Artificial Intelligence in Rehabilitation

Patrick M. Pilarski, Ph.D.

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

Principal Investigator, Alberta Machine Intelligence Institute (Amii)

UNIVERSITY OF ALBERTA
EDMONTON·ALBERTA·CANADA

amii

C.O.I. DISCLOSURE

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

Unrelated to the content or ideas noted in this talk:
Senior Staff Research Scientist with DeepMind

Learning Objectives

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

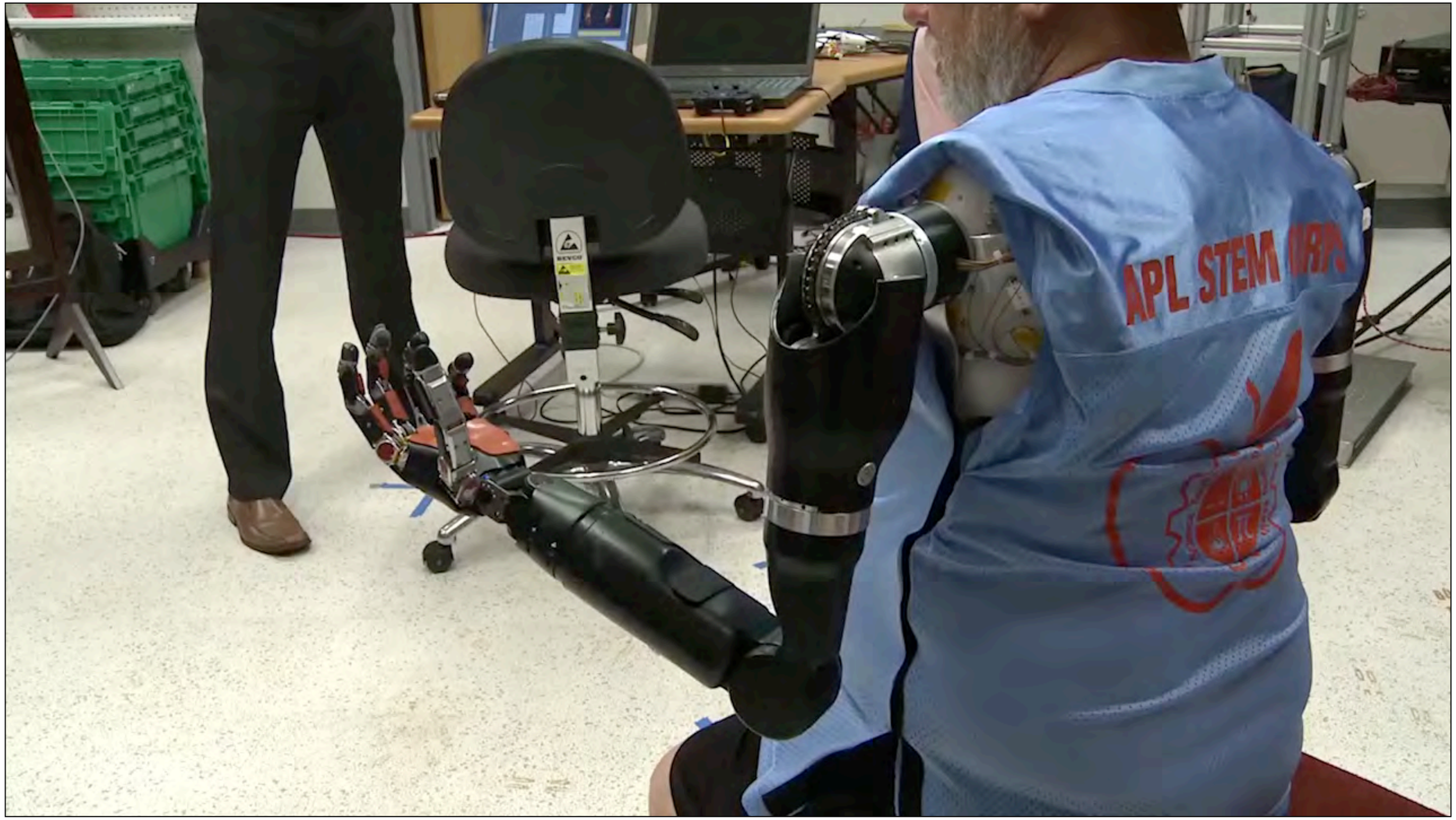
2. be able to describe and **discuss the defining characteristics of AI and ML**.

3. be able to describe and **discuss how AI has been applied in physical medicine and rehabilitation**.

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

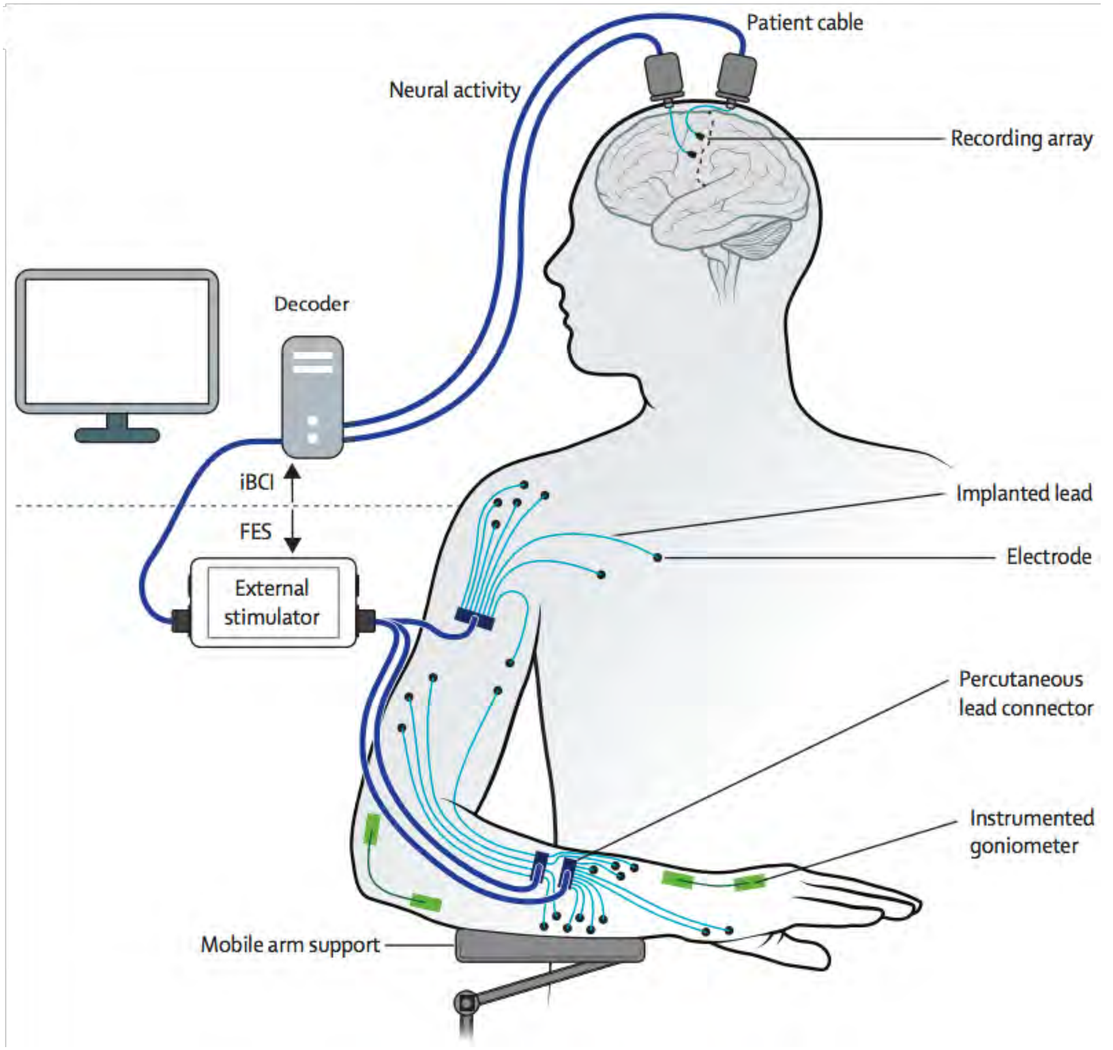
5. be able to **find and cite appropriate resources for future self-study** on AI and its application within physical medicine and rehabilitation.

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



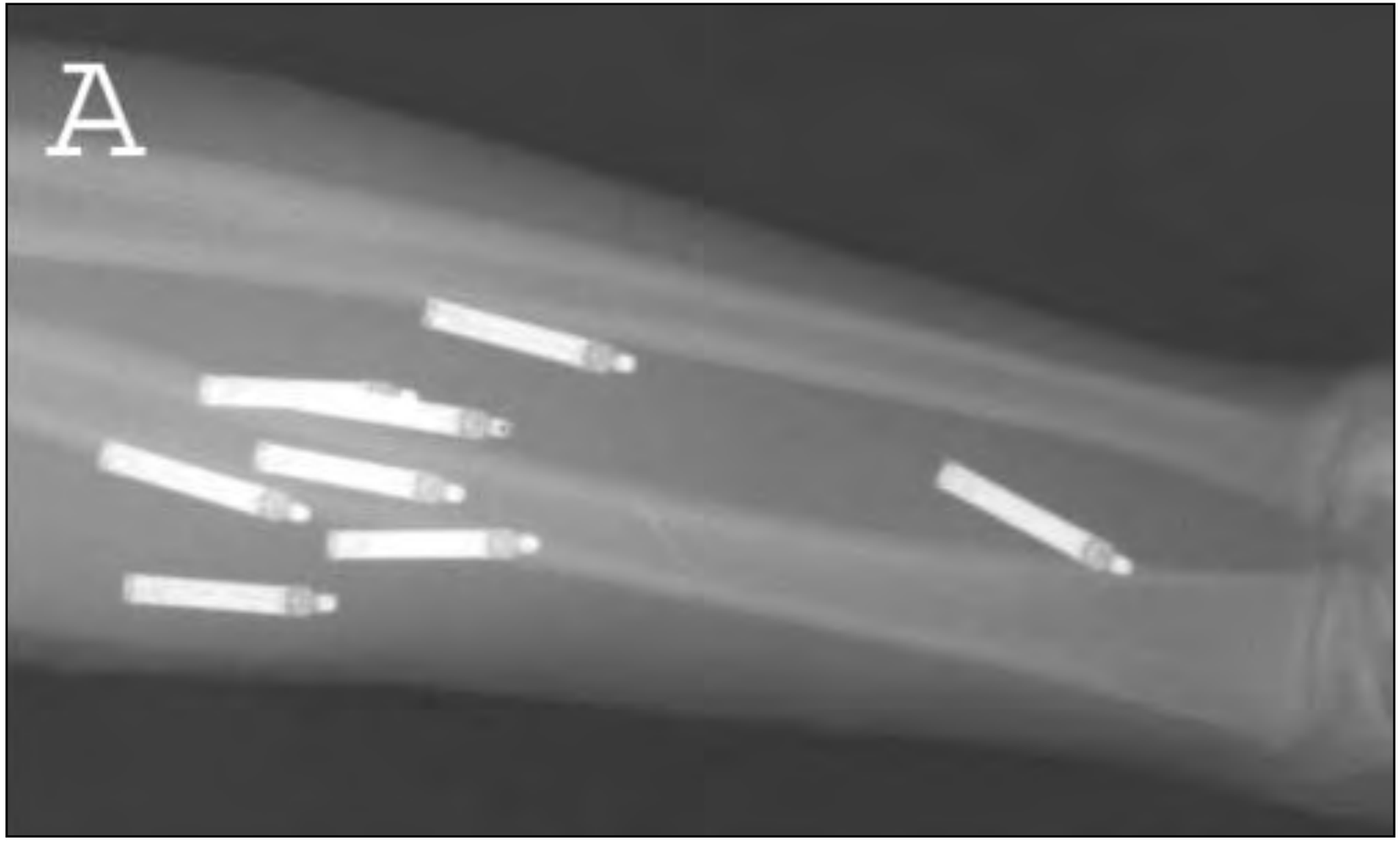
Brain-body-machine interfaces: “Amputee Makes History with APL’s Modular Prosthetic Limb” (JHU Applied Physics Laboratory); https://youtu.be/9NOncx2jU0Q

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.

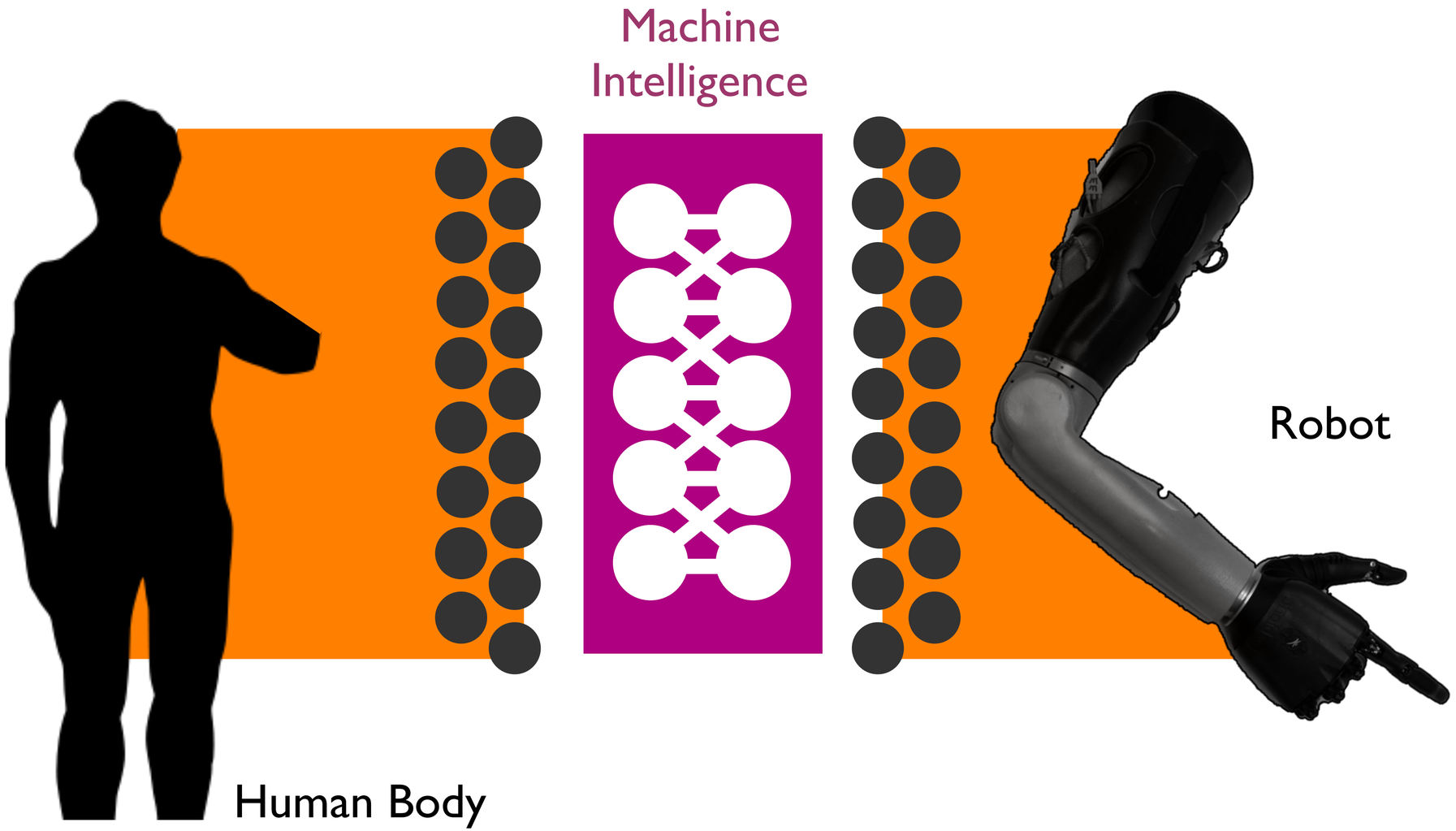
Commercially Deployed
Pattern Recognition for Prostheses

Muse

Myo (Thalmic Labs)

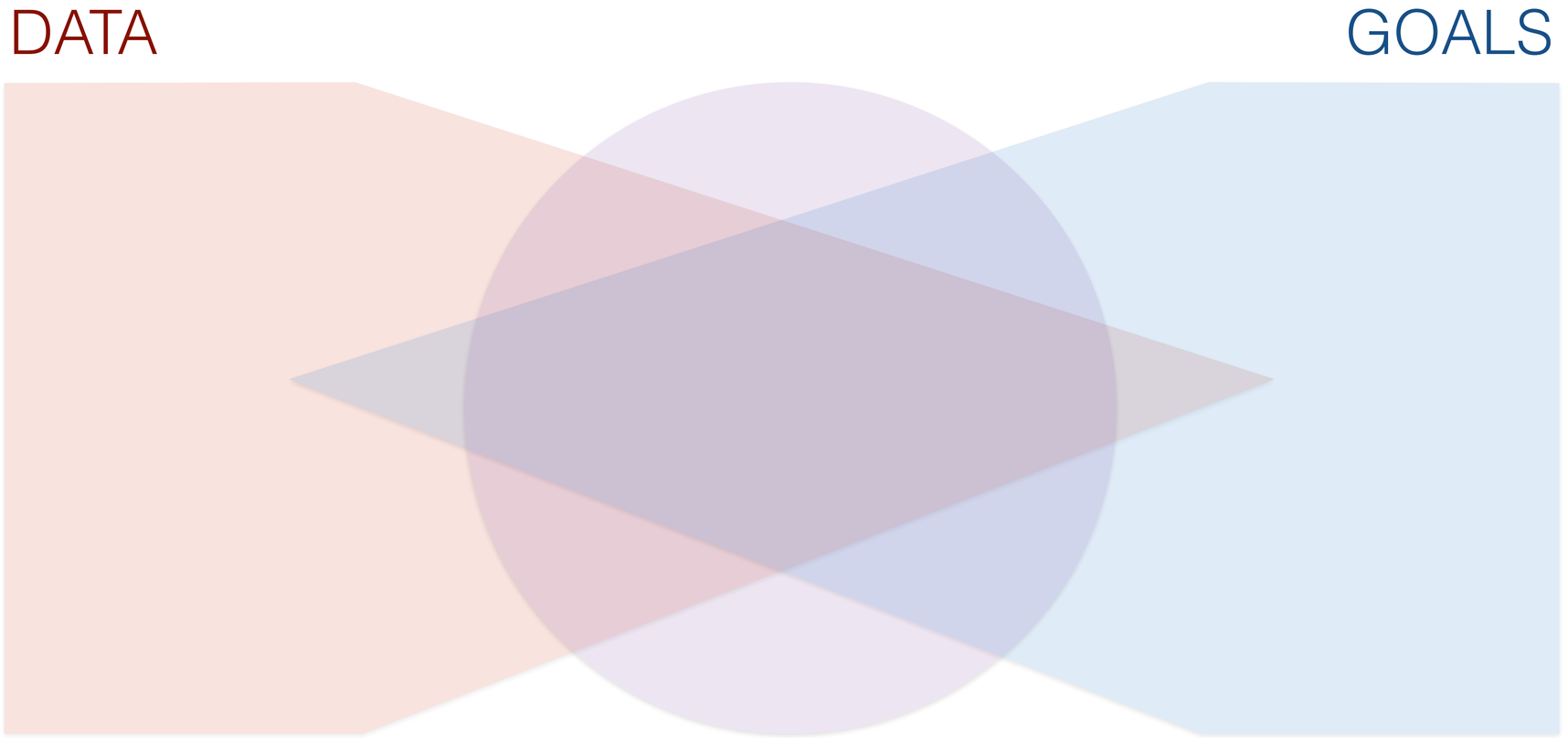
Consumer-Available BCI and BMI

These examples
all involve machine intelligence
or machine learning

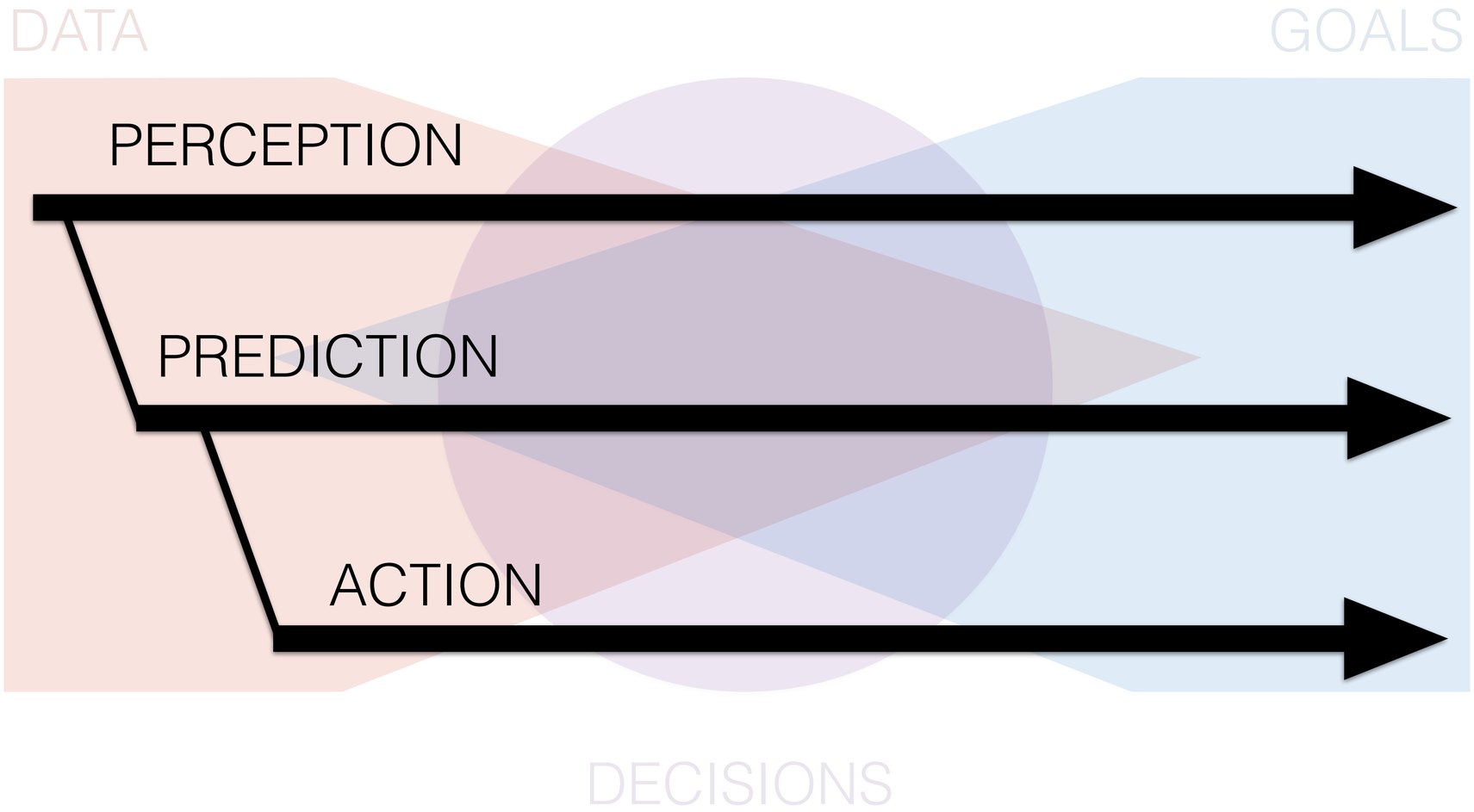

Machine
Intelligence
Robot
Human Body

Hallmarks of Intelligence:

Artificial, Machine (and Human)



Hallmarks of Intelligence:
Artificial, Machine (and Human)



Hallmarks of Intelligence:

Artificial, Machine (and Human)

Intelligent or not?

Intelligent or not?

Intelligent or not?

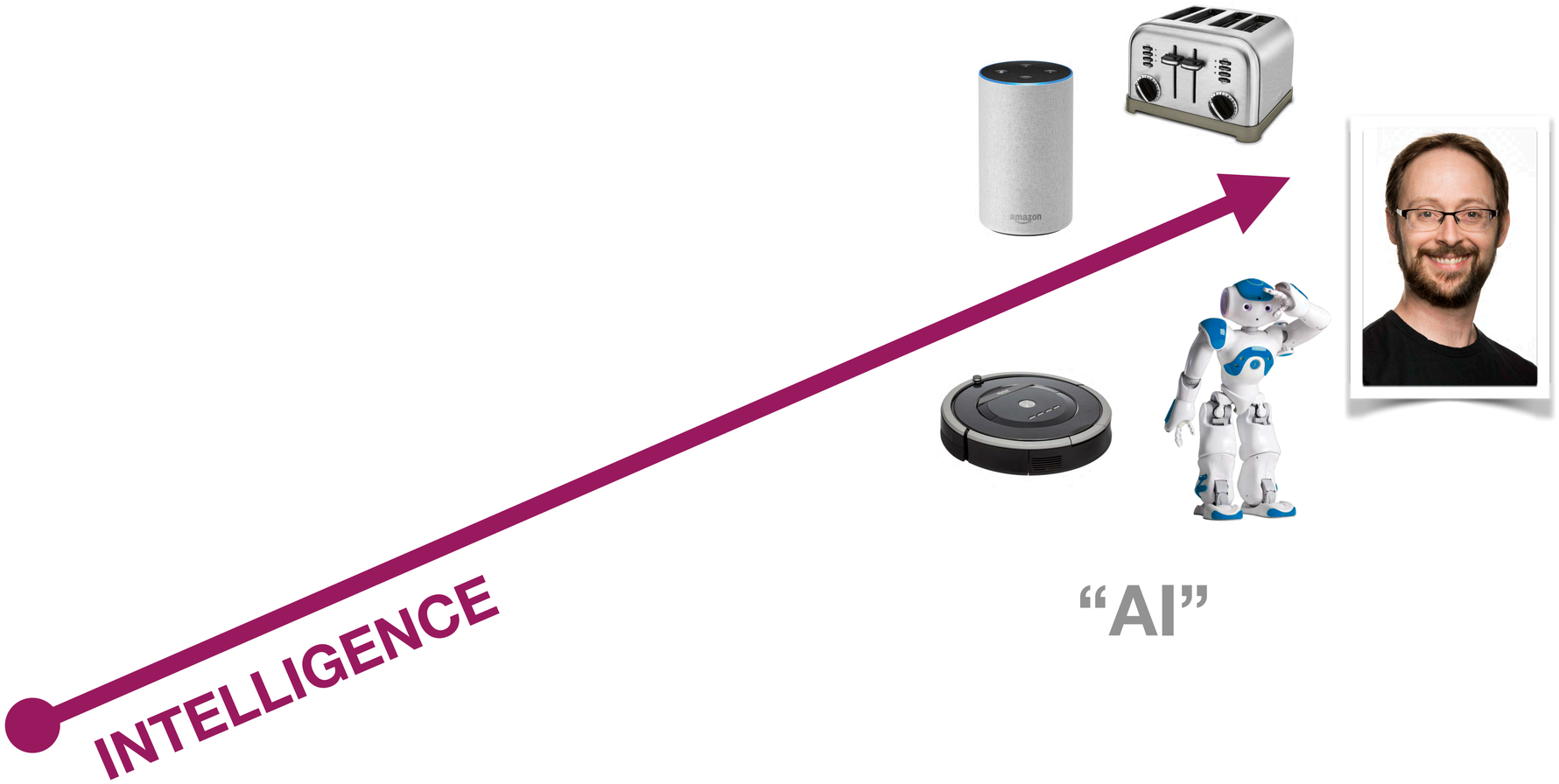
Intelligent or not?

Intelligent or not?

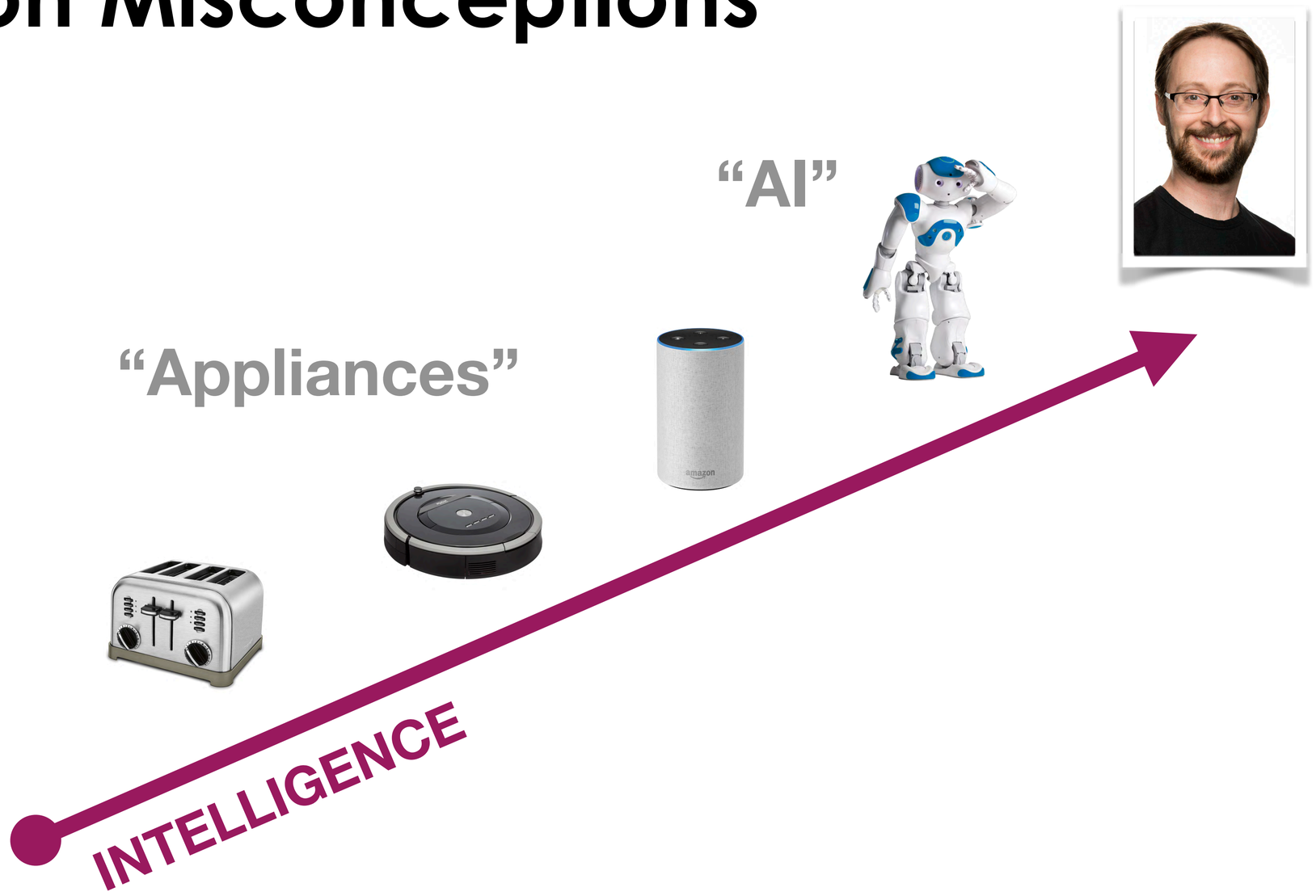
Intelligent or not?

Common Misconceptions

Common Misconceptions

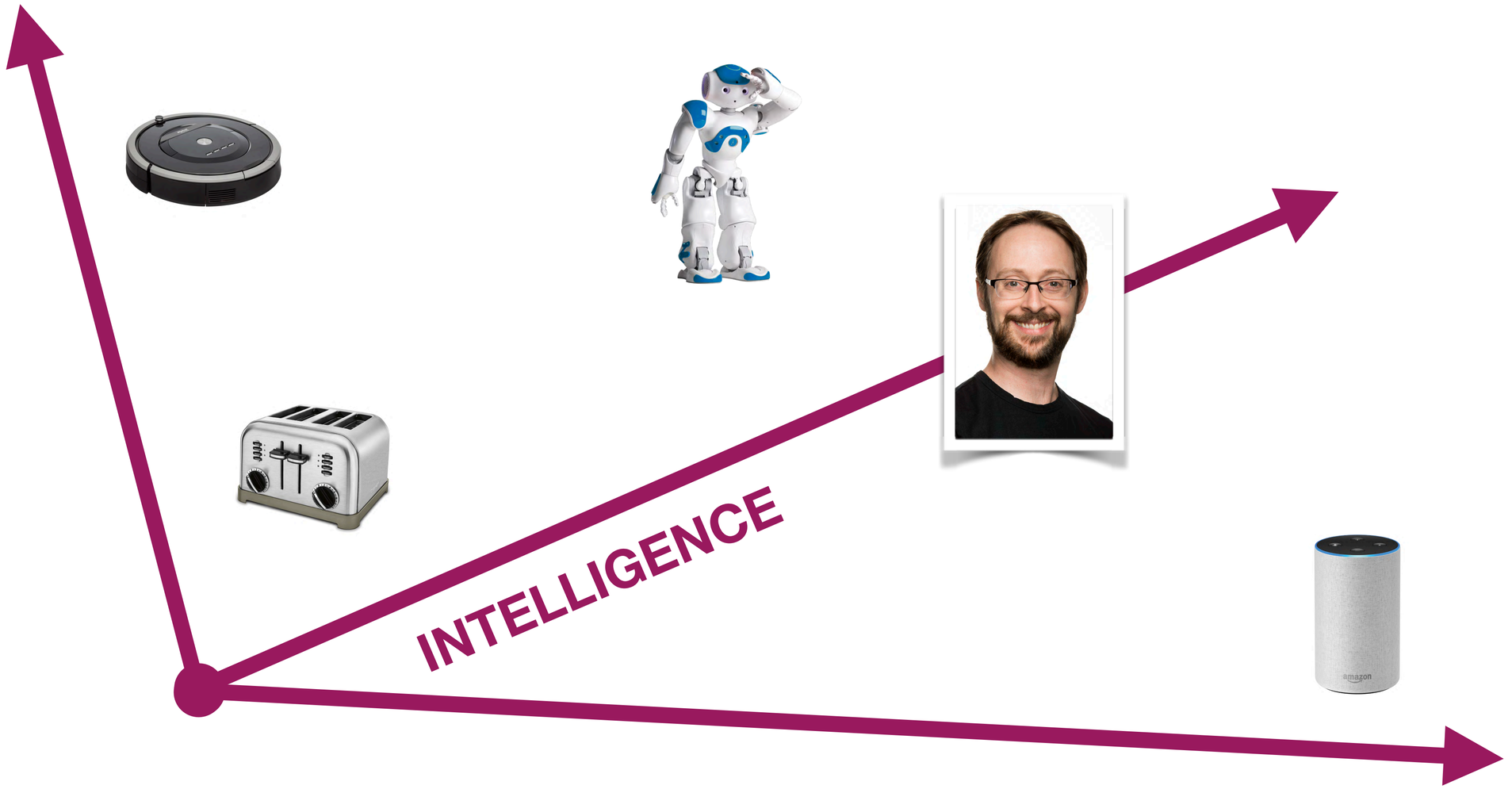


Common Misconceptions



Data, Decisions, Goals

Perception, Prediction, Action

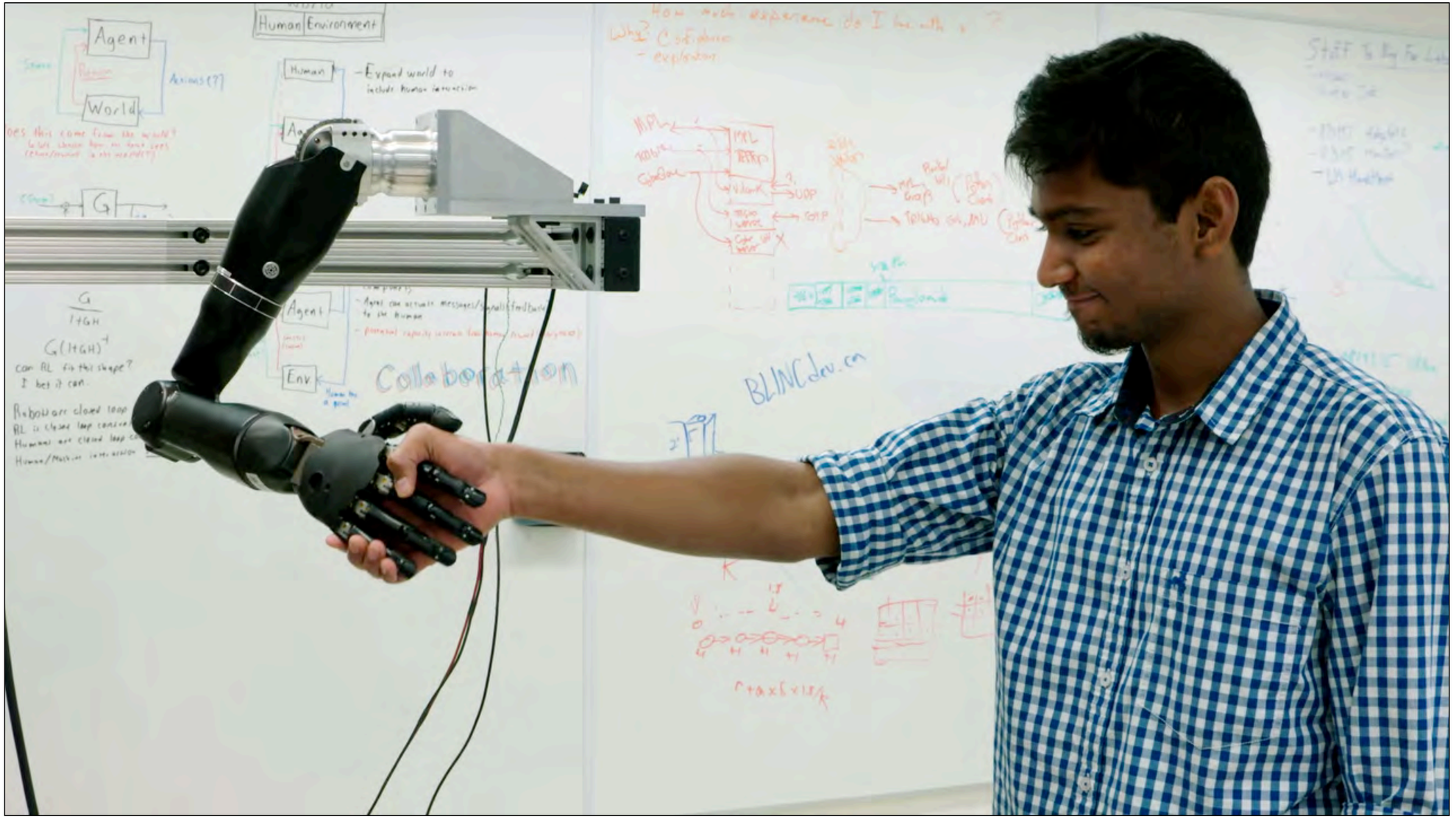


Why Machine Intelligence?

- **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.

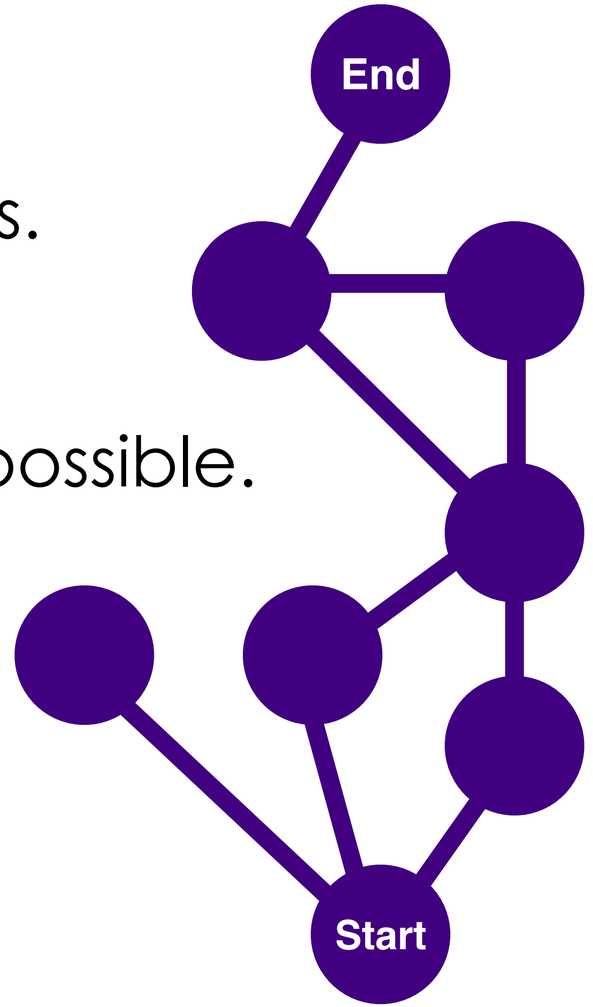
- **Things Change:**
  systems need to adapt!

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!

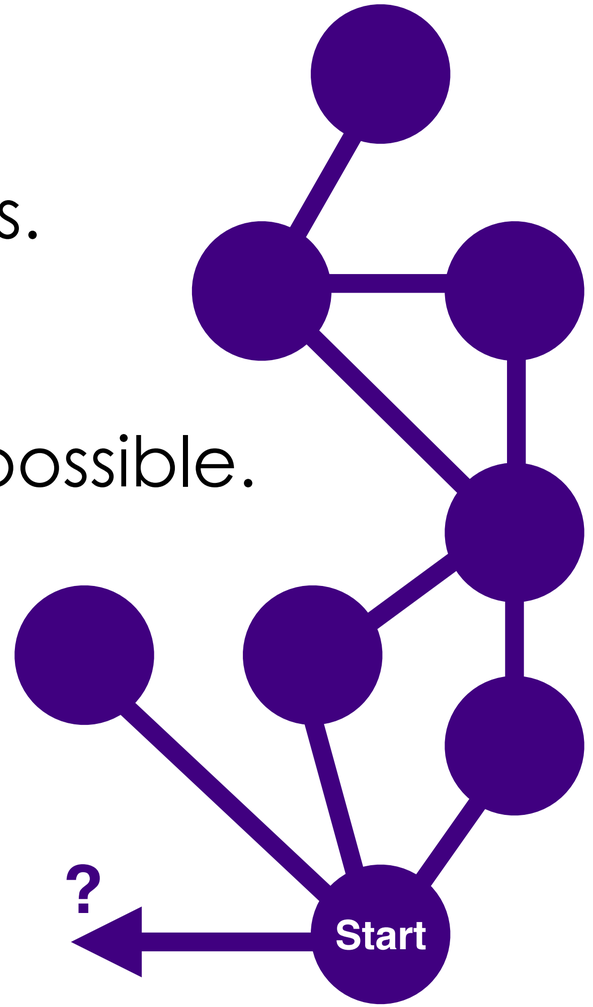


Why Learning?

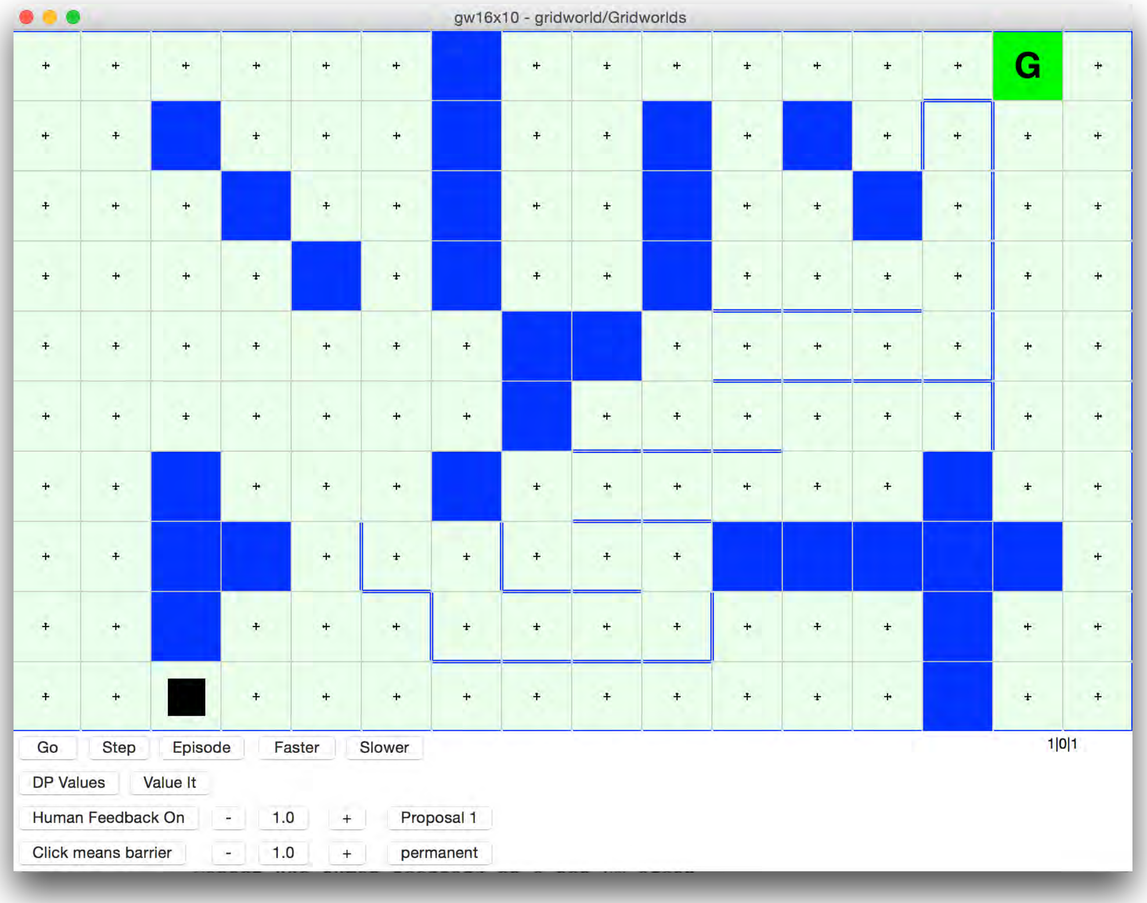
- **Things are Unknown:**
  known ends but unclear means.

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

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



End

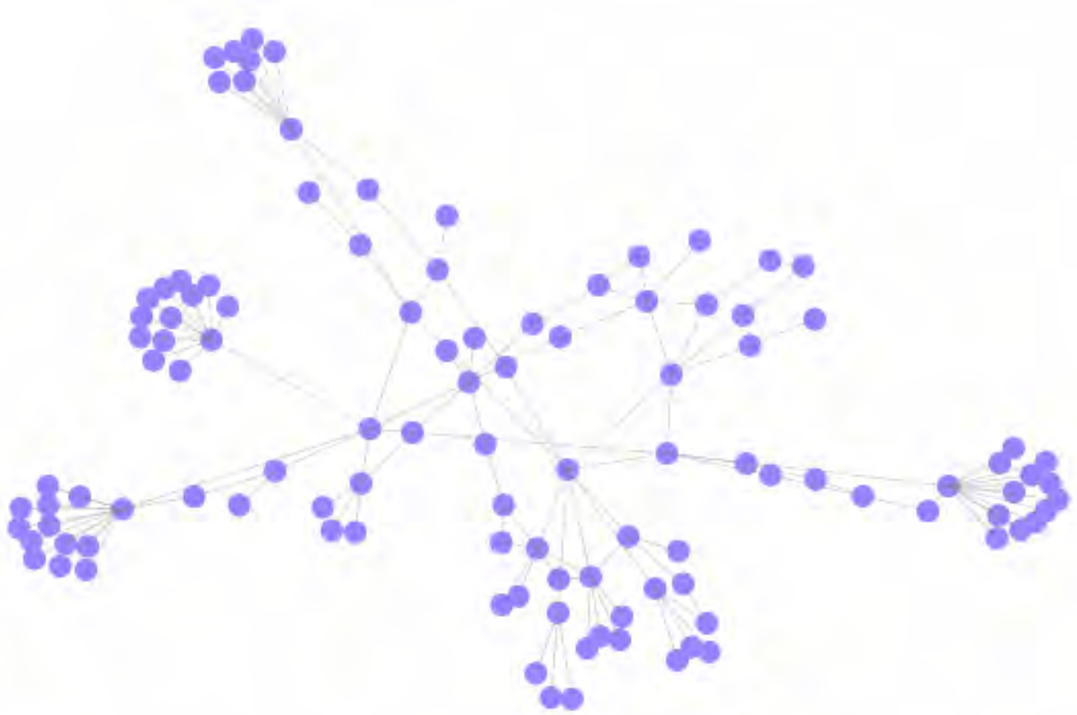


Demonstration

AI and ML in PM&R

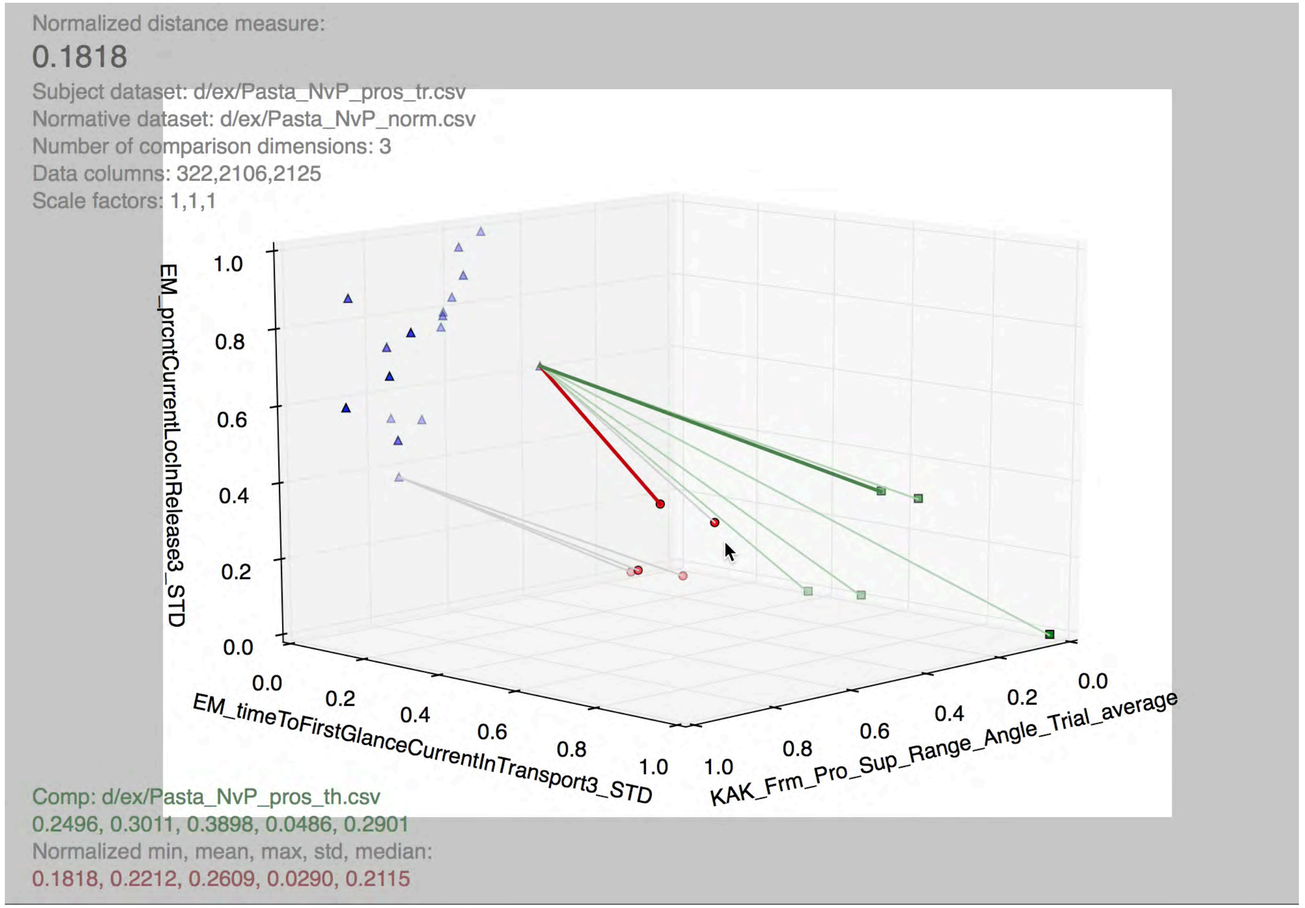
1. Helping to understand patient populations (**generalization**);
2. Helping to understand individual patients (**personalization**);
3. Helping choose and improve interventions (**optimization**):
    - by connecting patients to their assistive devices;
    - by helping deploy rehabilitation strategies.

AI and ML in PM&R



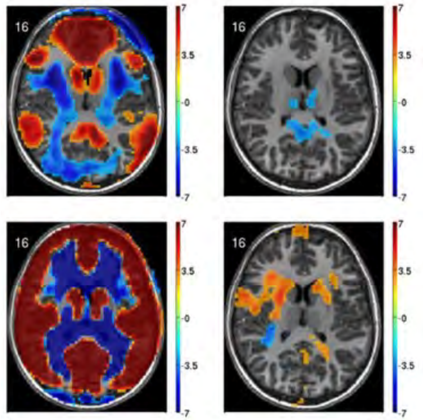
Helping to understand patient populations (**generalization**).

AI and ML in PM&R

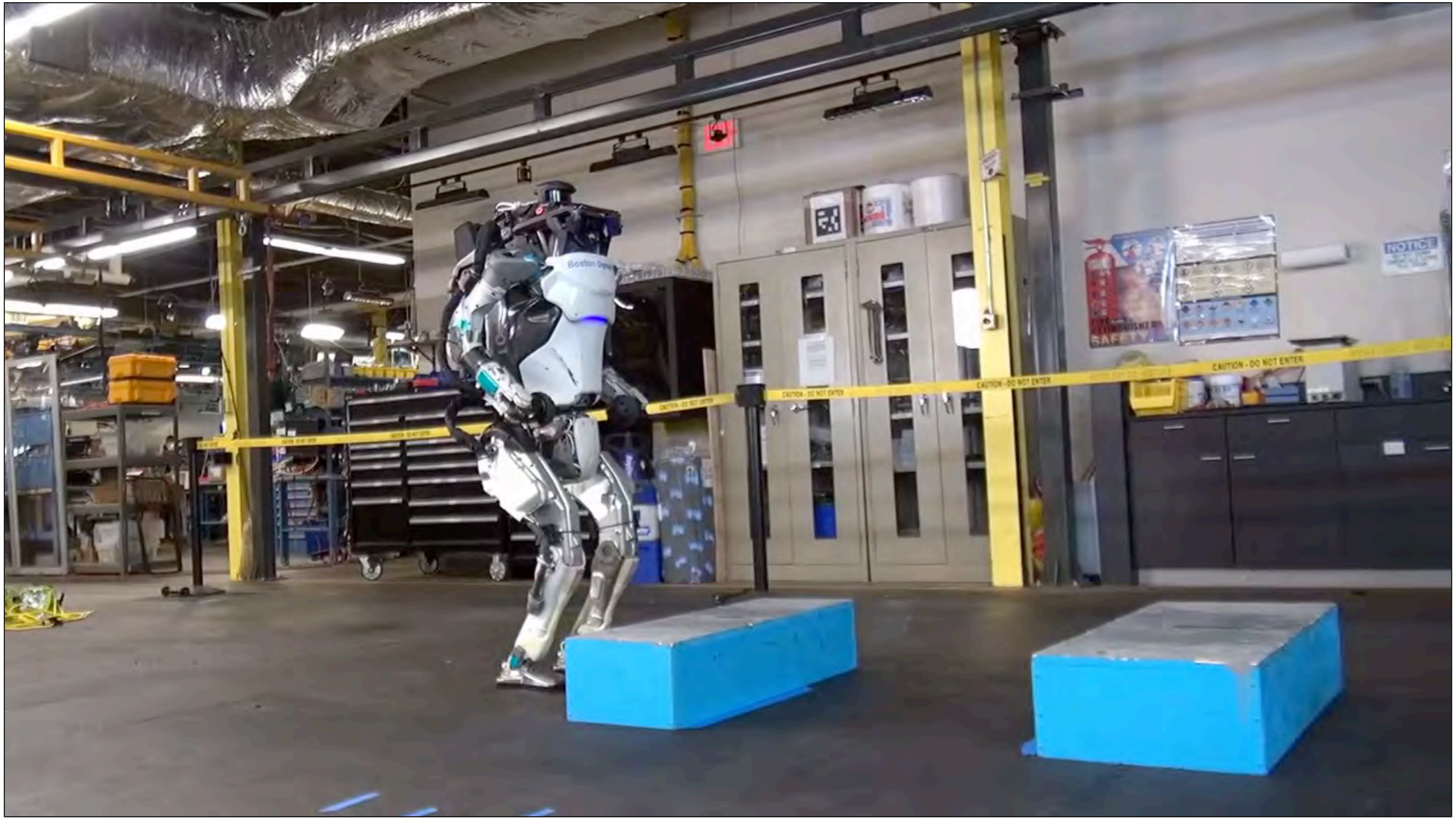


Helping to understand individual patients (**personalization**).

AI and ML in PM&R



Helping choose and improve interventions (**optimization**).



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

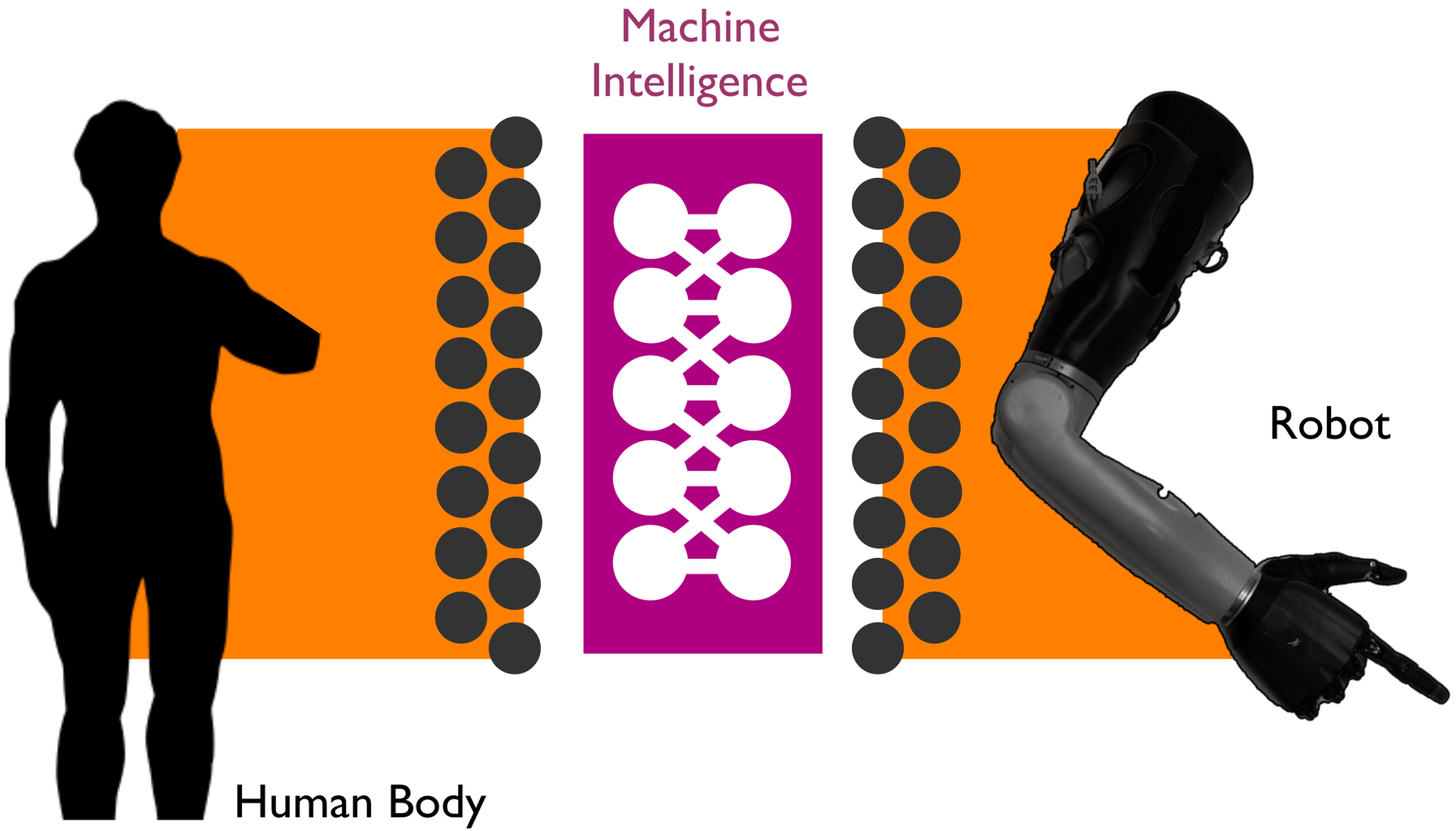
Atlas Robot (Boston Dynamics): https://youtu.be/fRj34o4hN4I

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

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***.


Machine
Intelligence
Robot
Human Body

Machine
Intelligence

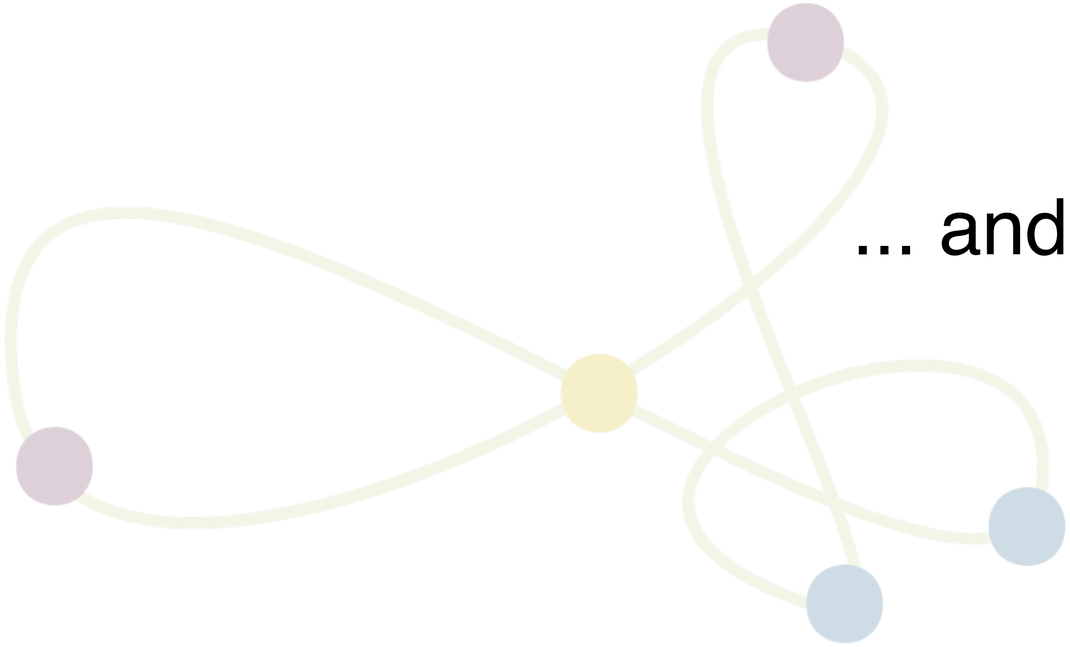
Human Mind:

Patient

Care Giver

Policy Maker

Questions



... and thank you very much!

pilarski@ualberta.ca

http://www.ualberta.ca/~pilarski/

Spencer Murray
Public Relations & Communications

spencer@amii.ca
+1.780.492.8448

Alberta Machine Intelligence Institute
Department of Computing Science
University of Alberta
2-21 Athabasca Hall
Edmonton, AB, Canada T6G 2E8