Artificial Intelligence in Medicine

Patrick M. Pilarski, Ph.D.

Canada Research Chair in Machine Intelligence for Rehabilitation
Division of Physical Medicine and Rehabilitation, Dept. of Medicine

Fellow, Alberta Machine Intelligence Institute (Amii)

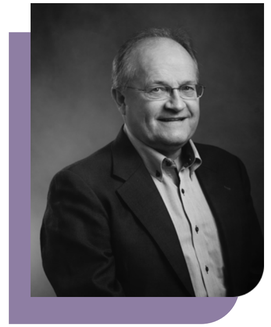
Alberta Machine Intelligence Institute

Amii researchers lead the world in the research and development of machine intelligence.

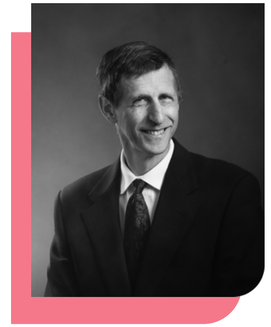
Michael Bowling

Angel Chang

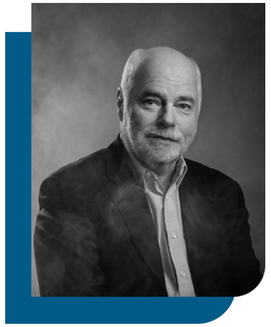
Alona Fyshe



Randy Goebel



Russ Greiner

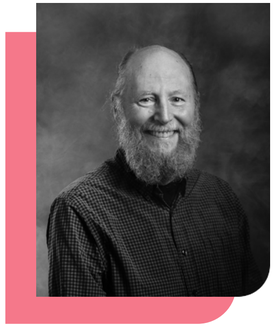


Robert Holte

Patrick M. Pilarski

Dale Schuurmans

Or Sheffet



Richard S. Sutton

Csaba Szepesvári

Martha White

James Wright

Yutaka Yasui

Osmar Zaïane

Amii is a key partner in many notable machine intelligence achievements

Pioneer of reinforcement learning – Richard Sutton

First group to beat poker pros at Heads-up no-limit Texas hold'em – Michael Bowling

Solved the game of Checkers – Jonathan Schaeffer

Academic origins of AlphaGo and the Atari Game Project

Developed UCT algorithm at the heart of many advancements in games – Csaba Szepesvári

Thailand National Innovation Award for Tuberculosis Diagnosis – Yutaka Yasui

System capable of passing Japanese Bar exam – Randy Goebel

Open-source community centred around adaptive prosthetic limbs – Patrick Pilarski

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Artificial Intelligence in Medicine thinking, moving, and perceiving

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UNIVERSITY OF ALBERTA
EDMONTON·ALBERTA·CANADA

amii

Learning Objectives

1. be able to **define artificial intelligence (AI), machine learning (ML)**, and related concepts from the field of intelligent systems.

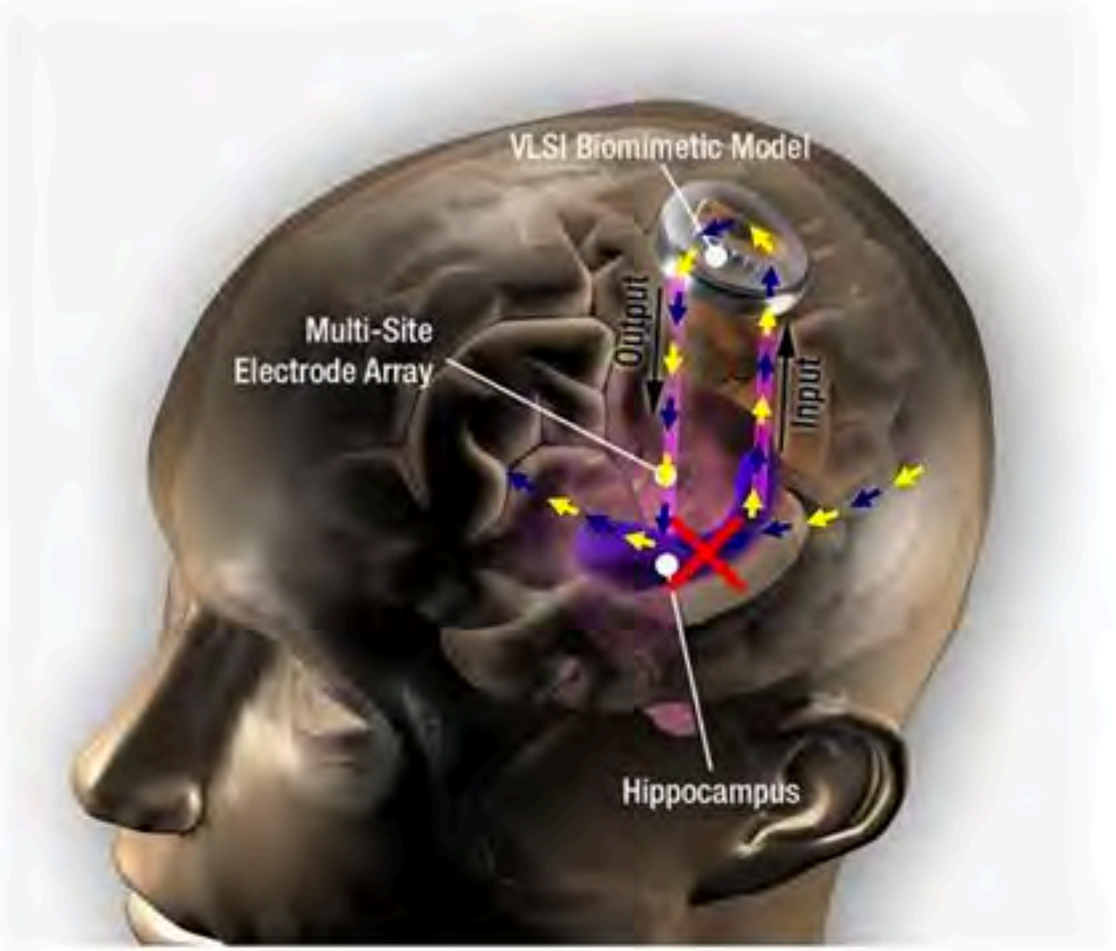
2. be able to describe and **discuss the defining characteristics of AI and ML**.

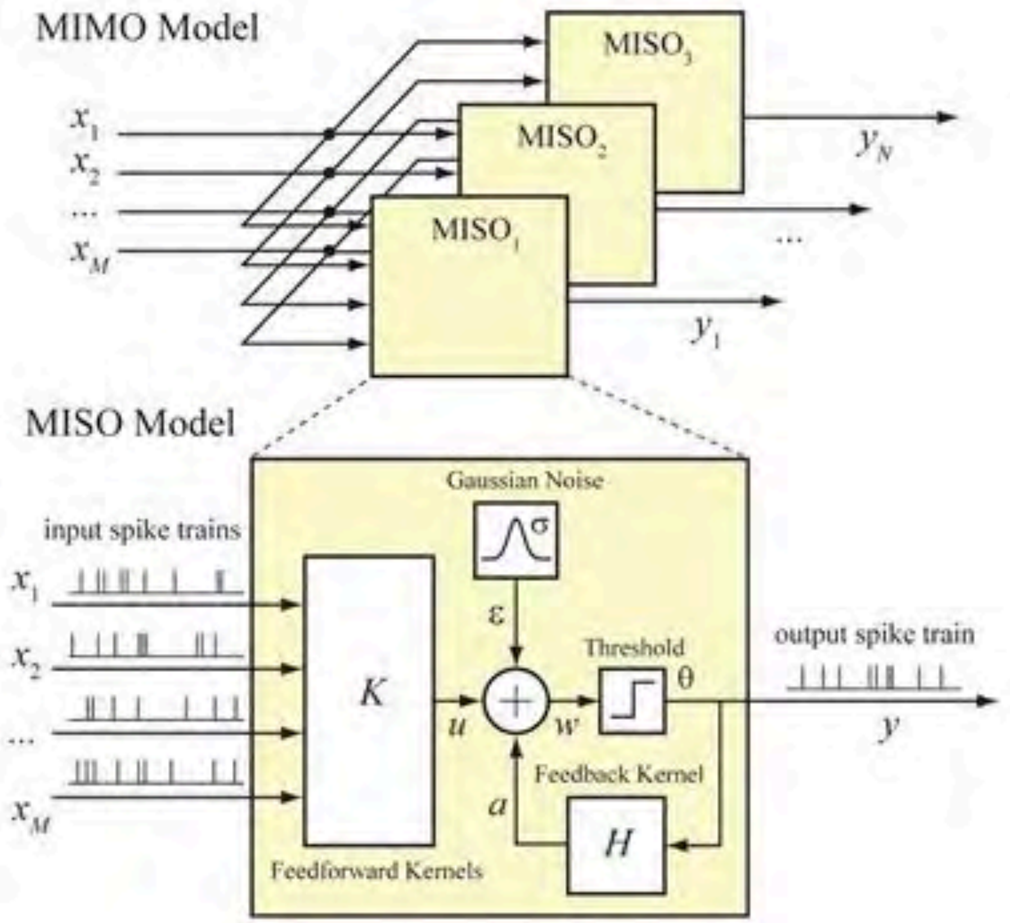
3. be able to describe and **discuss how AI has been applied in medicine** (specifically with regard to muscles and nerves).

4. be able to **estimate the impact emerging intelligent systems technology** will have on your own life, practice, study, or work within the next 5-10 years.

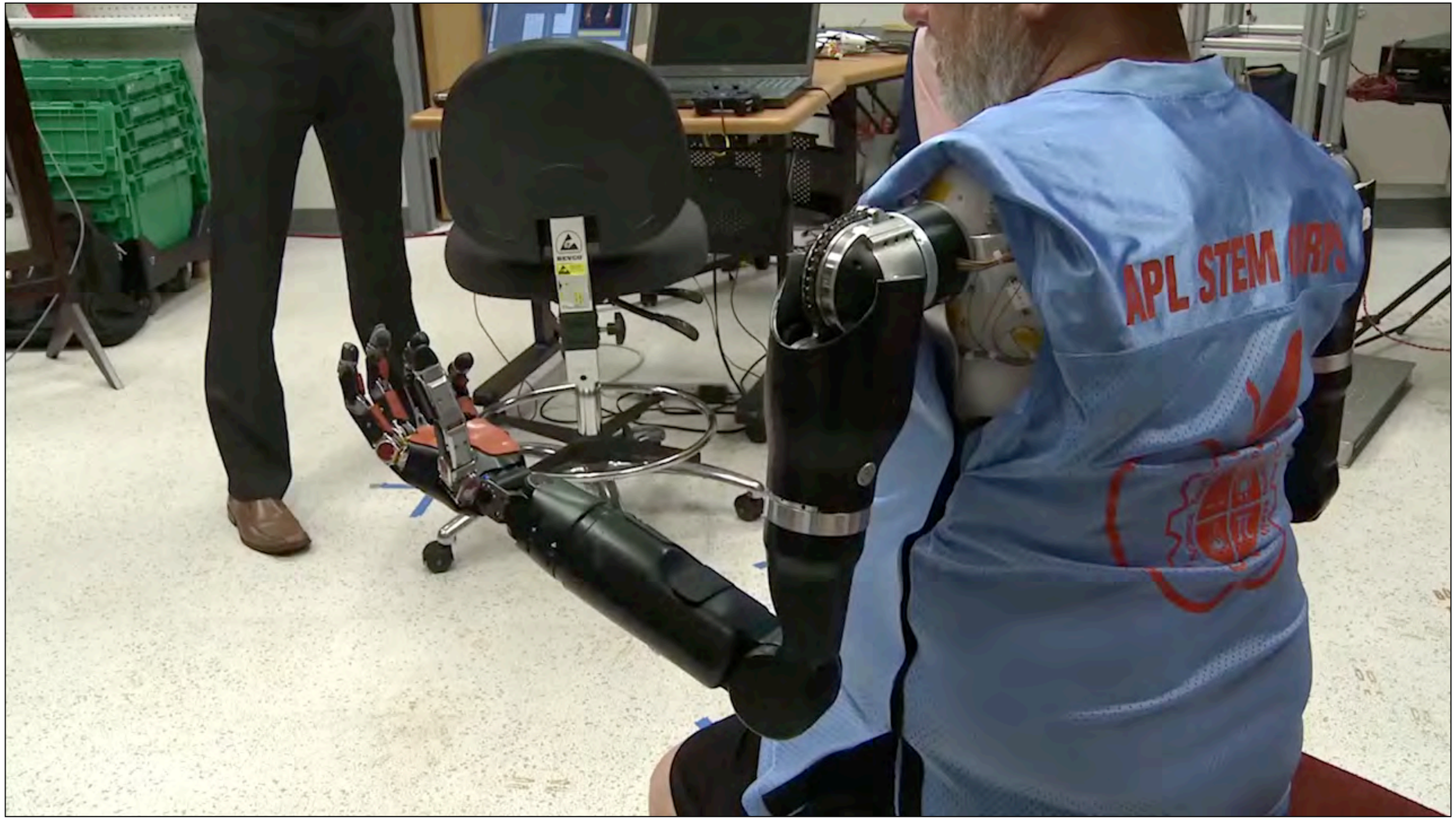
5. be able to **find and cite appropriate resources for future self-study** on AI and its application within medicine.

Direct brain-computer interfaces: study participant Jan Scheuermann feeding herself with a robotic limb (University of Pittsburgh); http://www.upmc.com/media/media-kit/bci/Pages/default.aspx



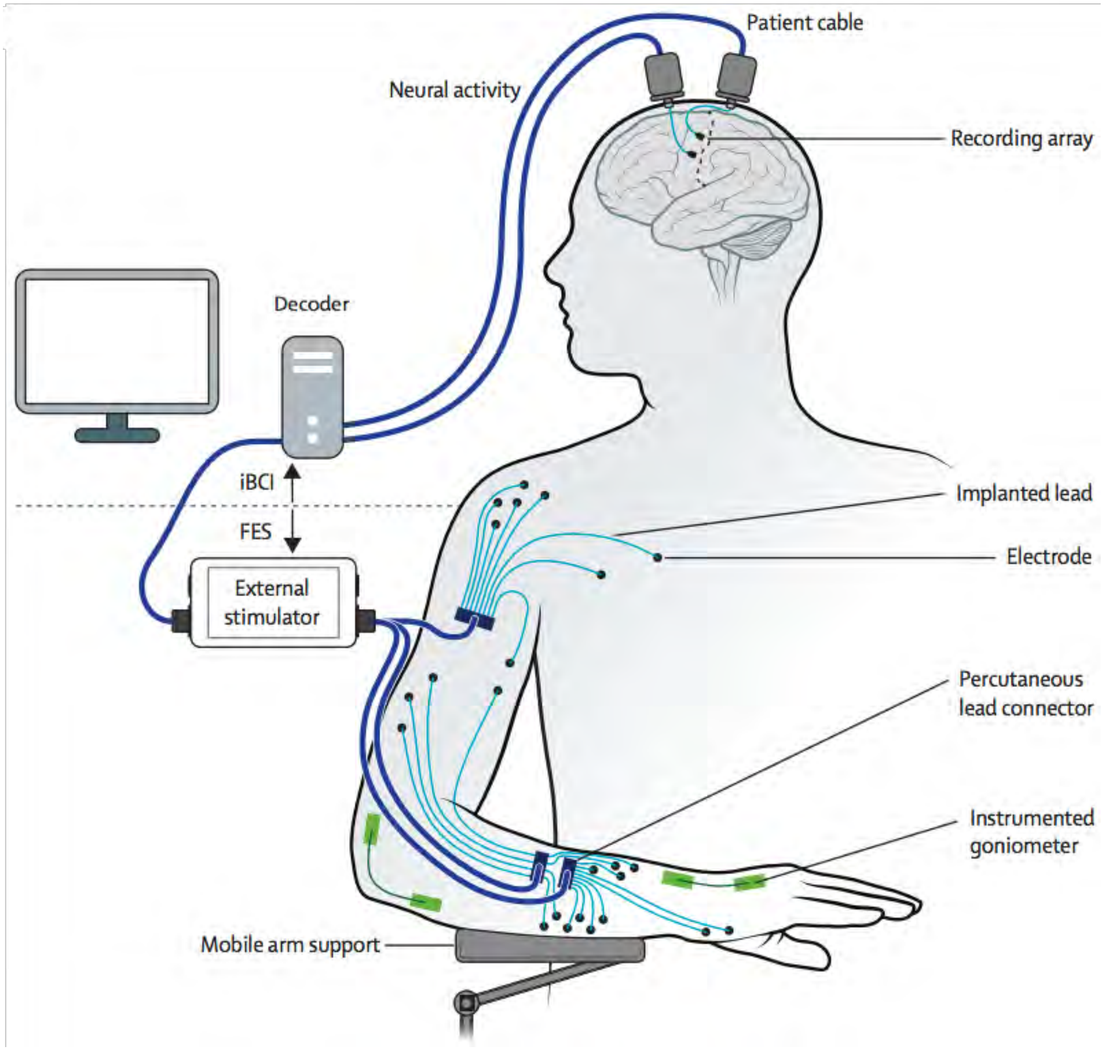


Direct brain-computer interfaces: *memory protheses* from the Center for Neural Engineering, Viterbi School of Engineering. https://cne.usc.edu/neural-prosthesis-for-hippocampal-memory-function/ and IEEE Trans Neural Syst Rehabil Eng. 2018, 26(2):272-280.



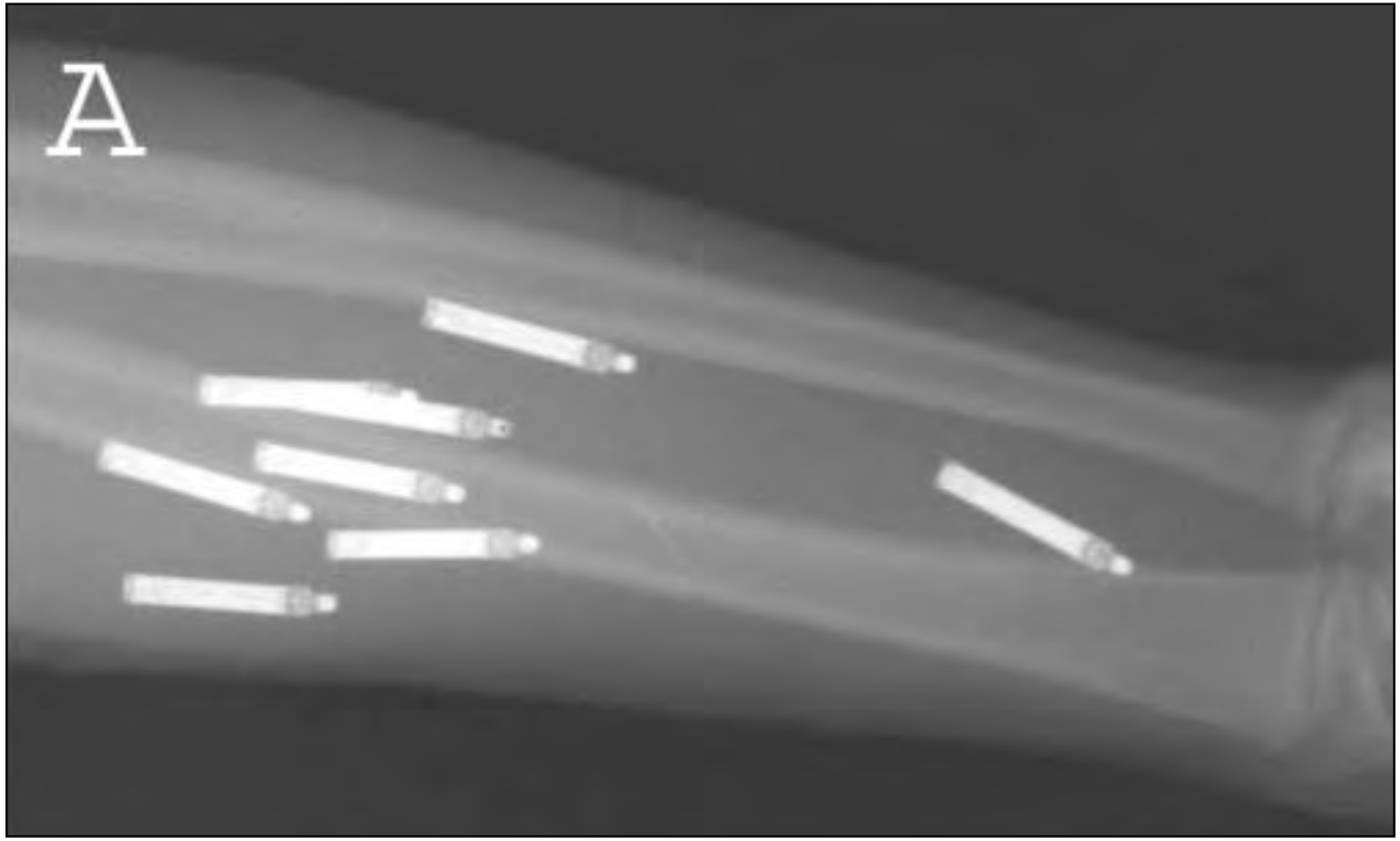
Brain-body-machine interfaces: “Amputee Makes History with APL’s Modular Prosthetic Limb” (JHU Applied Physics Laboratory); https://youtu.be/9NOncx2jU0Q

Brain-body-machine interfaces: “APL’s Modular Prosthetic Limb Reaches New Levels of Operability” (JHU Applied Physics Laboratory); https://youtu.be/-0srXvOQlu0



Brain-body-machine interfaces: "Restoration of reaching and grasping movements through brain-controlled muscle stimulation in a person with tetraplegia: a proof-of-concept demonstration" Ajiboye, A Bolu et al., *The Lancet*, Volume 389 , Issue 10081, 1821-1830, 2017.

Brain-body-machine interfaces: “Brain-Machine Interface @ EPFL- Wheelchair” (École polytechnique fédérale de Lausanne); https://youtu.be/0-1sdtnuqcE



Brain-body-machine interfaces: Baker et al., “Continuous Detection and Decoding of Dexterous Finger Flexions With Implantable MyoElectric Sensors,” IEEE TNSRE 18(4):424-32, 2010.

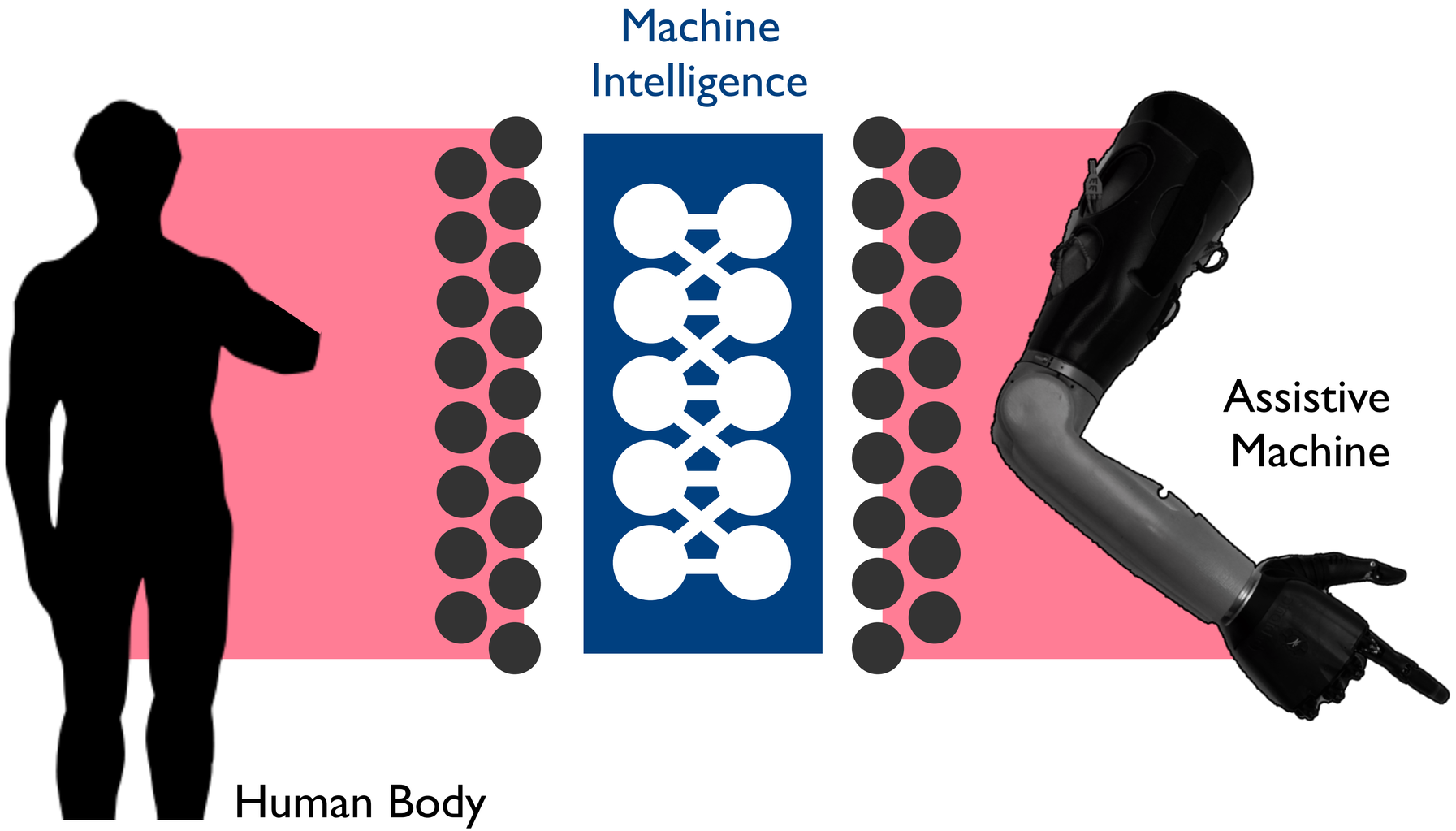
Commercially Deployed
Pattern Recognition for Prostheses

Muse

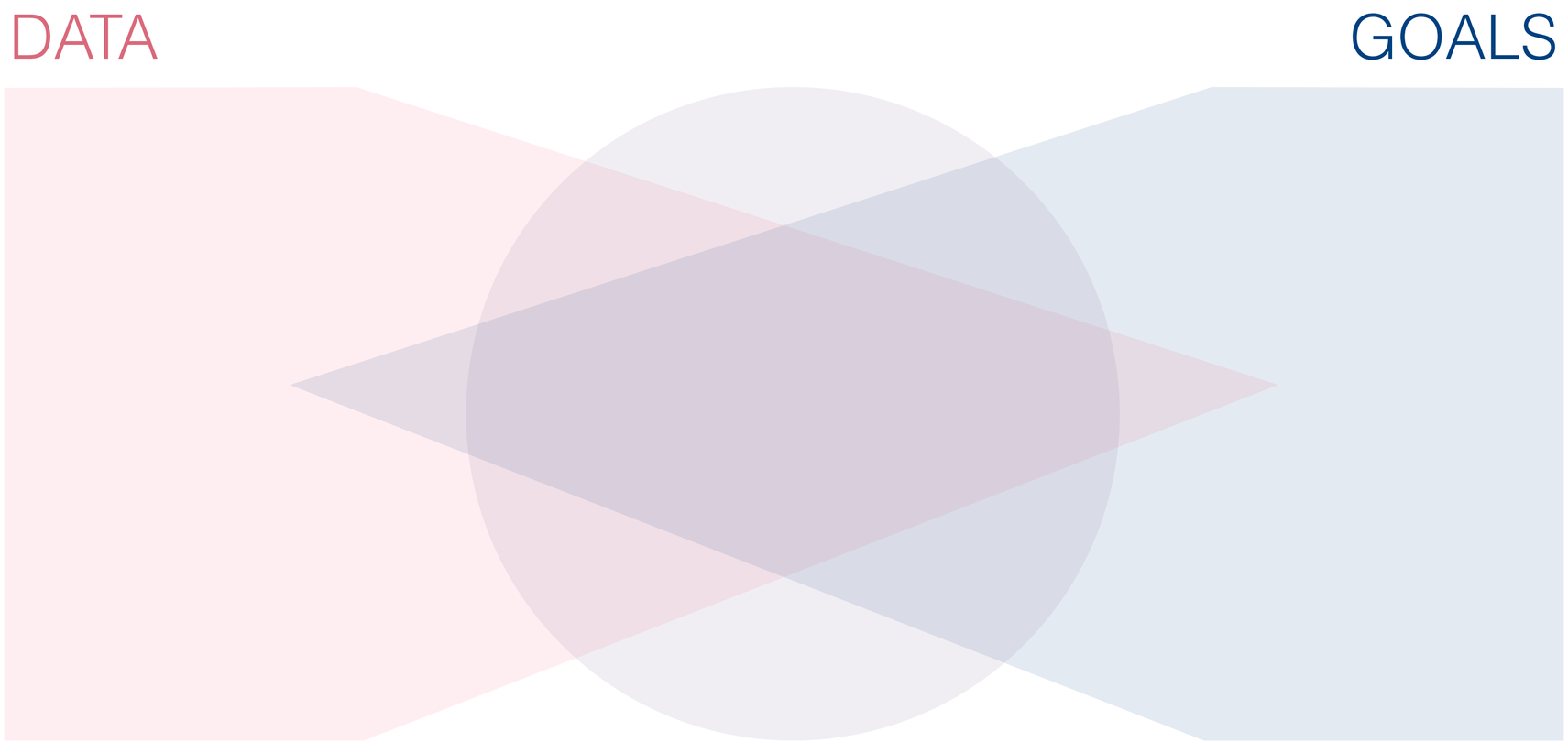
Myo (Thalmic Labs)

Consumer-Available BCI and BMI

These examples
all involve machine intelligence
or machine learning


Machine
Intelligence
Assistive
Machine
Human Body

Hallmarks of Intelligence:
Artificial, Machine (and Human)



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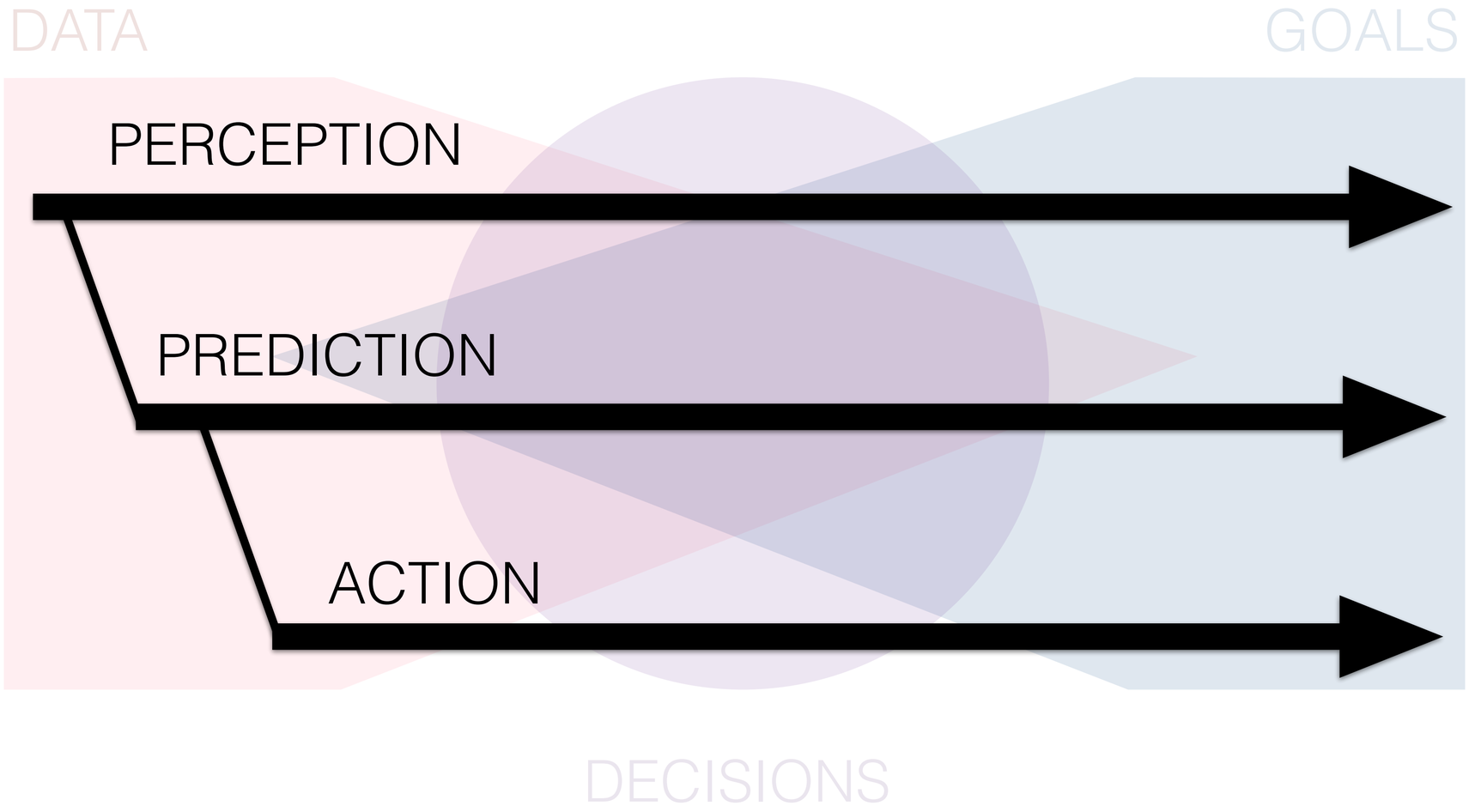

Hallmarks of Intelligence:

Artificial, Machine (and Human)

Intelligent or not?

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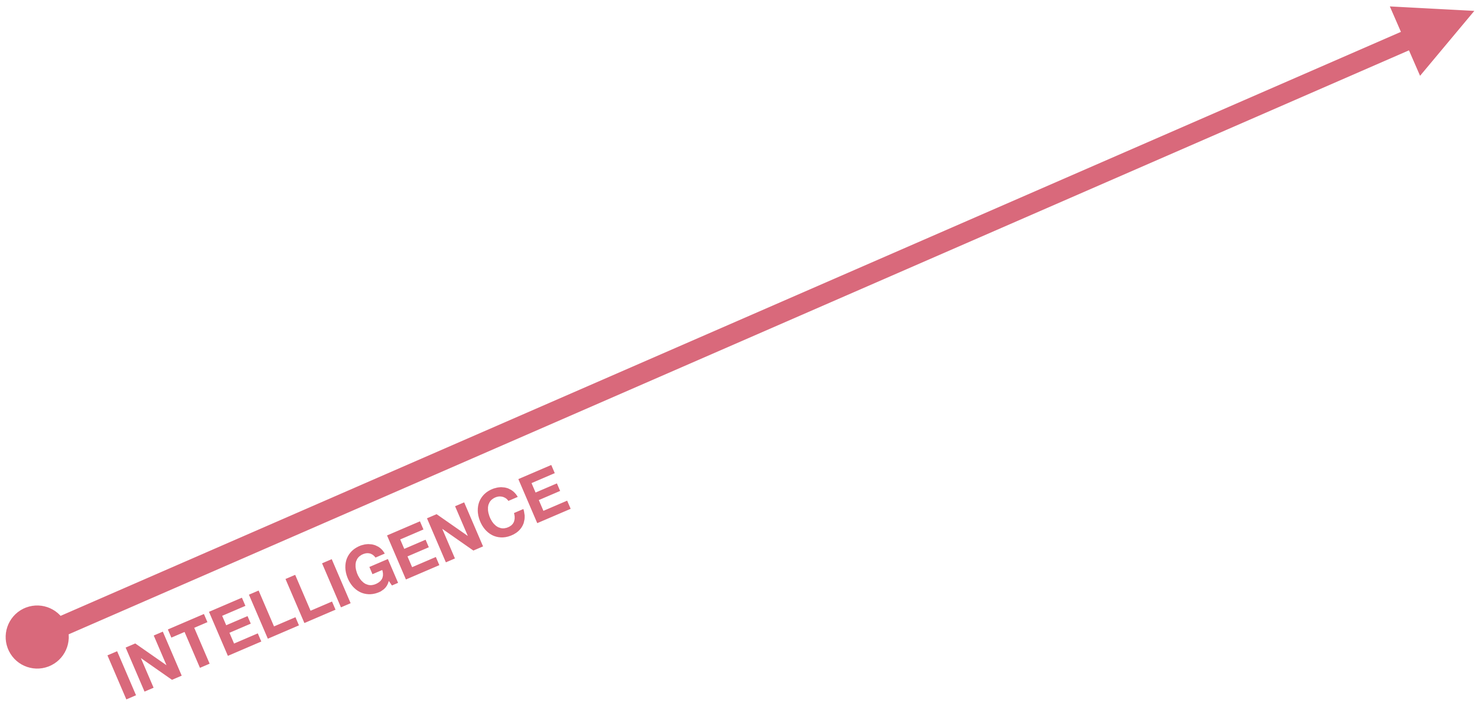
Common Misconceptions



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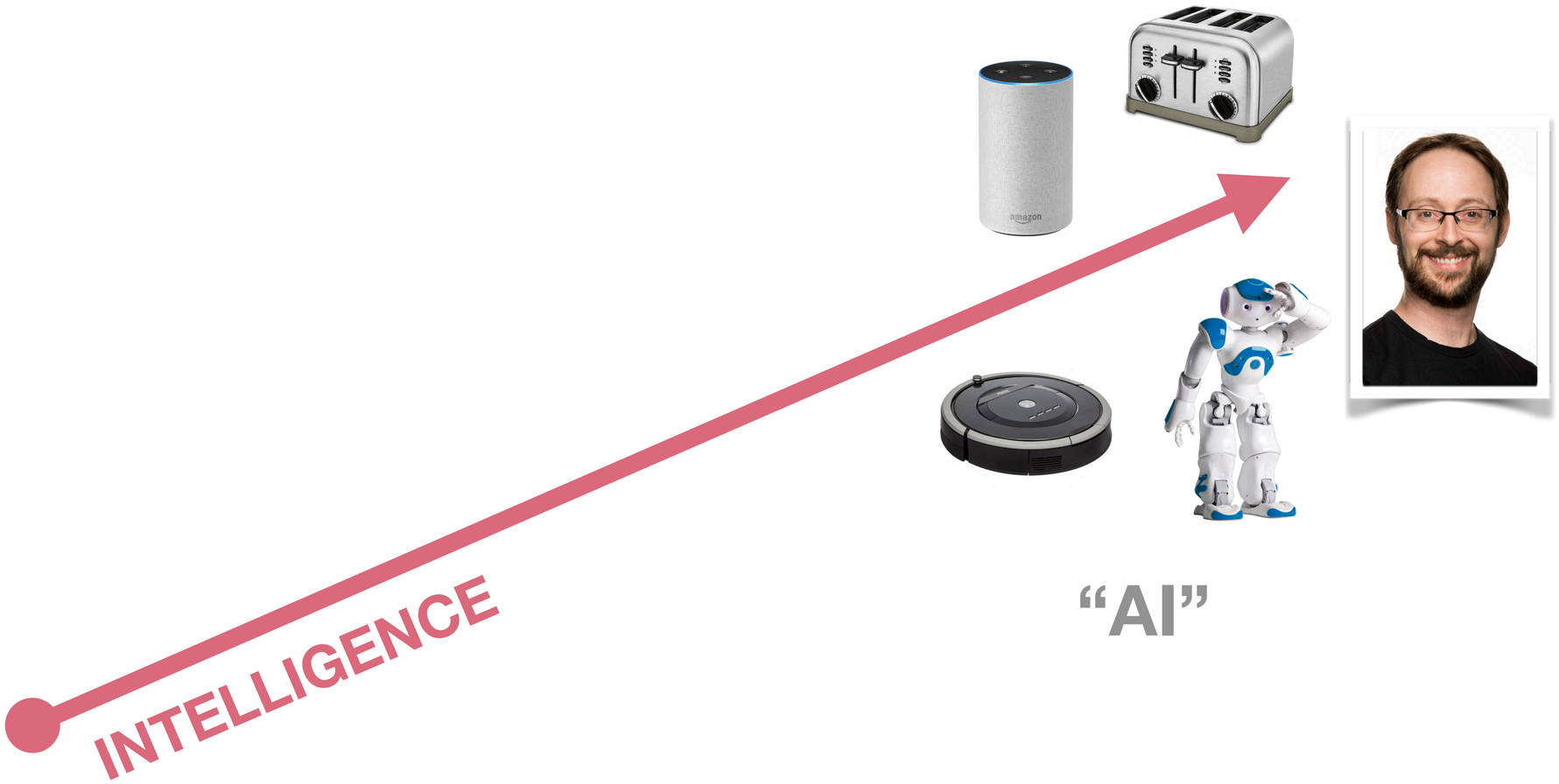

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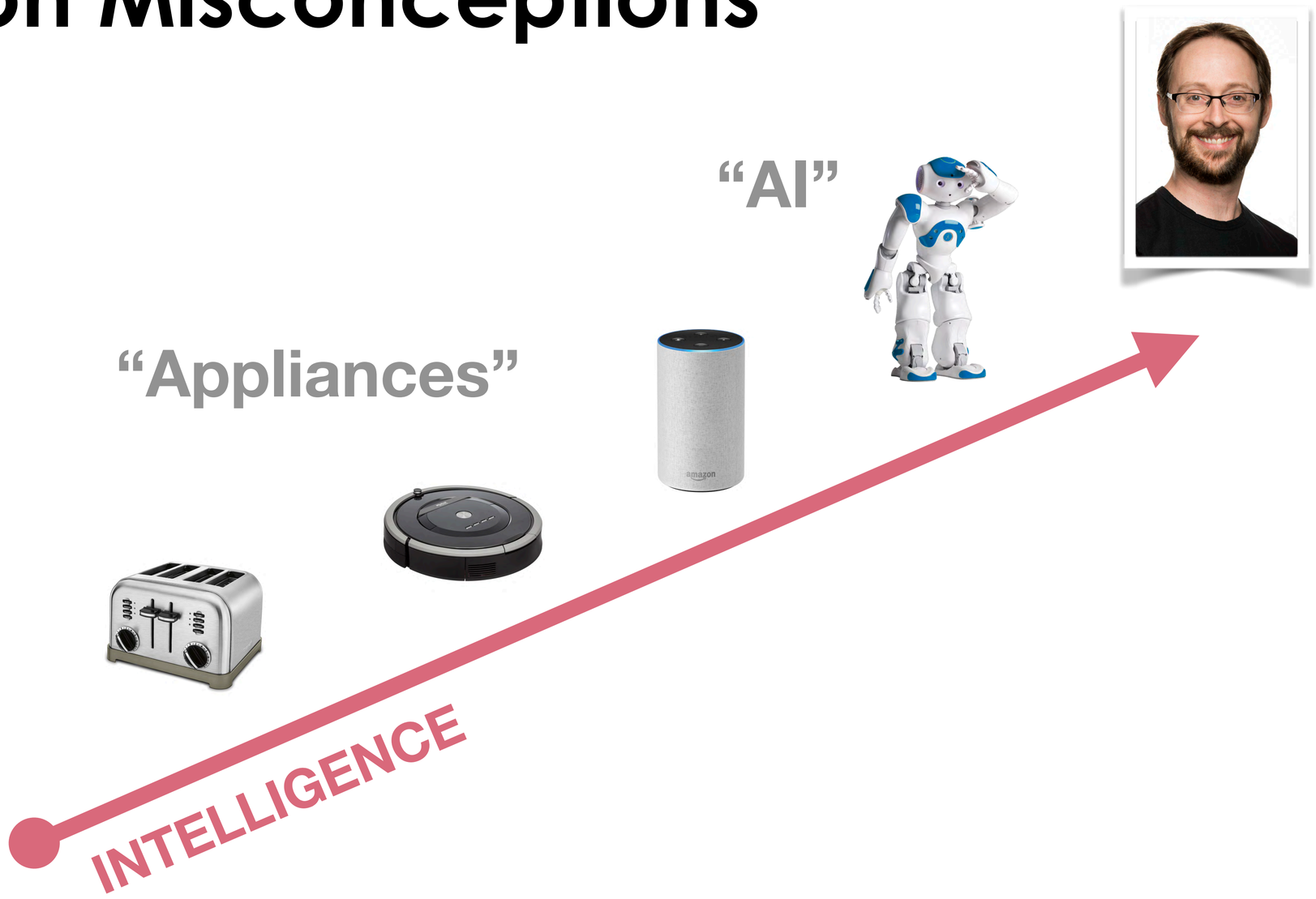
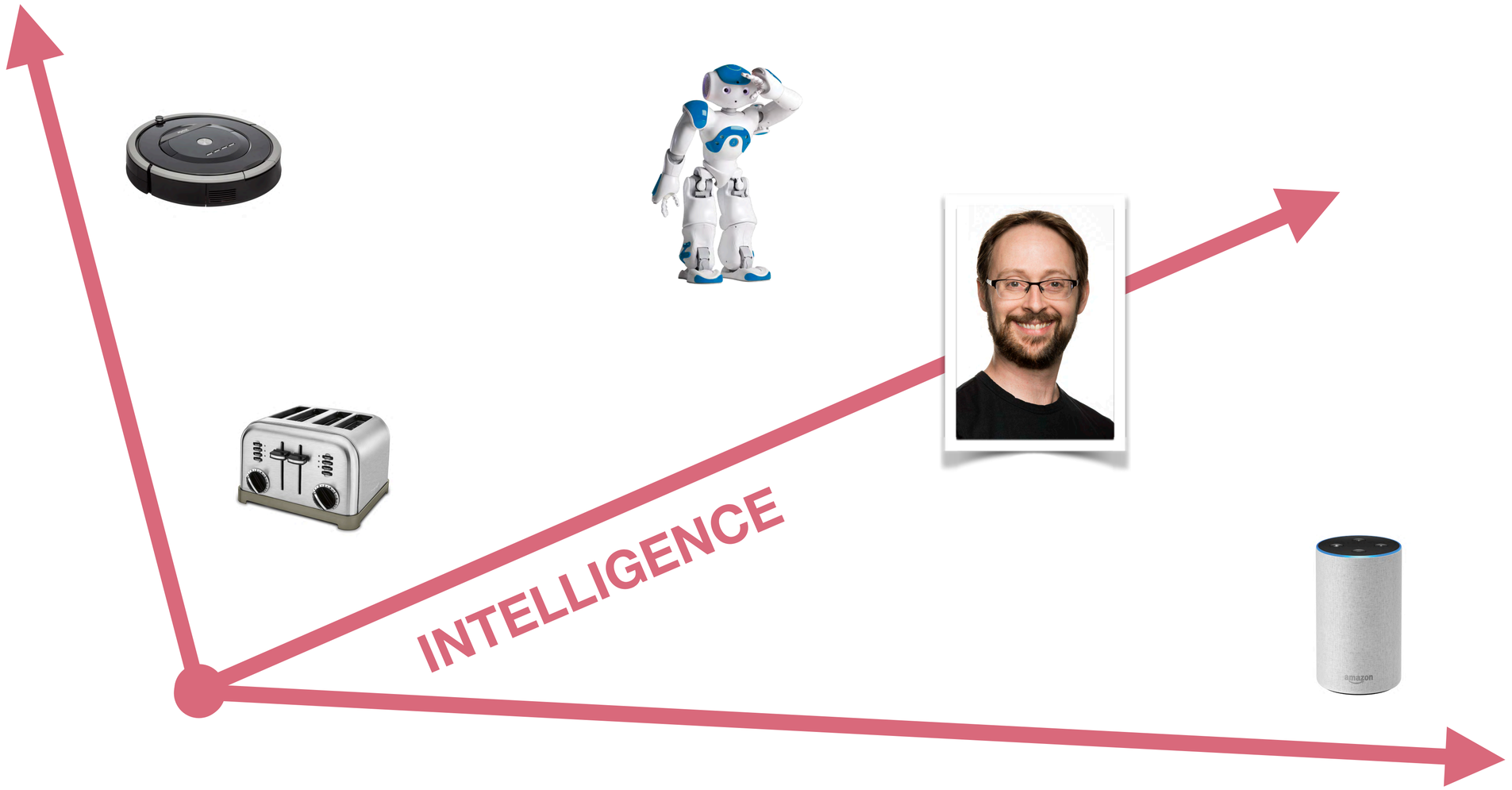


Data, Decisions, Goals

Perception, Prediction, Action

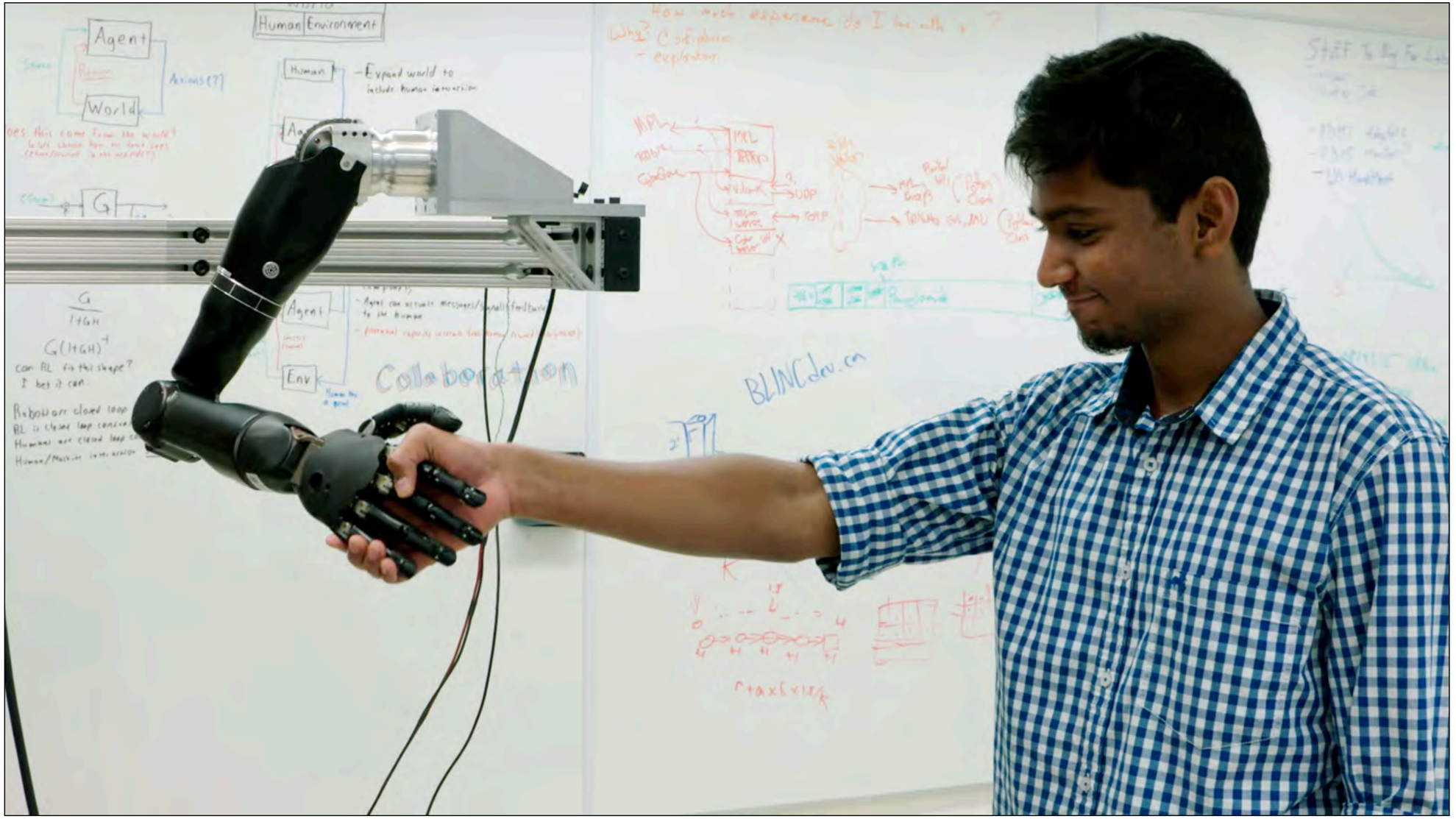


Why Machine Intelligence?

- **Enhanced control** over a changing and increasingly complex world.
- **Anticipation** of future events and outcomes.
- **General tools** for solving hard problems.

"Controlling complex systems and extracting knowledge from massive amounts of data."

Examples: finance, healthcare, energy, resources, transport, information processing.



Pilarski Lab

August 2016

Why Learning?

- **Things are Unknown:**
  known ends but unclear means.

- **Things are Complex:**
  scaling up is demanding or impossible.

- **Things Change:**
  systems need to adapt!

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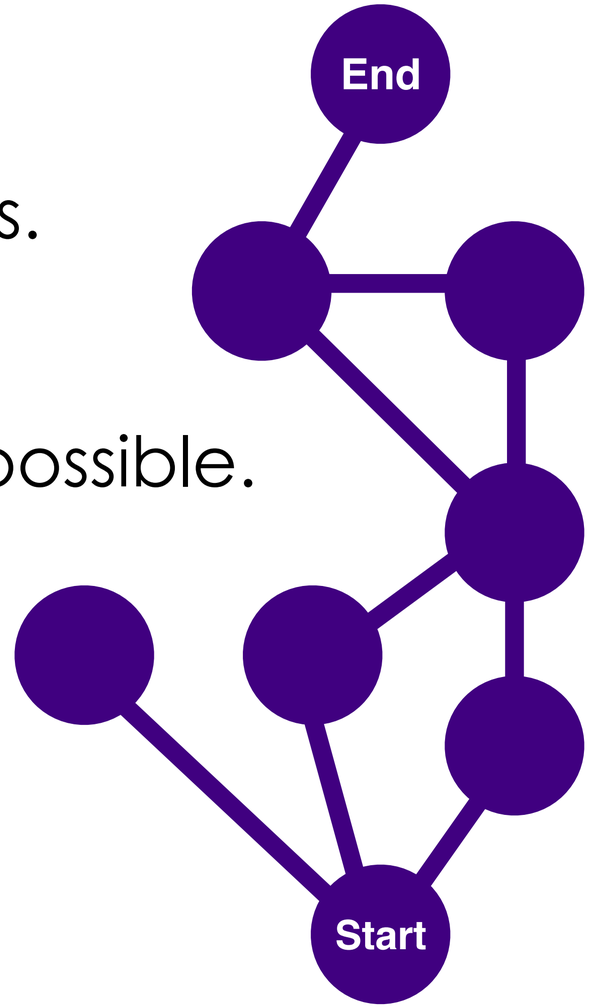

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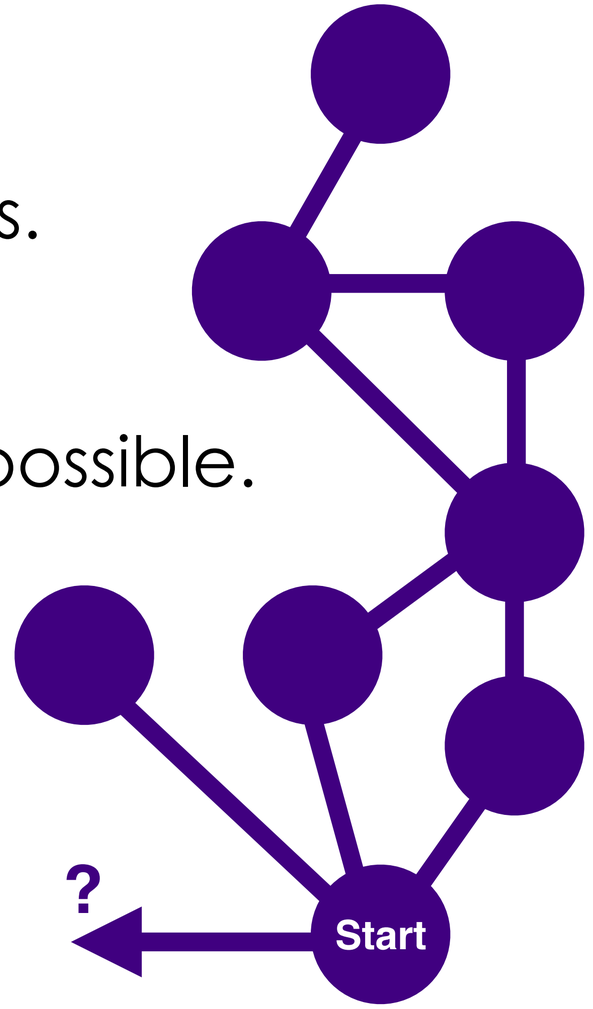
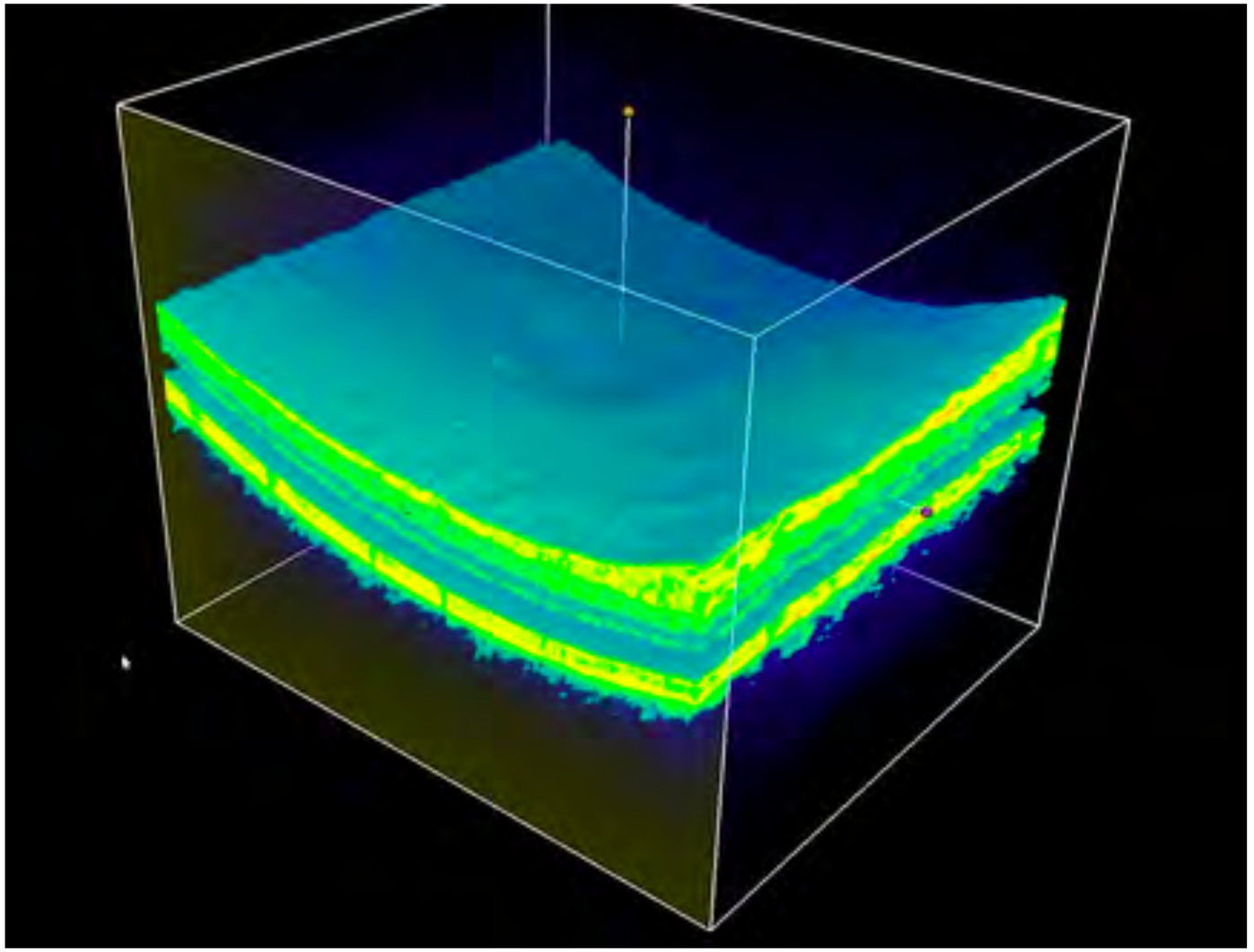


End

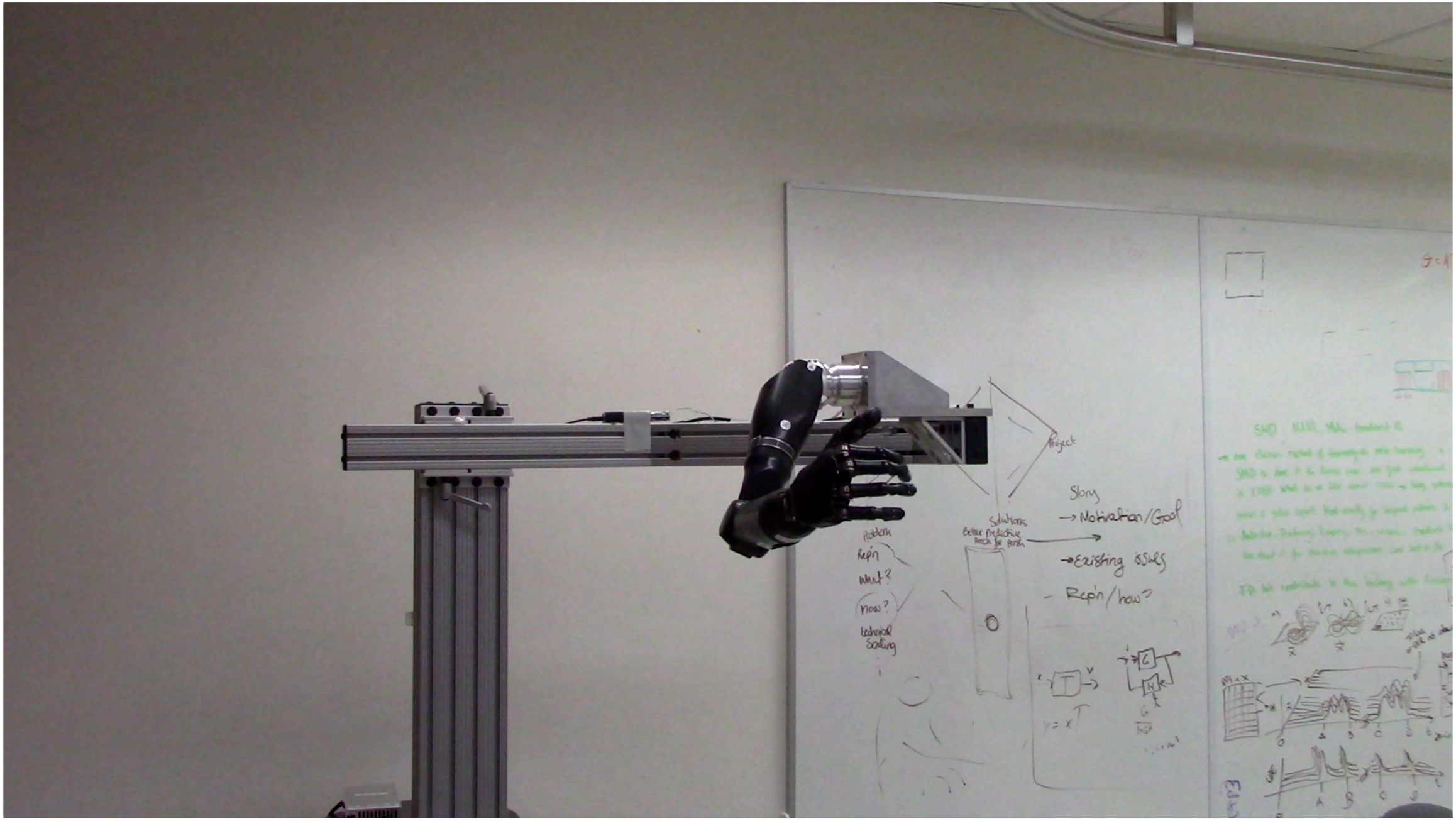
AI and ML in Medicine

1. Helping to understand patient populations (**generalization**);
2. Helping to understand individual patients (**personalization**);
3. Helping choose and improve interventions (**optimization**):
    - by connecting patients to assistive devices;
    - by helping deploy treatment strategies.

http://www.humanconnectomeproject.org/



J. De Fauw et al., *Nature Medicine* 24:1342–1350 (2018)



University of Alberta: http://blinclab.ca, https://www.smartnetworkcentre.ca/

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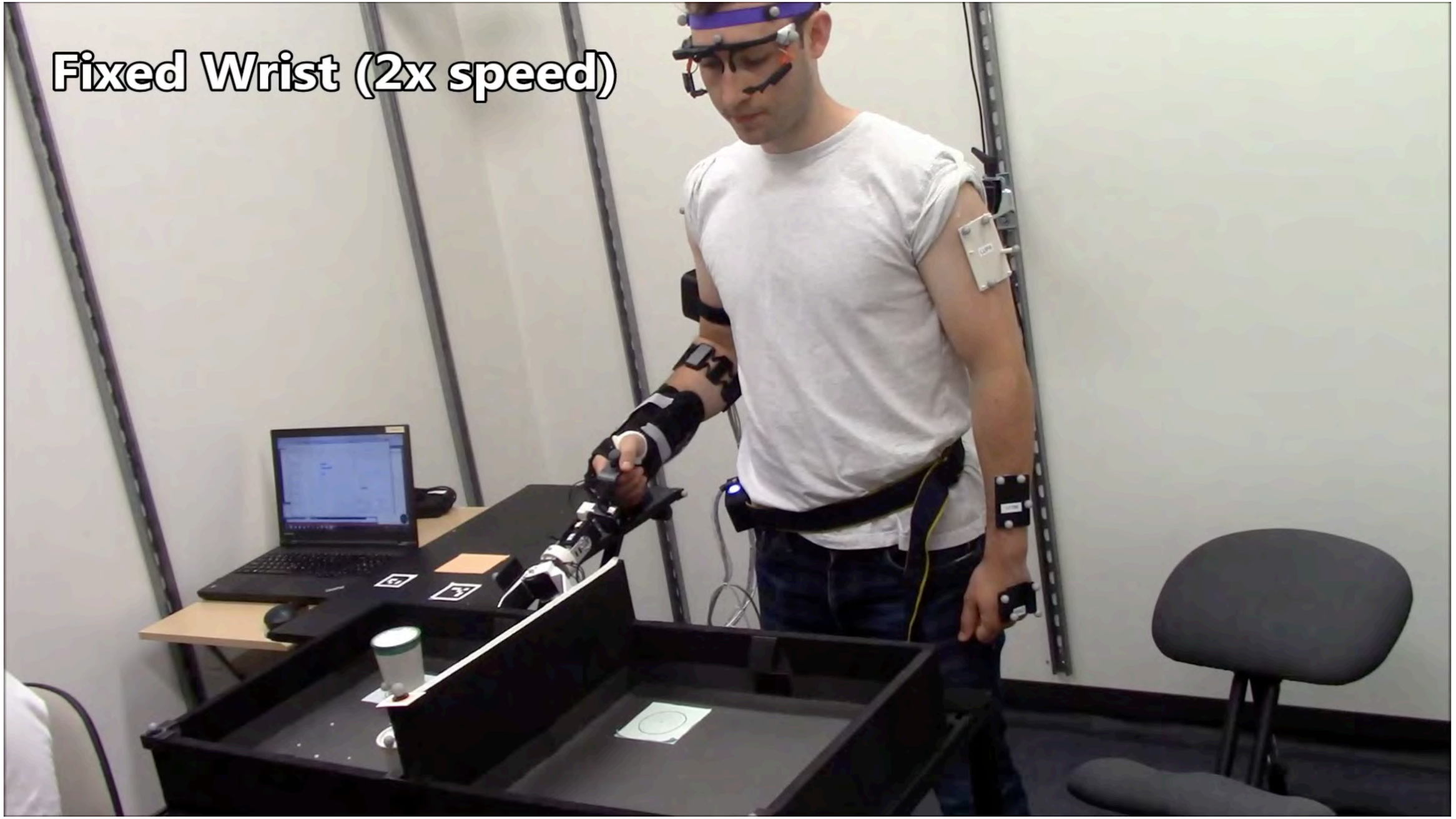

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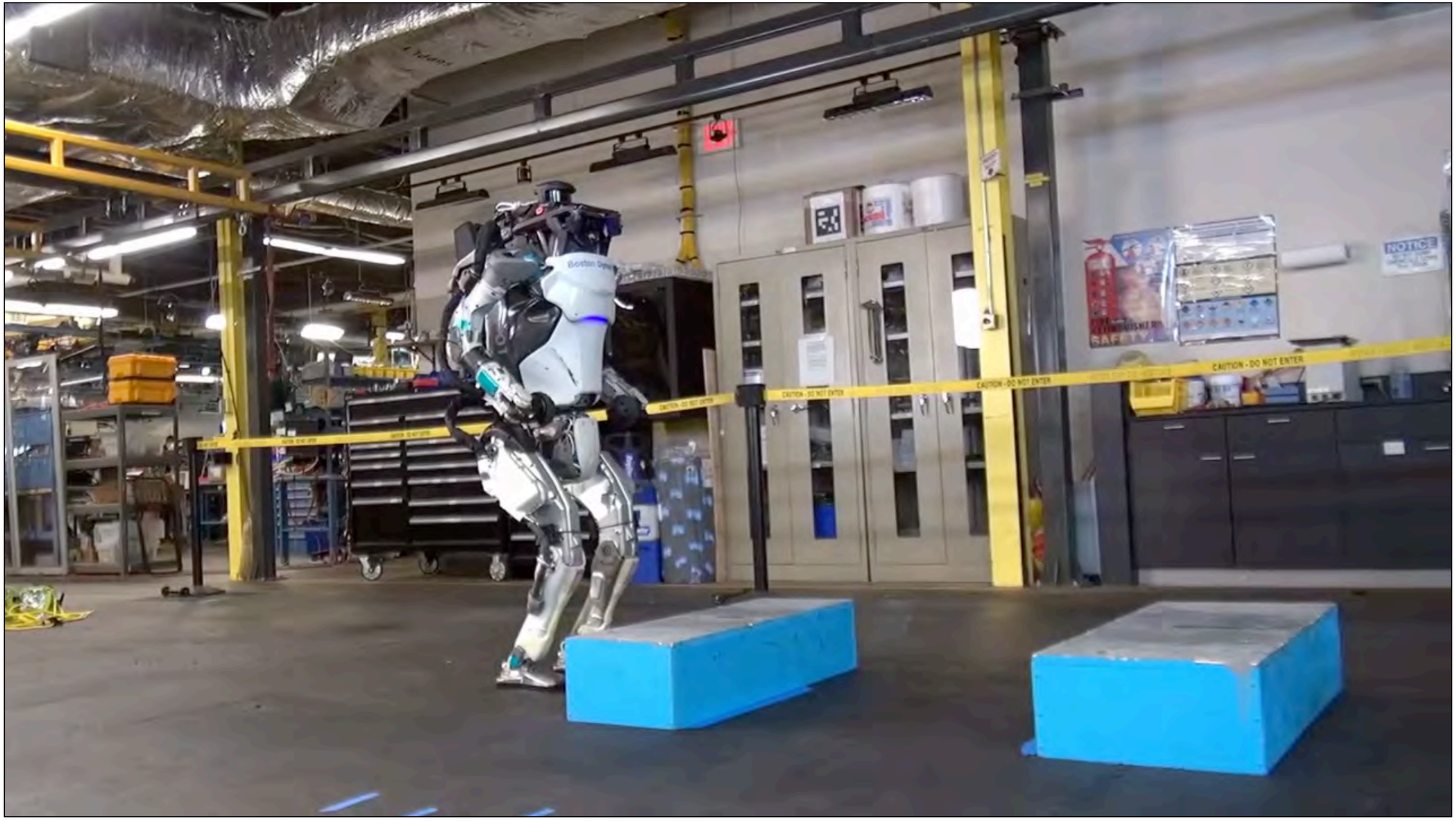


And in case you were wondering what the robots are up to these days…

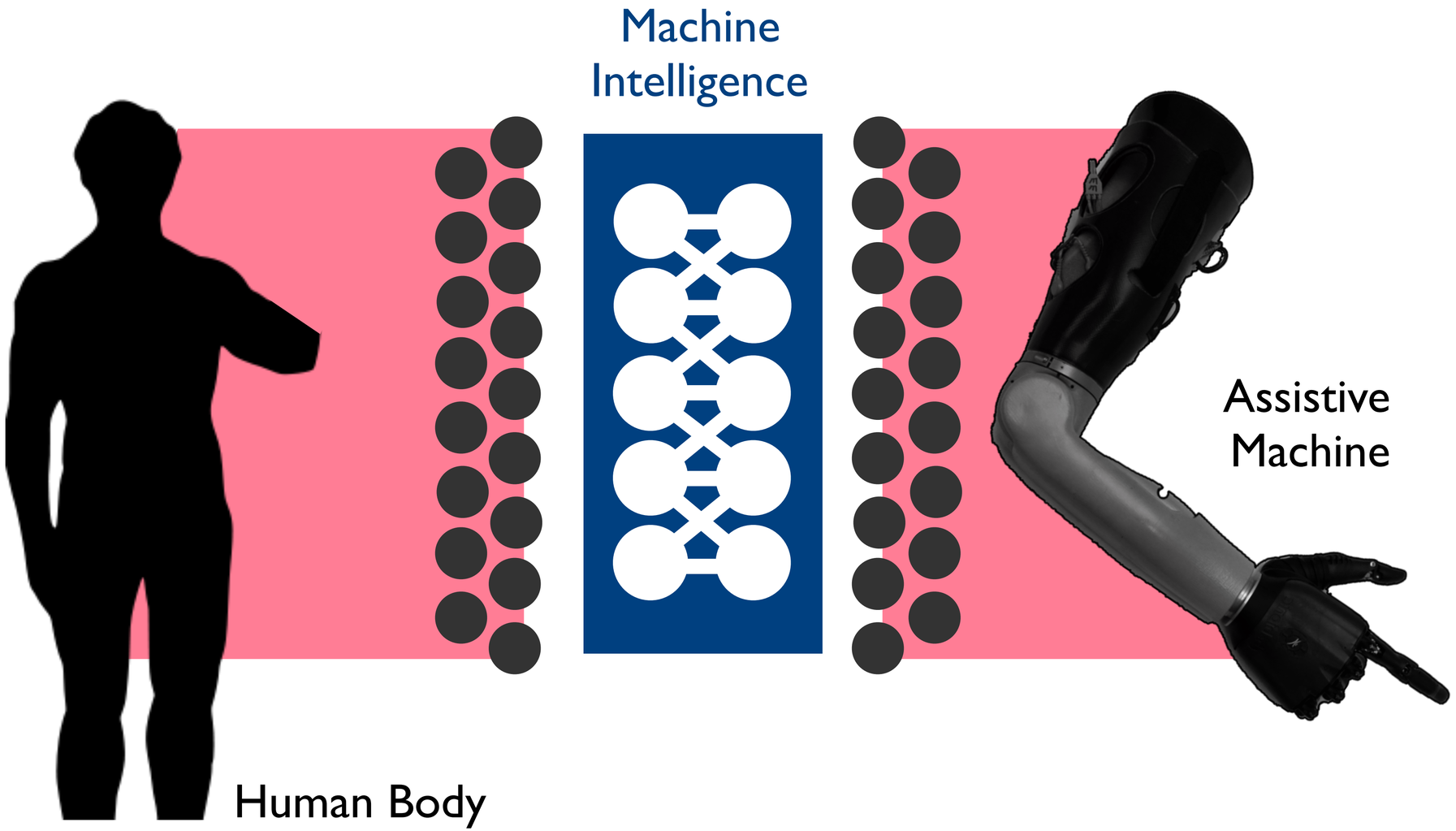
Atlas Robot (Boston Dynamics): https://youtu.be/fRj34o4hN4I

Exoskeletons: UC Berkeley spin-off suitX exoskeleton technology; https://www.youtube.com/watch?v=I3roYI3CB2Y

Looking Forward: Complex Bodies, Multidisciplinary Care

If a patient's body and mind are comprised of both biology and technology, how do we best treat the whole patient?

- patients may (do) consider their technology part of themselves;
- biology and technology may not be easily separable;
- biological and technical care may not be easily separable;
- normal care may soon involve experts in ***muscles***, ***nerves***, and ***bones***, alongside experts in ***hardware***, ***software***, and ***data science***.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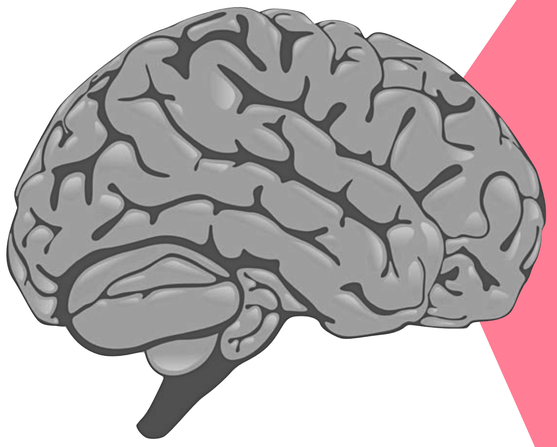

Human Mind:

Patient

Care Giver

Policy Maker

Let’s connect.

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