Some recent trends in prosthetics

Jyothish K. J. | Subhankar Mishra Lab

Background:

Core Topic: Research and analysis of various actuation and control strategies for robotic prosthesis.

Talk 1: CURRENT STATE OF ROBOTIC PROSTHETICS AND SOFT ROBOTICS:

https://drive.google.com/drive/folders/1R7HF5zCEvQLcnYmlgDvSDrcNvhcKsy2k?usp=sharing

Contents

1. Understanding the Term: “Prosthetics”

- “*Pros*” (Instead of) + “*Theses*”(Placing) = Replacement of whole or part of a diseased or damaged bodily organ by an artificial device.
- Includes:
  - Prosthetic Limbs
  - Artificial Heart Valves
  - Hernia Mesh, Urinary Catheters or Vascular Stents
  - Intrauterine Contraceptive Devices (IUD)
  - Dental or Orthopedic Implants, Penile Implants, Breast Implants
  - Hearing Aid
  - *Communication Prosthetics*

2. Neuroprostheses

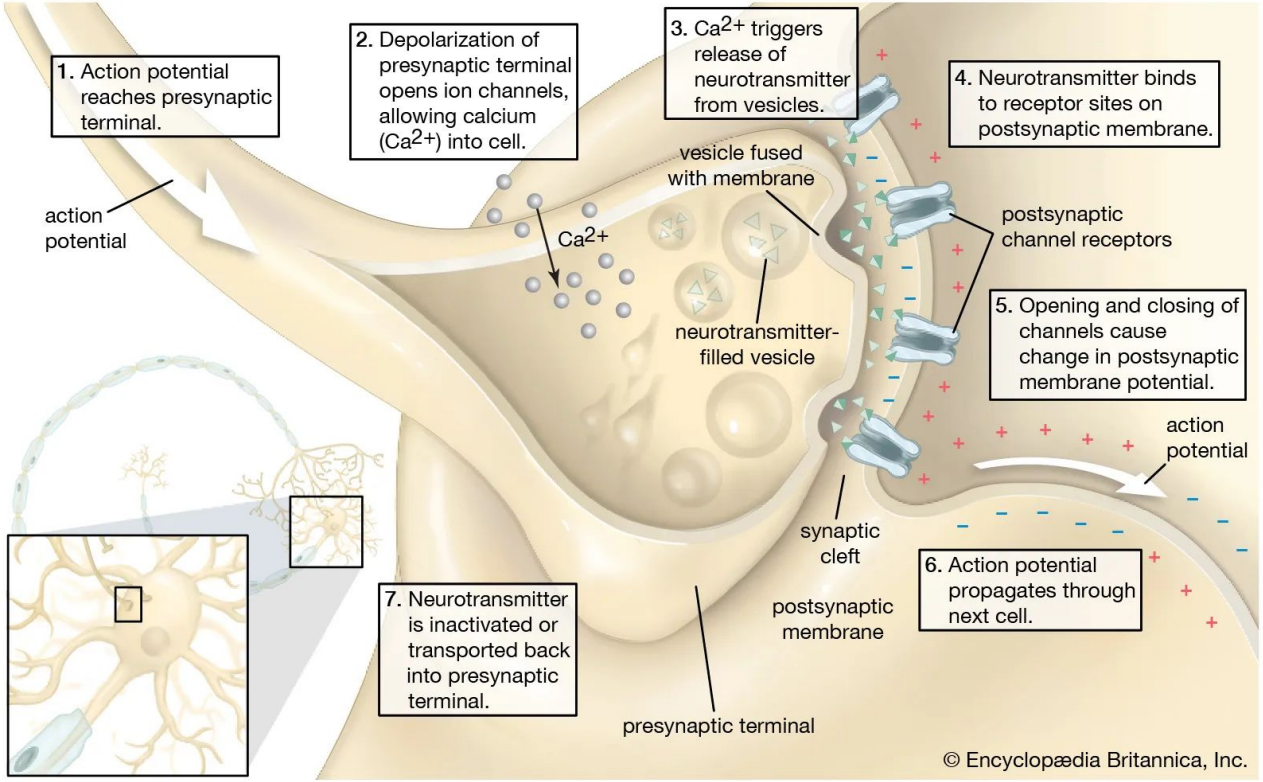
1. **Definition**:

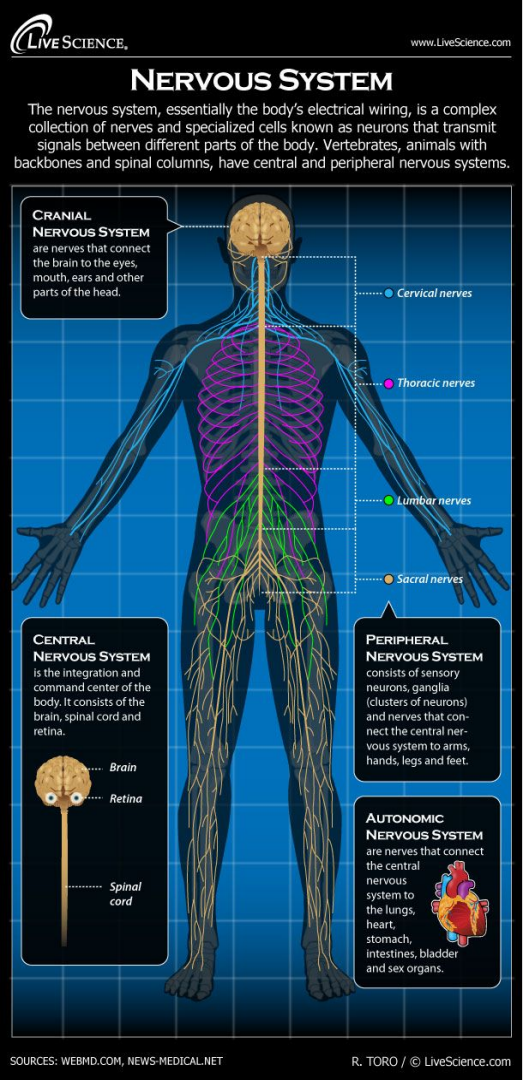
   Area of medicine developed from two converging areas of science: Information Technology + Neuroscience

Information Technology allowed for separation of information from its physical substrate and provide tools that quantify and process this information to develop software and equipment	Neuroscience discovered that nervous system uses electric phenomena to control body parts and that neurons process information using these phenomena. Neuroscience allowed electrically interfacing with Nervous system.

2. Nervous system
3. Sensory Rehabilitation Prostheses
   - Visual Prostheses
   - Auditory Prostheses
4. BCI : Brain Computer Interface
5. Neural Implants

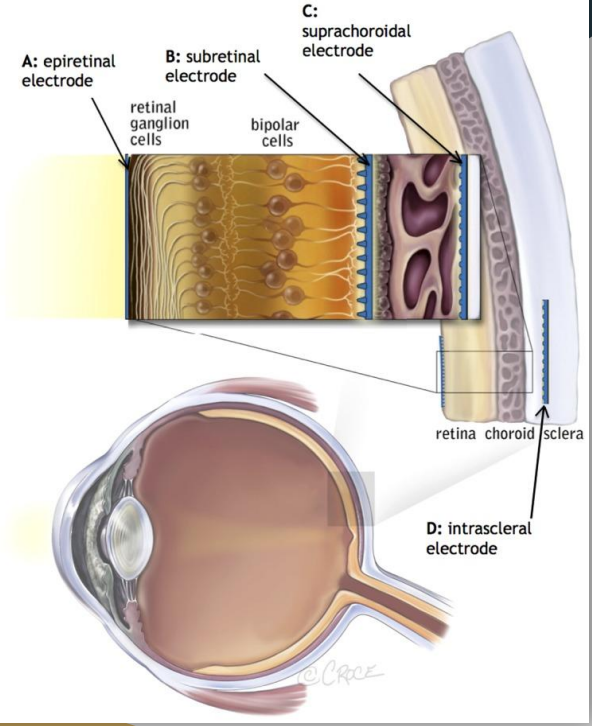
2.2 Nervous System, Neurons, Neural Signals

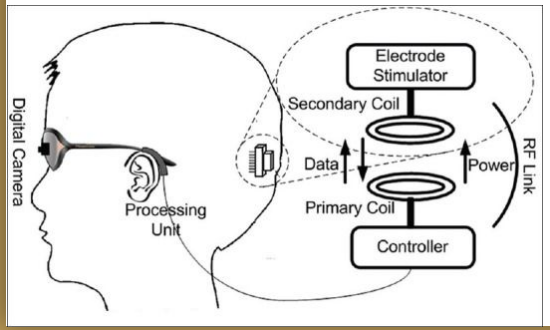


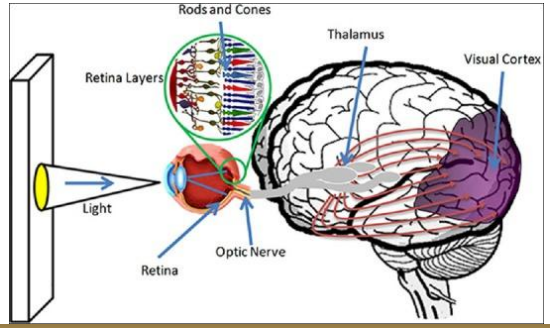


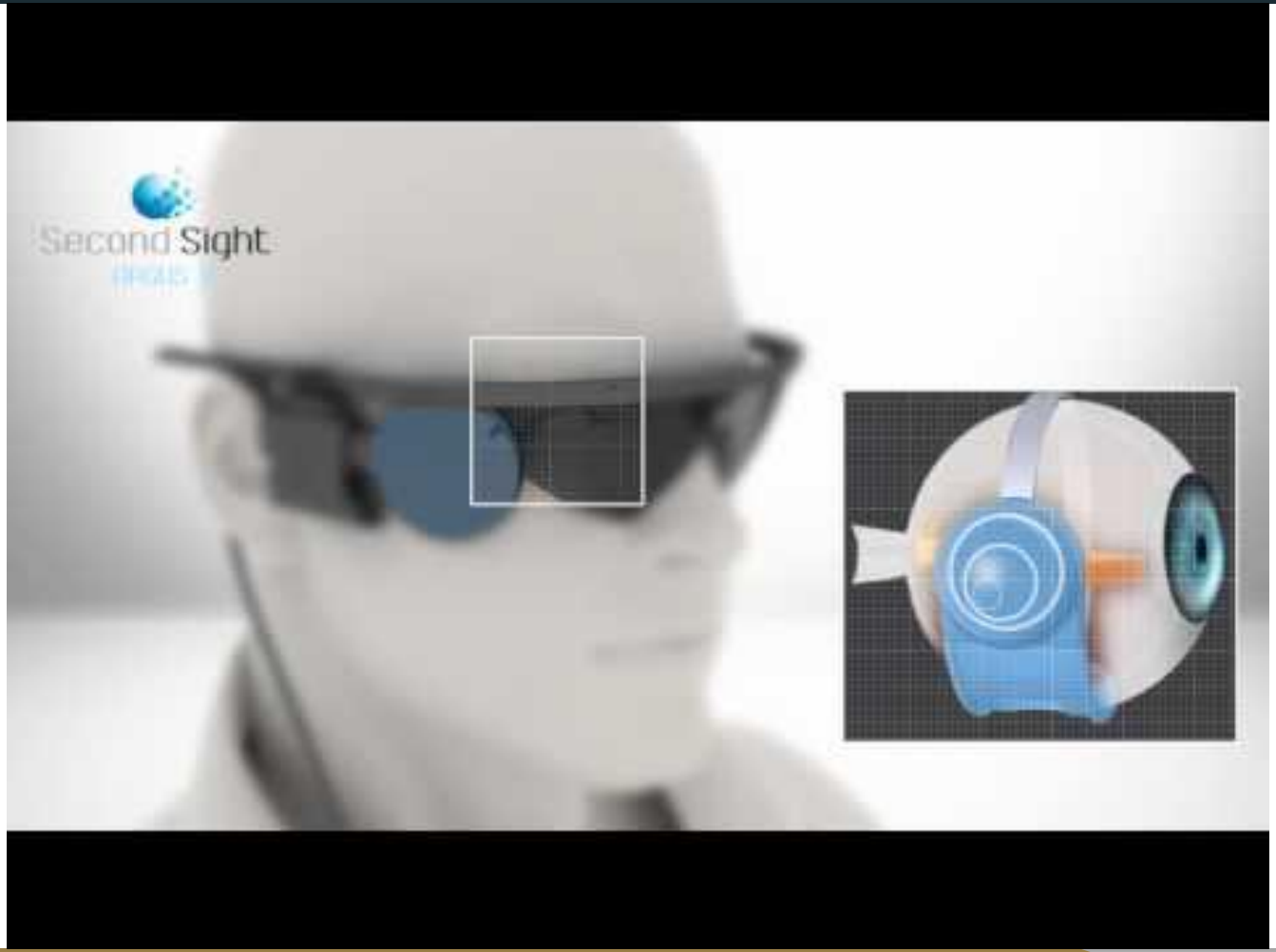
2.3 (a) Visual Prostheses

- Devices that use electronic circuitry and electrical impulses to generate vision-compatible stimuli for the signal pathway of vision:
  - Epiretinal Visual Prostheses
  - Optic Nerve Visual Prostheses
  - Cortical Visual Prostheses etc.
- Patterned electrical stimulation along the vision pathway can evoke patterned light perceptions.





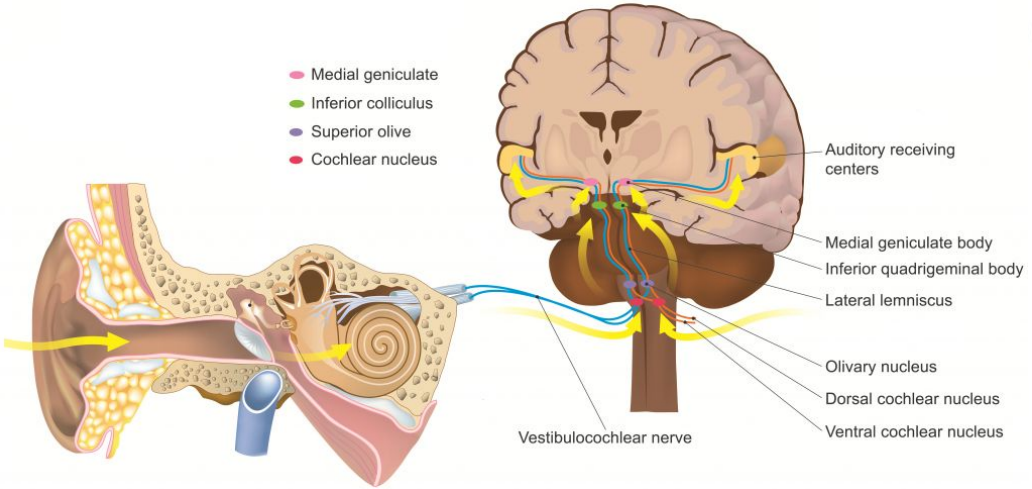


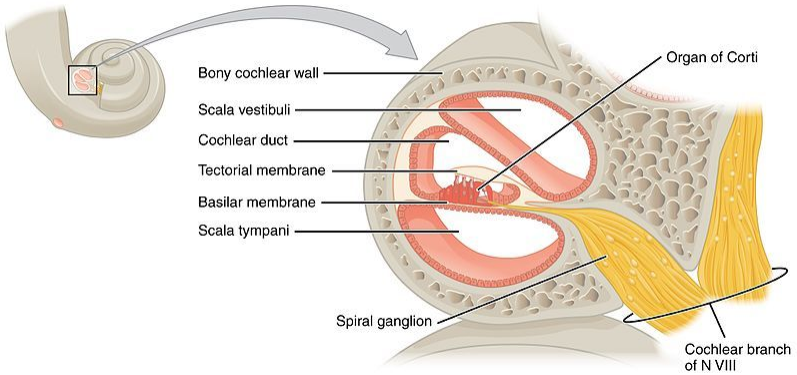


Second Sight's Argus II Retinal Prosthesis System:

2.3.(b) Auditory Prostheses

- Typical Hearing Aid: Functionally just voice amplifier tuned to specific frequencies.
- Auditory Prostheses:
  - **Middle Ear Prosthesis**: Mechanical compensation for lack of mobility/absence/necrosis in middle ear bones.
  - **Inner Ear Prosthesis:** Electrodes are implanted into scala tympani of cochlea
  - **Auditory Brainstem Implants.**





2.4 Brain Computer Interface

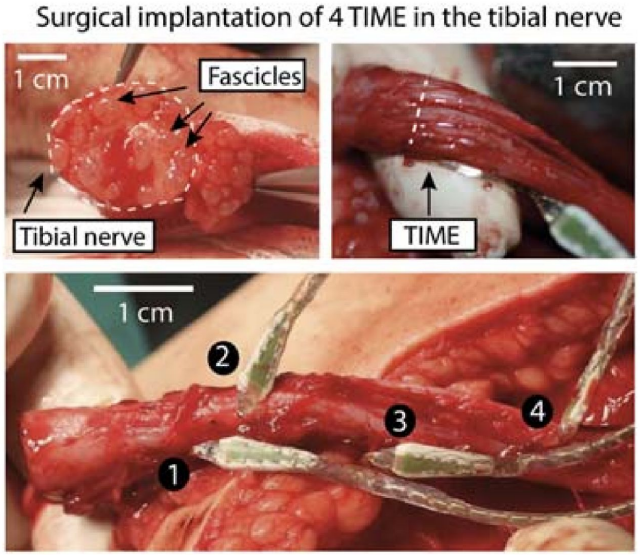
1. Translate electrical neural activity of the brain to control signals for guiding paralyzed limb, prosthetic arm and computer cursors.

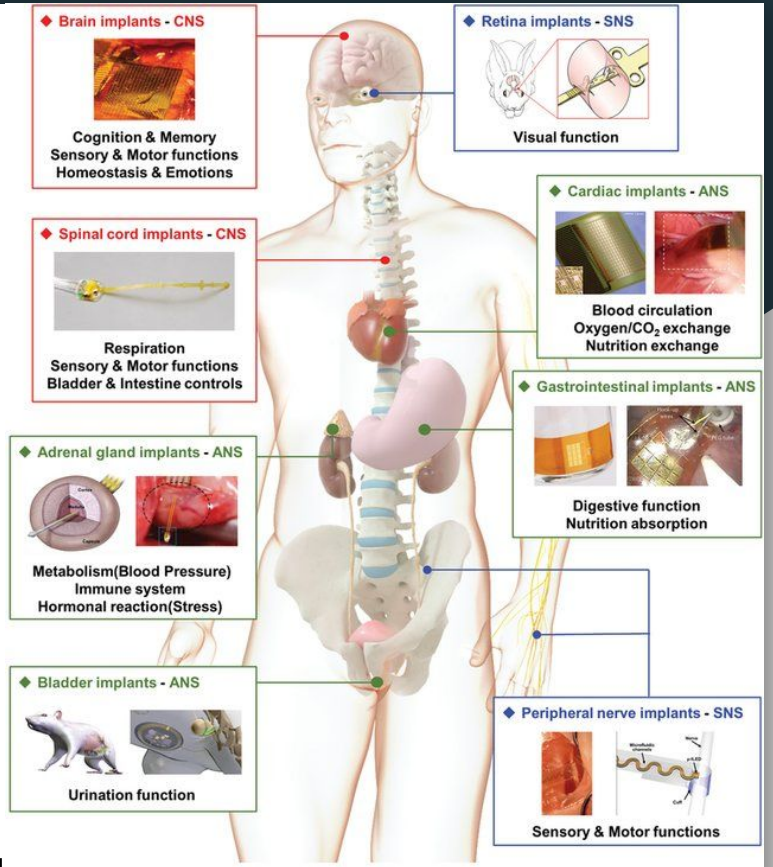
   Keywords: *Electroencephalography (EEG)*, *Functional Electrical Stimulus (FES), BIONs, Speech generation, etc.*

2. Translate physical stimulus captured by external sensors from a desensitized body part to relay corresponding electrical stimulus directly to nerves.

   Example: Discussed in section 4.

2.5 Neural Implants





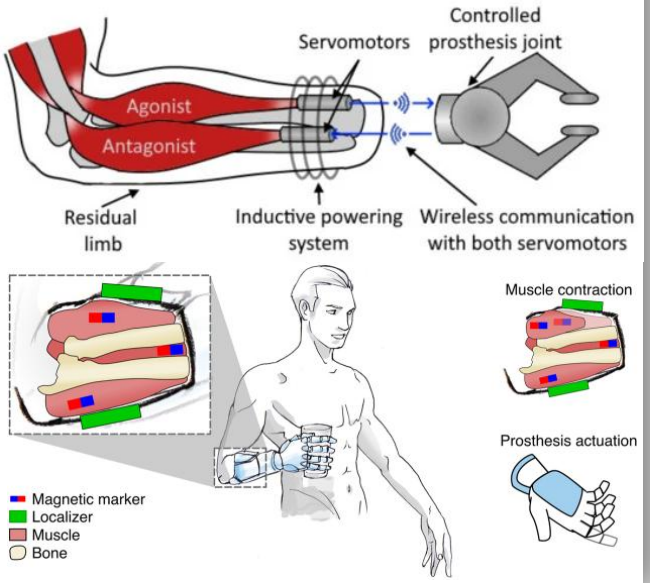
- Central Nervous system (CNS)
  - Brain
  - Spinal cord
- Peripheral Nervous system (PNS)
  - Autonomic Nervous System (ANS)
  - Somatic Nervous System (SNS)

3. Control Strategies for Robotic Prosthesis

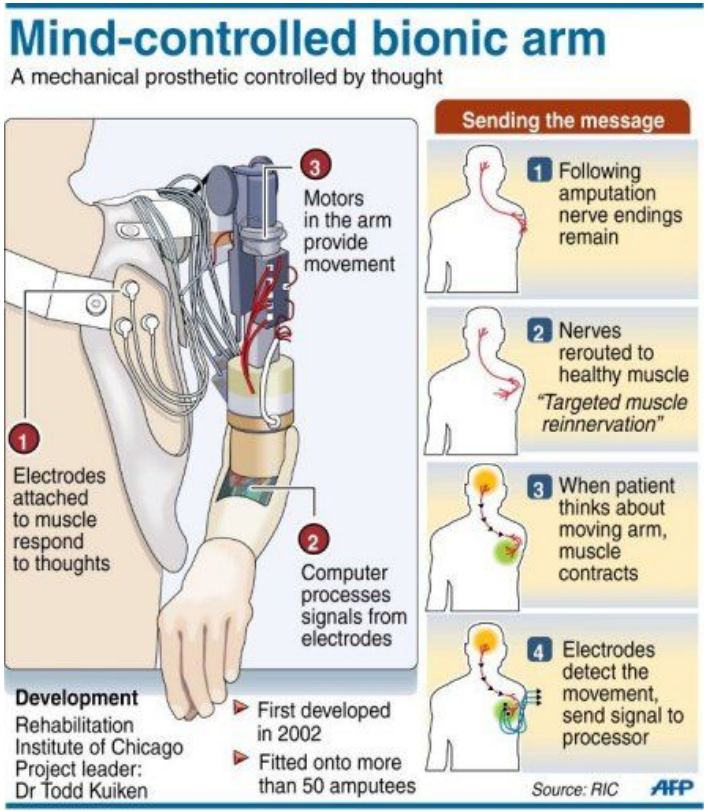
1. **Residual Muscle Contraction**: Electrical Impedance Tomography (EIT), Near IR Spectroscopy (NIRS), Various myography techniques (Optoelectronic, sonomyography, force, phonomyography, capacitance sensing, optical myography, magnetomyography etc.), *Cineplasty, Myokinetic control Interface (MYKI), Electromyography (EMG)***.**
2. **Targeted Muscle Reinnervation**.
3. **Neural Implants and BCI.**

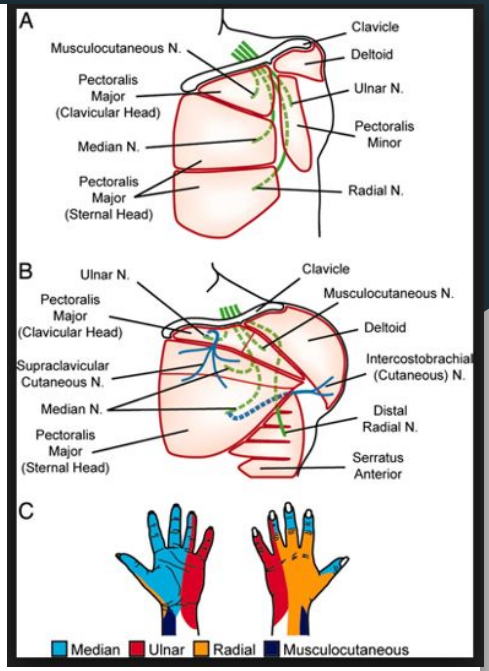
   …

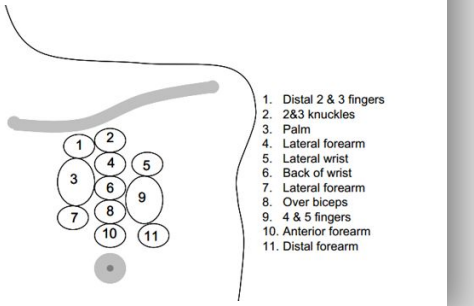
4. **Basic Human-Machine-Interfaces (HMIs)**



3.2 Targeted Muscle Reinnervation





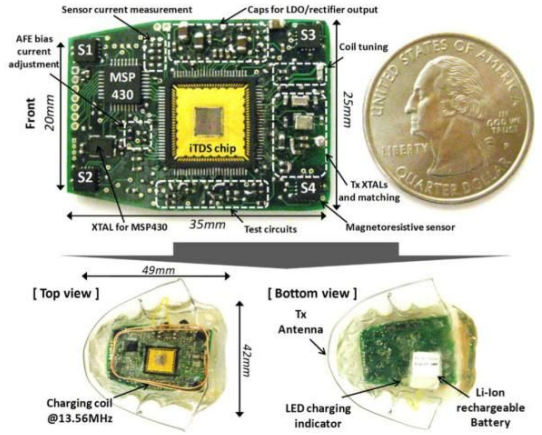


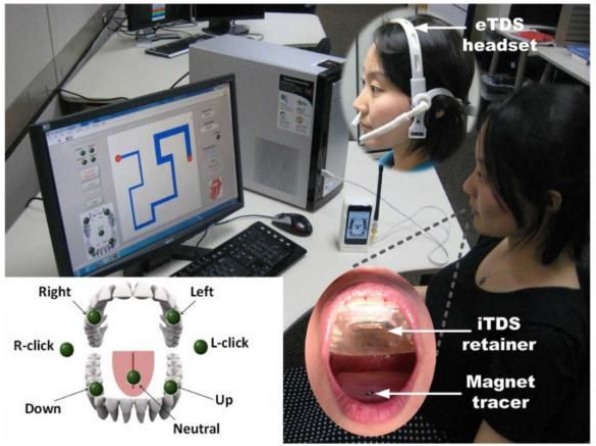
3.4 Basic HMIs for Prostheses Applications

- Tongue control
- Eye Tracking
- Voice Command
- Sip and Puff
- Face tracking

etc.


Control Unit
Magnetic sensors


Sensor current measurement
Caps for LDO/rectifier output
AFE bias current adjustment
S1
S3
Coil tuning
MSP 430
iTDS chip
Front
20mm
25mm
S2
S4
Tx XTALs and matching
XTAL for MSP430
35mm
Test circuits
Magnetoresistive sensor
49mm
[Top view]
[Bottom view]
Tx Antenna
42mm
Charging coil @13.56MHz
LED charging indicator
Li-Ion rechargeable Battery


eTDS headset
Right
Left
R-click
L-click
Down
Up
Neutral
iTDS retainer
Magnet tracer

4. Cognitive Rehabilitation

1. Phantom Limb Syndrome
2. Virtual Reality based Rehabilitation
3. Neural Implant based Sensory Rehabilitation

Connecting residual nervous system and prosthetic legs for sensorimotor and cognitive rehabilitation

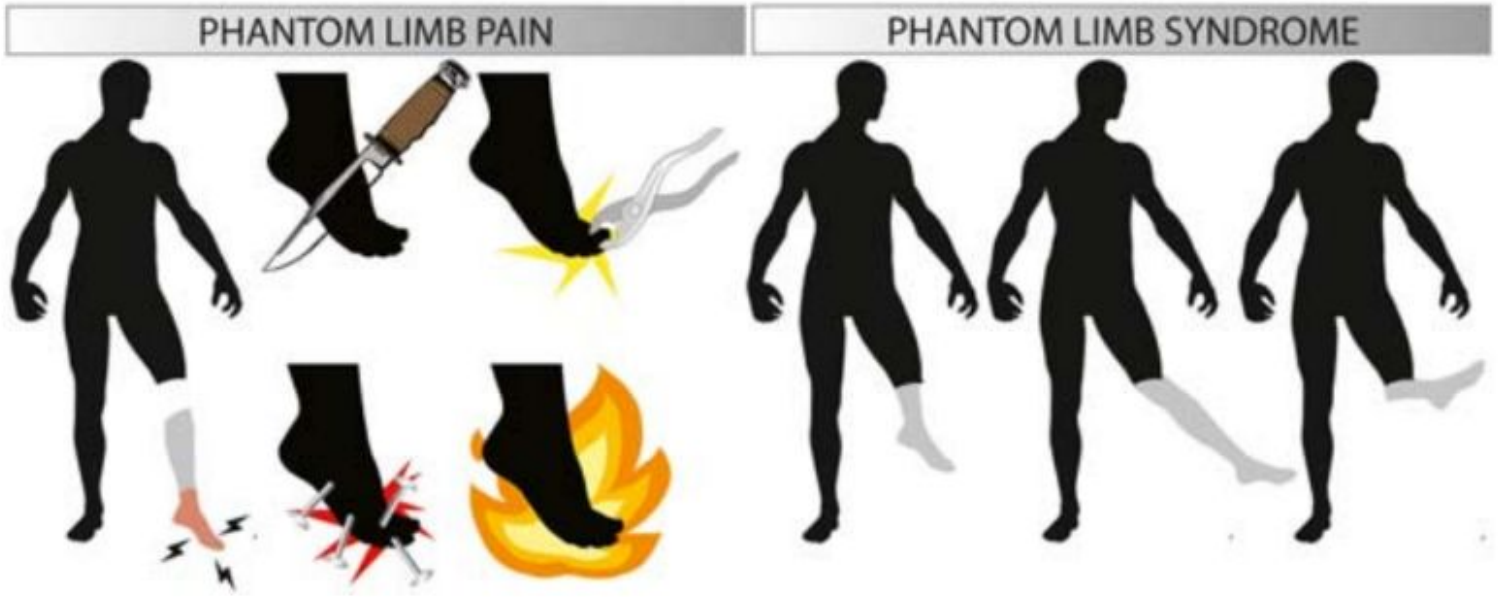
Giacomo Valle, Greta Preatoni and Stanisa Raspopovic
Neuroengineering Laboratory, Department of Health Sciences and Technology, Institute for Robotics and Intelligent Systems, ETH Zürich, Zürich, Switzerland

https://doi.org/10.1016/B978-0-12-822828-9.00007-1

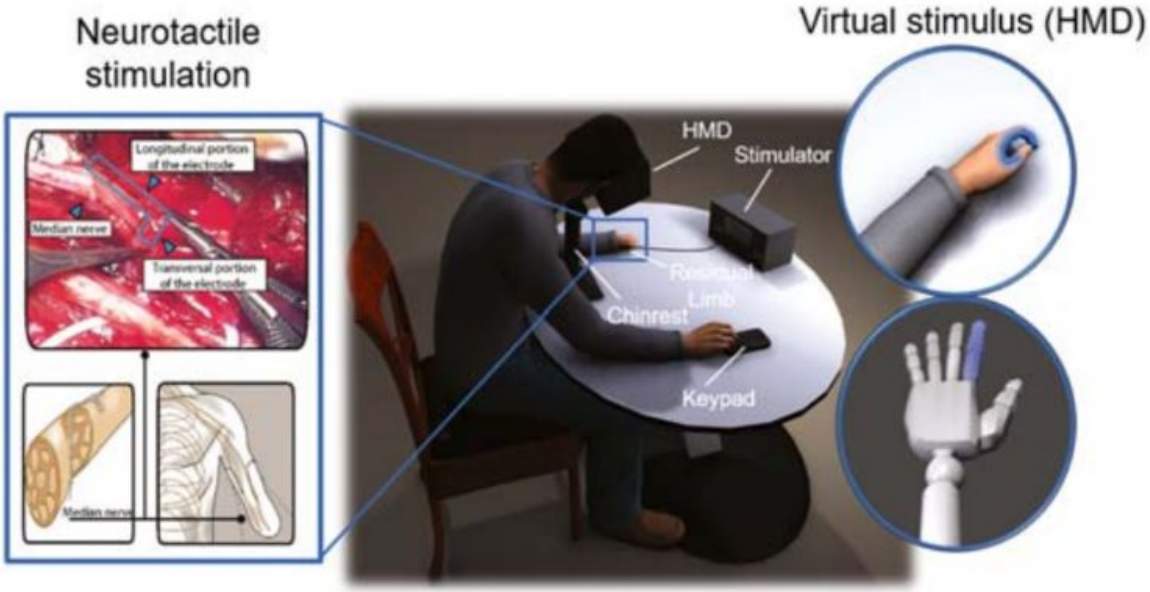
ABSTRACT
Leg amputees wear commercial prosthetic devices that do not give any sensory information about the interaction of the device with the ground or its movement. Amputees, relying on a very limited and uncomfortable haptic information from the stump–socket interaction, face grave impairments: risk of falls, decreased mobility, perception of the prosthesis as an extraneous body (low embodiment), and increased cognitive burden during walking with consequent psychological distress and device abandonment. Recently, the restoration of sensory feedback was obtained by stimulating the tibial nerve of the amputees through electrodes implanted in the nerve. It has been shown that this allows subjects to restore symmetric walking and confidence in the prosthesis, which enable increased speed of walking over uneven terrains. Touch and proprioception restored through intraneural stimulation diminish the fatigue during ambulation tasks as well as phantom limb pain. This also enhanced prosthesis embodiment and provided cognitive relief to amputees.

Keywords: Sensory feedback; amputees; neural stimulation; neural interfaces; prosthesis; peripheral nervous system; touch; neuroprosthesis; embodiment; cognitive

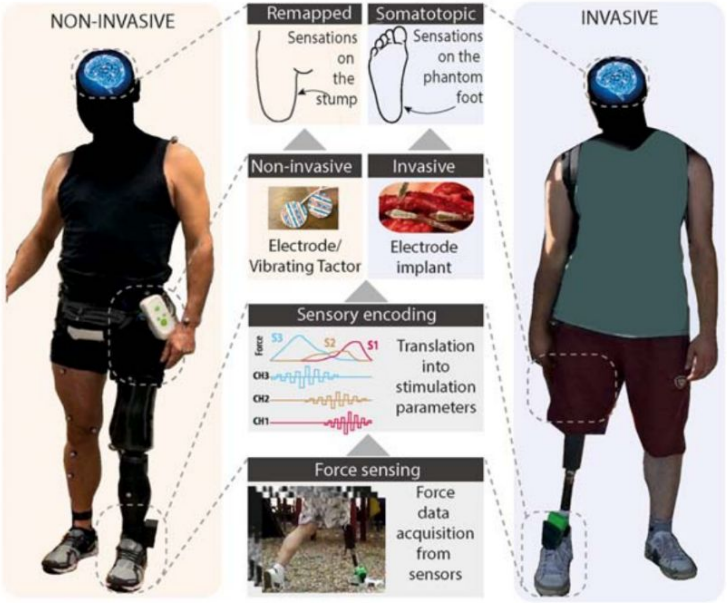
4.1 Phantom Limb Syndrome



4.2 Virtual Reality based rehabilitation



4.3 Sensory Rehabilitation



5. eSkin

Thank You :)