Artificial intelligence in Bionic Medicine

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C.O.I. Disclosure

No affiliation (financial or otherwise) with pharmaceutical, medical device or medical communications organizations.

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950BC - 700BC, The "Cairo Toe"(The University of Manchester),
Video courtesy:
Amii / Chris Onciul
Direct brain-computer interfaces: study participant Jan Scheuermann feeding herself with a robotic limb (University of Pittsburgh / UPMC); http://www.upmc.com/media/media-kit/bci/Pages/default.aspx
cortical implants

bone, muscle, and nerve integration

Brain-body-machine interfaces: “APL’s Modular Prosthetic Limb Reaches New Levels of Operability” (JHU Applied Physics Laboratory); https://youtu.be/-0srXv0Qlu0
Consumer-Available BCI and BMI
perception
action
cognition
Tightly Coupled
Licklider, 1960
the control pathway

Hallworth, et al.,
MEC, 2020
machine intelligence

the feedback path
(mechanical, auditory, visual)
engineered feedback

surgically enhanced feedback

Marasco, et al., Science Robotics, 2021
Hebert, et al., IEEE TNSRE, 2014
machine learned bidirectional coordination
Tightly coupled interfaces require adaptation and sculpting to individual agents (machine and human) and their unique flow of daily life.
Progress relies on the continual construction of representations, predictions, policies, and models in tightly coupled interfaces
Main Considerations & Starting Points

Train/test or continual learning?  Continual learning
Pre-trained or tabula rasa?  No Minimize prior biases*
Relationship or a code channel?  Evolving relationship
Continual learning in **motor prediction**. Parker et al., *IEEE SMC* 2022 (submitted); Parker et al., *ICORR* 2019.


Continual learning in **exoskeleton control**. Faridi et al., *ICORR* 2022.
Continual learning in **motor prediction**. Parker et al., *IEEE SMC 2022* (submitted); Parker et al., *ICORR 2019*.

**Predicted muscle fatigue** in wheelchair propulsion. Pilarski, et al., *IFESS 2013*.

Continual learning in **mode switching**. Edwards et al., *BioRob 2016*.

Continual learning in **exoskeleton control**. Faridi et al., *ICORR 2022*. 
Continual learning in **motor prediction**.
Parker et al., *IEEE SMC* 2022 (submitted);
Parker et al., *ICORR* 2019.

Continual learning in **mode switching**.

Continual learning in **exoskeleton control**.
Faridi et al., *ICORR* 2022.
Continual learning in **motor prediction**. Parker et al., IEEE SMC 2022 (submitted); Parker et al., ICORR 2019.


Continual learning in **exoskeleton control**. Faridi et al., ICORR 2022.
Examples: 2011-2021

Identifying patterns with TIDBD
 GV F collections predicting surprise
 LfD from a contralateral limb
 Learned feedback
 Learned joint synergies
 RL policies from human reward
 Pavlovian control in SCI

Gunther 2020
Gunther 2018, Pilarski 2016
Vasan 2017, Vasan 2018
Parker 2014, 2019
Pilarski 2013, Sherstan 2015
Pilarski 2011
Dalrymple 2020
Examples: 2011–2021

Identifying patterns with TIDBD
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Constructed based on sensorimotor interactions with an individual and what they do, not an objective “task”

Gunther 2020
Gunther 2018, Pilarski 2016
Vasan 2017, Vasan 2018
Parker 2014, 2019
Pilarski 2013, Sherstan 2015
Pilarski 2011
Dalrymple 2020
Situated & Assessable


Video courtesy:
Amii / Chris Onciul
Continual learning is important.
Constructing representations, predictions, policies, and models from ongoing experience lets tightly coupled interfaces align & specialize to individual human (or machine) agents and needs.
machine learned bidirectional coordination
Continually learning tightly coupled intelligent systems
Post-surgery Osseointegration Rehabilitation conducted at the Glenrose Rehabilitation Hospital
Thank you and questions!

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