Physiopathology – Motor prostheses

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Cortical control of a prosthetic arm (invasive or non-invasive)

Re-wiring of motor neuron signals from lost limb through chest muscles

The MANUS HAND uses EMG from arm to control robotic hand

Central control signals

Myoelectric (muscle) signals
Functionality by sharing control between user and automation

Allows 4 different grasp types (~90% of hand use): cylindrical, precision, hook and lateral
A single EMG channel is used to control the prosthetic hand.

3 levels of EMG amplitude input recognized: nonexistent, low, high.

3-bit “word” communicated to controller through sequence of 3 EMG bursts. In theory, 27 different commands can be sent (in practice, only 18)

Example shown: sequence of low, high, low
MANUS Hand - Conclusions

In trials, users successfully able to learn command language and grasp objects

Could be expanded to higher-level arm amputees due to low ratio of input EMG channels to active joints

Non-intuitive control requires concentration, has high rejection rate in practice

Although more active joints than commercial alternatives, motion is still limited by under-actuation
Targeted muscle reinnervation - Overview

Thinking about moving your arm will result in your chest muscles contracting and your robotic arm moving.

Natural control of prosthetic limb while still using EMG as input by “re-wiring” motor neurons to intact muscle.

Denervate an “expendable” area of muscle, such as in the chest.

Attach motor neurons from the amputated arm to different areas of the deinnervated chest muscles.

Use surface electrodes over chest muscles to provide many channels of EMG control input to prosthetic.
Targeted muscle reinnervation - Video
Control of multiple joints simultaneously
Natural-feeling, intuitive control compared to conventional EMG controlled prosthetics
Invasive procedure, not guaranteed to work
Still face challenge of interpreting EMG signals, must use classifier to select from subset of recognized motions
Cortical motor control – Broadly tuned M1 neurons
Cortical motor control – Population vector principle
Cortical motor prosthesis - Overview
Cortical motor prosthesis - Video

BrainGate Pilot Clinical Trial
Five Consecutive Assessment Days
Trial Days 999–1003
Simeral et al, 2011

Signal types for decoding, LFP example

A

B

Cortical motor prosthesis - Conclusions

Allows (directional) control of computer cursor or robot arm.

Performance varies depending on electrophysiological signal type.

Cortical surgical procedure associated with risks. Ability of cortex to learn might be a considerable advantage.

Variety of signals available for decoding with particular advantages / disadvantages.