Man machine interfaces for hand prostheses: retrospective and future trends

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About the lecture

When we grasp an object, we do not really think about how we do it. Grasp type, adjustment of the wrist angle, and movement of the fingers seem to happen automatically. Sudden loss of a hand dramatically changes this situation with impact on a person's ability to perform work-related, social and daily life activities. Current hand prostheses are advanced robotic systems that mechanically closely mimic the degrees of freedom of biological hands, allowing individual finger movements and up to 24 different grip types.

However, the amputee user has to learn how to individually control these functions without feedback from touch or proprioception and in a relatively short time. Indeed, and somewhat surprisingly, one of the primary complains of amputees is on the lack of prosthesis dexterity. This perceived incapability leads to high rejection rates (one quarter of the amputees) and in many cases the subjects eventually give up and use the highly functional prosthetic device as a simple cosmetic replacement (one third of amputees are so called passive users).

In this lecture we will investigate the state-of-the-art man machine interfaces for hand prostheses. We will discuss current and future trends in research, with the special emphasis on understanding the overall rehabilitation process.

Lecture outline

- Background and prevalence
  - Who needs a prosthetic device? Understanding amputees needs.
  - Which conditions lead to a limb loss?
- Historical development
  - Cosmetic (passive) prostheses
  - Body and battery powered (active) prostheses
- State of the art man-machine interfaces
  - Two-channel myocontrol (industry standard)
  - Machine learning myocontrol (academia)
- The pitfalls of contemporary interfaces:
  - Amputation paradox: too few information sources?
  - The noise is inherent to the myocontrol
  - Can effective control be achieved without feedback?
- Some modern approaches:
  - Invasive interfaces: oseointegration, electrode implantation
  - Surgical procedures: TMR, muscle transplantation
  - Closing the control loop (feedback)
- Future of man machine interfaces:
  - Optogenetics
  - Multi-modal sensor fusion for natural prostheses control

About the lecturer

Marko Markovic received his Master of (biomedical) Engineering at the University of Belgrade, Serbia, in 2011 and PhD degree (summa cum laude) at University of Göttingen in 2016. In period 2014 - 2016, he was employed in a world-leading prosthetic company OttoBock HealthCare. In 2016, he switched to University Medical Center Göttingen (UMG) to work as a research assistant (postdoc) on a nationally funded research project focused on the design of intelligent prosthetic hands. Since 2018, he is an active member of a Postdoc Committee at the University of Goettingen, which is devoted to promoting interests of a postdoc community. During his research career he has (co)authored more than 15 peer-reviewed publications in the area of man-machine interfaces for prosthetic devices. Among others, these include multi-modal feedback interfaces, sensor-fusion and machine learning algorithms for prosthesis control. He also holds rights to a European patent in this area - EP 13171671.4.