# SmartHand Transradial Hand Prosthesis

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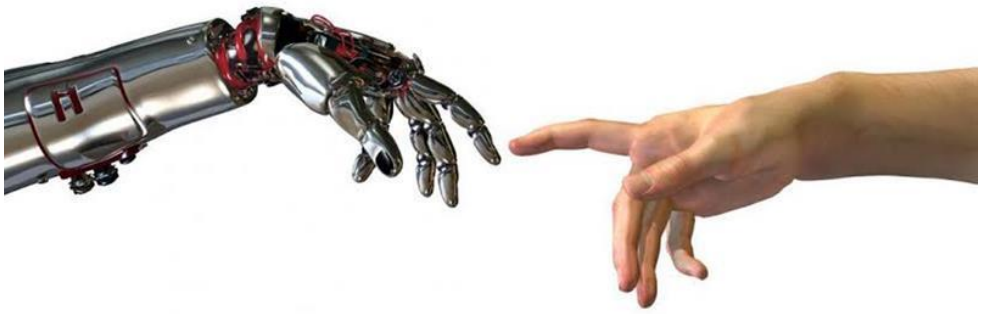
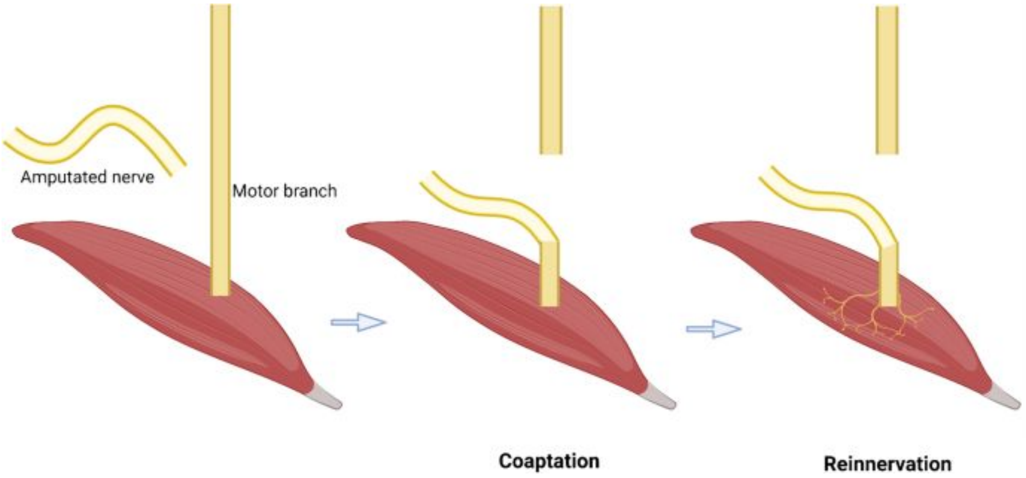
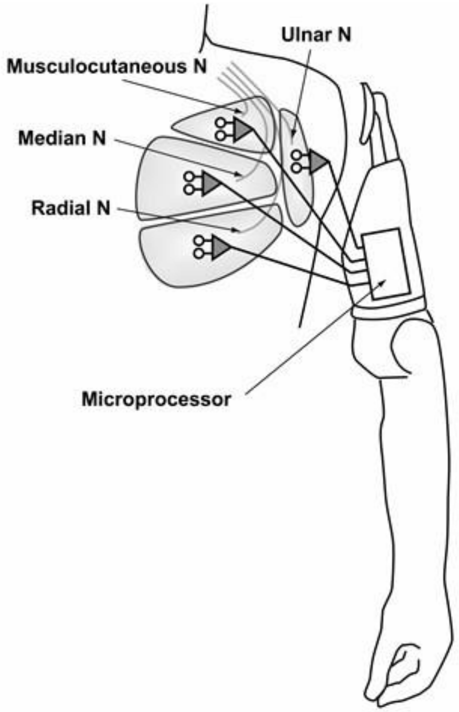


# Targeted Muscle Reinnervation

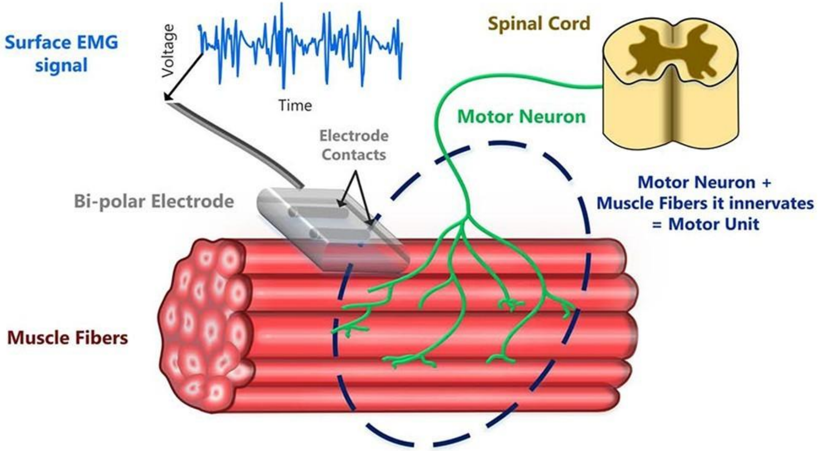
- Necessity to increase the **number** of **EMG control signals**
- More **intuitive** control

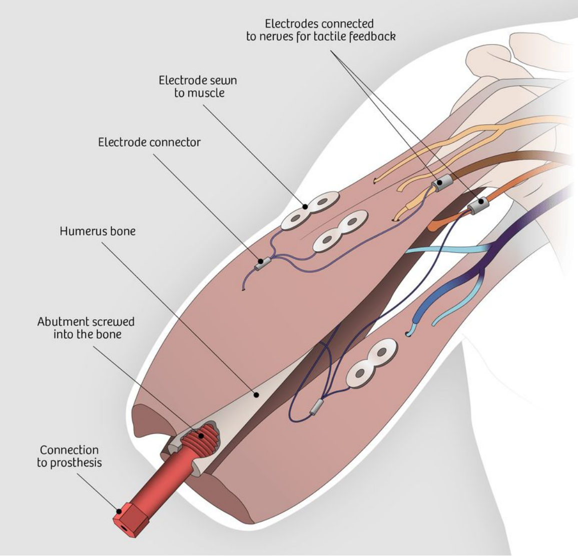


# Improvements

- Implantable EMG systems: **MyoPlant** and **IMES**
- Neurostimulation artifact removal algorithms
- **Osseointegration**



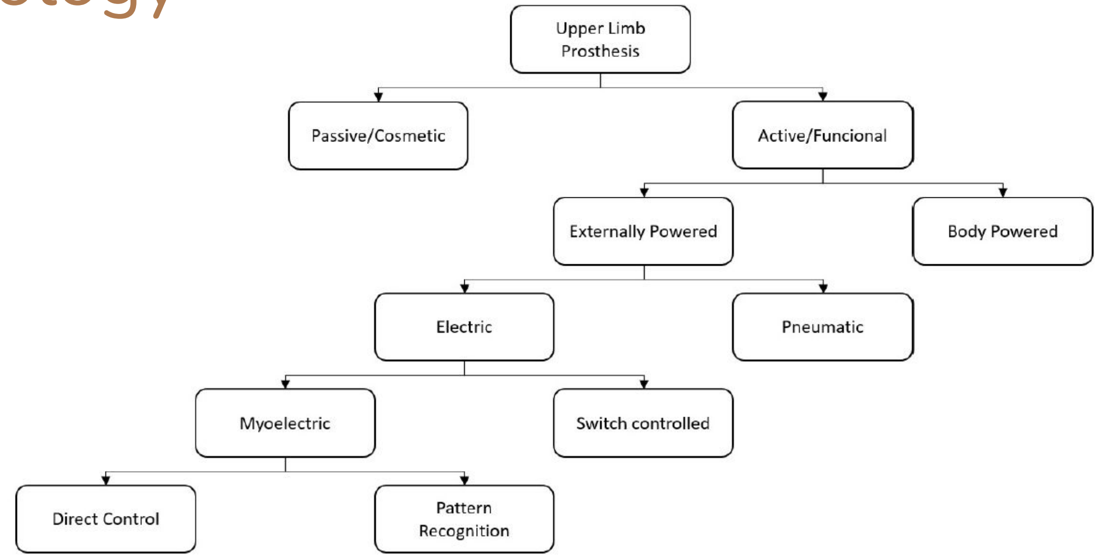



# Prosthesis Technology

**Cosmetic prostheses** are used to restored the aesthetic aspect, while **active** ones are used to restore, as far as possible, the functionality of the lost arm.

**The most used control system** is the **myoelectric** one, which exploits the electromyographic (EMG) signals.

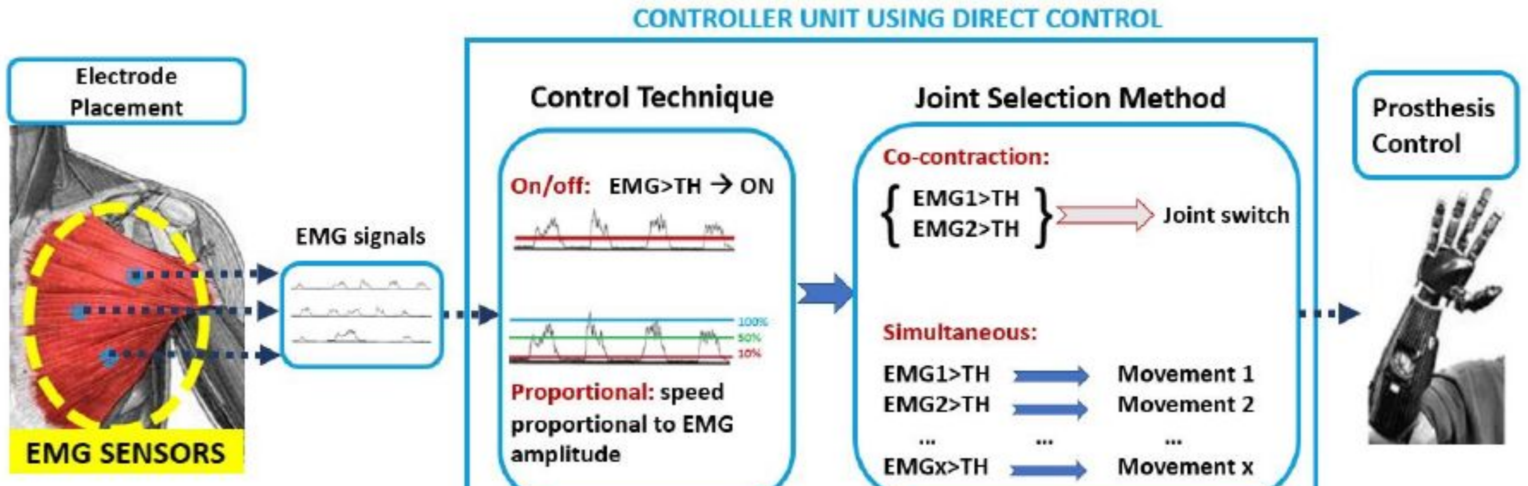
The control system must be **simple**, **direct** and **user-friendly**.



# Control Strategies: Direct Control (DC)

The **on/off strategy** is used to control one DoF and to allow two opposite movements to exceed a threshold.

In the **proportional control strategy**, the output applied to the motor is proportional to the level/intensity of the EMG signals' contraction.



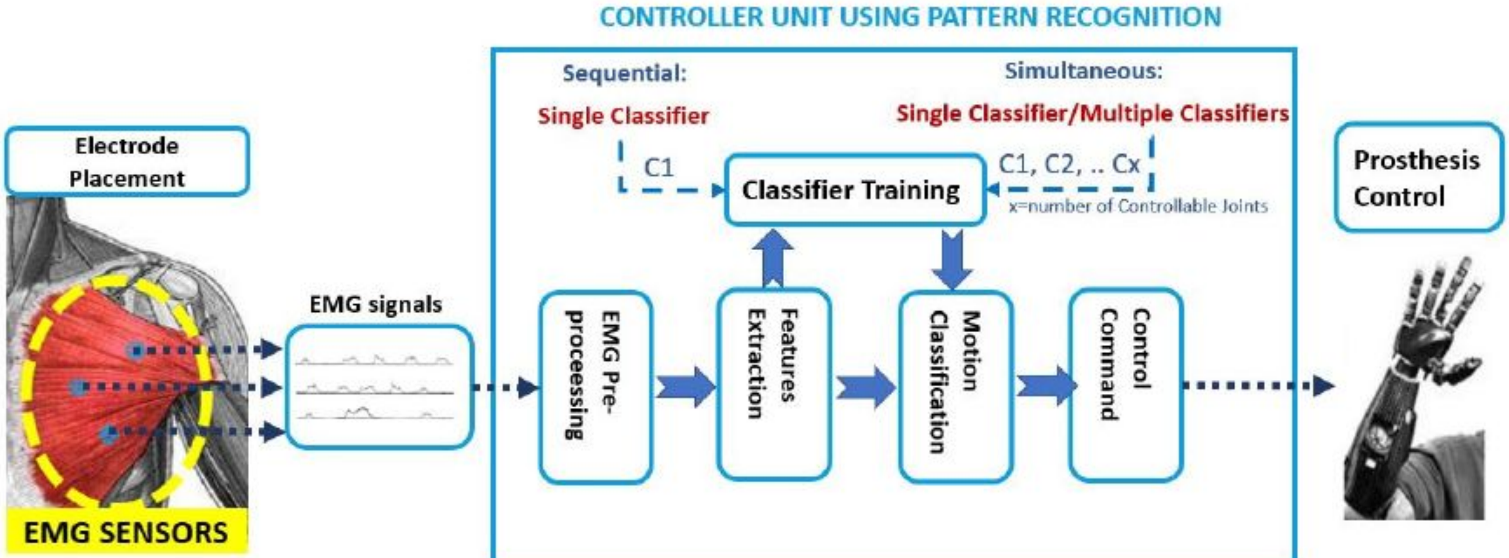

shoulder disarticulation amputee

# Control Strategies: Pattern Recognition (PR)

These strategies use **machine learning** techniques.

The **sequential control** technique works by only moving one DoF at a time.

The **simultaneous method** is used to control multi-DoF prostheses, handling more than one joint at the same time.

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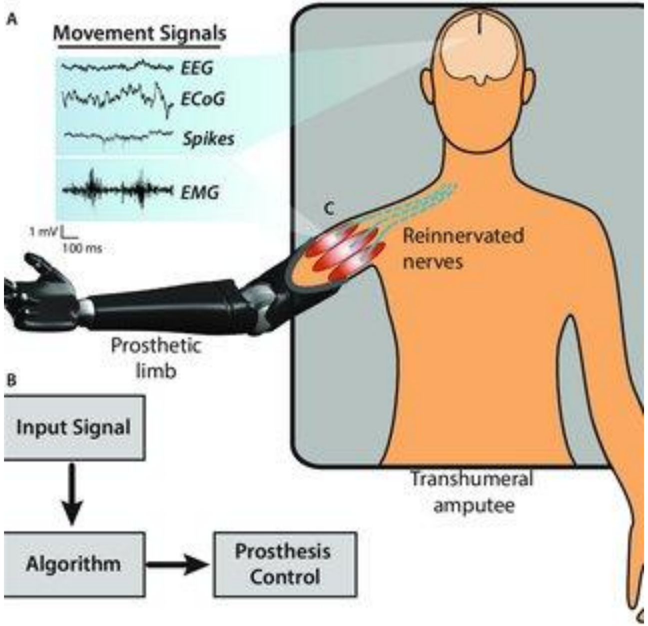
# Comparison Between DC and PR Control

**Simultaneous PR** control works better in path efficiencies, and task completion times when compared to both DC and traditional PR strategies.

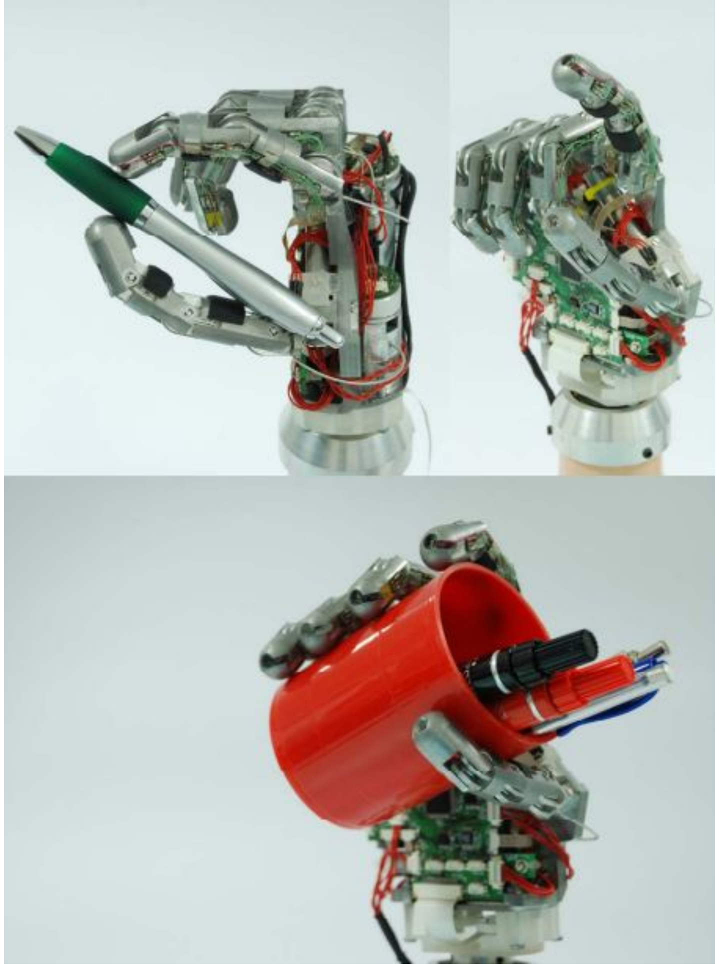
**Patients** generally favor PR control due to its intuitive nature, especially for tasks involving multiple DoFs.

**The choice between DC and PR** depends on factors such as amputation level, desired control complexity and user preferences.



# Design Criteria for Prosthetic Hand

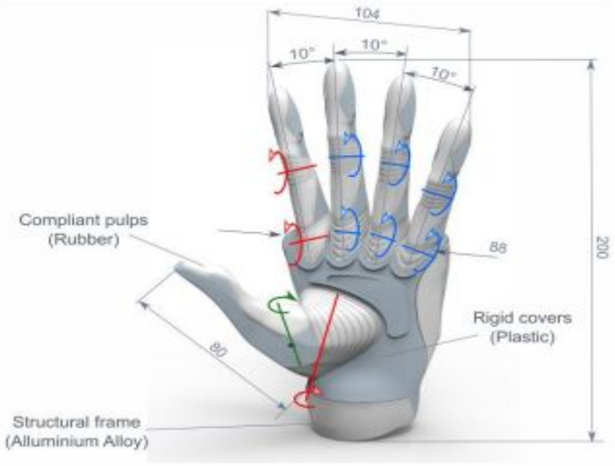
- ***Functional Requirements:***
  - *Power Grasp (35% of ADLs)*
  - *Precision Grasp (30% of ADLs)*
  - *Lateral Grasp (20% of ADLs)*
  - *Pressing Key/Buttons (7% of ADLs)*
  - *Basic Gestures/Natural Position (40% of day time)*
- ***Bioinspired Design:***
  - *Target Mass (around 400g)*
  - *Mimic Human Hand RoM*
  - *Minimize Perceived Weight for Ease of Use*
  - *Reduce Compensatory Movements & Overuse Syndromes*
- ***Performance Metrics:***
  - *Speed (whole hand closing in < 2s)*
  - *Grasping Force (able to grasp everyday objects)*
  - *Low Power Consumption*

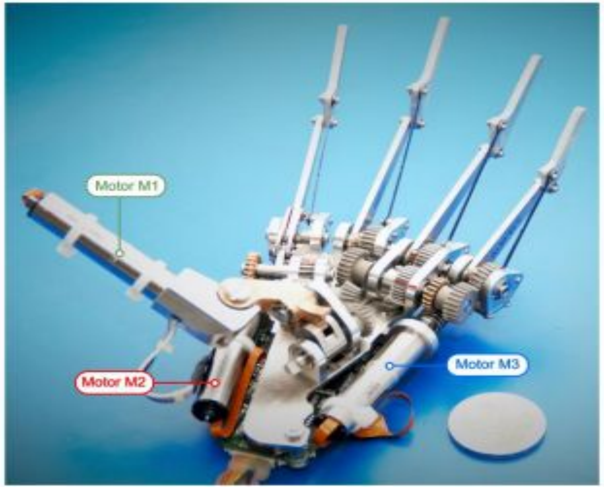


# MyHand (2016) [SSSA]

- ***Long Fingers with Two Joints Each**: proximal and distal (except for  the thumb)*
- ***Three Identical DC Brushless Motors**:*
    - ***M1** - flexion/extension of the thumb*
    - ***M2** - abduction/adduction of the thumb and flexion/extension of the index*
    - ***M3** - synchronous flexion/extension of the last three fingers*
- ***Finger Pads**: designed to replicate the human skin*

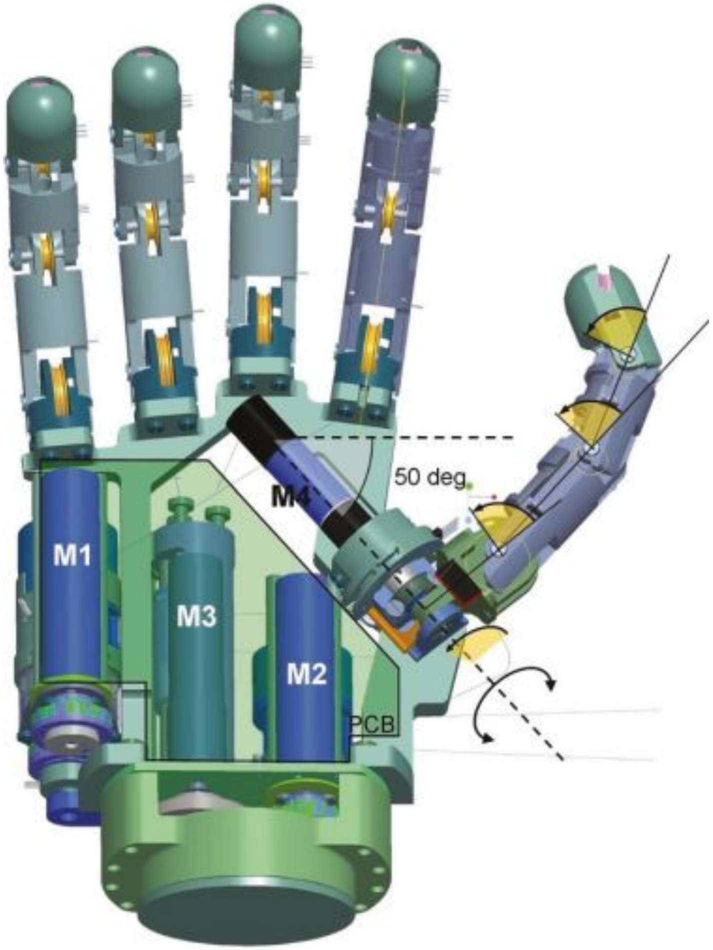
Controzzi M et al. The SSSA-MyHand: A Dexterous Lightweight Myoelectric Hand Prosthesis. IEEE Trans Neural Syst Rehabil Eng. 2017 May;25(5):459-468.



# SmartHand (2011)

- ***Four DC Brushed Motors***:
  - ***M1*** - flexion/extension of the thumb
  - ***M2*** - flexion/extension of index
  - ***M3*** - synchronous flexion/extension of the last three fingers
  - ***M4*** - abduction/adduction of the thumb
- ***Nylon Coated Steel Tendons***
- *Equipped with **32 Proprioceptive and Exteroceptive Sensors***
- ***Customized Control Architecture** Embedded in the Palm*




Cipriani et al. (2011). The SmartHand transradial prosthesis. Journal of neuroengineering and rehabilitation. 8. 29. 10.1186/1743-0003-8-29.

# Pros and Cons Comparison

***SSSA-MyHand***
***Designed for Real-World Use***

✓ Anthropomorphic Design (Size, Weight - 478g)

✓ Robust and Low Cost

✓ Time to Complete a Grasp - 270ms

*X* Limited Sensory Feedback

*X* 4 DoFs

VS

***SmartHand***
***Designed for Laboratory Experiments***

✓ Advanced Sensory Feedback and Control

✓ 16 DoFs (closer to human hand - 27 DoFs)

*X* Weight (530g)

*X* Complex and High Cost

*X* Time to Complete a Grasp - 1.5s

# Sensory Feedback - System Overview

***Introduction***:

- Growing interest in ***vibrotactile feedback*** in prosthetics.
- Limited integration of high-frequency tactile information in prostheses.

***VIBES System***:

- Wearable vibrotactile system for prosthetic sockets.
- Compact planar vibrotactile actuators in direct skin contact.
- Utilizes acceleration profiles from IMUs on the robotic prosthesis (SoftHand Pro).

***Objectives***:

- Transmit high-frequency tactile information (e.g., surface roughness) to prosthetic users.
- Achieve somatotopic matching (SM) and modality matching (MM) paradigms.

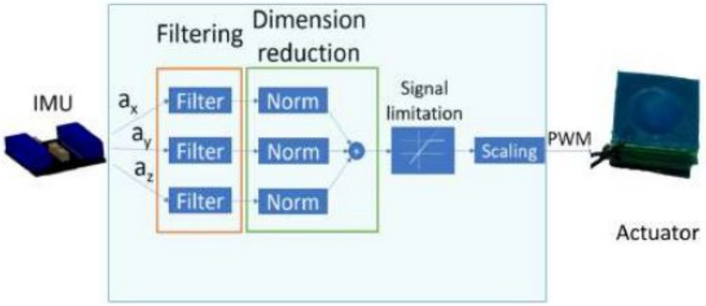
# Experimental Characterization and Design

***Experimental Characterization***:

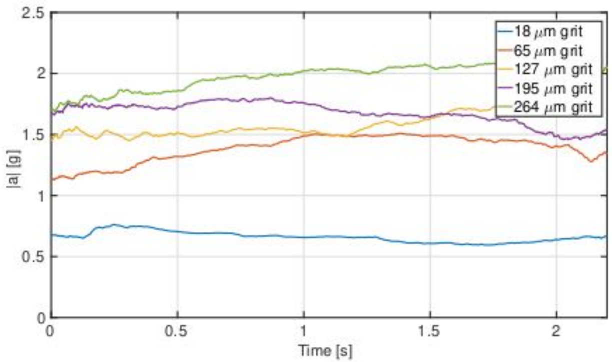
- Psychophysical study with 15 able-bodied participants.
- Computing the Just Noticeable Difference (JND) for discrimination of vibrotactile cues.
- Positive results: Users could detect and distinguish contact a texture cues.

***System Design***:

- Integration of Haptuator Planar (HP) actuators into the inner socket.
- Control strategy maps IMU-acceleration signals to activate corresponding actuators.







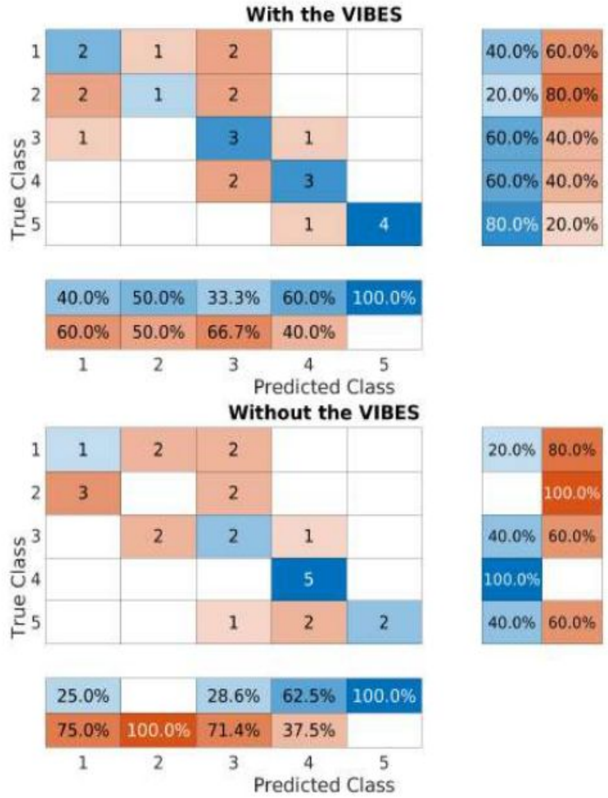
# Experimental Results and Conclusions

***Pilot Experiments with Prosthetic User***:

- Positive outcomes in roughness discrimination.
- Active Texture Identification Experiment showed improvement with VIBES feedback.
- System Usability Scale (SUS) questionnaire indicated a positive user experience.

***Conclusion and Future Directions***:

- VIBES is a promising solution for transmitting and restoring tactile feedback.
- Acknowledgment of preliminary nature and plans for further research.
- Mention potential areas for improvement and expansion of the study.



# Conclusions

1) Remarkable progress and innovation in the field of prosthetic technology, encompassing the intricate design and future aspirations of all of these technologies

2) Together, these insights underscore a collective dedication to advancing prosthetic capabilities

3) They also illuminate the persistent challenges of standardization and the ongoing pursuit of interdisciplinary collaboration to ensure the continued evolution and optimal integration of these technologies for the benefit of prosthetic users worldwide

# Thank You For Listening

We’d Be Happy To Answer Any Question