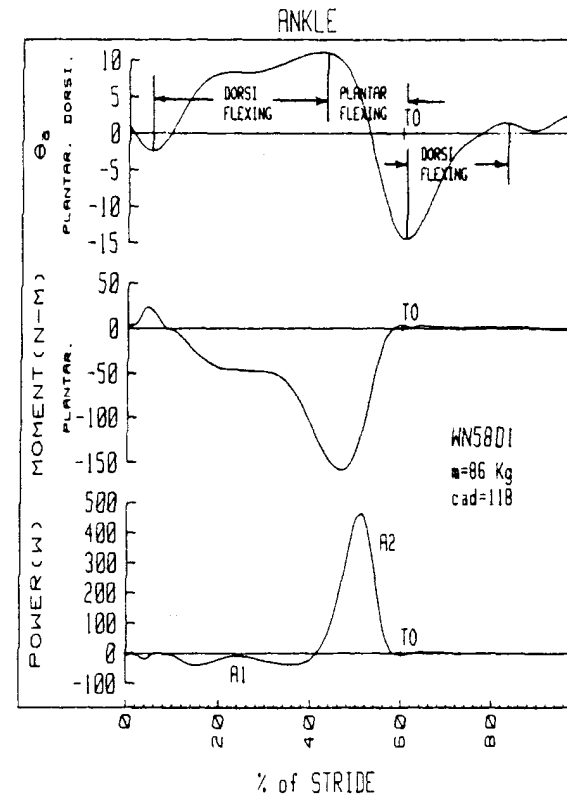
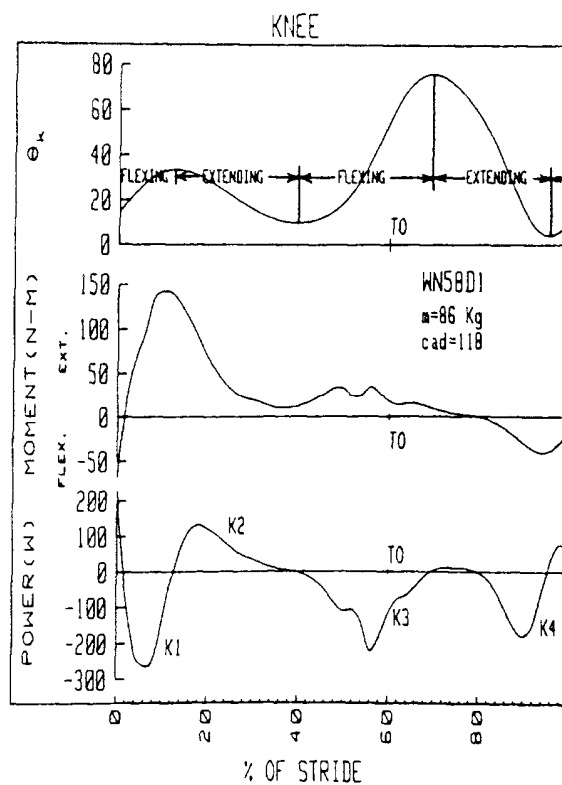
- Requires 60% more energy for level walking
- Requires 3 times hip torque for level walking
- Presumably leads to long-term musculoskeletal problems
- Lack of power precludes or significantly impairs stair and ramp climbing, backward walking, and other activities

Joint Power during Stair Climbing

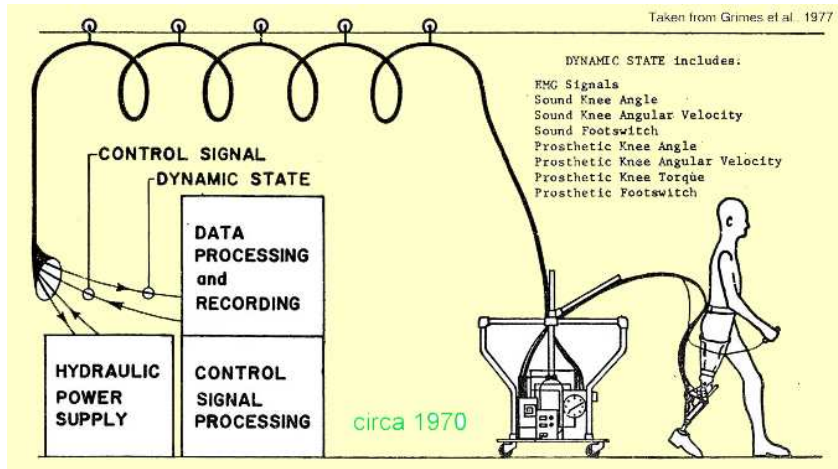


Impediments to Power

- Power and torque required for powered joints stretch power and actuator technology
- Powered joints change the significance and nature of the control problem.
 - Passive prosthesis fundamentally can only react.
 - Powered prosthesis can both act and react.
- Lack of sensory feedback significant issue



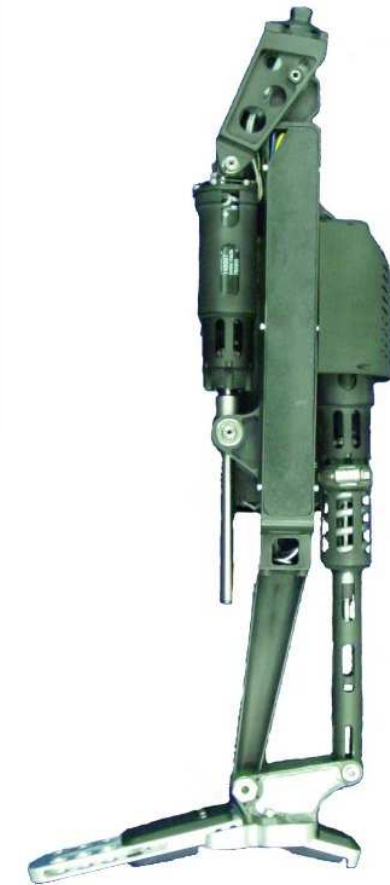
Past and Current Efforts in Powered Prostheses



Flowers et al., circa 1970



Ossur Power Ankle



Vanderbilt Powered Knee and Ankle

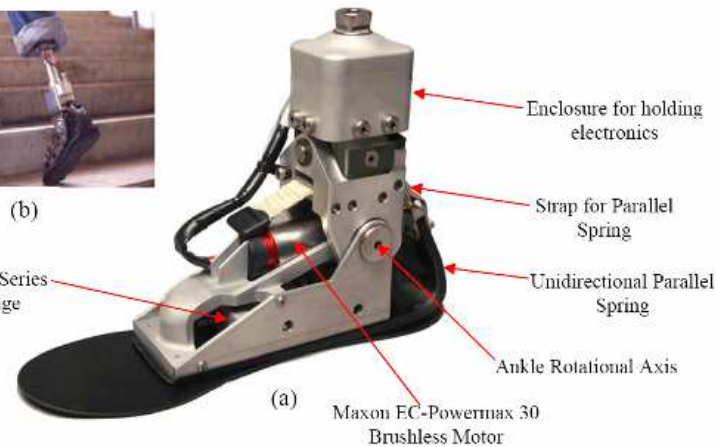


Ossur PowerKnee



(b)

Ball-nut and Series Spring Cage



(a)

iWalk/MIT Ankle



Vanderbilt Powered Lower Limb Prostheses

Leg Video #1

Leg Video #2

