Neuroprosthetics & AI:

Challenges & Opportunities
Interfacing with the ultimate electrical system

- Neural recordings
- Neural stimulation

- Restore hearing
- Restore sight
- Treat neuropsych disorders
- Restore movement
Parallel revolutions in neuro hardware & software

**Hardware:**
Tools to record & stimulate the nervous system

- **High-density electrodes**
- **Large-scale imaging**

Jun et al., *Nature* 2017

Sofroniew et al., *eLife* 2016

**Software:**
Tools to analyze large data (ML/AI)

- **Feedforward neural network**
- **Recurrent neural network**

Stevenson lab, *Uconn*
Restoring movement with neuroprostheses

Translation to human clinical trials

- Hochberg et al., Nature 2012
- Collinger et al., Lancet 2012
- Raspopovic et al., Sci Trans Med 2014
- Willet et al., Nature 2021

Diverse user needs

- Causes of Paralysis:
  - Spinal Cord Injury: 1,275,000 (23%)
  - Multiple Sclerosis: 939,000 (17%)
  - Unspecified Birth Defect: 110,000 (2%)
  - Traumatic Brain Injury: 242,000 (4%)
  - Neurofibromatosis: 212,000 (4%)
  - Cerebral Palsy: 412,000 (7%)
  - Cerebral Palsy: 272,000 (5%)
  - Other: 526,000 (9%)
  - Post-Polio Syndrome: 5,596,000 (N=5,596,000)

Christopher and Dana Reeve Foundation
Huge challenges and opportunities

Neural interface:
- high throughput
- low power, noise
- stable
- minimal tissue reaction

Algorithms:
- high-performance, low-latency decoding / encoding
- Reliable across users, settings

Prosthetic devices:
- dexterous control
- adaptable for user needs
- low power, lightweight

Solutions are inter-dependent

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Prosthetics and AI
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Possibilities for amputees

**Replantation**
- Time constraint for action
- Amputated part destroyed

**Transplantation**
- Life-long Immunosupression
- Psychological effect

**Muscular Reinnervation**
- Control & Sensing same area
- Sensory gating issue

**Direct nerve interfacing**
- Tyler Lab/Cleveland Medical

**BIONICS**

**Direct muscle interfacing**
- Pasquina/ Walter Reed
Sophisticated robotic prostheses are arriving.
Human-machine interfacing enables:

- Restoration of lost motor and sensory functions,
- Pain management,
- Bidirectional control of artificial limbs


Raspopovic et al., *Nature Materials* 2021
Restoring realistic leg feelings years after amputation

Petrini et al. 2019, Sci Trans Med