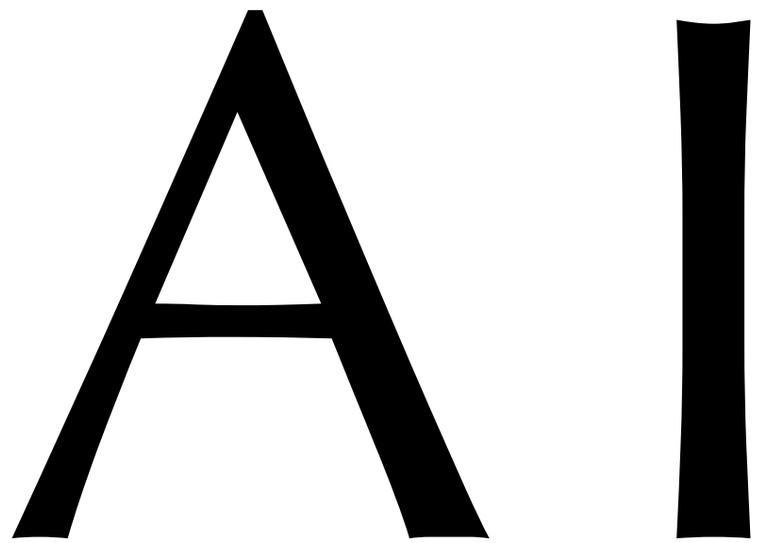
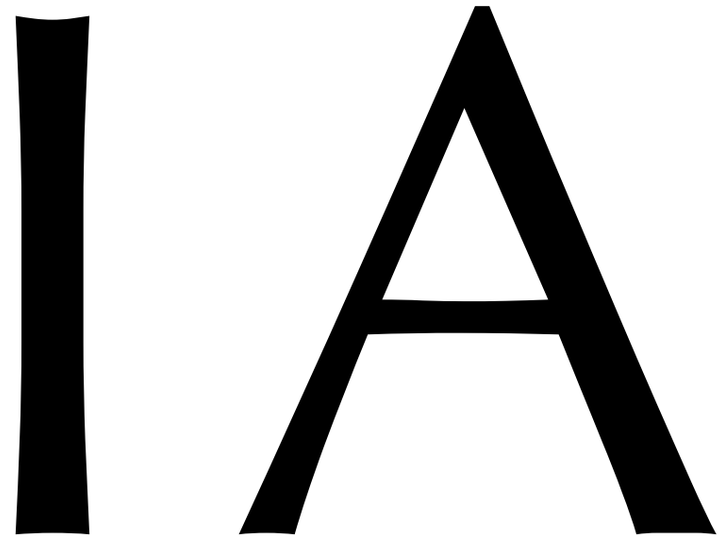




IA

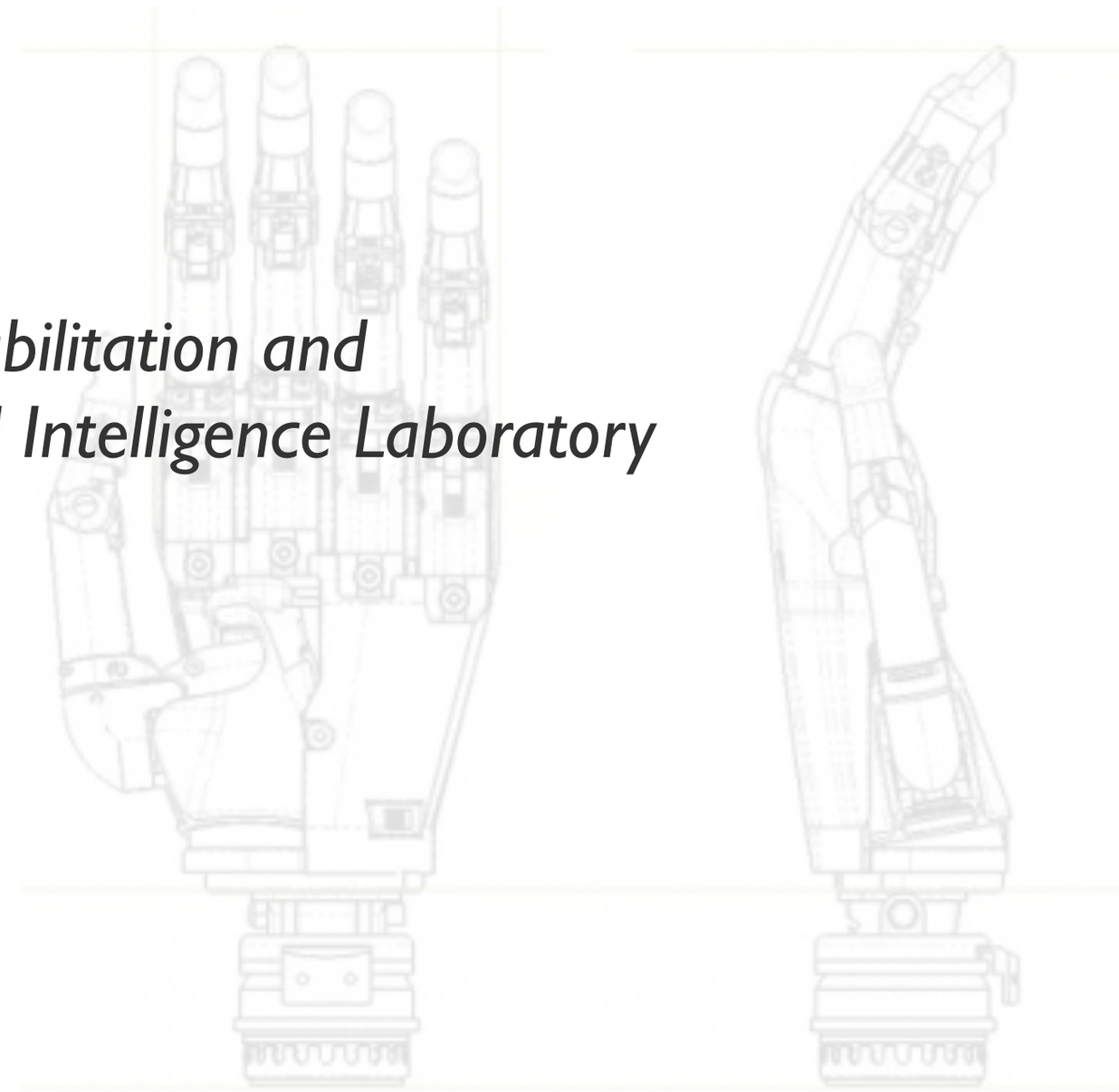
(Intelligence Amplification)

Solving Artificial Intelligence (AI) with help from Intelligence Amplification (IA)

Patrick M. Pilarski
(with Richard Sutton)

Division of Physical Medicine & Rehabilitation and
Reinforcement Learning and Artificial Intelligence Laboratory

UNIVERSITY OF ALBERTA
EDMONTON·ALBERTA·CANADA



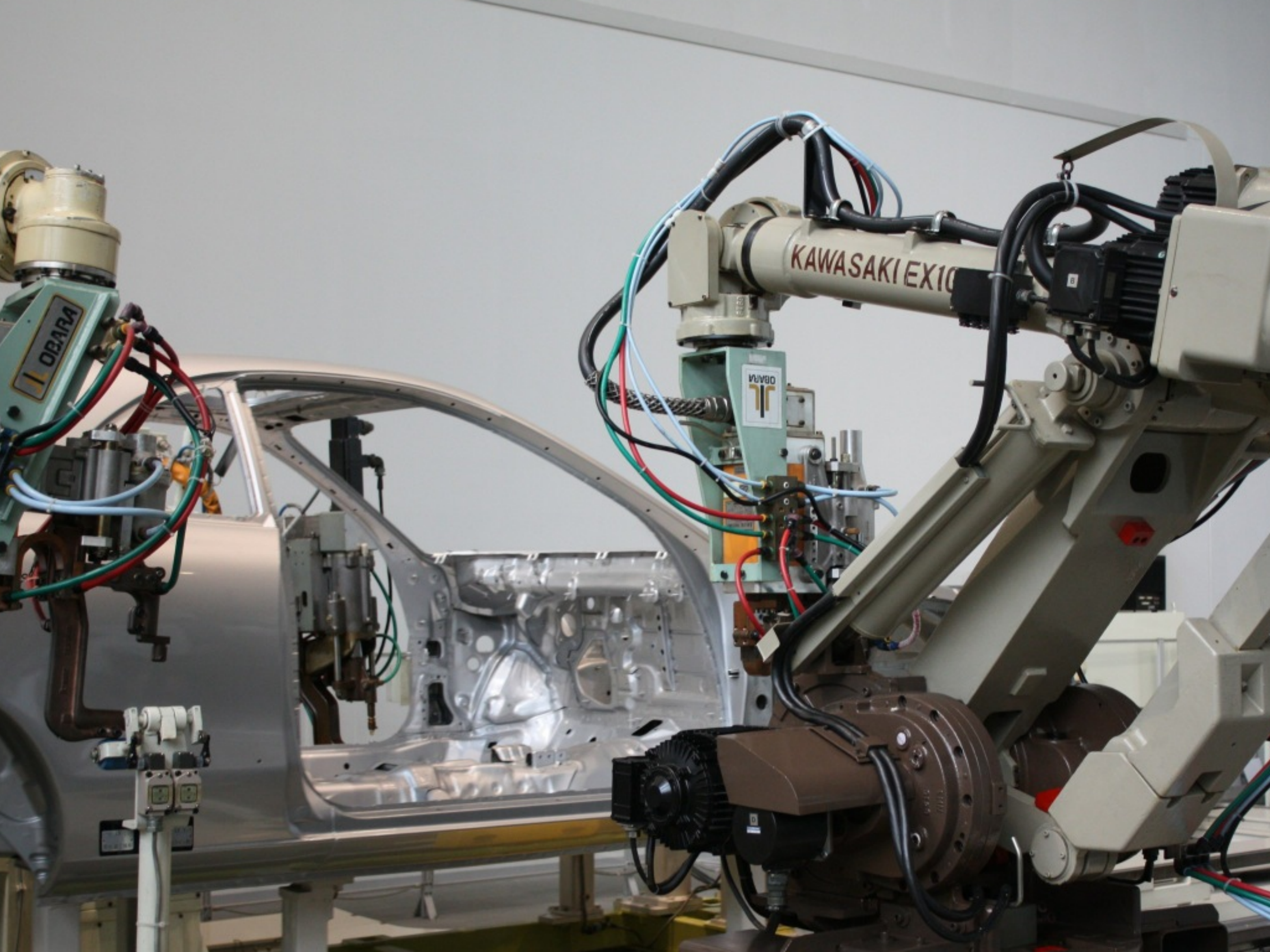
I get ~~by~~ AI with a little help from my ~~friends~~ friend's brains

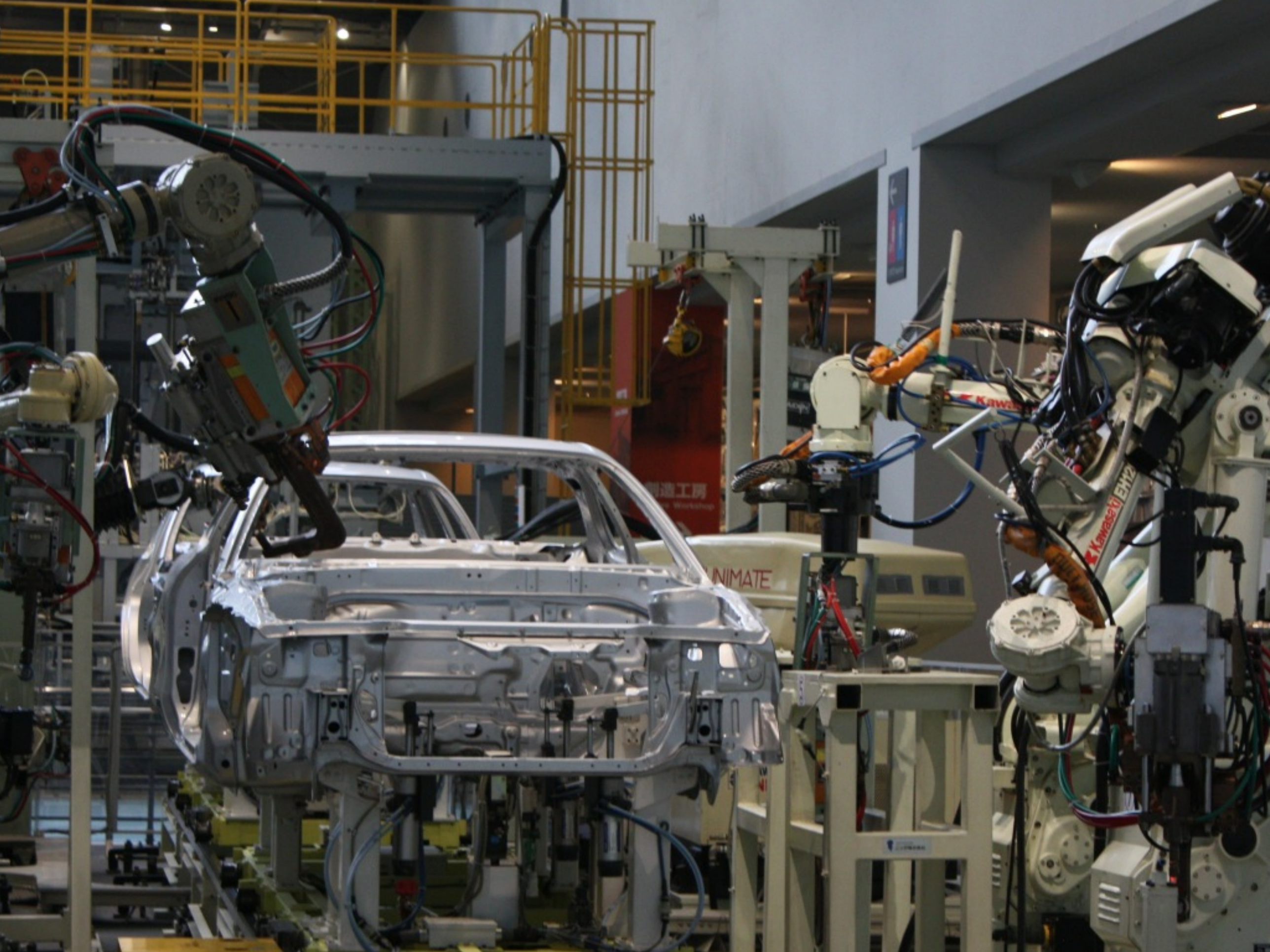
John Lennon

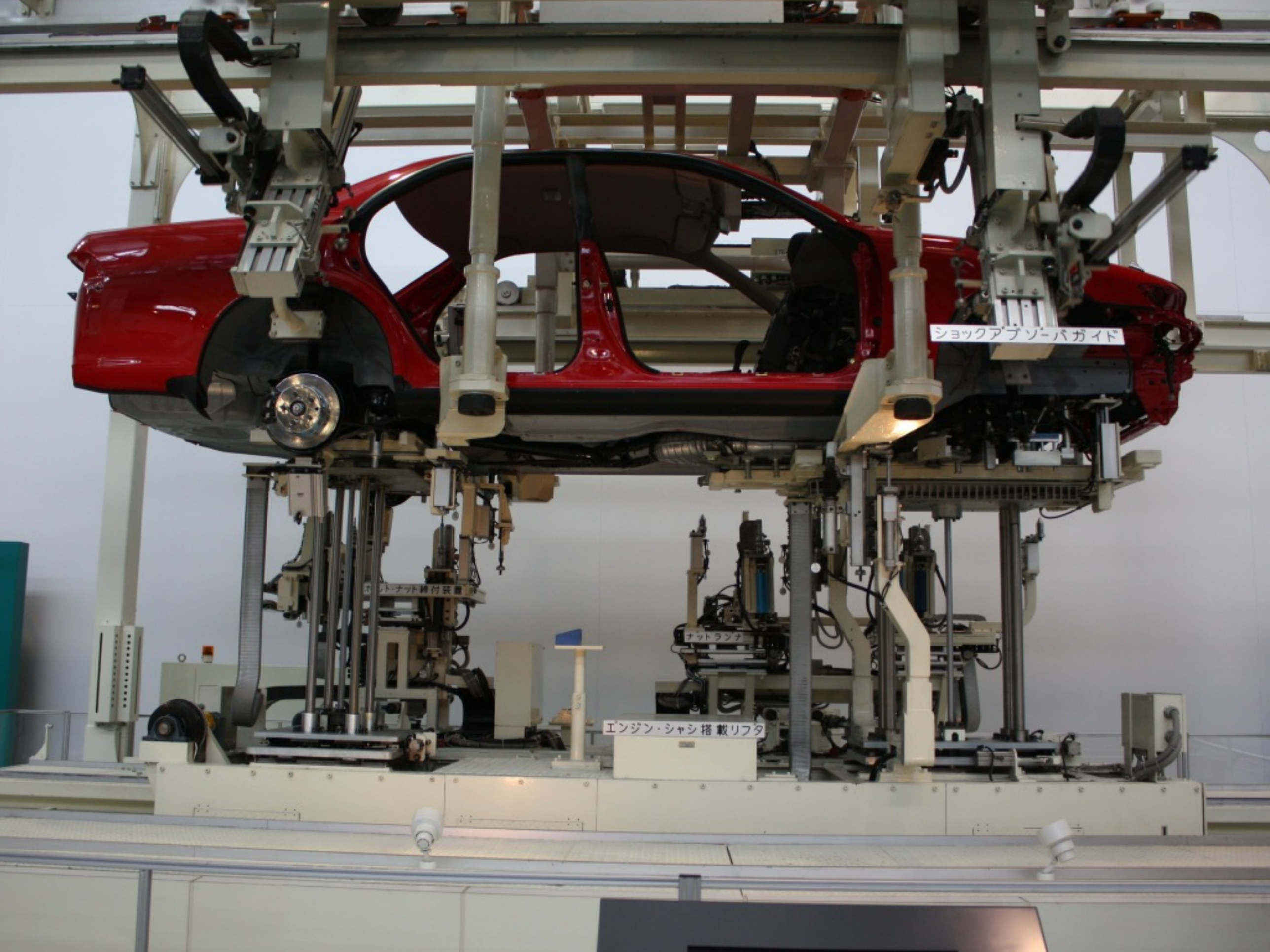
STICK
{a stick,
branch,
twig}

{force multiplier,
remote actuation}

STICK
{a stick,
branch,
twig}


OBARA
KAWASAKI EX1
OBARA


UNIMATE


ショックアブソーバガイド
ナットランナ
エンジン・シャシ搭載リフタ

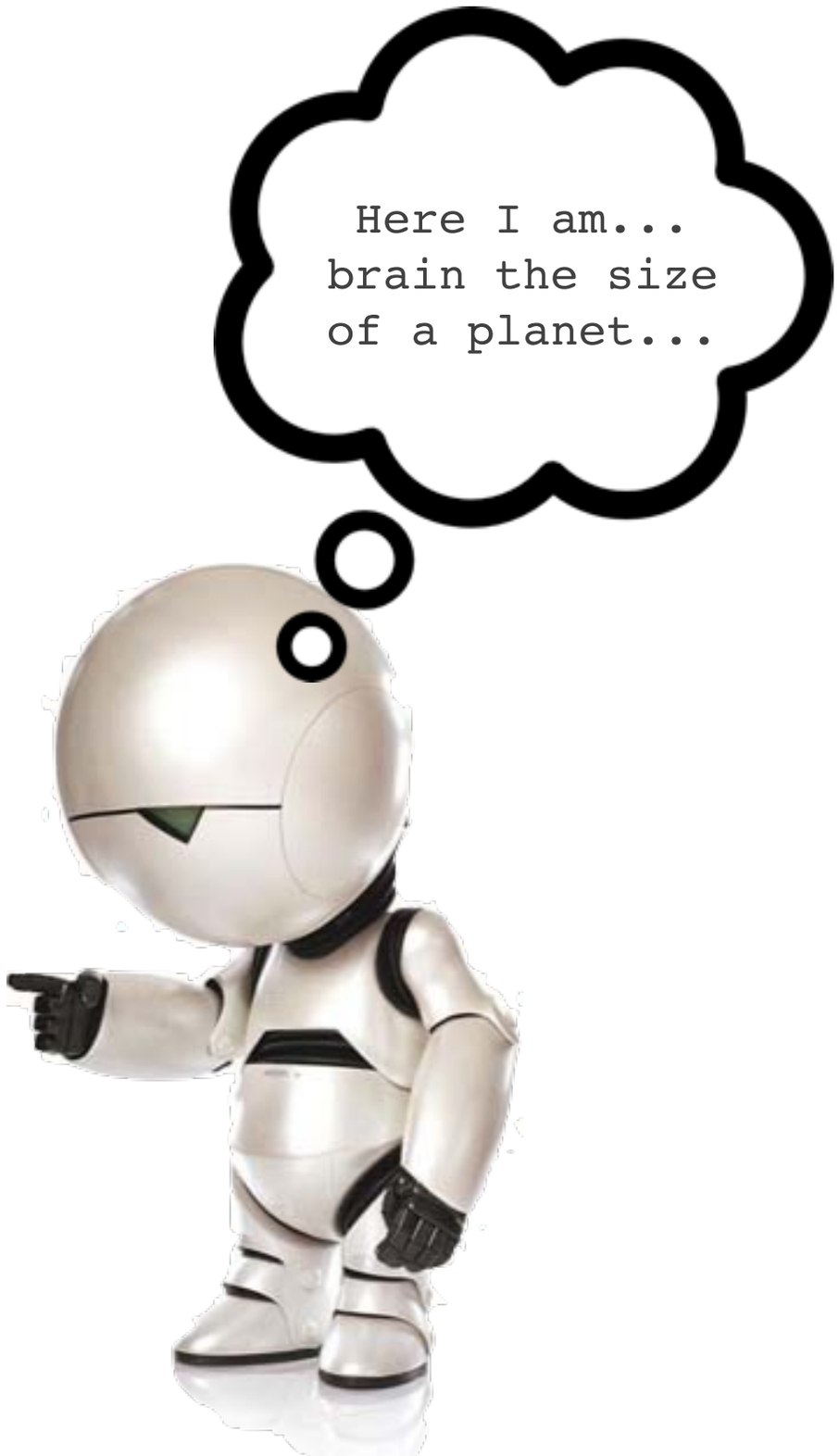
SPINNING WHEEL

{animal fur, plant matter}

>>

{thread, yarn}

… and, in short order …



Marvin the paranoid android from THHGTTG.

Intelligence:
One Possible Definition

- A system that can:

  Perceive and Represent its world.

  Predict its world.

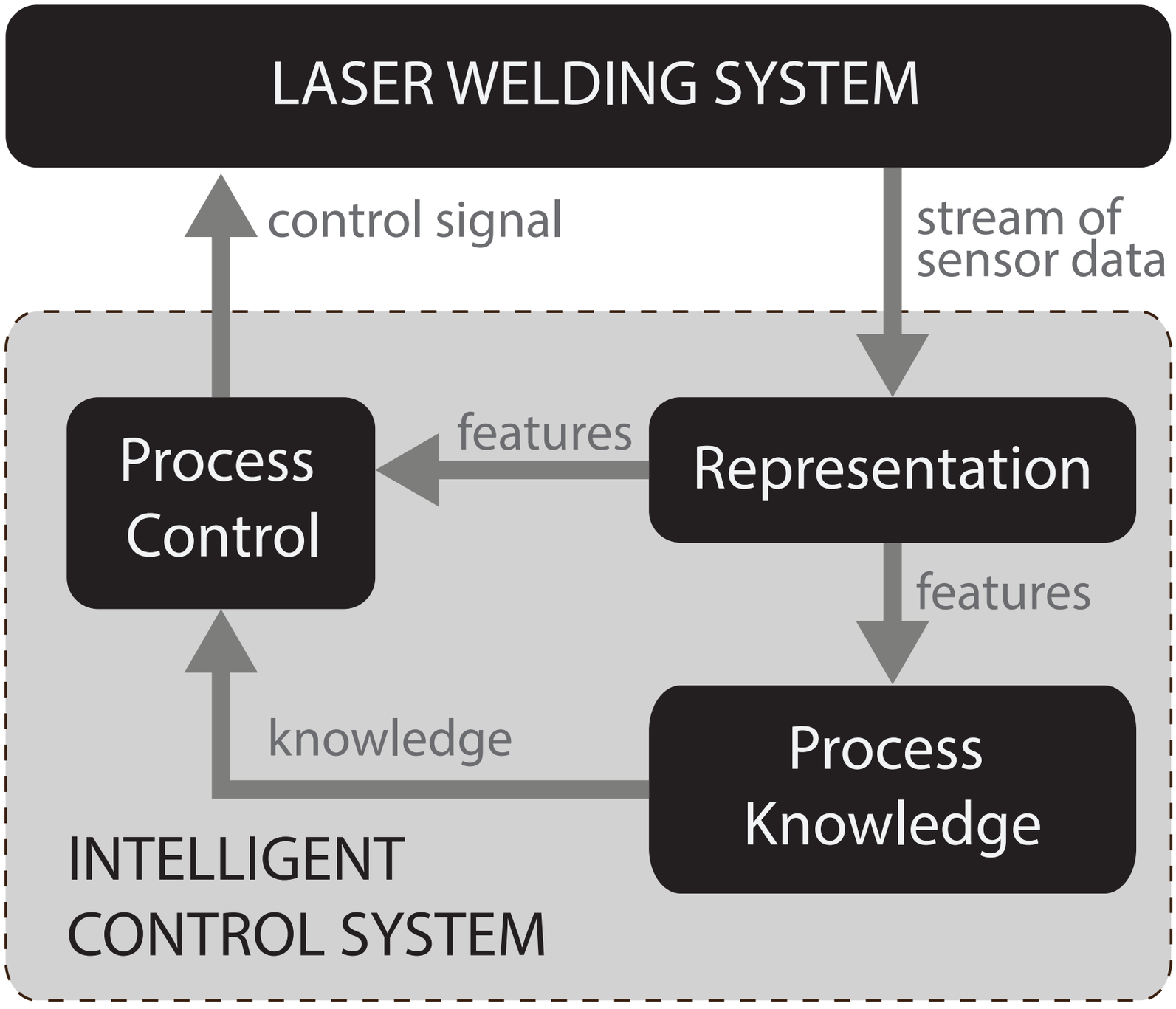
  Control its world.

- "The **Pursuance of future ends** and the **choice of means** for their attainment, are thus the mark and criterion of the presence of mentality in a phenomenon" (James, 1890)

- **Purposeful**: to have, seek & achieve goals (Sutton, 2001).

Key Aspects of Intelligence

Intelligence revolves around maintaining and using knowledge (representation, prediction, control) in a purposeful way.



Example: *Gunther et al. 2014, 2015, in revision.*

Door I

- Perhaps the most popular approach?
- Create or enable a goal-seeking agent that integrates representation, prediction, and control.
- Undertake learning and planning so as to achieve the agent's goals.

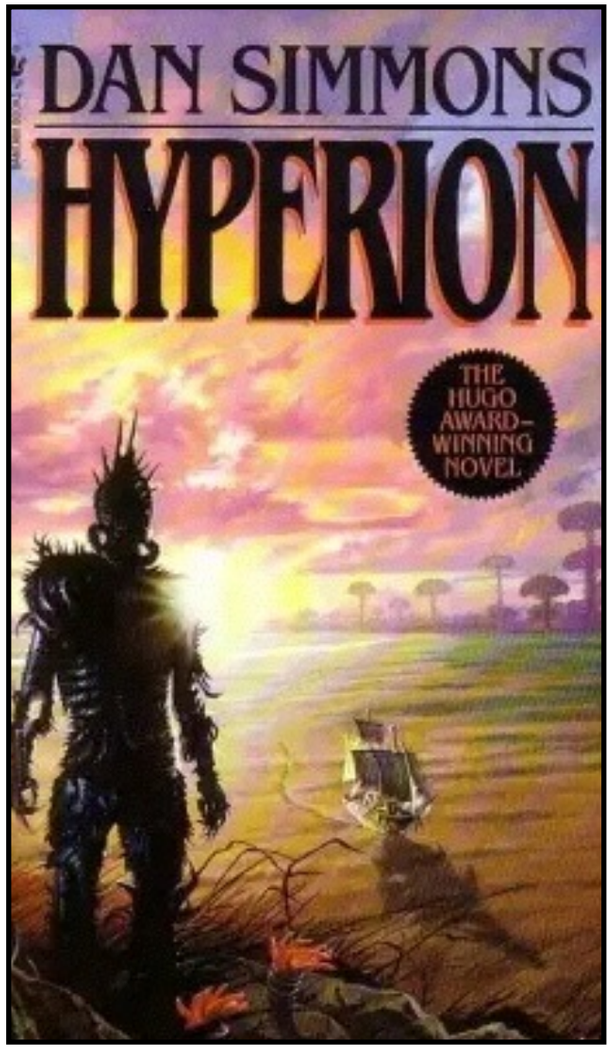
This door is reasonable and fruitful.

Door II

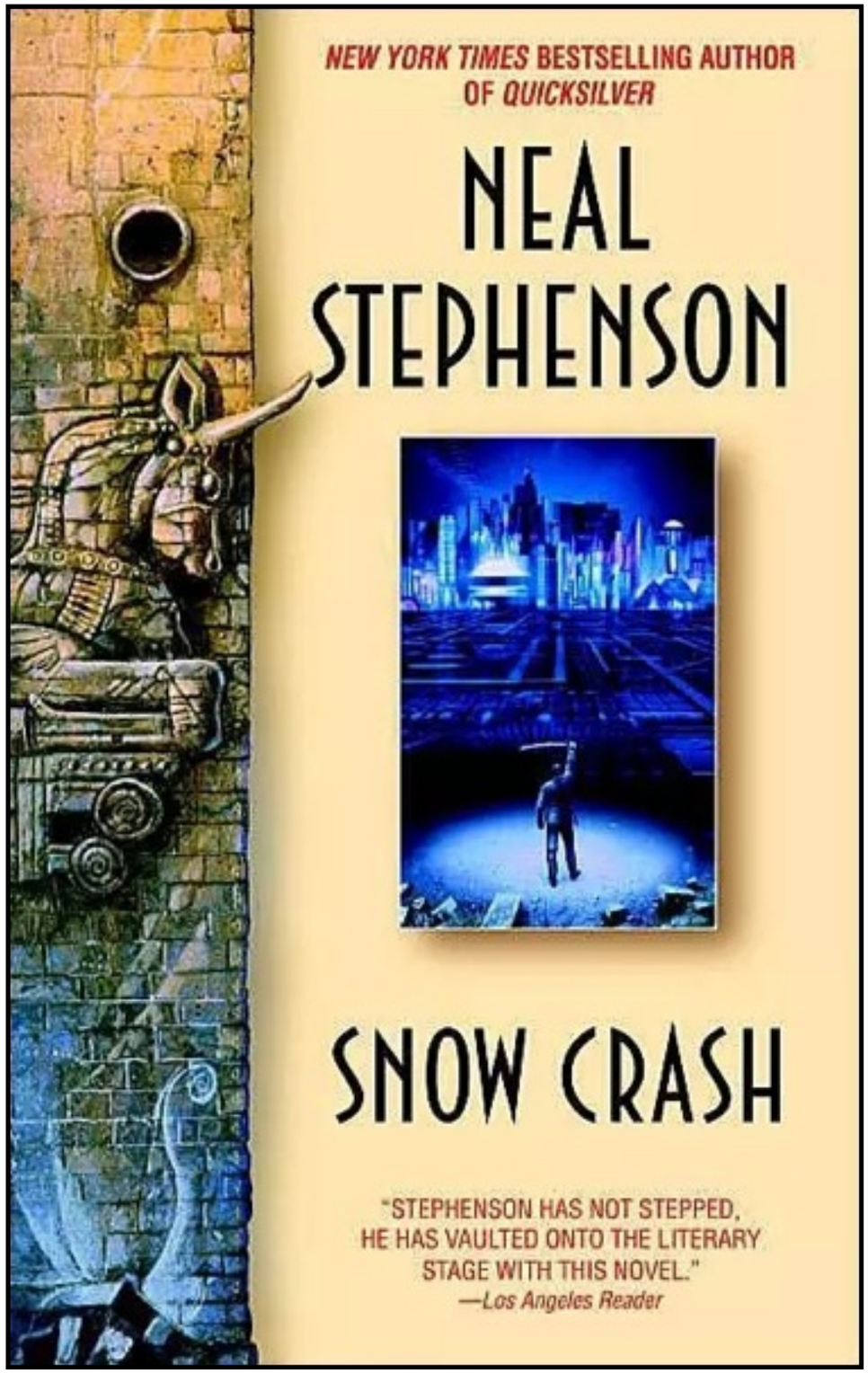
- **Enhance** an existing goal-seeking agent using representation, prediction, and control.
- Undertake learning and planning so as to achieve the agent's goals.
- Key point: **communication**. The emerging, adapting connections between two complex intelligent systems.

How to Approach Door 2?

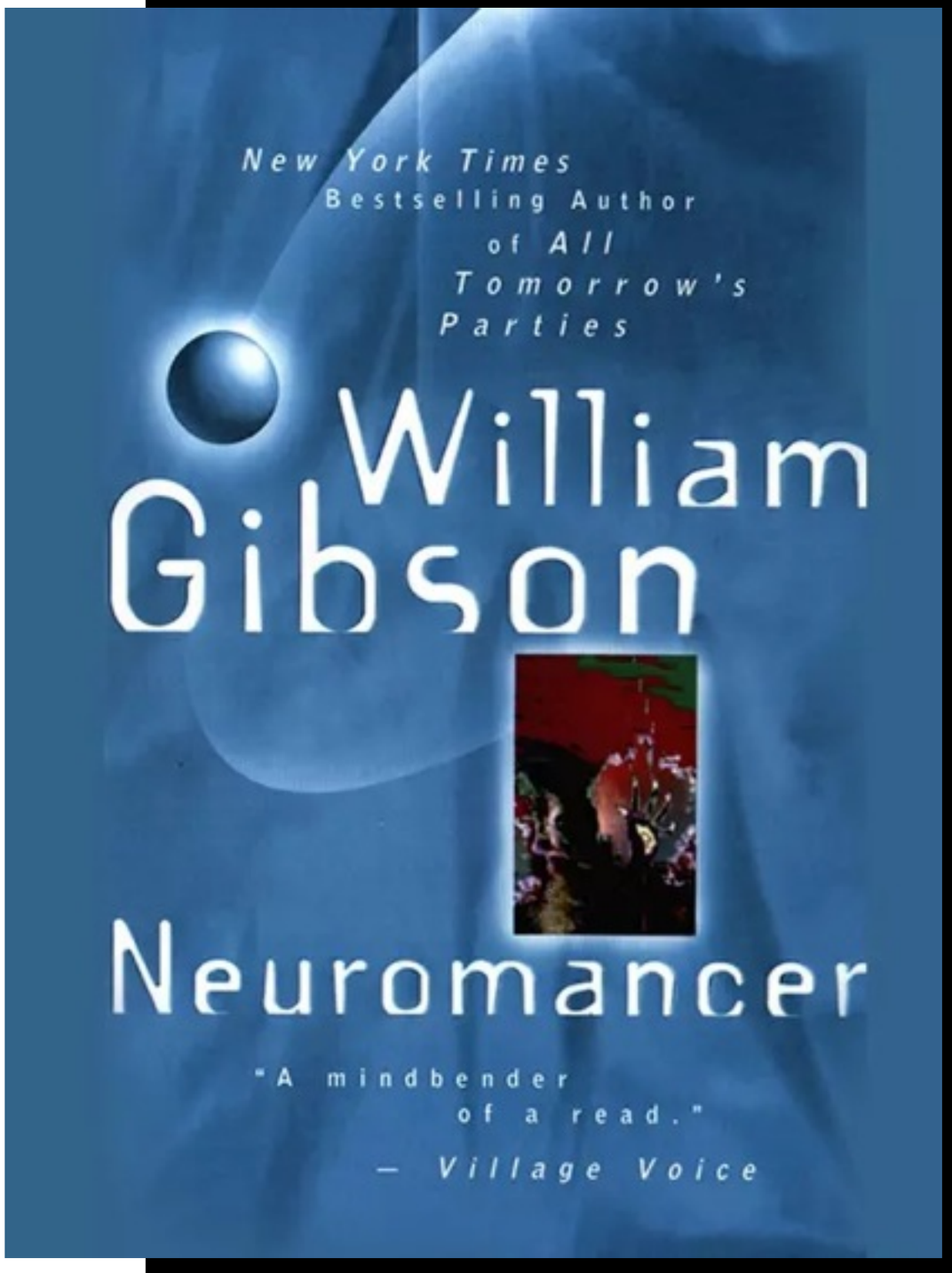
- Multi-agent RL?
- Boosting?
- Systems of experts?
- Extreme connectivism?
- **Enhancement: extending (augmenting or restoring) innate or acquired human abilities.**



Ousters from Dan Simmons' *Hyperion* series.



The **Gargoyles** from Neal Stephenson's cyberpunk dystopia novel *Snow Crash*.



Molly Millions from Williams Gibson's sprawl trilogy and short stories.

Samus Aran from the Metroid video game franchise.

Kinds of Enhancement

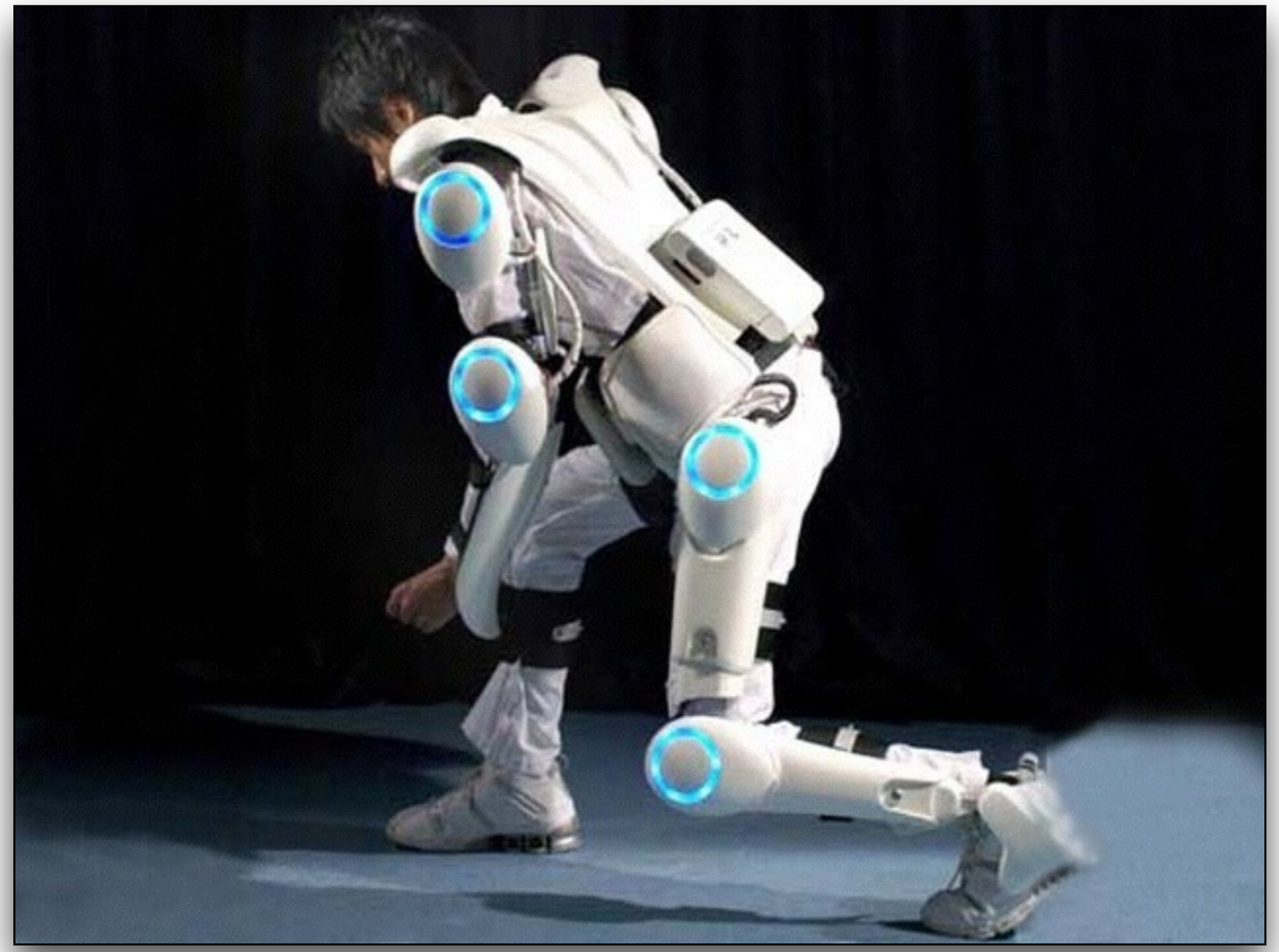
	Extend	Restore/Recover
Motor		
Sensory		
Cognitive		

These areas are continuous with ordinary, normal things that humans do every day.

Why we should care.

- All six cases occur & are important
- All six cases range from fancy to ordinary
- Lots of mid-range economically and socially important instances of them.

Samus Aran from the Metroid video game franchise.



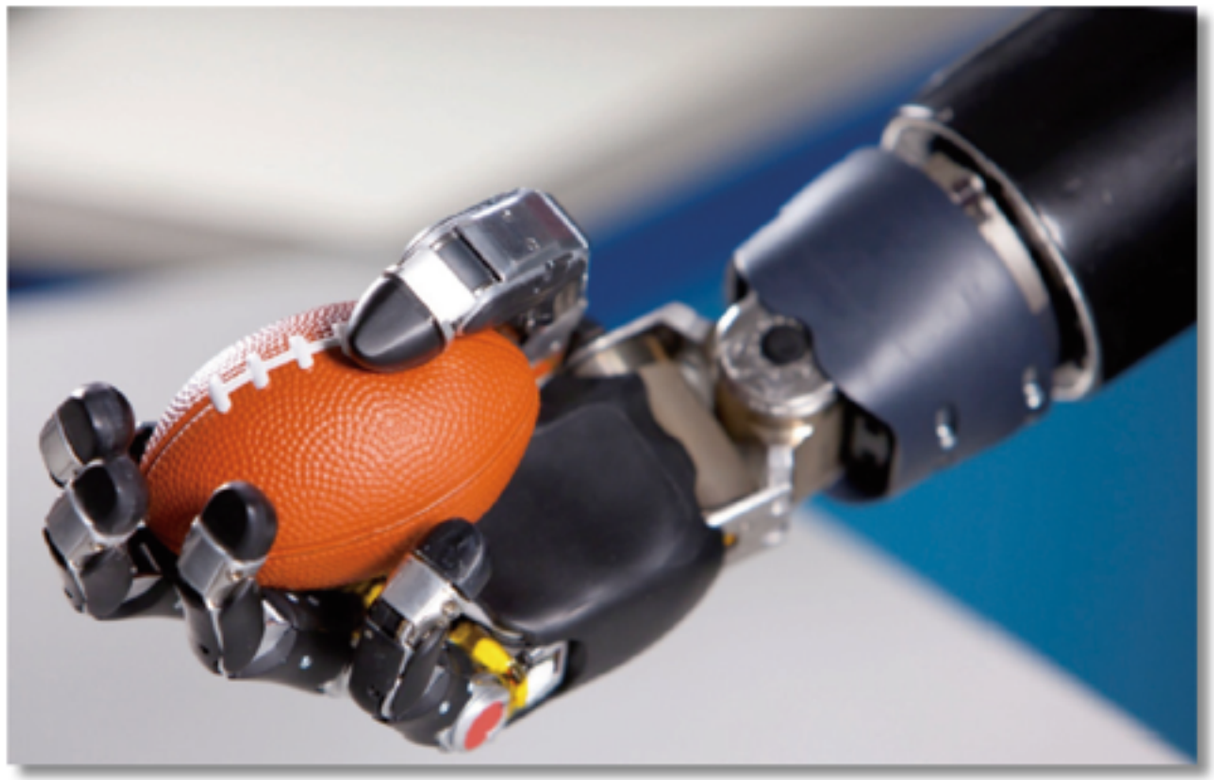
Hybrid Assistive Limb (HAL): Cyberdyne Inc., Japan.

Hybrid Assistive Limb (HAL): Cyberdyne Inc., Japan.

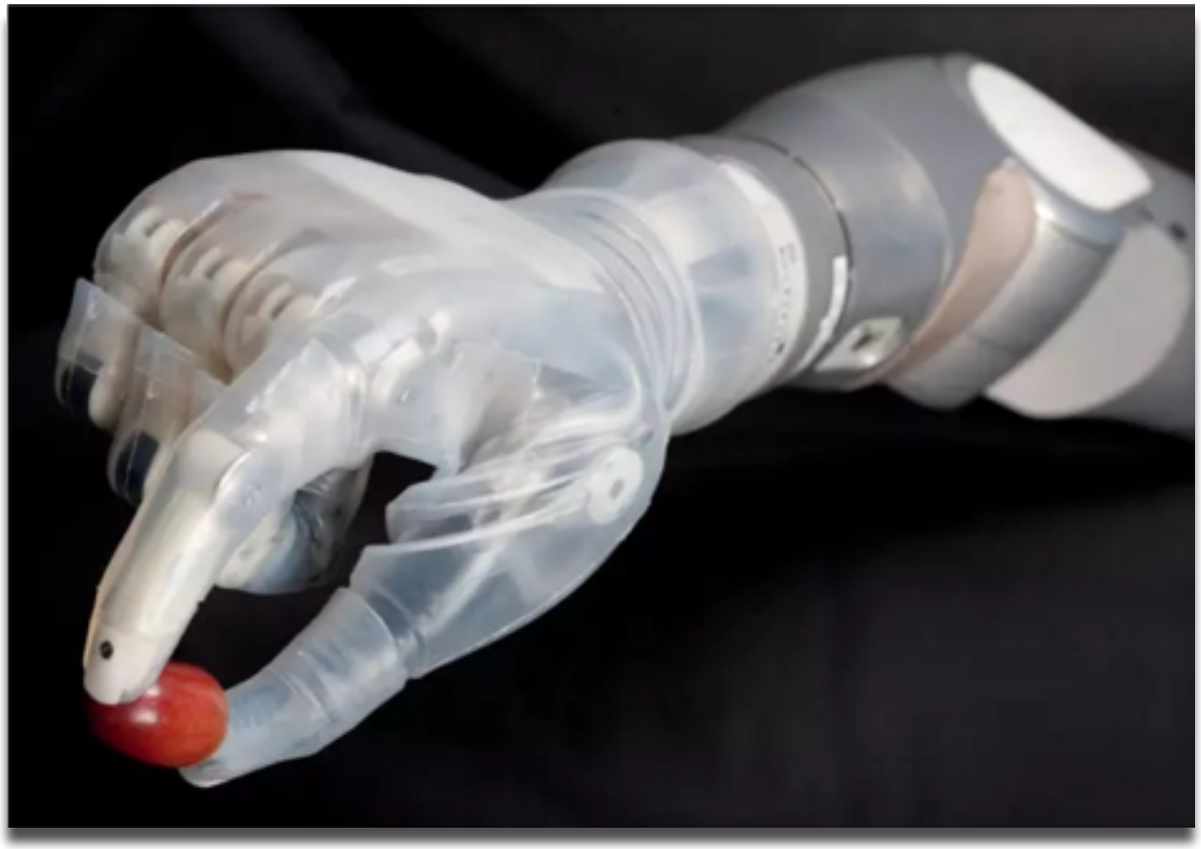
Geminoid Robot designs of Hiroshi Ishiguro

Rehabilitation Institute of Chicago (RIC) research subject, **Zac Vawter** at the top of the Willis Tower in Chicago (Photo: The Associated Press).

***MPL** v1.0 (Johannes et al., 2011)*



***MPL** v2.0 Serial 1 (Johannes et al., 2011)*



***DEKA Arm,** 2014*


Courtesy of DEKA Research & Development and
The Rehabilitation Institute of Chicago


Courtesy of DEKA Research & Development and
The Rehabilitation Institute of Chicago

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

Regarding Enhancement

- **Opportunity for research:** much (all?) work in direct human machine interfaces has focused on the physical connection (e.g. electrodes, wires, materials).
- Need for more thought regarding interfaces w.r.t. computation and info proc.
- We suggest there is a need for an overarching perspective.

An Overarching View

1. An enhancing (assistive or augmentative) device should be a goal-seeking **agent**.
2. An agent-based viewpoint enables a fruitful **progression** in terms of human-device interaction.
3. **Prediction**, integrated with representation and control, forms a strong basis for progressive assistance and augmentation.

Machines learn and adapt to human users …

. . . humans change to better interact with machines.

Towards a Perfect Assistant

Stairwell from
Antoni Gaudi's La Sagrada Familia

Putting things together at scale …

- Not algorithm to algorithm or module to module.
- **Intelligence** to **intelligence.**
- ***Communication***, ***intentions***, and building up ***communicative capital***. Can it start from simple primitive signals? +/- reward?

Maybe re-read Norbert Wiener, 1948: *Cybernetics: Or Control and Communication in the Animal and the Machine.*

What are we doing to help out?

A special / constrained / unusual / fruitful setting:
robots directly attached to the human body.

RL & AI

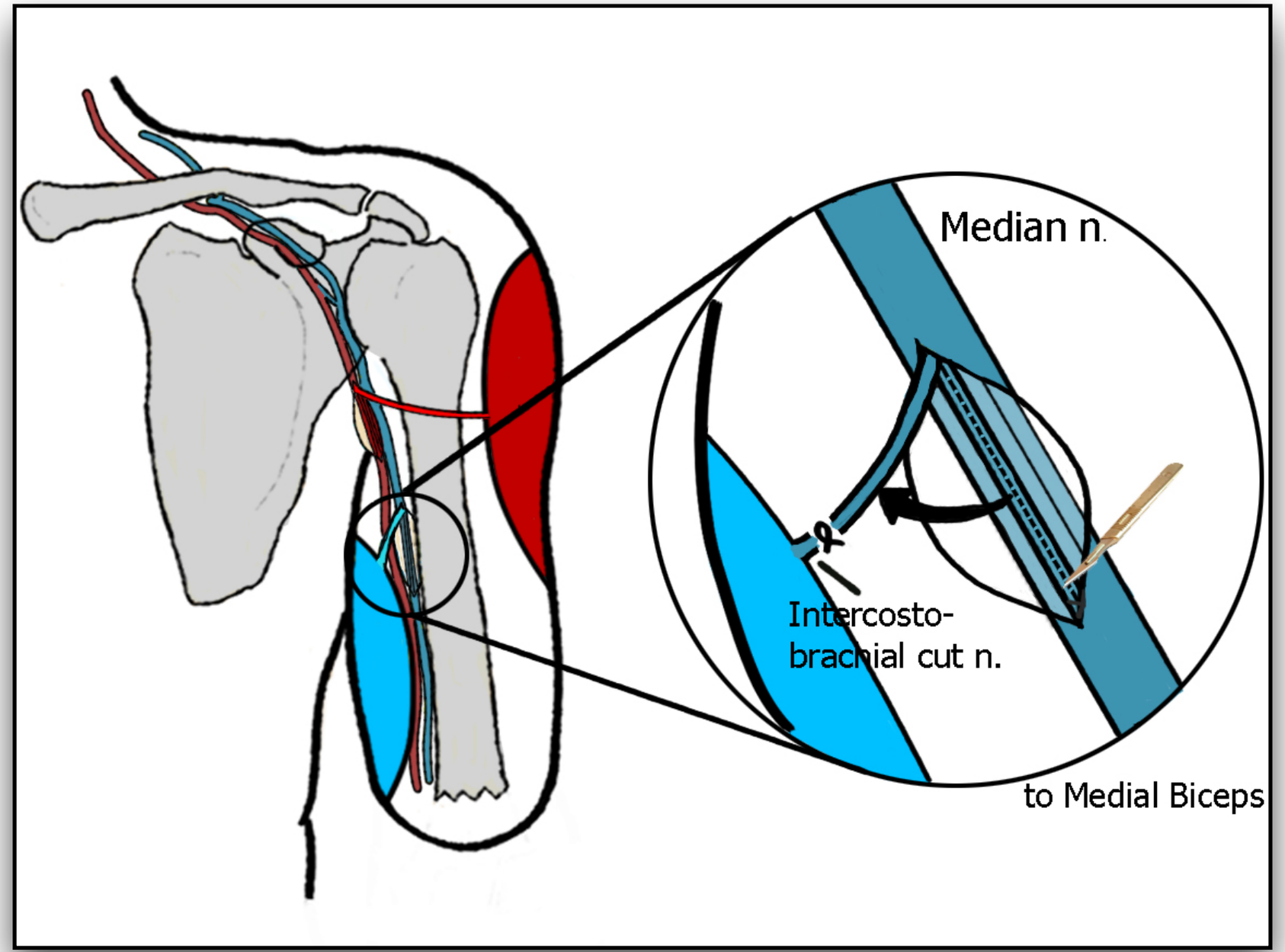
BLINC

AICML ALBERTA INNOVATES CENTRE FOR MACHINE LEARNING

GLENROSE REHABILITATION • HOSPITAL FOUNDATION


CH2
CH1
CH0

Re-wiring the Nerves

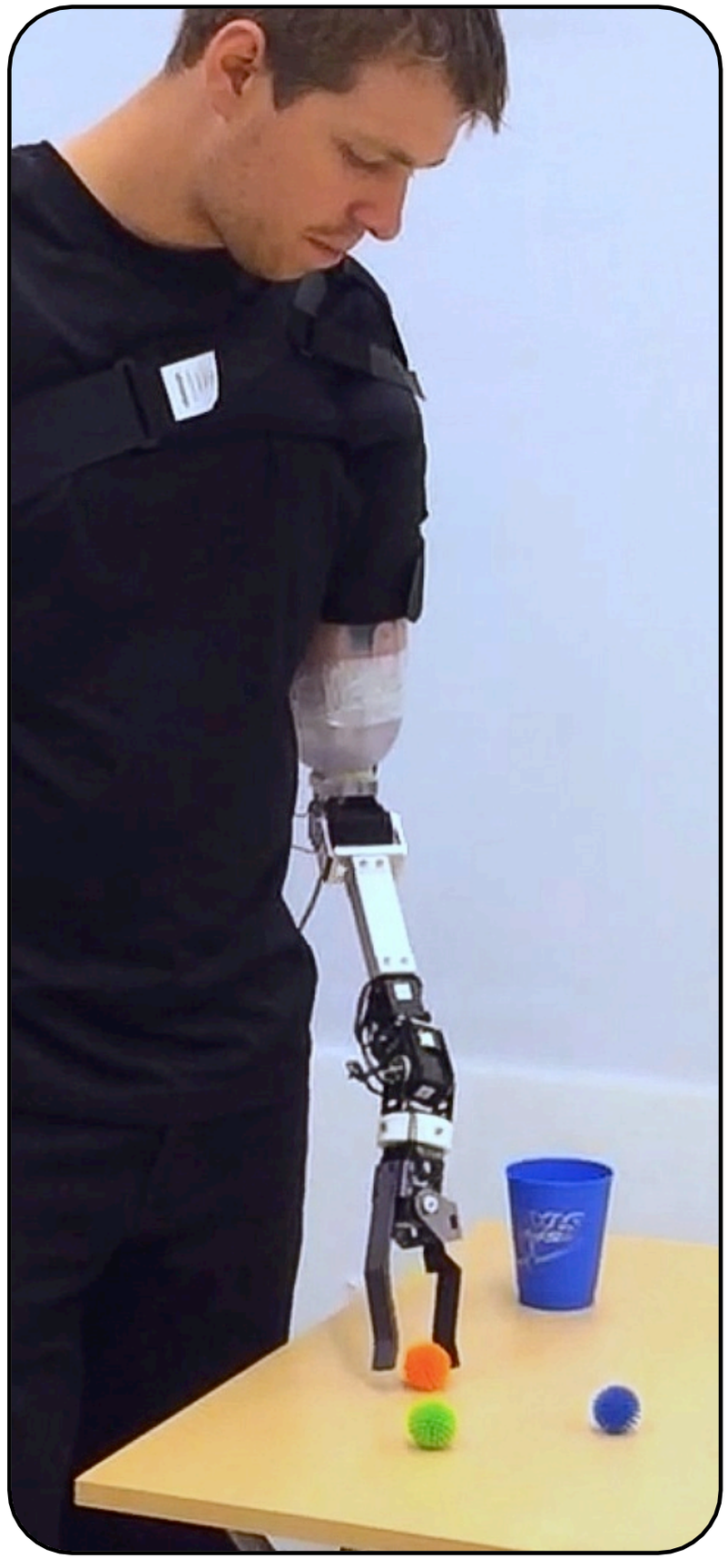


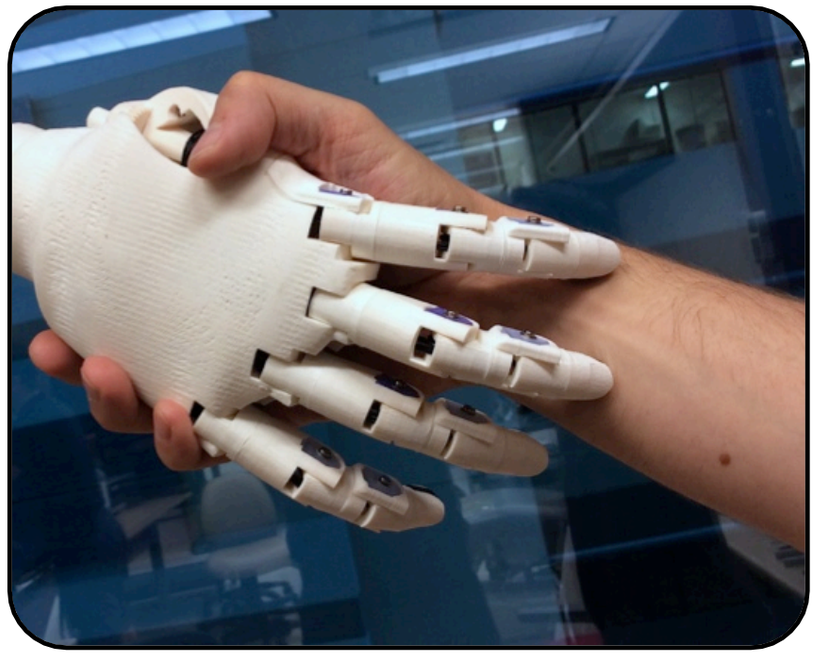
TSR: Targeted Sensory Reinnervation

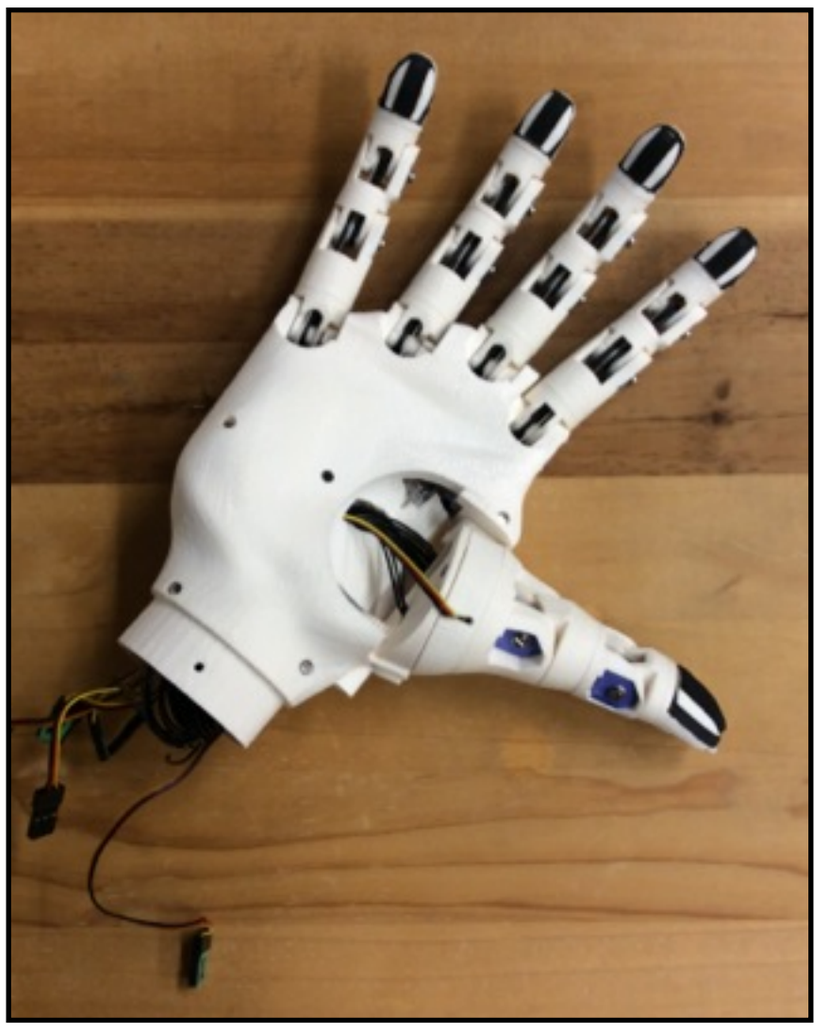
Hebert et al. 2014, IEEE-TNSRE

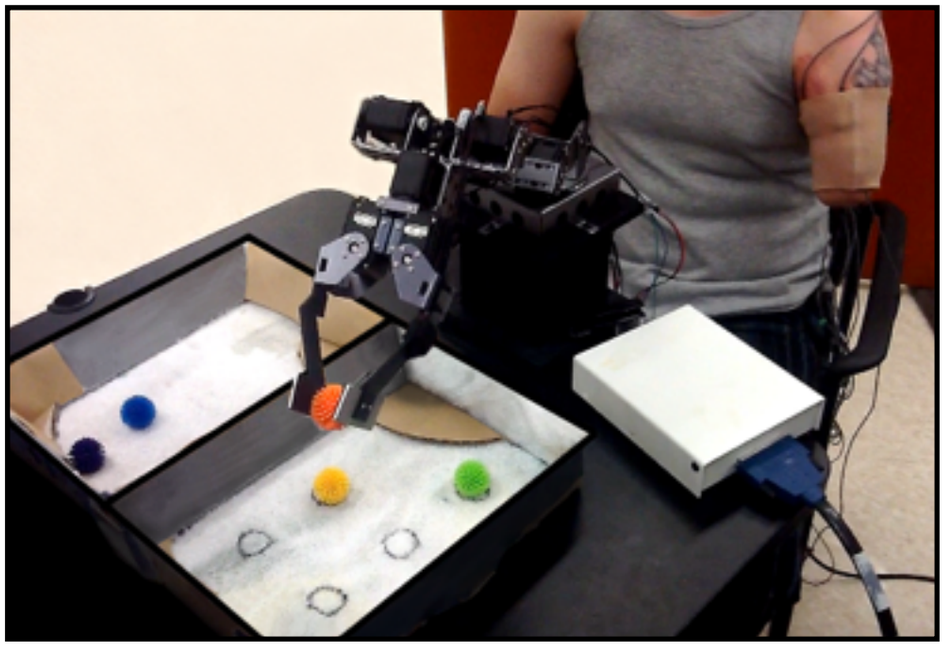
Custom Robotic Systems

Technology designed with machine learning in mind.

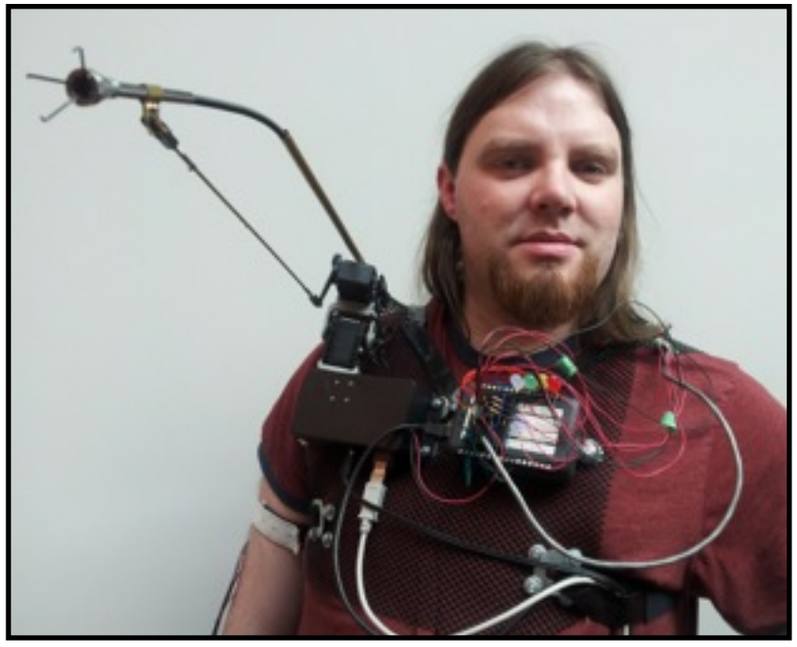




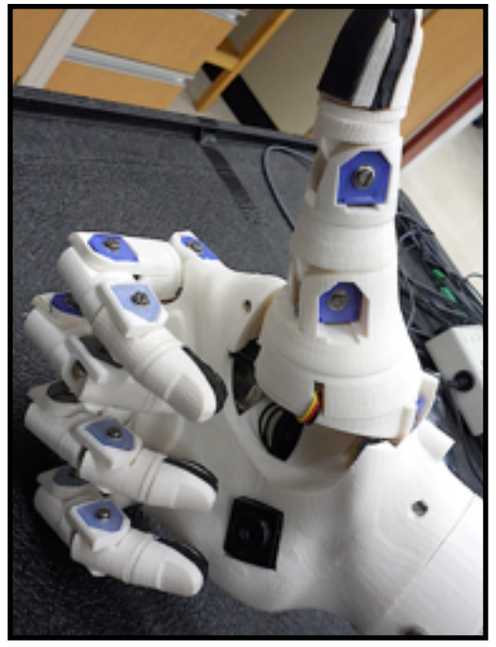




The Myoelectric Training Tool
5 DoF + >20 Sensors

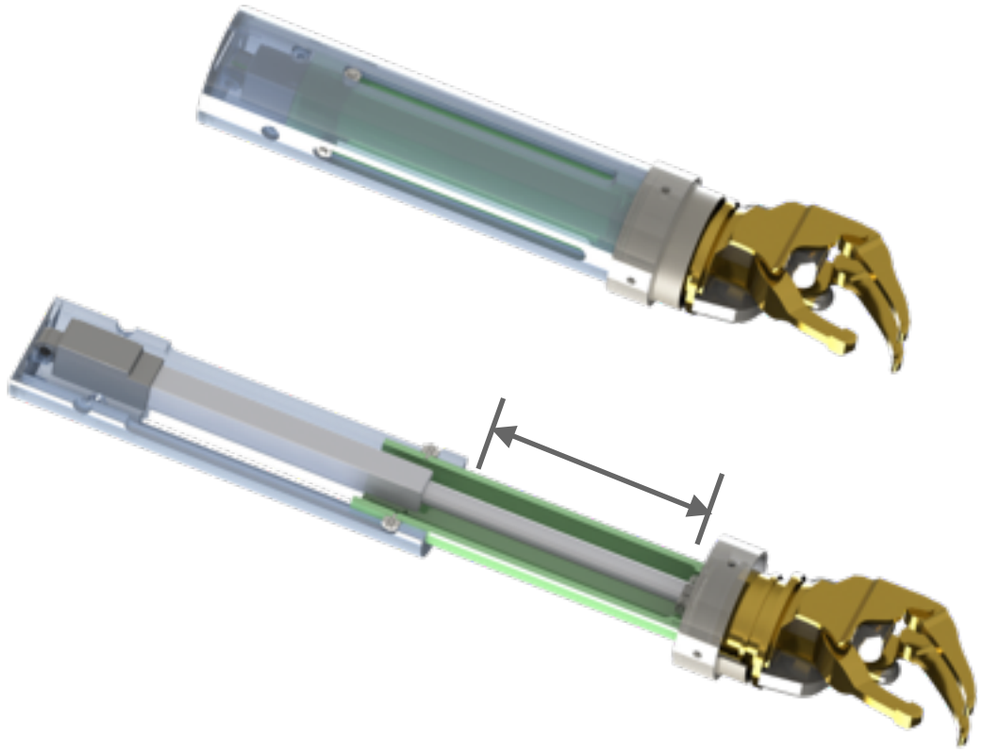


The exArm
4 DoF + 4 FbDoF + >16 sensors



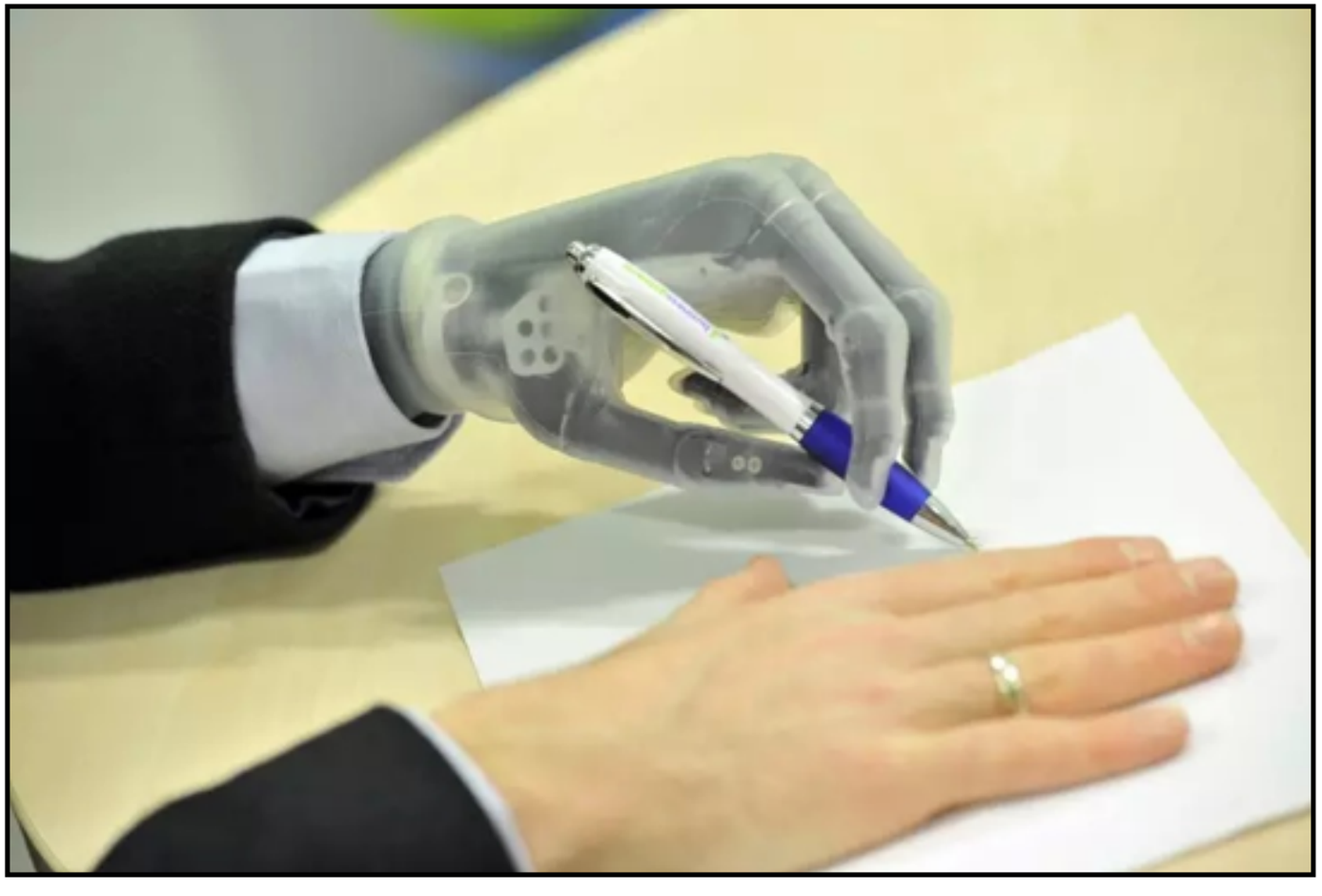
HANDi Hand
6 DoF + 25 Sensors + Camera

The Bento Arm and HANDi Hand
11 DoF + 41 Sensors + Camera



Extendable Forearm Prosthesis
Hand + 1 DoF (Non-Physiological)


i-limb ultra



BLINC

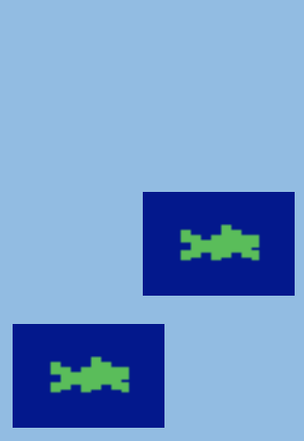
BLINC

Planning and Meta-learning

Control  2009

Prediction

Representation



Planning and Meta-learning

Control

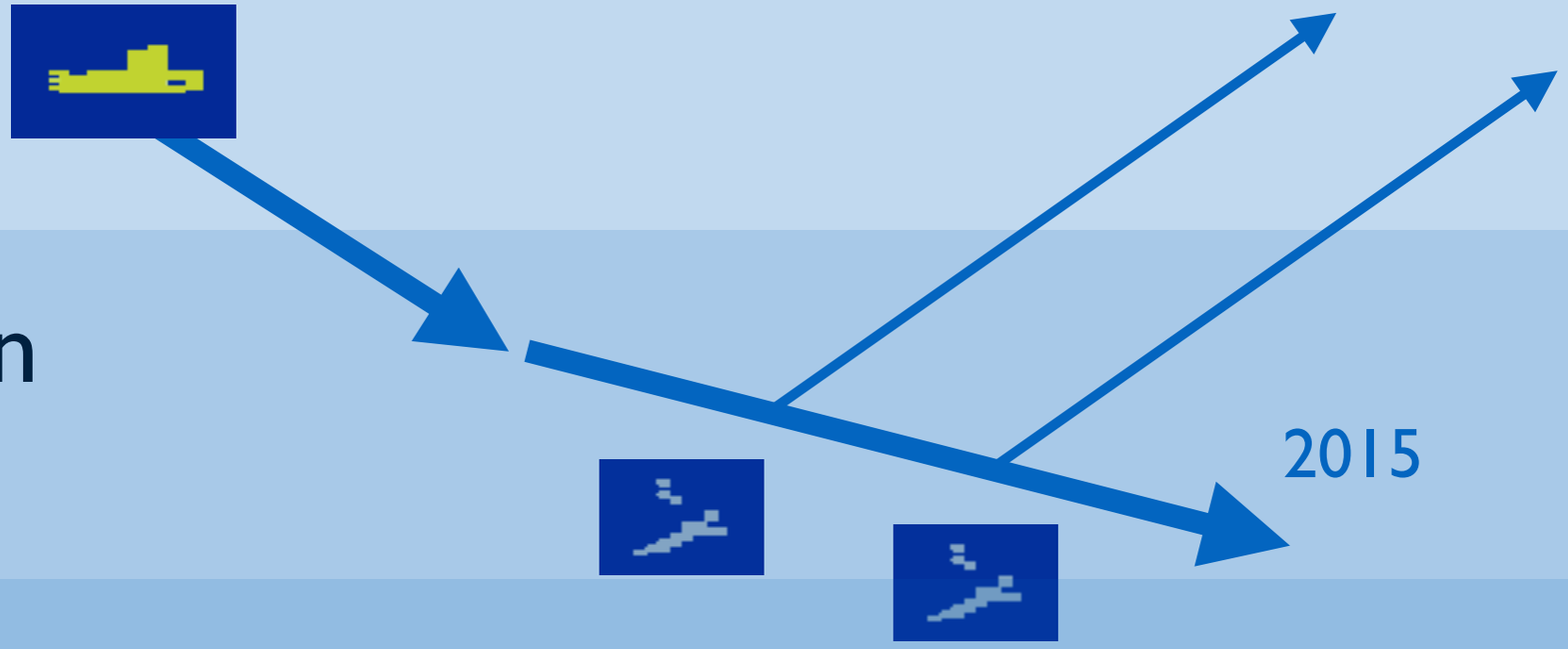
Prediction

2010

Representation

Planning and Meta-learning

Control



Prediction

Representation

Planning and Meta-learning

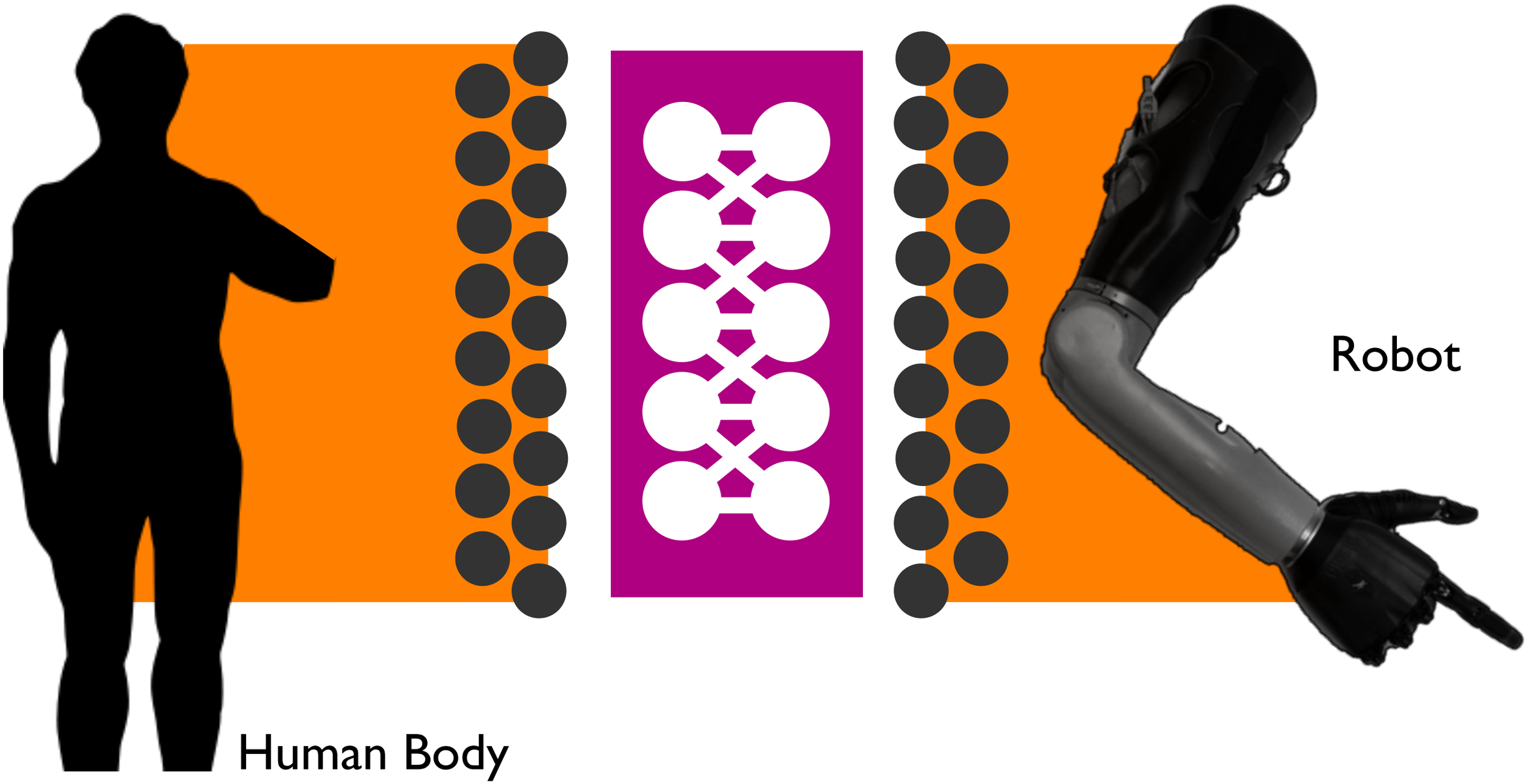
Control

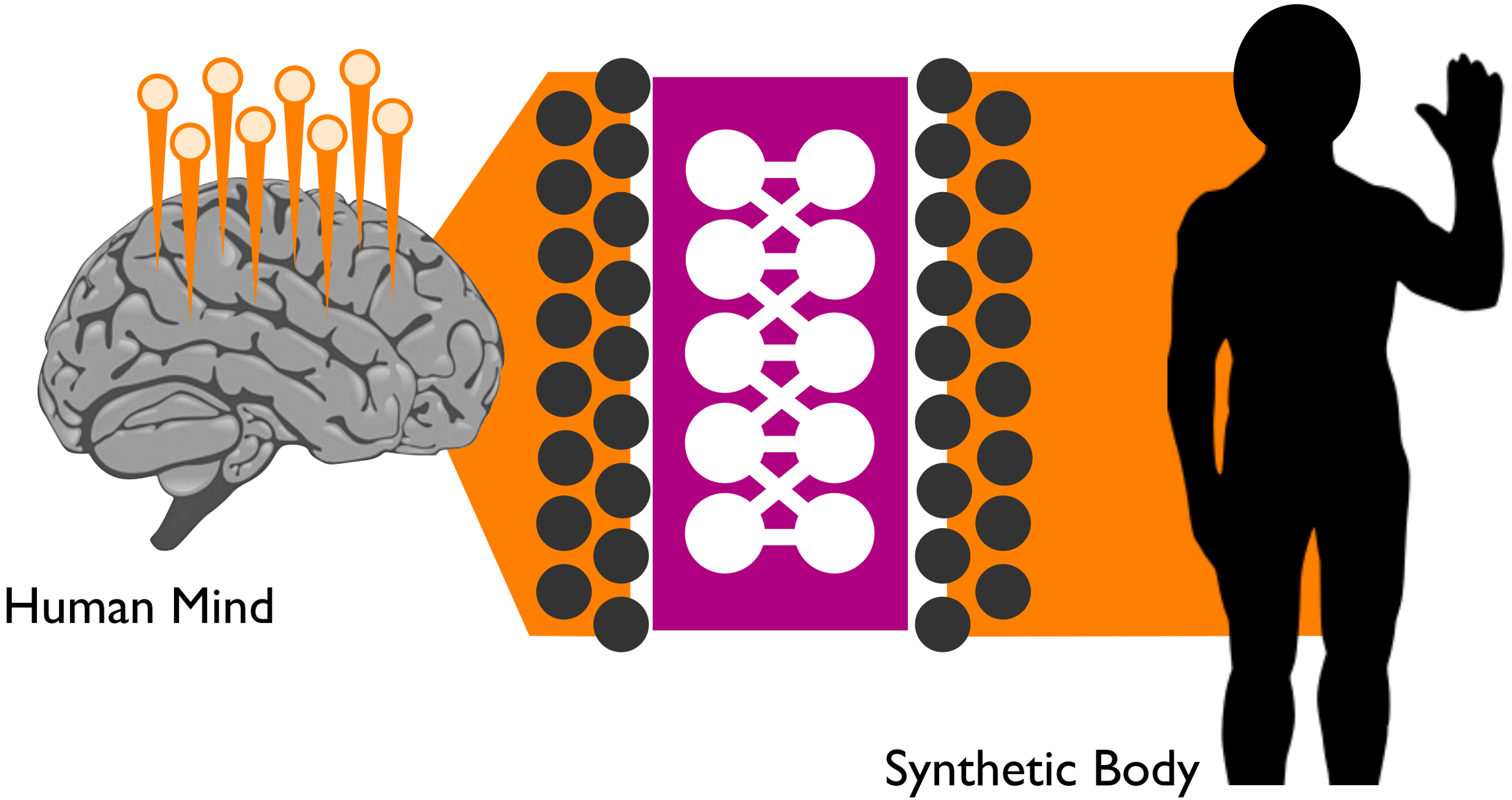
Prediction

Representation

Soapbox: new ways to think about representation learning could address most of the open problems discussed this week.

2020


Robot
Human Body


Human Mind
Synthetic Body

English – detected

maple syrup is not a robot

Japanese

メープルシロップは、ロボットではありません

Mēpurushiroppu wa, robottode wa arimasen

Google Translate
translate.google.ca/
Google's free online language **translation** service instantly **translates** text and web pages. This translator supports: English, Afrikaans, Albanian, Arabic, ...

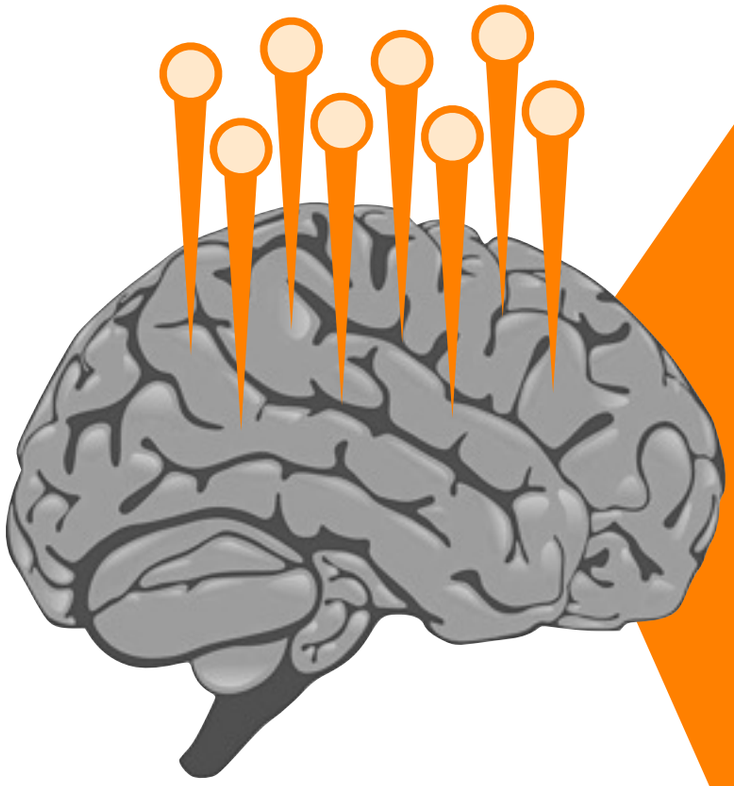
Free Translation and Professional Translation Services from SDL
www.free**translation**.com/
SDL is the world's number 1 provider of free and professional language **translation** services for websites and documents. **Translate** from English to Spanish, ...

Bing Translator
www.bing.com/translator/

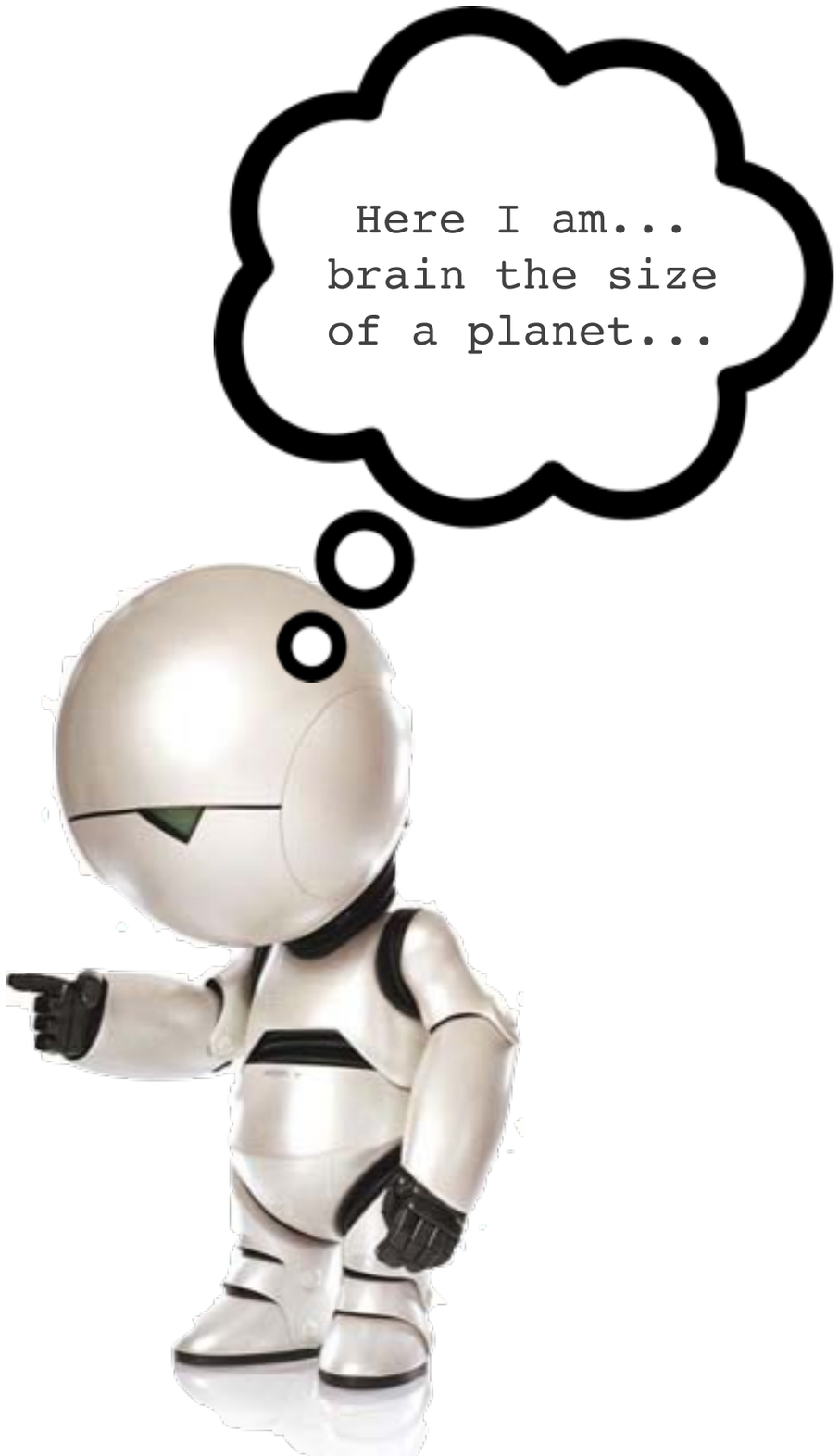
Alright, here's what
I found for
"baking squid pancakes"

Alright, here's what
I found for
"baking squid pancakes"

Texting “squid-cake recipe” to your mother. Ready to send?



Human Mind



Marvin the paranoid android from THHGTTG.

Overview

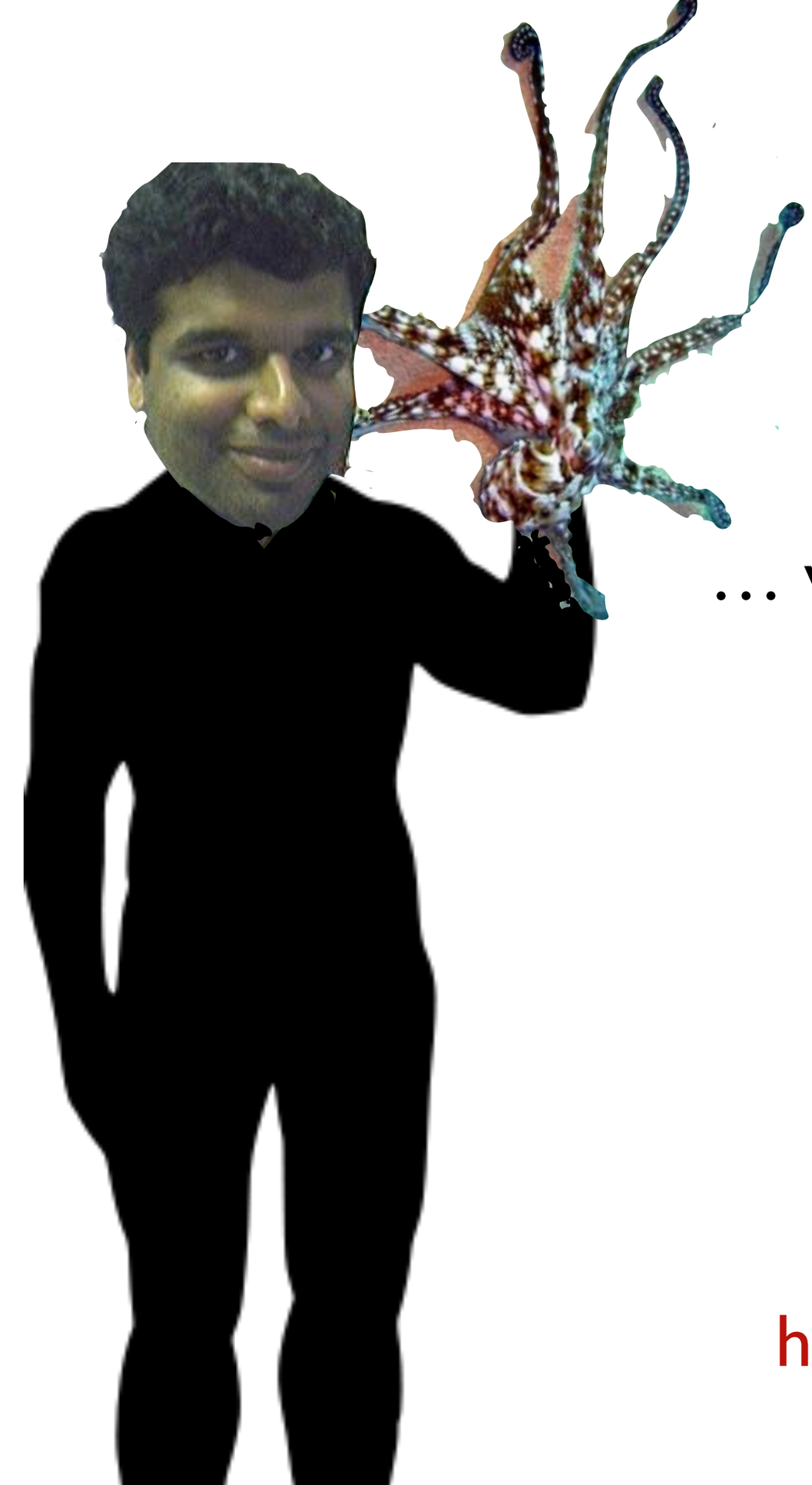
- AI and IA give us different views on the same problems; happily, approaches that enable one also enable the other.
- Both give us the ability to focus on important subproblems, most (all?) of which rely on combining representation, prediction, and control (learning and planning).

Overview

- IA allows us to specifically address communication: the connection of two complex, intelligence systems to achieve in ways a single system could not.
- IA seems like a reasonable approach to crafting, understanding, and inviting advanced intelligence (biological, synthetic, or some combination of the two).

Closing Thoughts

- Thanks to advances in multiple fields, we now have an excellent opportunity to study intelligence (representation, prediction, and control) through the lens of physical, sensory, and cognitive enhancement.
- A suggestion for future effort: we have prediction and control on the run; let's now get a solid handle on representation learning.



Questions

… with thanks to many colleagues,
students, and collaborators

... and thank you very much
for your attention.

pilarski@ualberta.ca

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