The Promise and Perils of AI: Part II
Assistance, Augmentation, and Interfaces

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Learning Objectives (1)

- Be able to **define** assistance & augmentation.
- Understand three key interface **challenges**.
  (increasing, decreasing, matching signals.)
- Be able to state **why** machine intelligence is important to human-machine interaction.

Supporting article: P.M. Pilarski, *Alberta ICT Magazine*, 2nd Ed., pp. 28-30
http://www.ualberta.ca/~pilarski/docs/papers/Pilarski-IntelligentArtificalLimbs-AlbertaICTMagazine2012.pdf

Learning Objectives (2)

- Understand **what** abilities
  machine intelligence might support.
  (sensation, actuation, and information processing.)

- Understand **how** machine intelligence is implemented within human-machine interfaces.

- Be able to give **examples** of how machine intelligence can enable better assistive and augmentative technology.

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QUESTION

What do you want to achieve that you <u>do not</u> have the ability to achieve?

QUESTION

What do you want <u>machines</u> to do for you?

STORY TIME

The search for a third arm (and the related challenges).

REVIEW

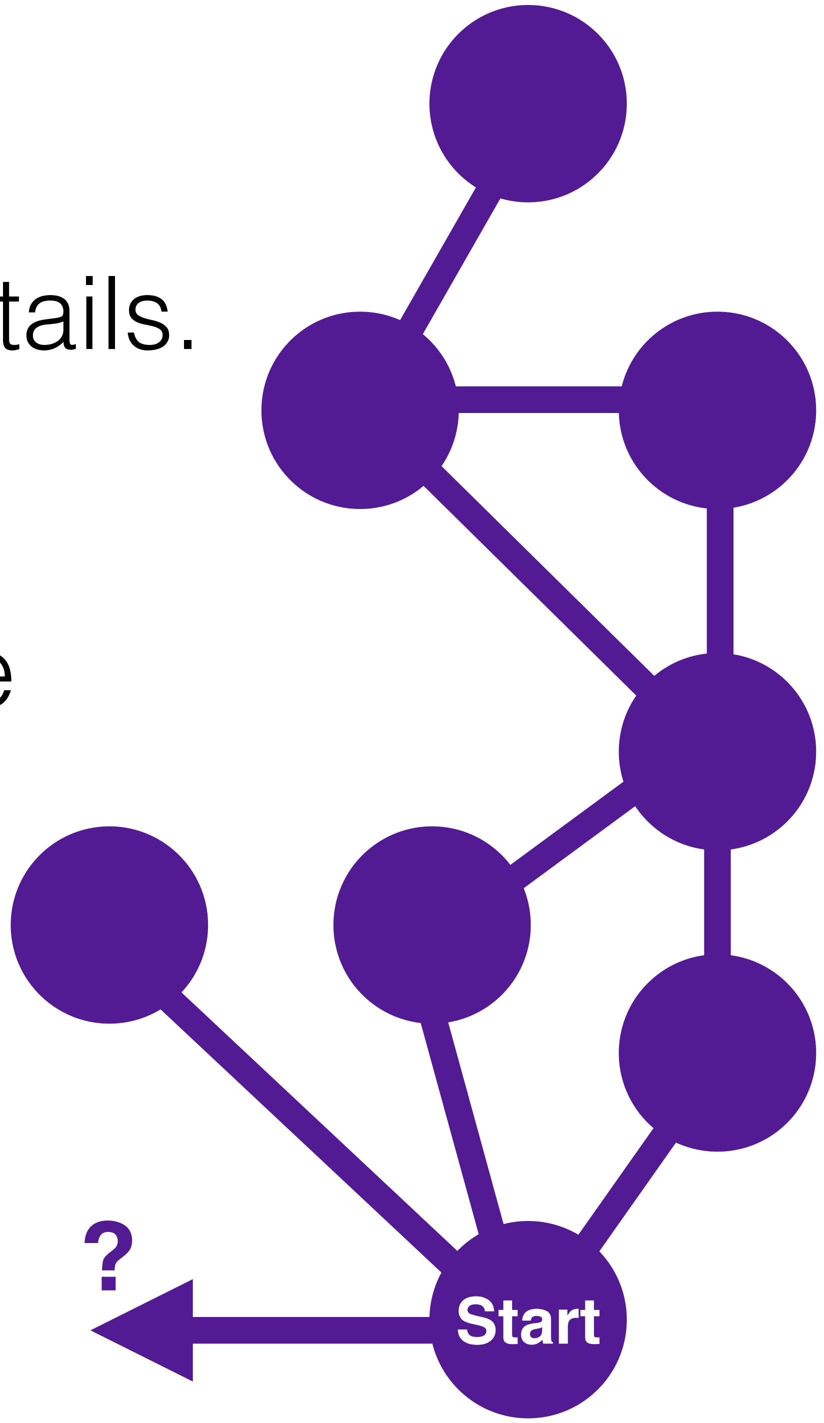
Machine intelligence revolves around maintaining and using knowledge (representation, prediction, control) in a purposeful way.

Strengths of Machine Intelligence

- **Enhanced control** over a changing and increasingly complex world.
- **Anticipation** of future events and outcomes.
- **General tools** for solving hard problems.
- "Optimizing the control of complex systems and extracting knowledge from massive amounts of data."

Strengths of Machine Learning

- **Dealing with Unknowns:** no need to specify all the details.
- **Dealing with Complexity:** systems can handle massive input/output/state spaces.
- **Dealing with Change:** allows systems to adapt!

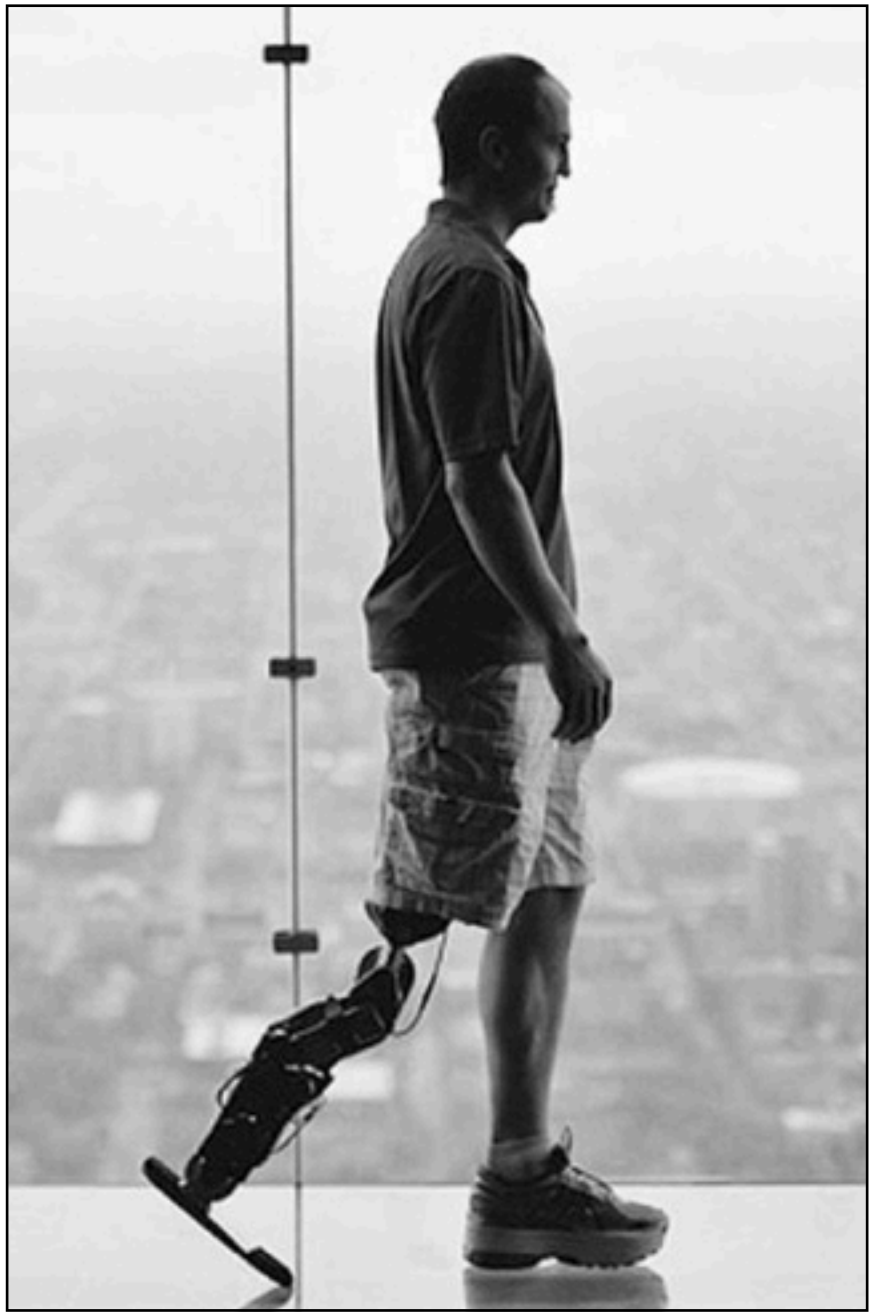


Human-Machine Interaction

- **A hard problem** that involves complexity, uncertainty, and change.
- **Assistance:** restoring or supporting innate or acquired human abilities.
- **Augmentation:** extending human abilities.
- **Interfaces:** connecting complex systems.

Assistance

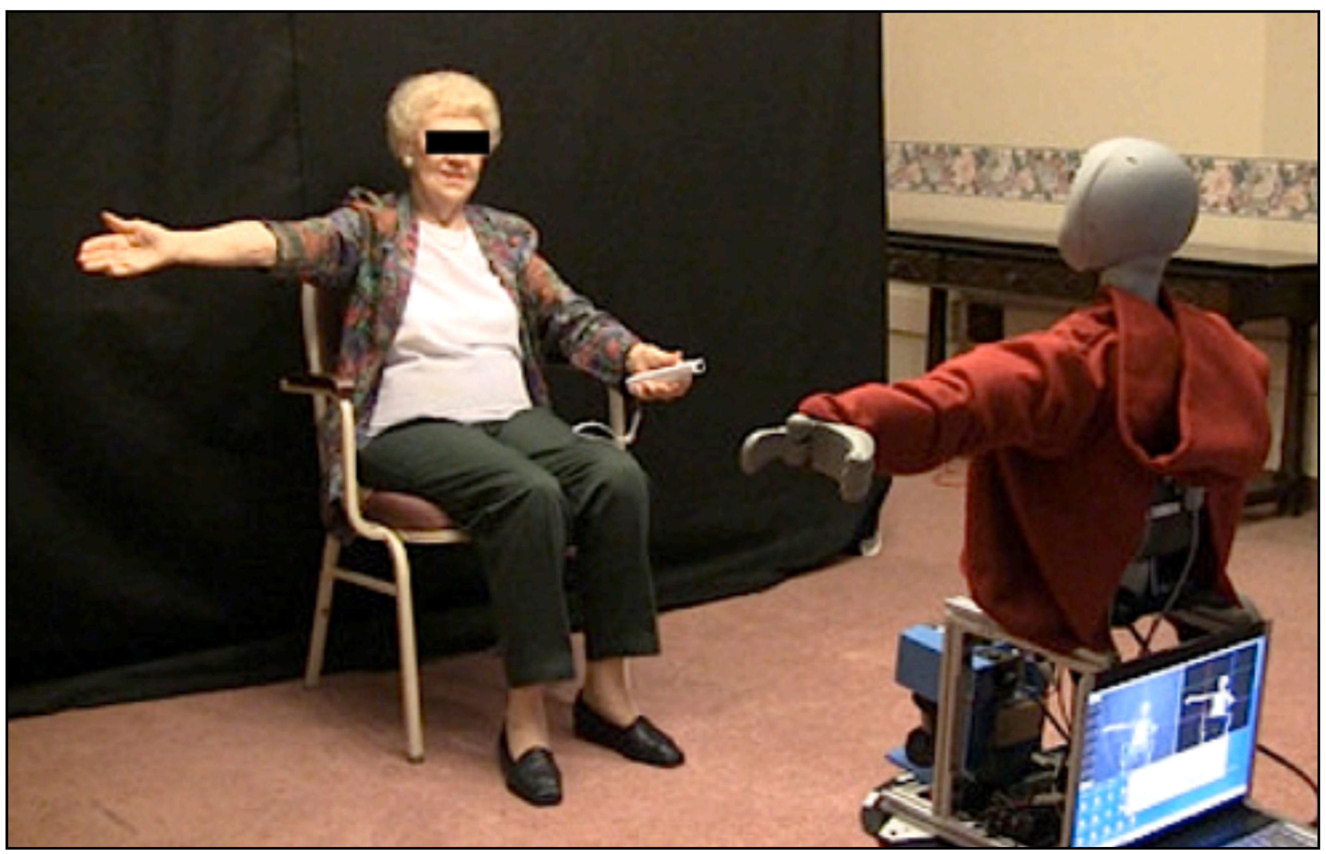
- **Restoring** or **supporting** innate or acquired abilities.
- **Example:** alleviating motor impairments. (prosthetics)



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

Assistance

- **Restoring** or **supporting** innate or acquired abilities.
- **Example:** cognitive and social support. (elder care, autism.)



Socially Assistive Robots act as coaches for stroke rehabilitation, and engage children with autism. (USC Robotics Research Laboratory)

Juan Fasola and Maja J. Matarić. "A Socially Assistive Robot Exercise Coach for the Elderly". In *Journal of Human-Robot Interaction*, 2(2):3-32, Jun 2013.

Augmentation

- **Extending** innate or acquired human abilities.
- **Example:** granting improved perception. (medical diagnostics.)

Eulerian Video Magnification for revealing subtle changes in the world (MIT Computer Science and Artificial Intelligence Laboratory) http://people.csail.mit.edu/mrub/vidmag/

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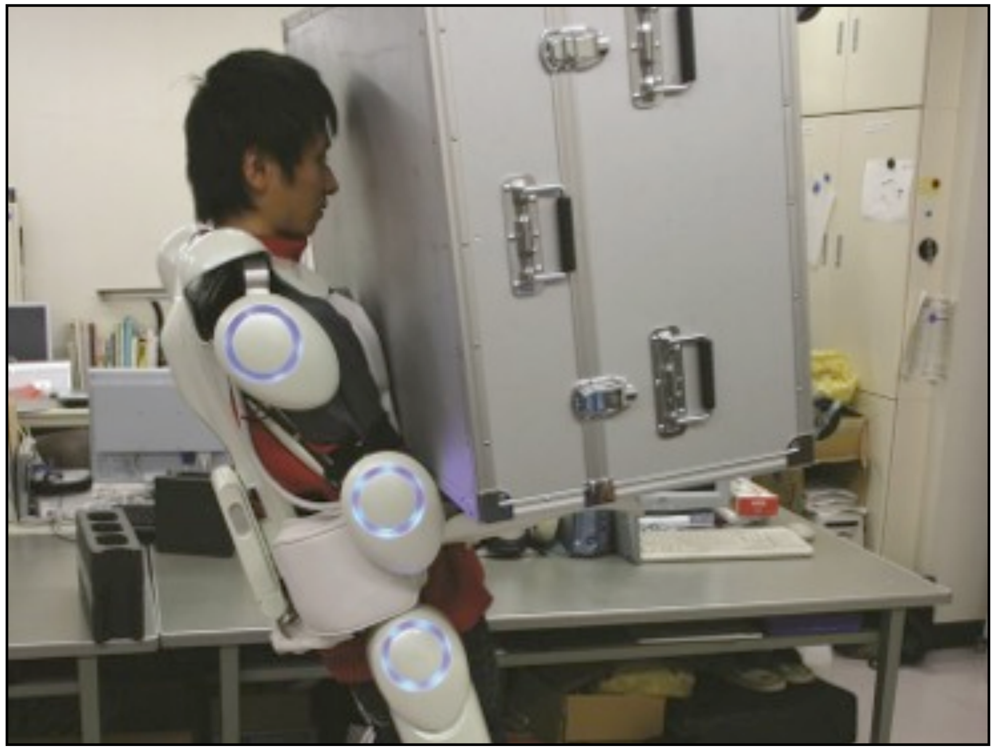
Augmentation

- **Extending** innate or acquired human abilities.
- **Example:** extending physical capacity. (exoskeletons.)



Hybrid Assistive Limb (HAL)
Cyberdyne Inc.
Japan

Augmentation

- **Extending** innate or acquired human abilities.

- **Example:** extending physical capacity.
  (robot surgery.)

Da Vinci surgery system for minimally invasive procedures (Intuitive Surgical, Inc.)

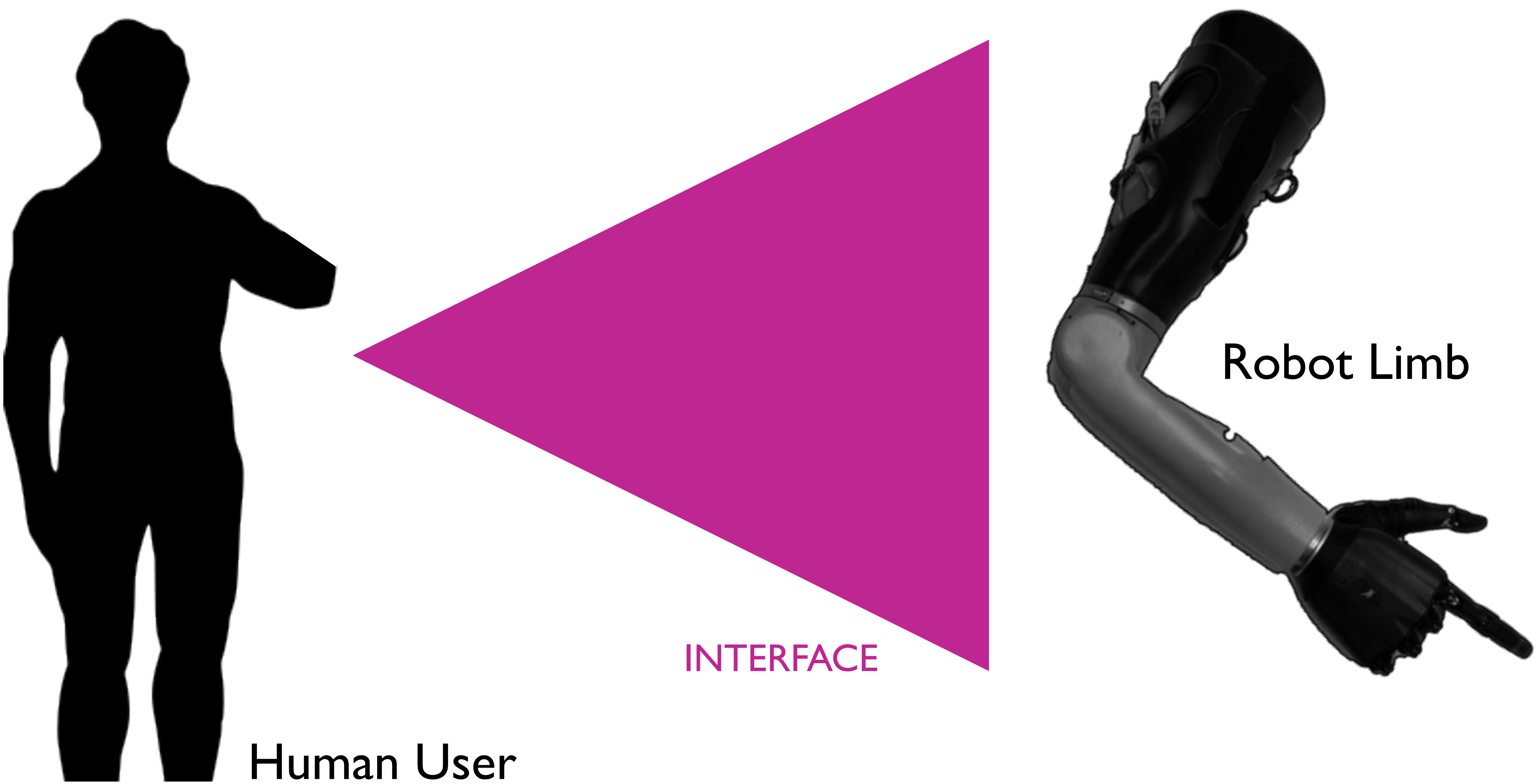
KEY IDEA

Machines can help to restore, replace, and extend innate human abilities.

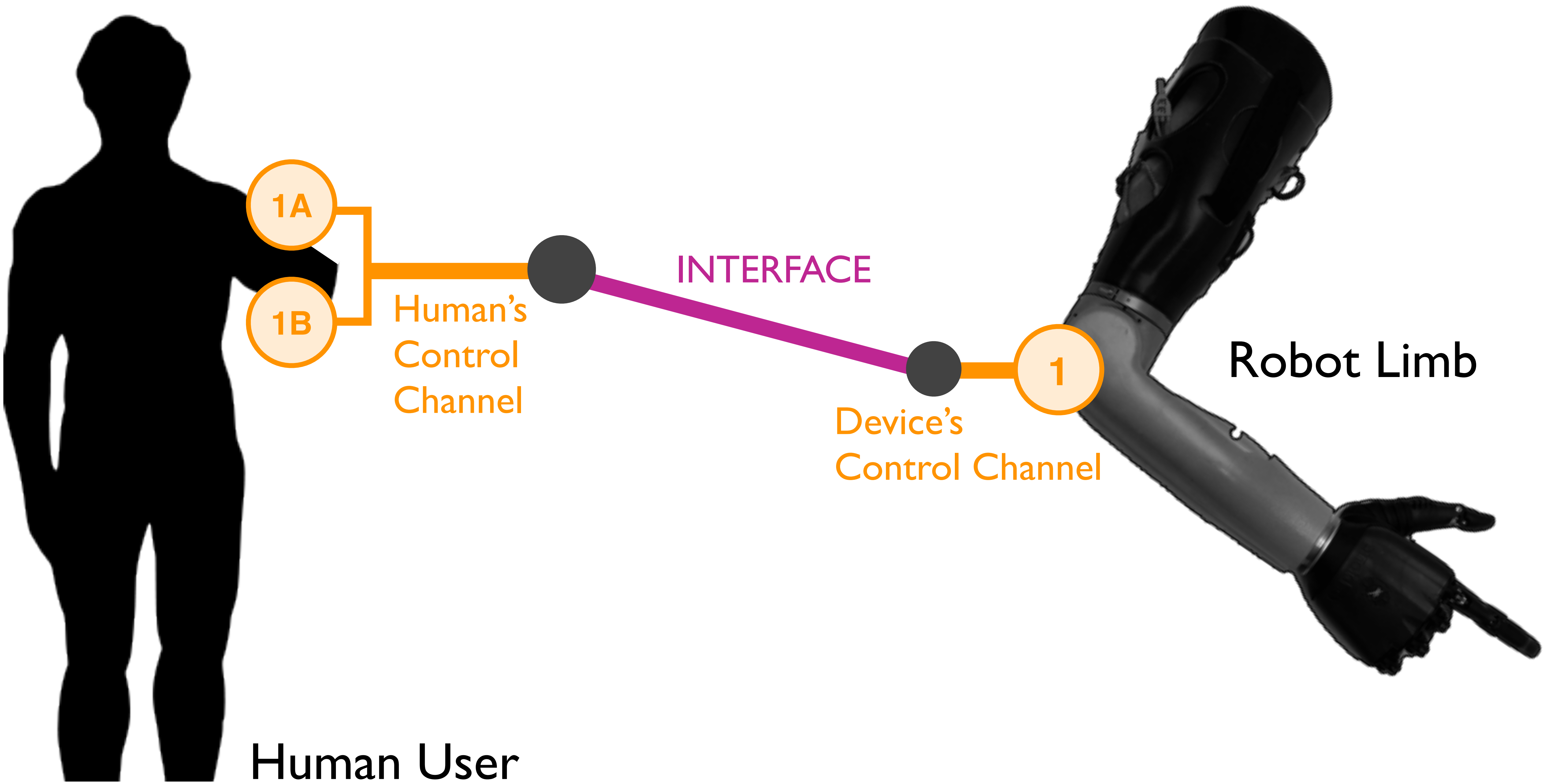
Interfaces

- **Connecting** complex systems.
- **Three notable challenges** with respect to assistive and augmentative technology:
  - Increasing or expanding a signal space
  - Decreasing or focusing a signal space.
  - Matching signal spaces (general case).
- Large-scale information processing.

Increasing or Expanding a Signal Space



Increasing or Expanding a Signal Space



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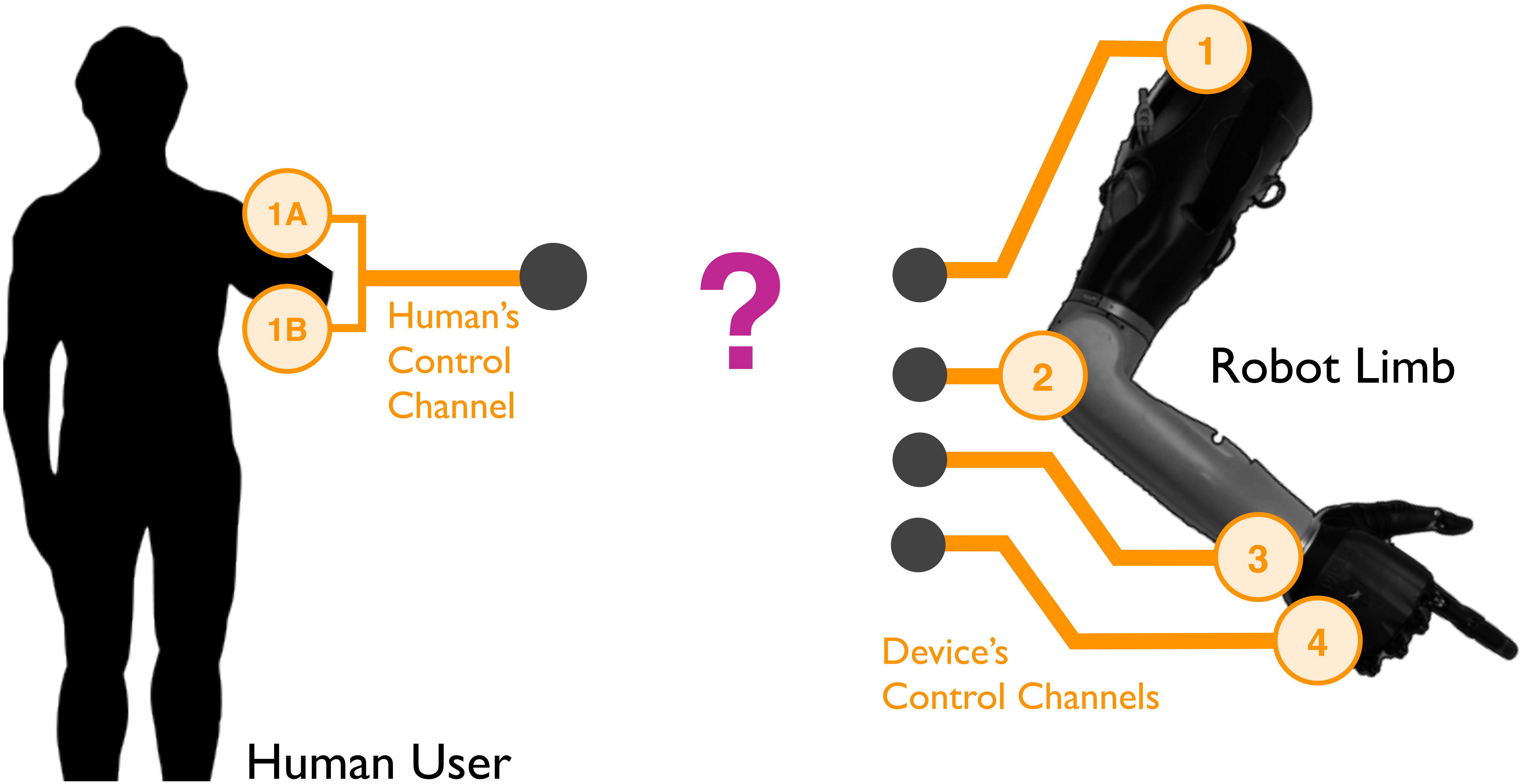

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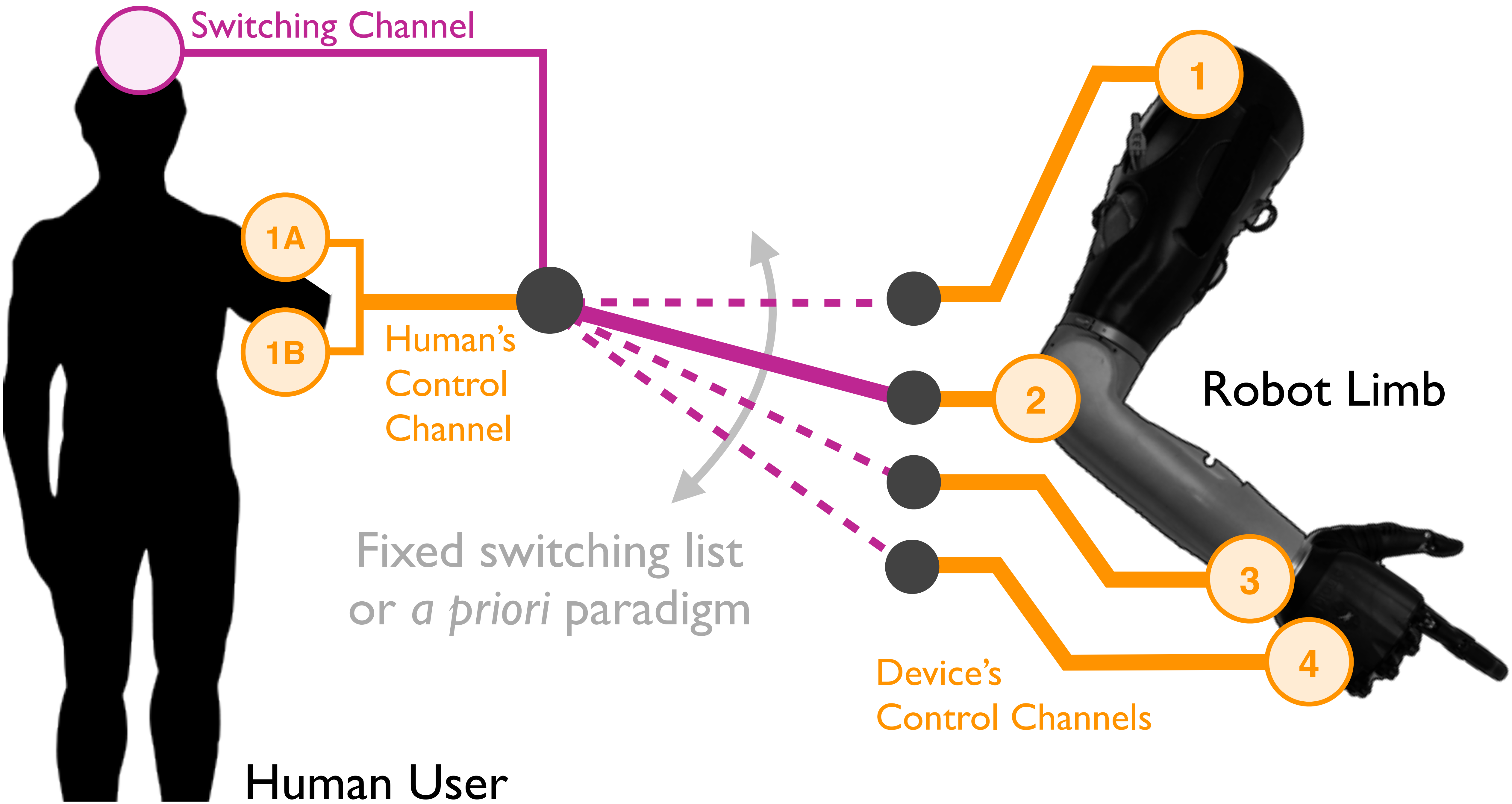

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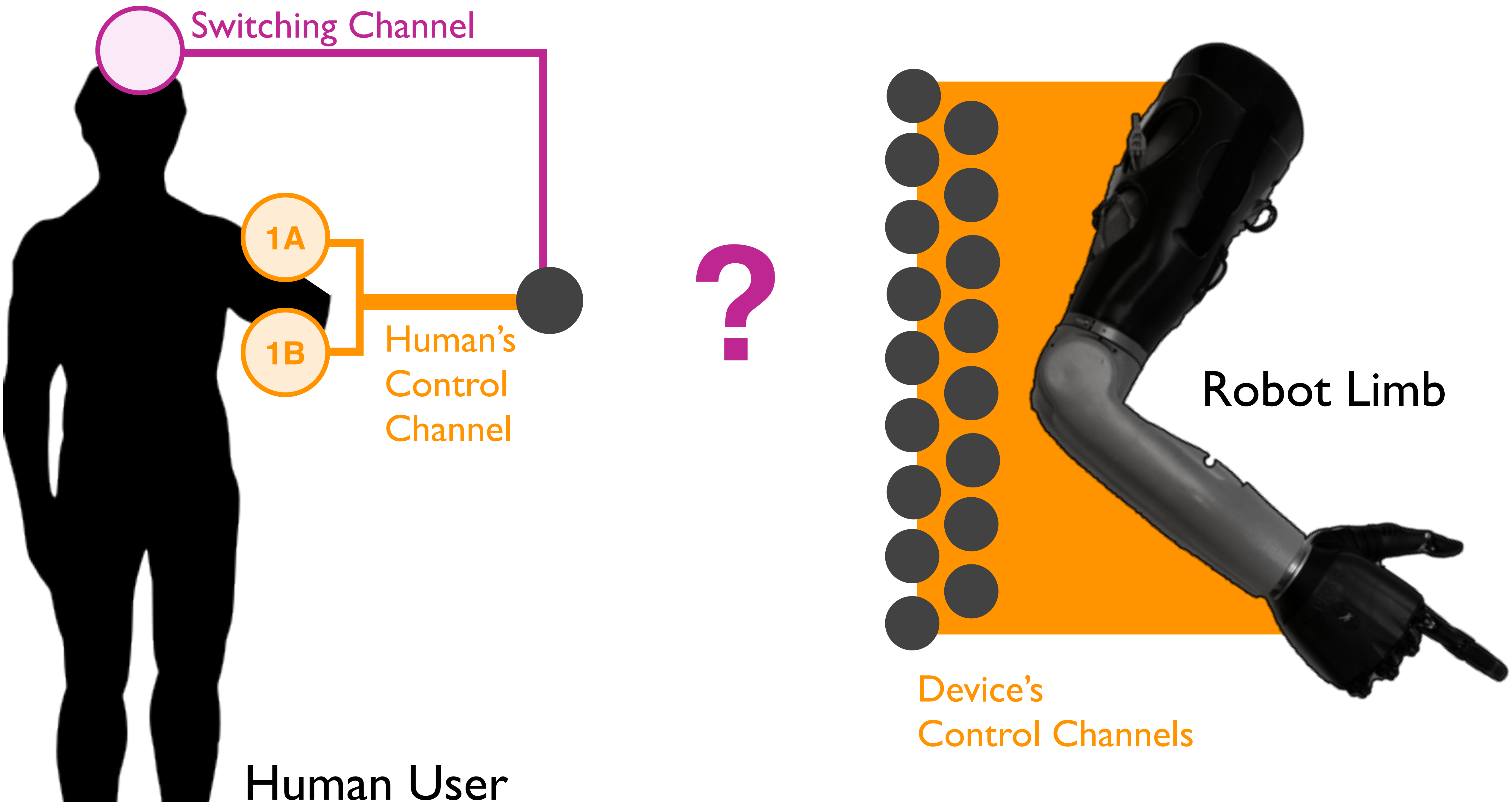
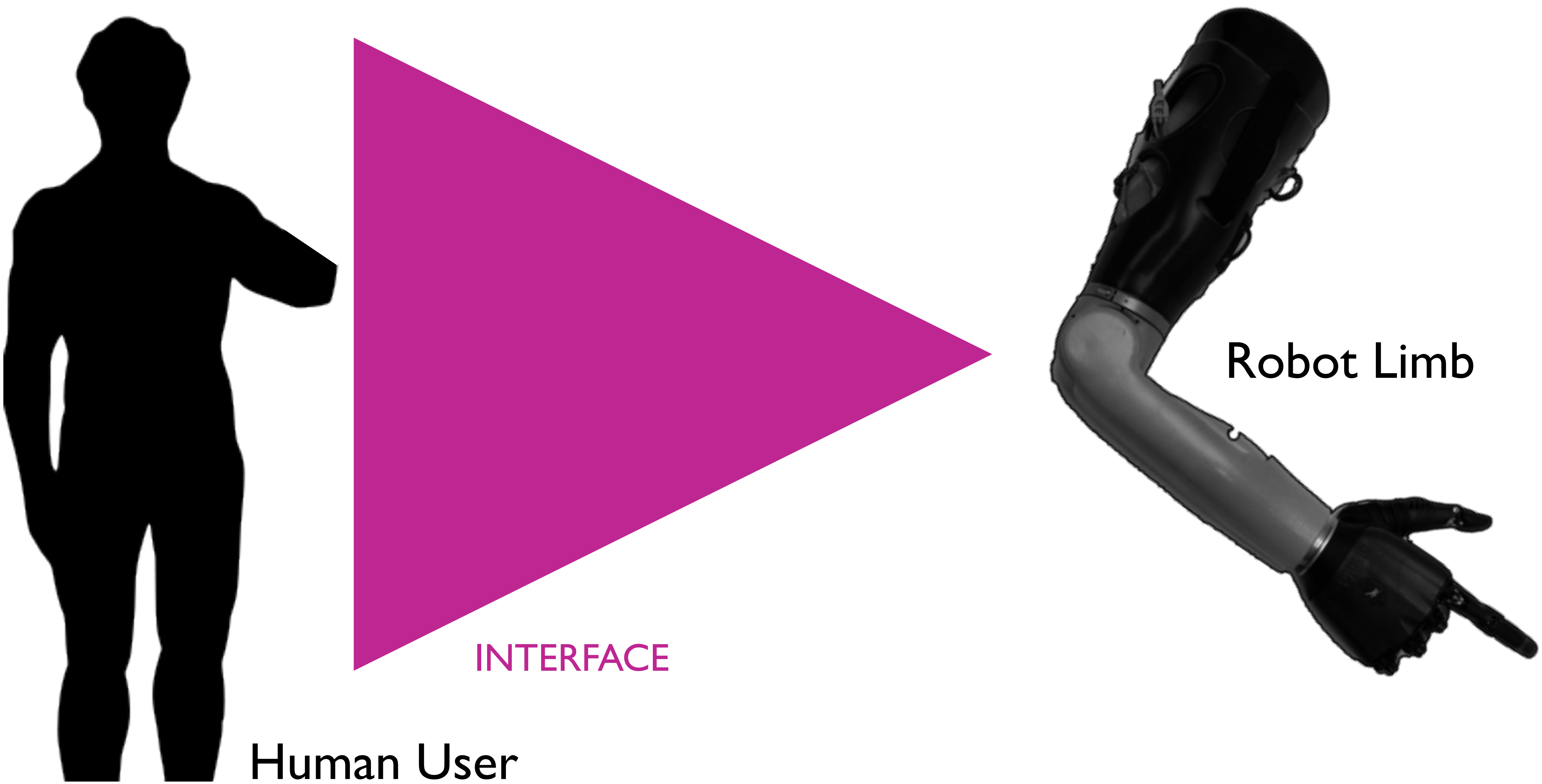


Decreasing or Focusing a Signal Space



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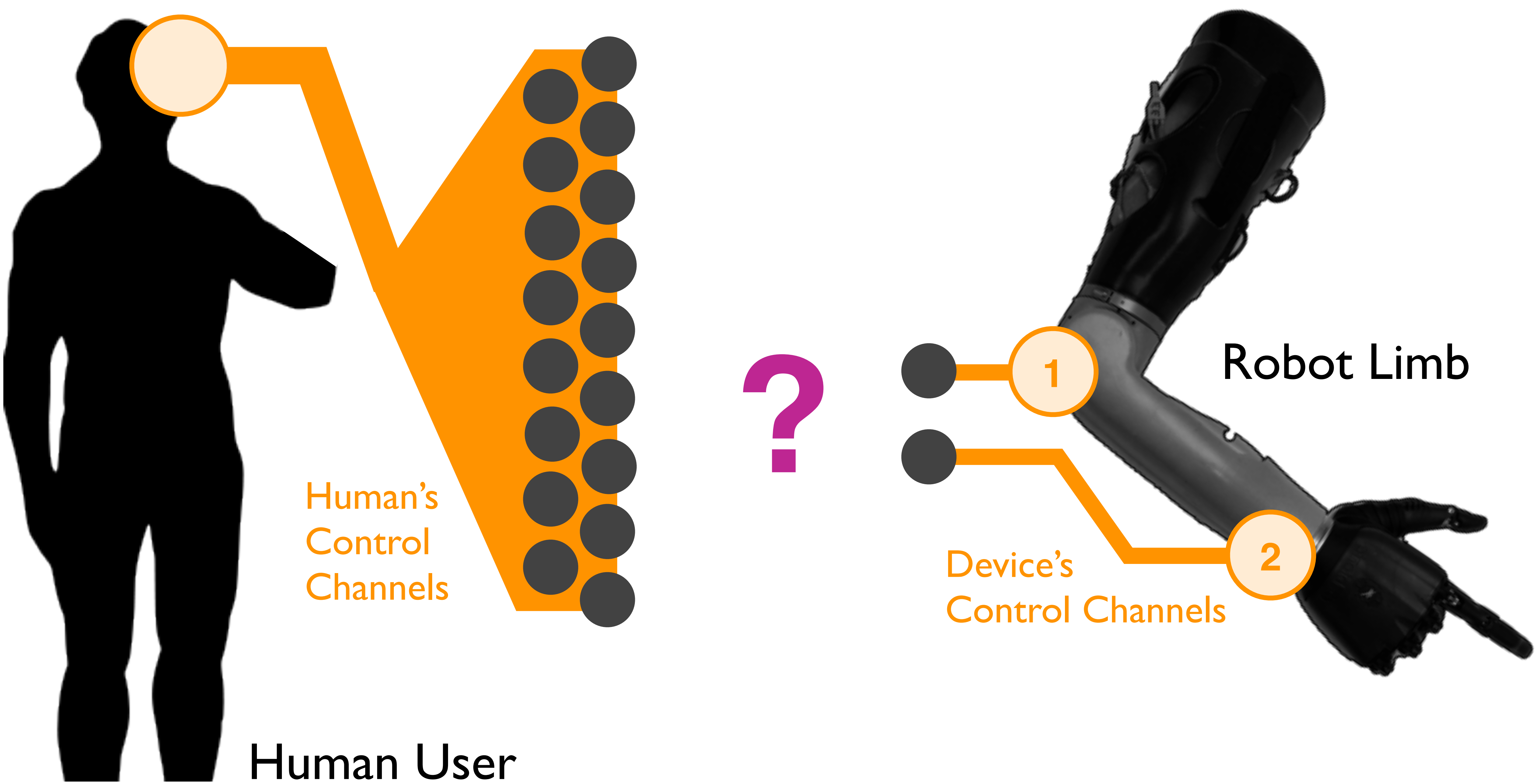

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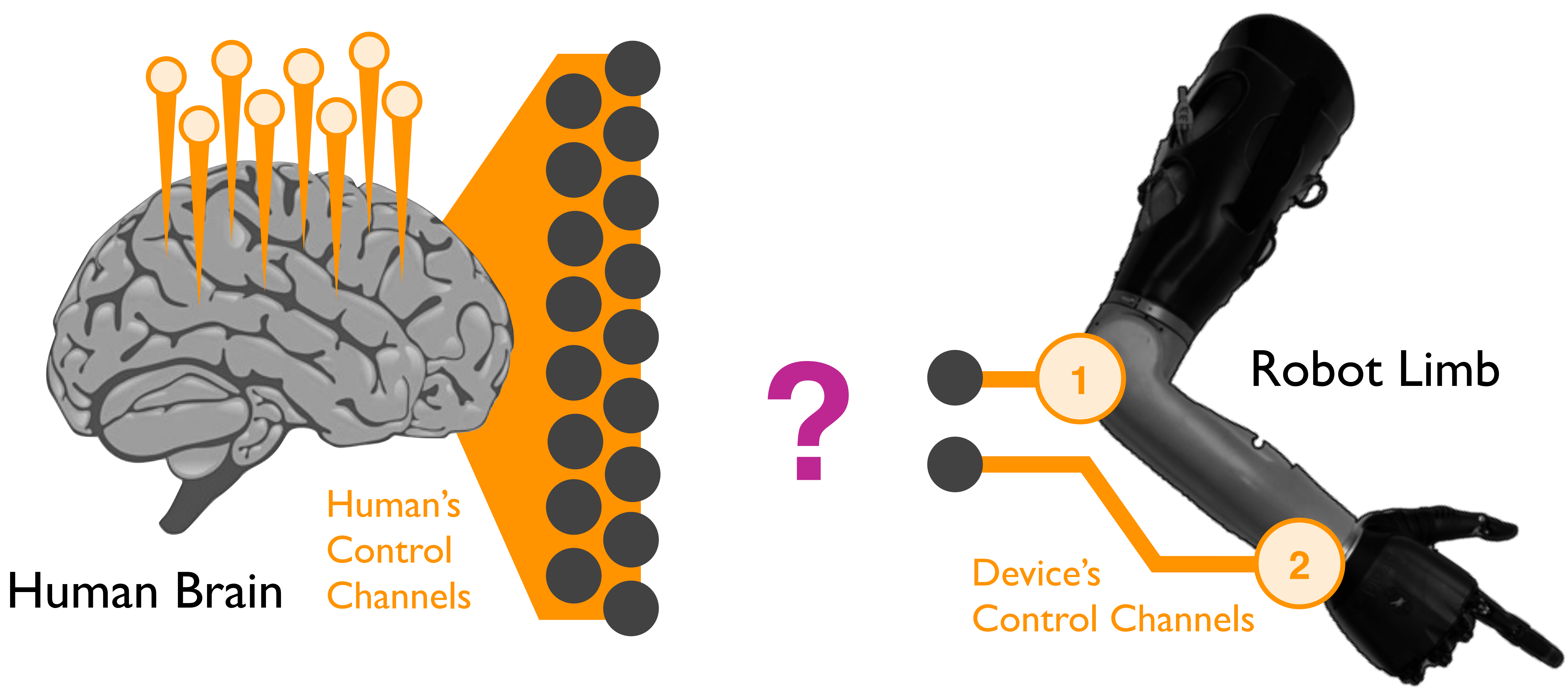
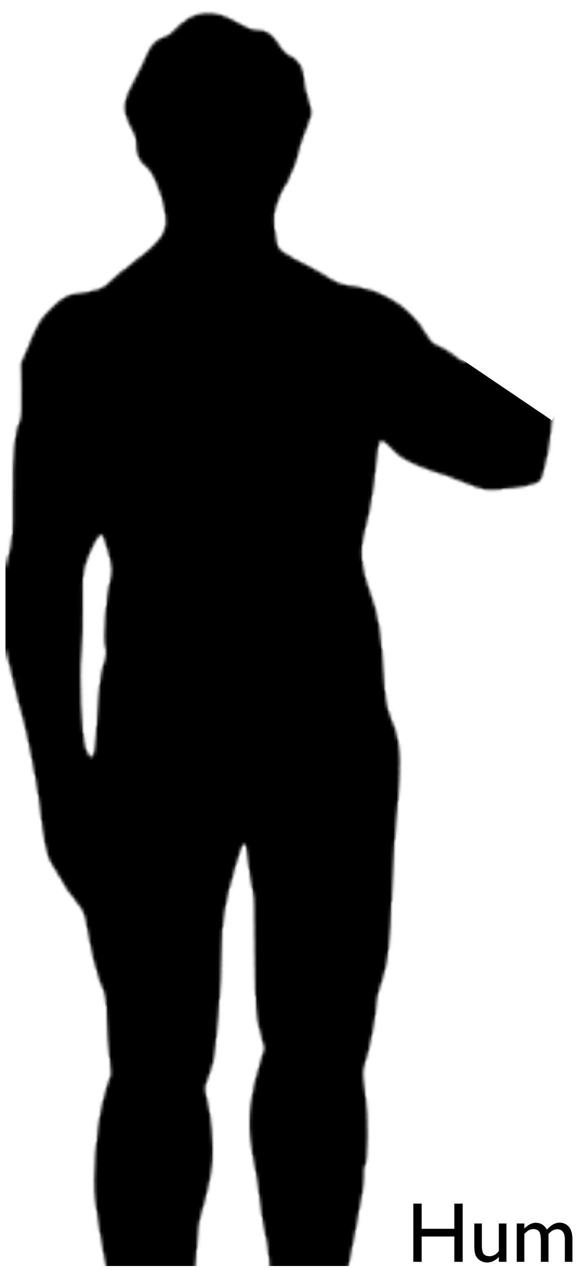
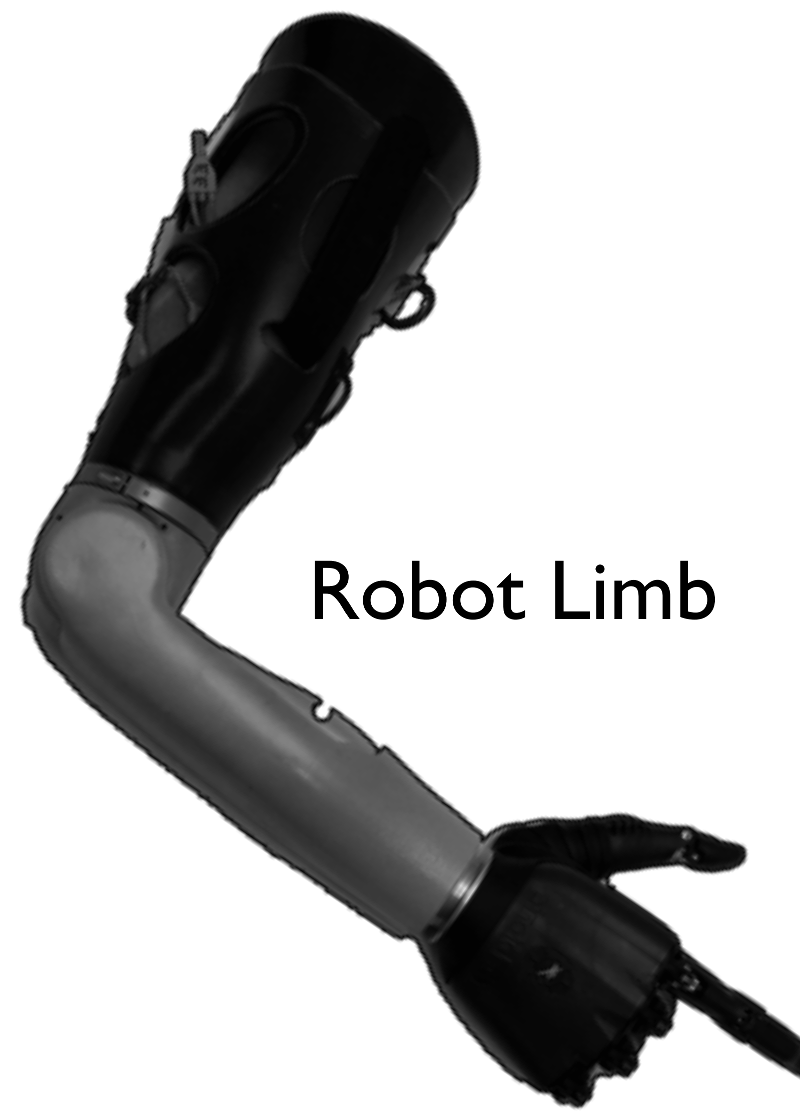


Matching Signal Spaces



Human User

INTERFACE



Robot Limb

P.M. Pilarski, LABMP 590, Sept. 24, 2013

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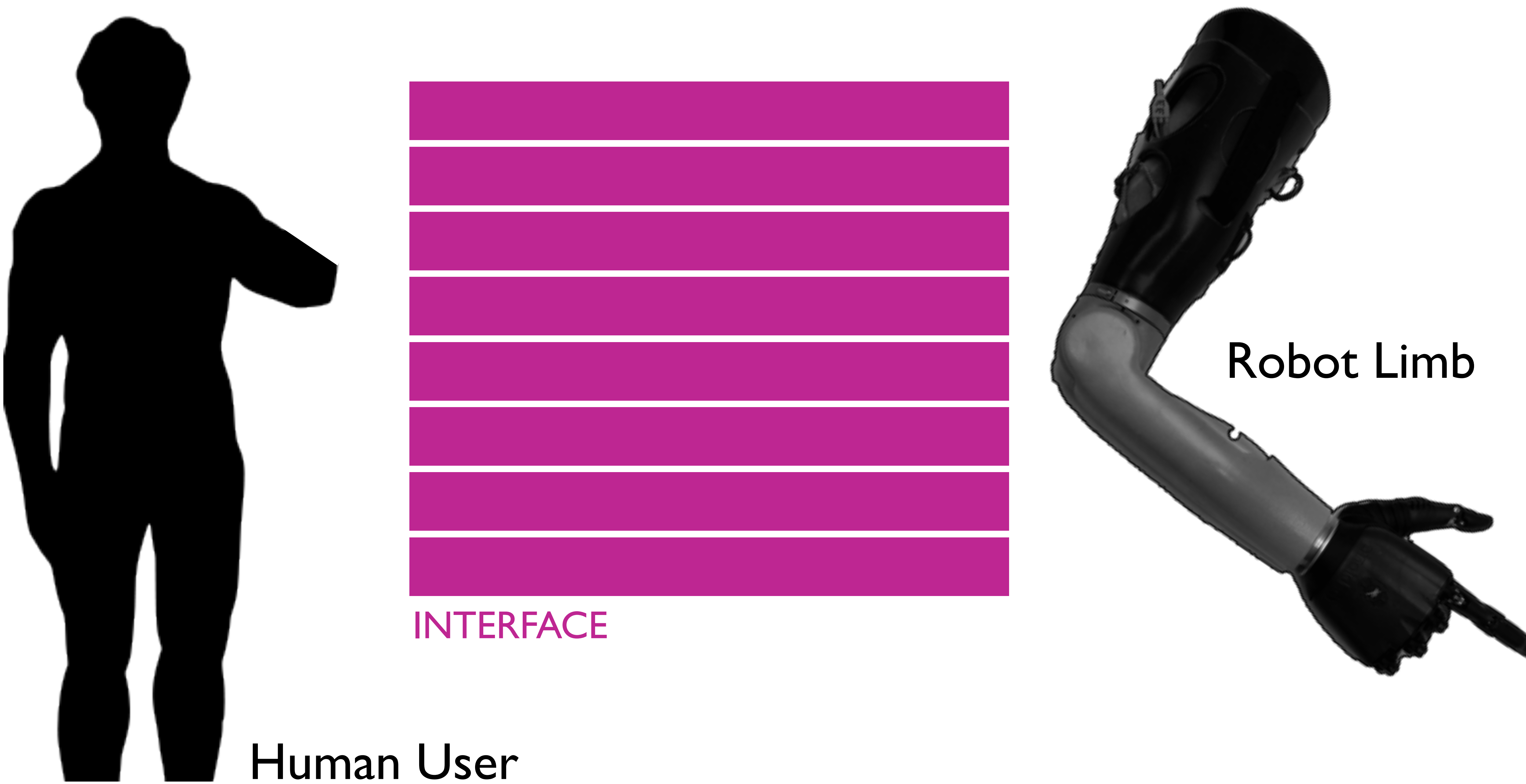

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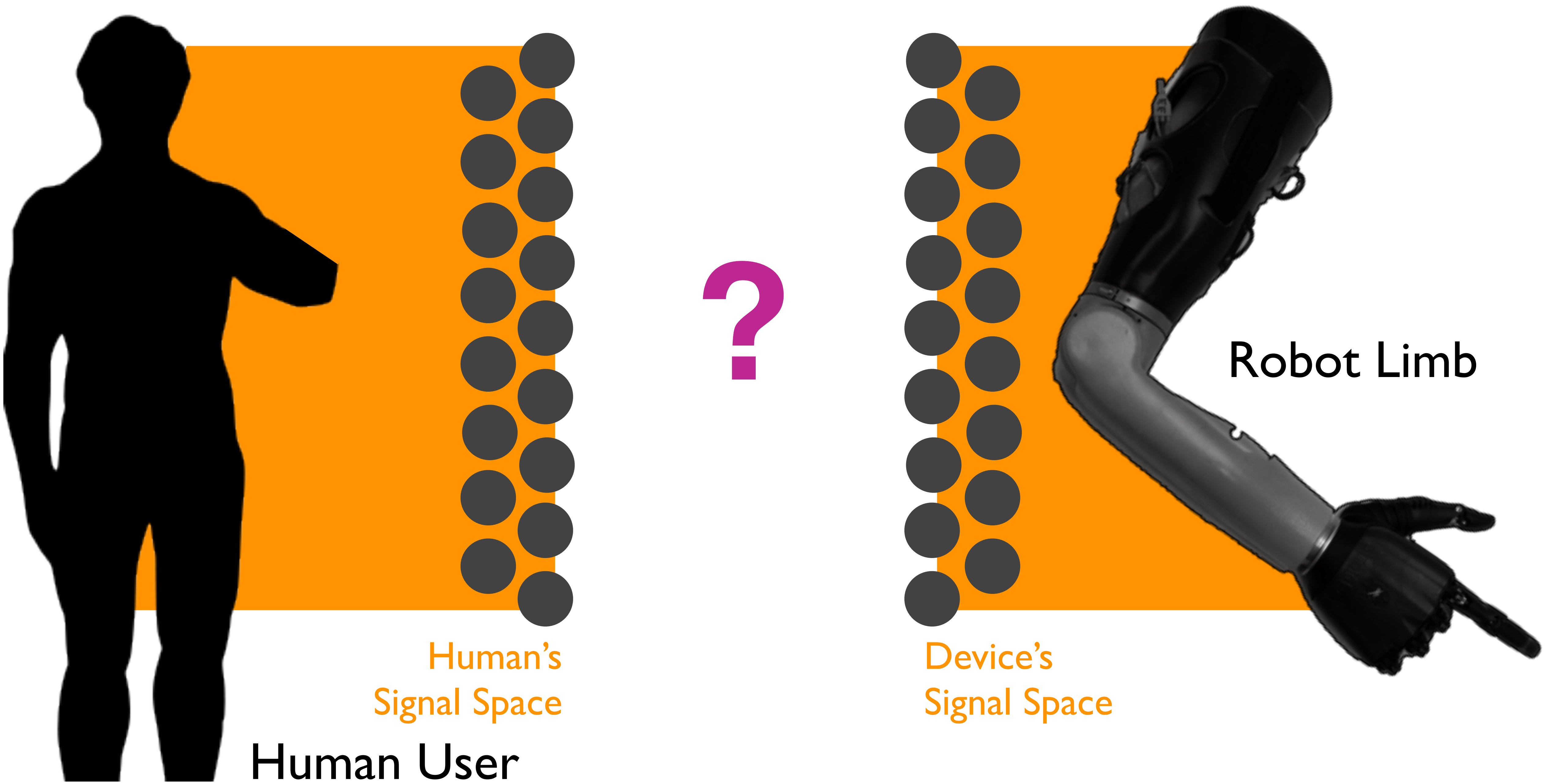

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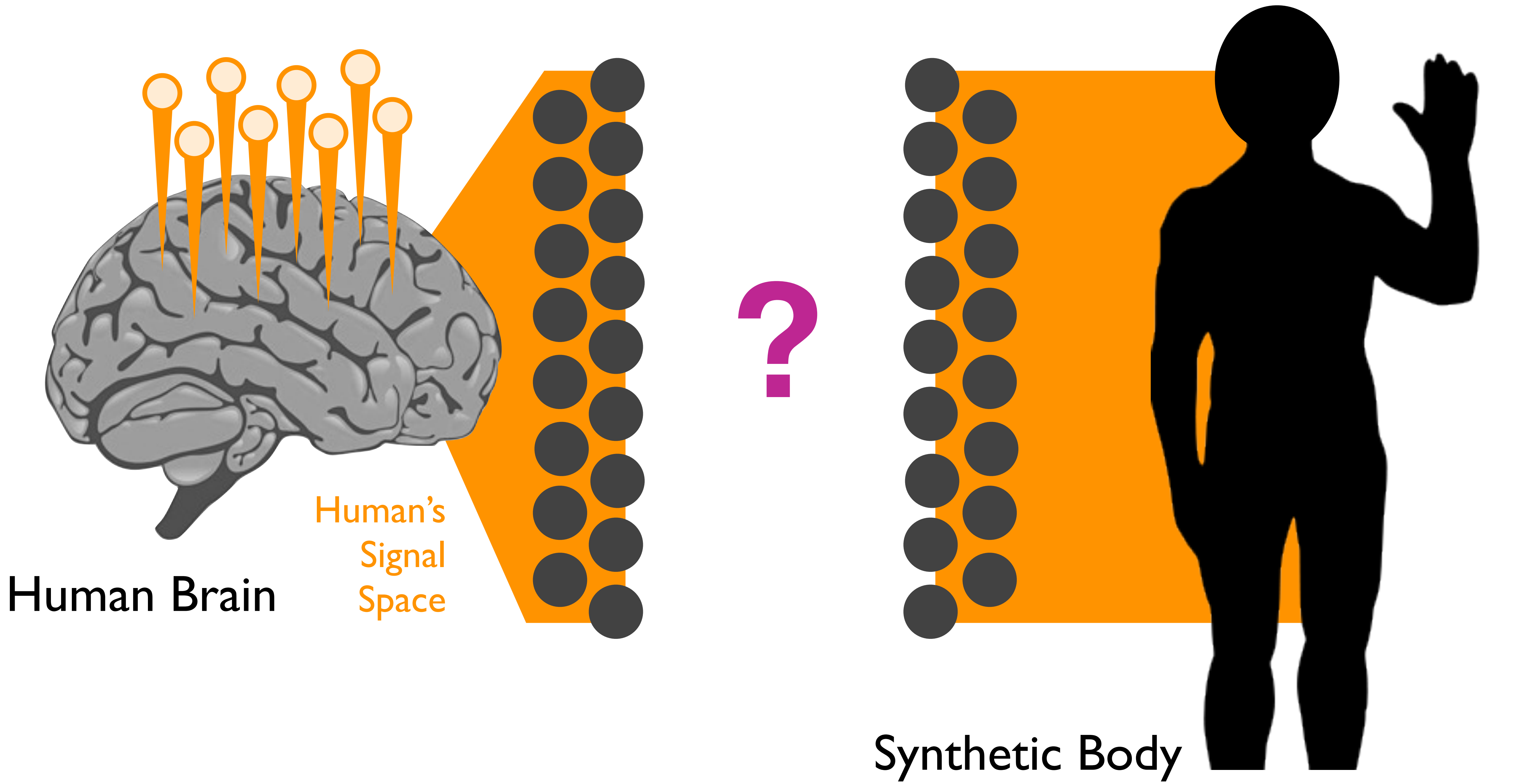

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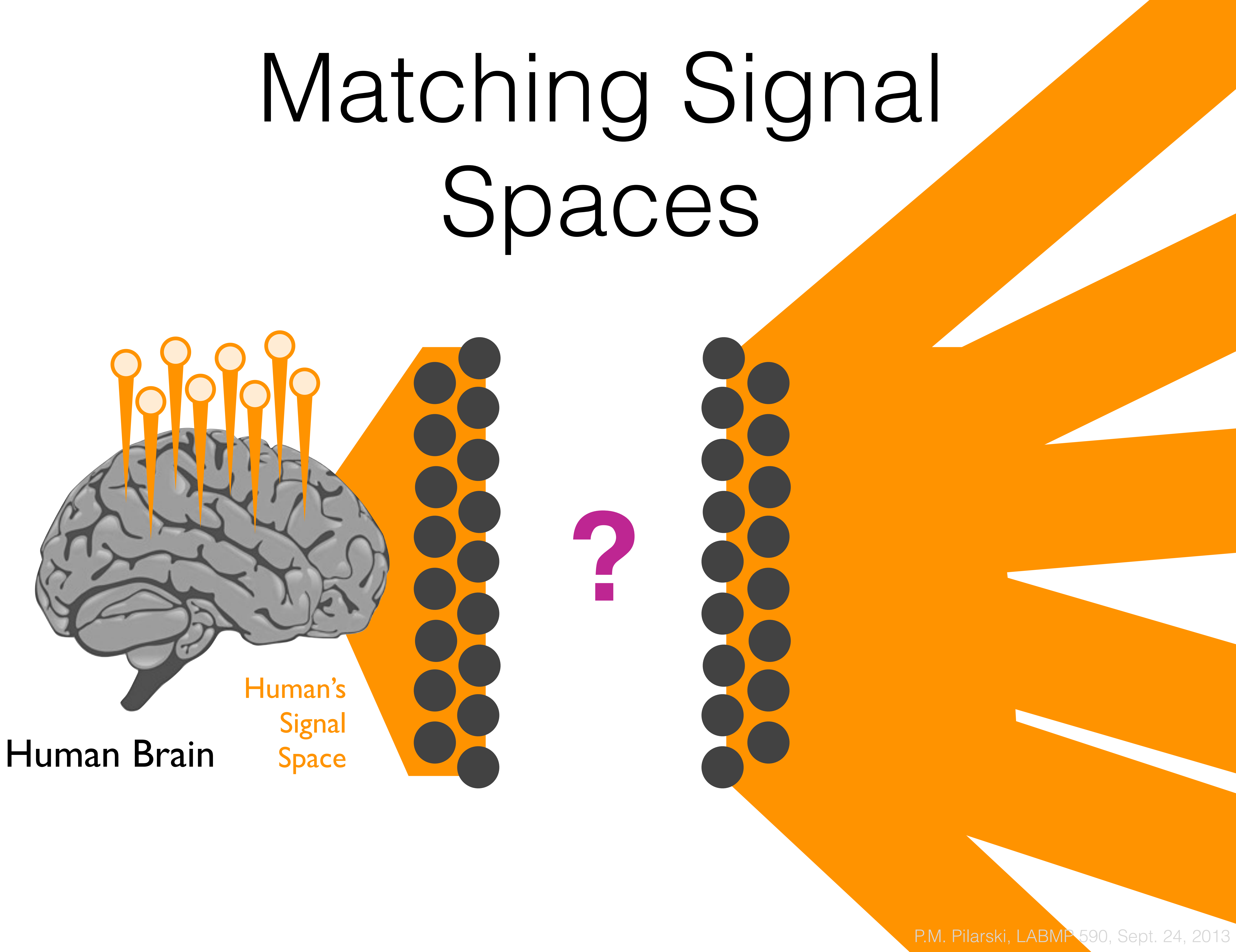
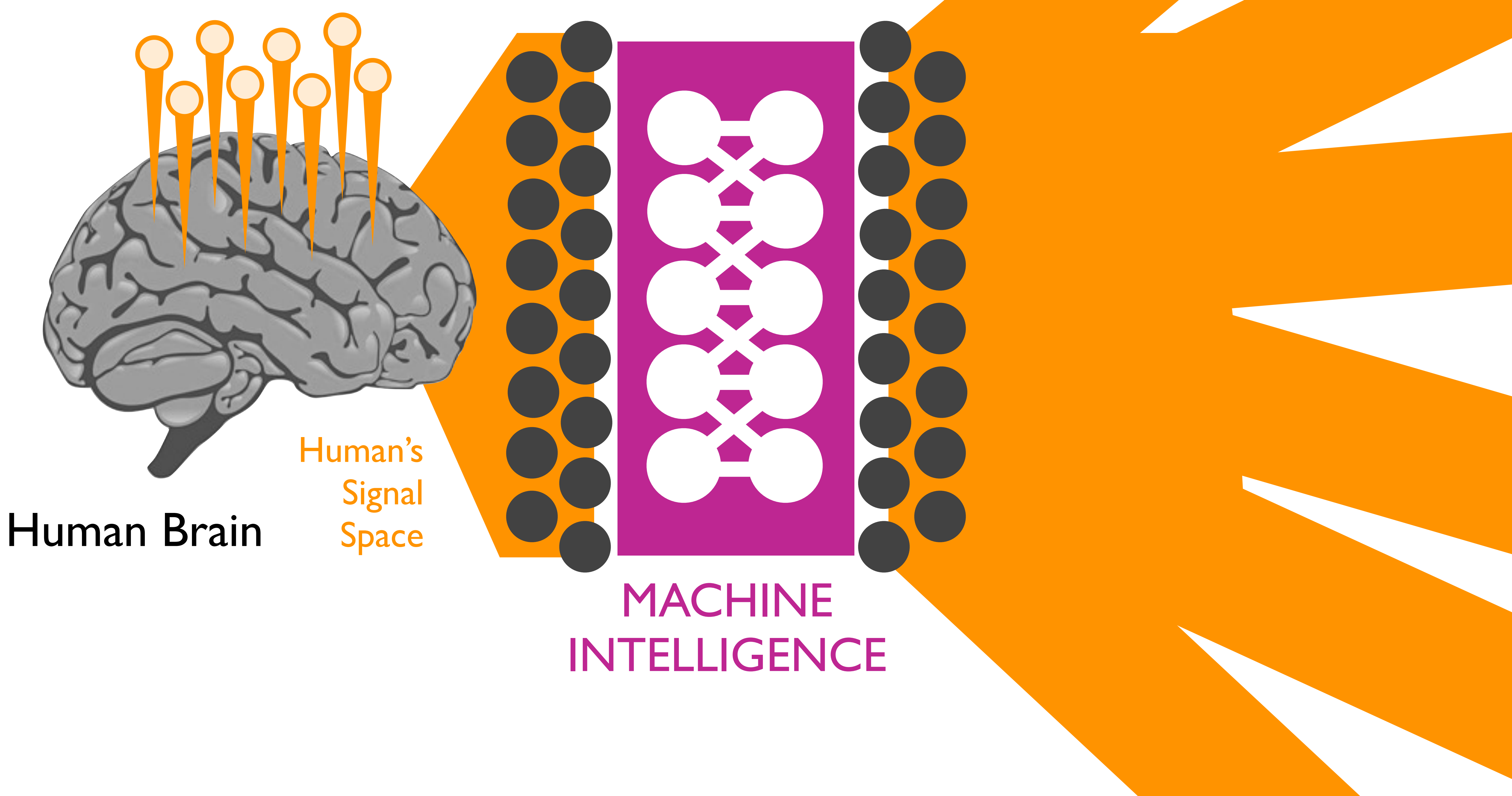


KEY IDEA

There is often a challenging disparity between the number of signals (and the nature of the signals) on both sides of an interface.

KEY IDEA



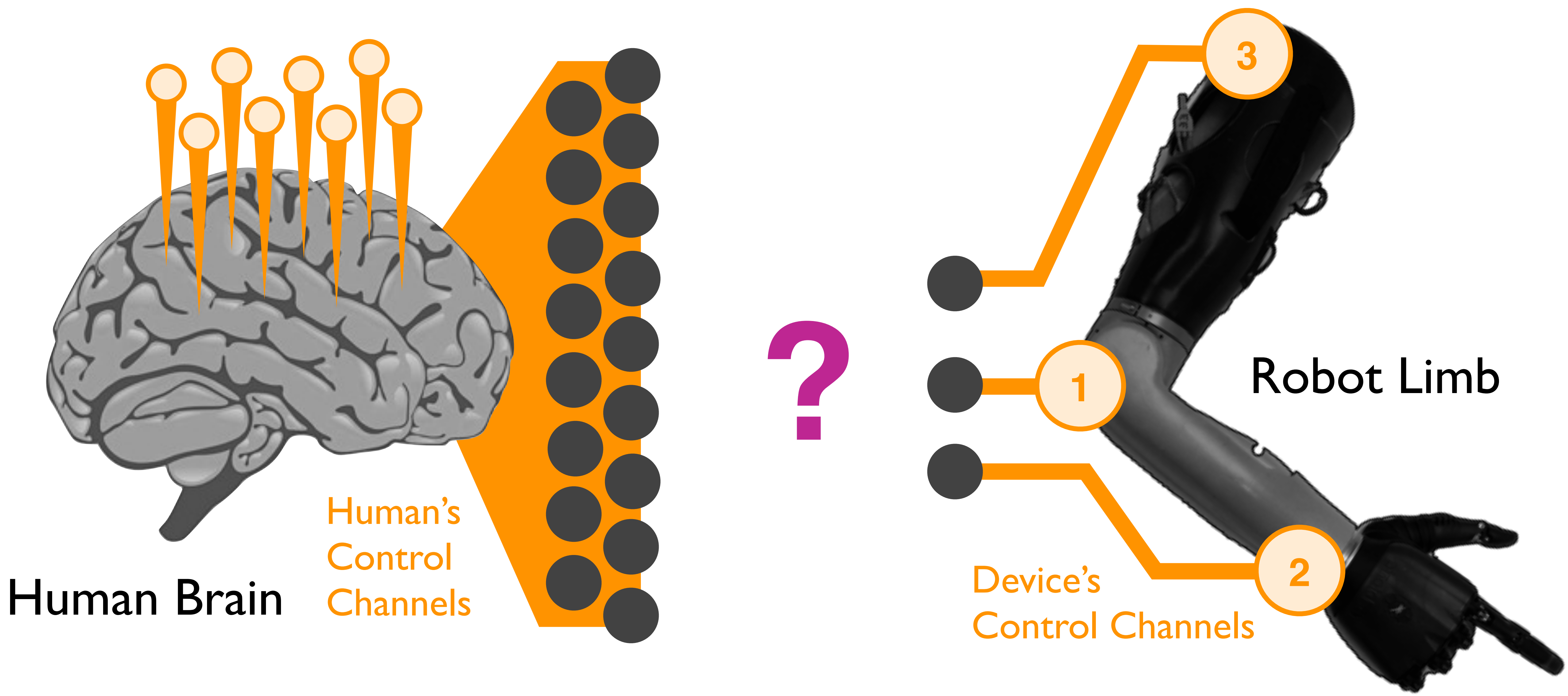
Areas for Augmentation and Assistance

- **Sensation:** perceiving of the world.
- **Actuation:** influencing the world.
- **Information Processing:** understanding the world.

What to Learn?

- **Sensation:** prediction.
- **Actuation:** control.
- **Information Processing:** representation.

Learning to Actuate (using labeled examples)



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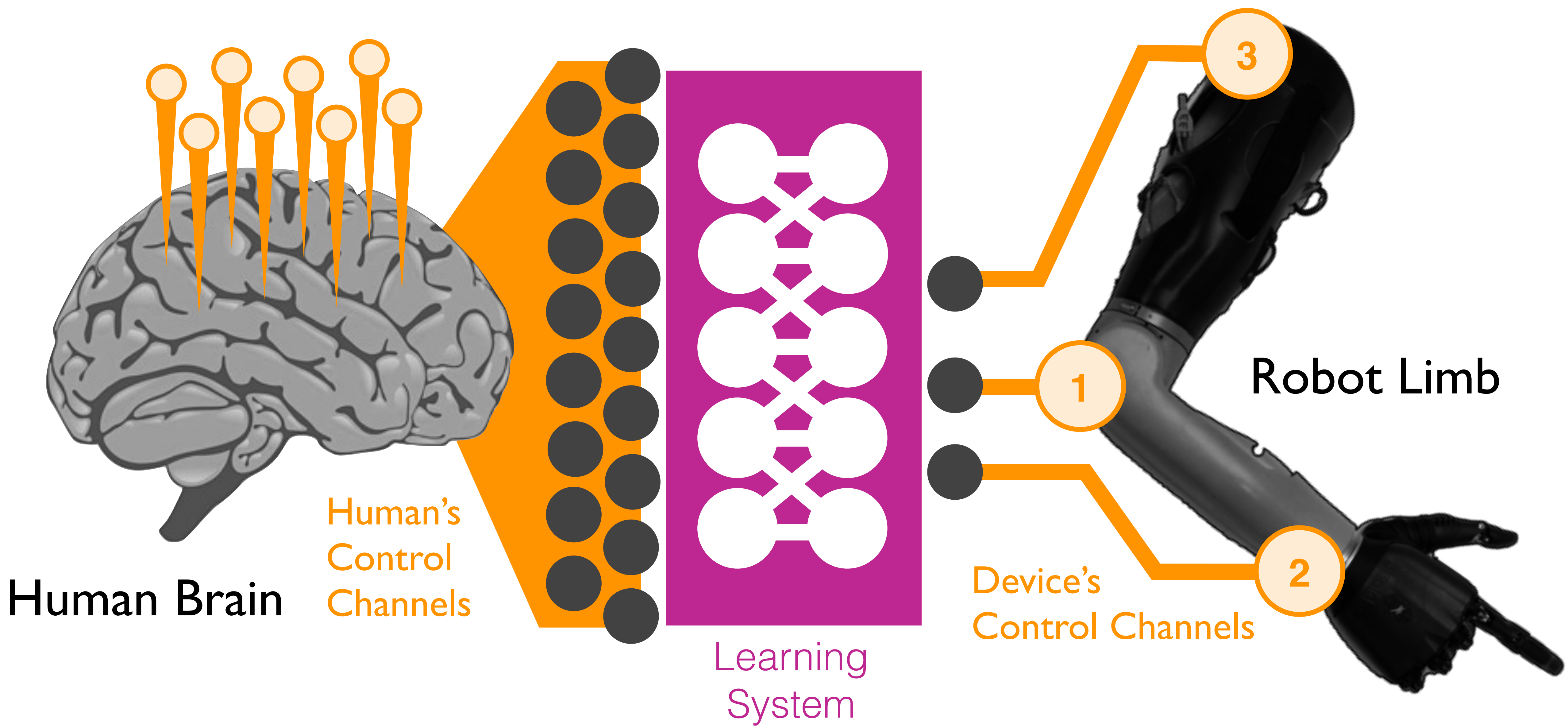
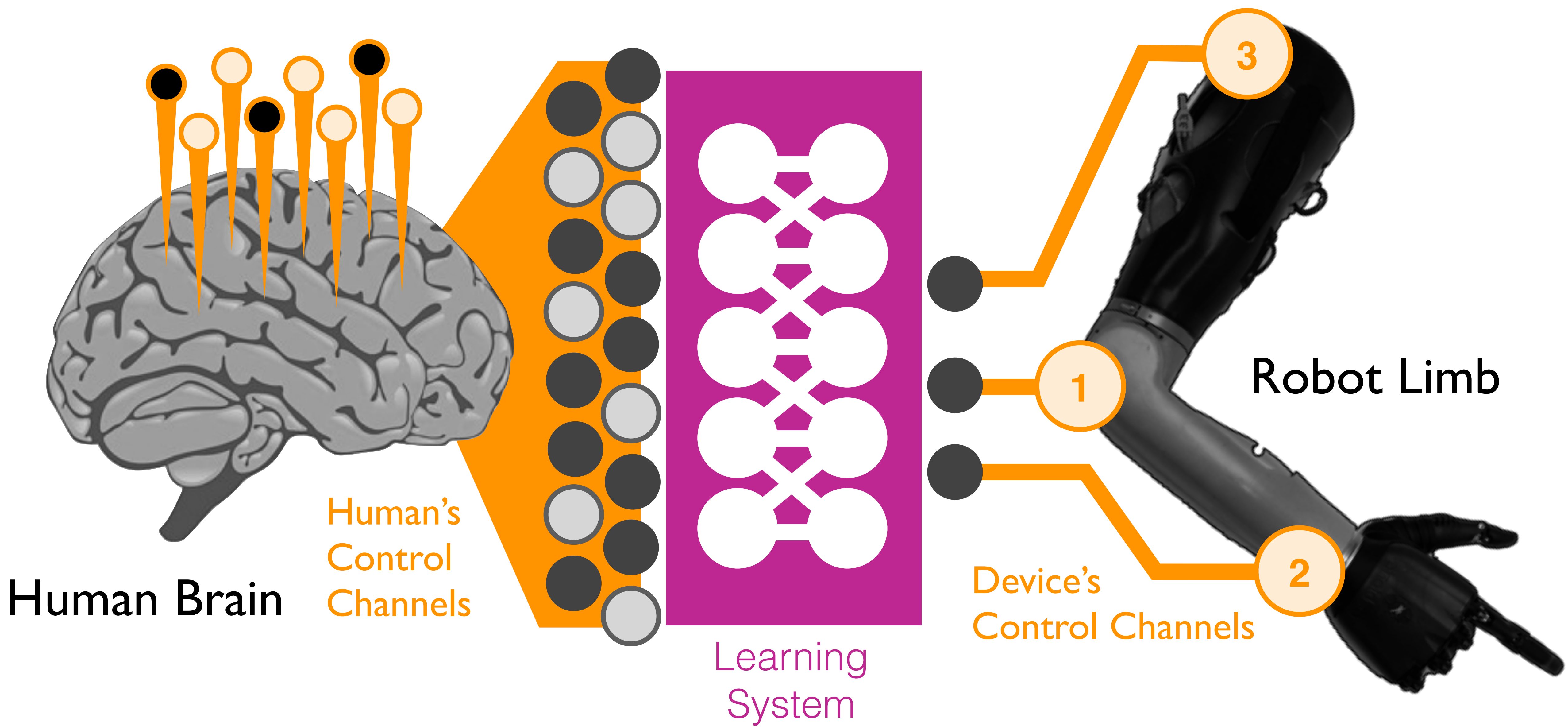


“Think about moving your wrist...”



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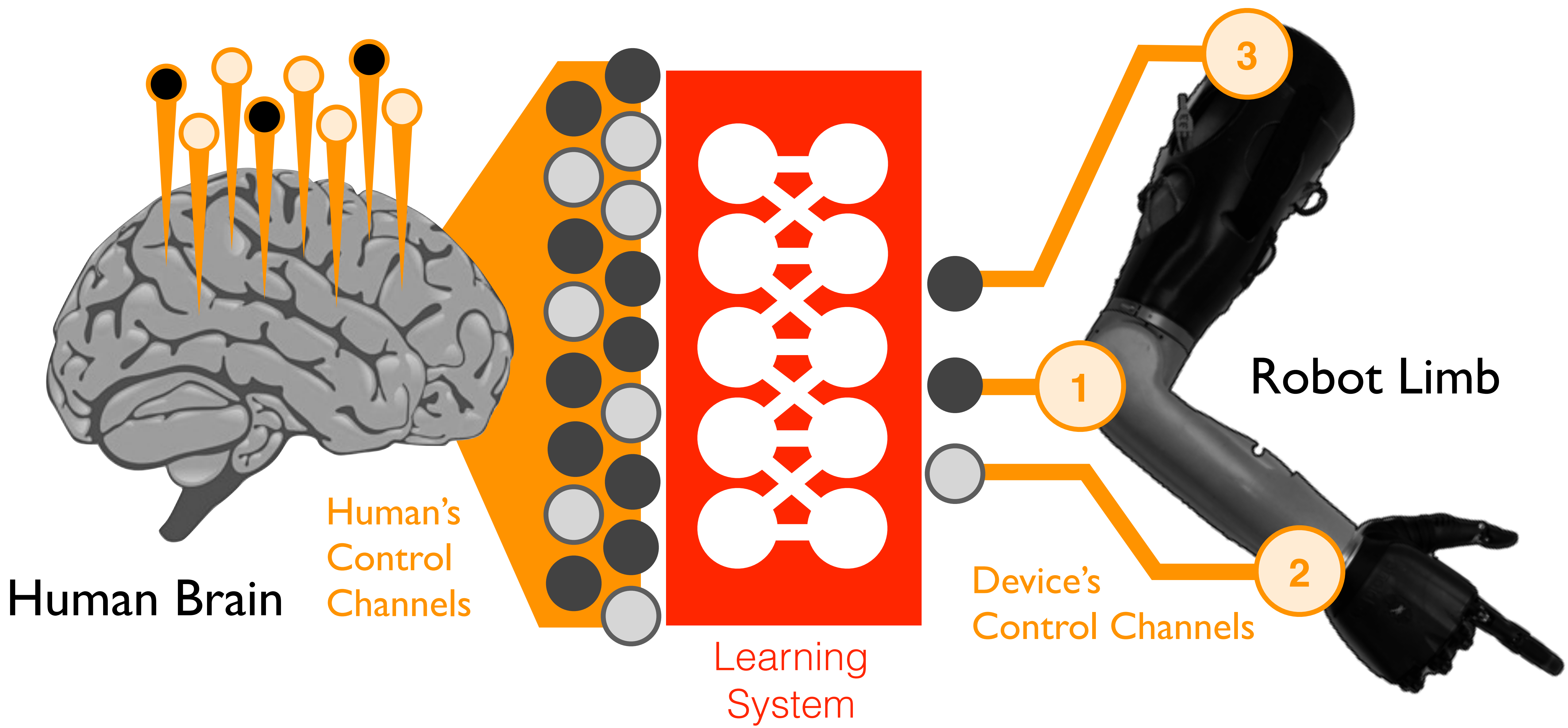

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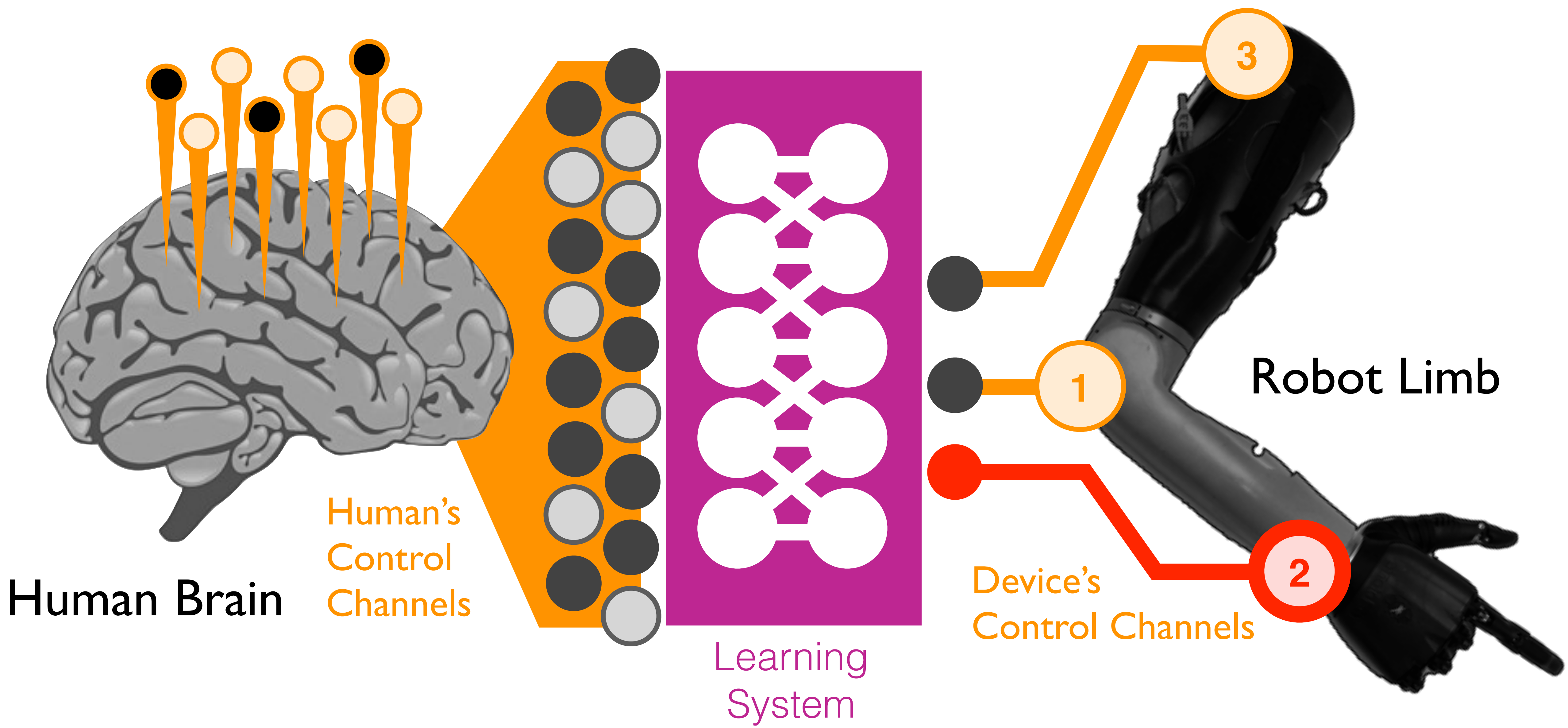

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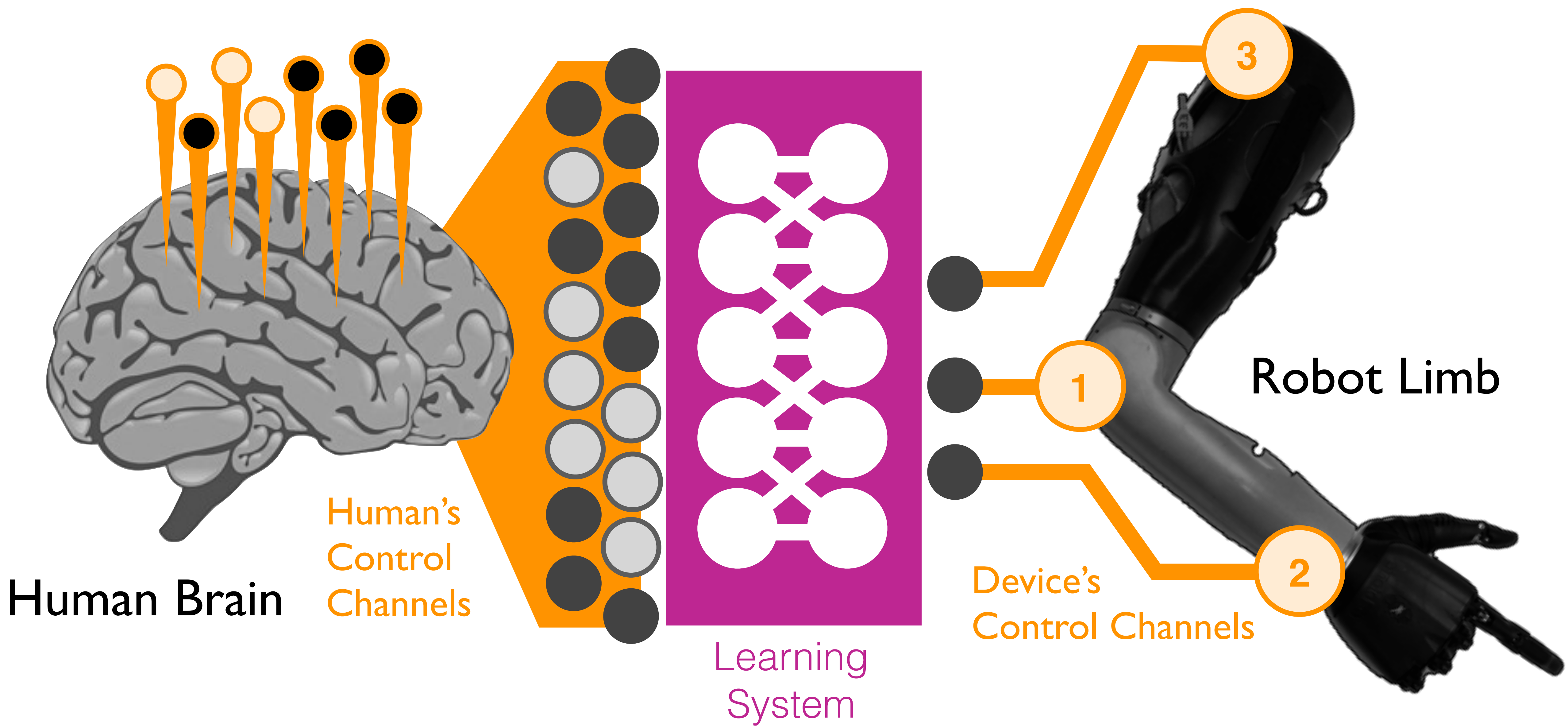

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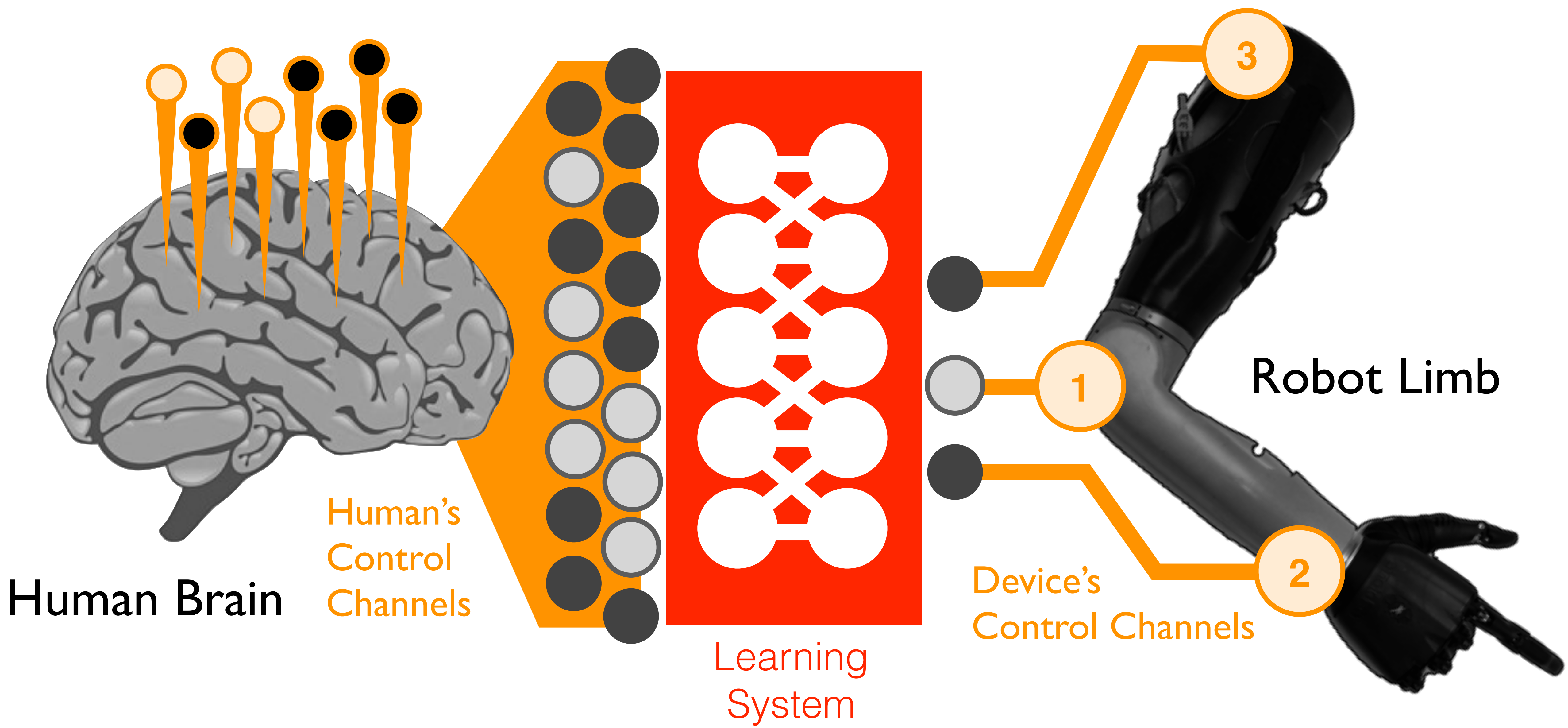

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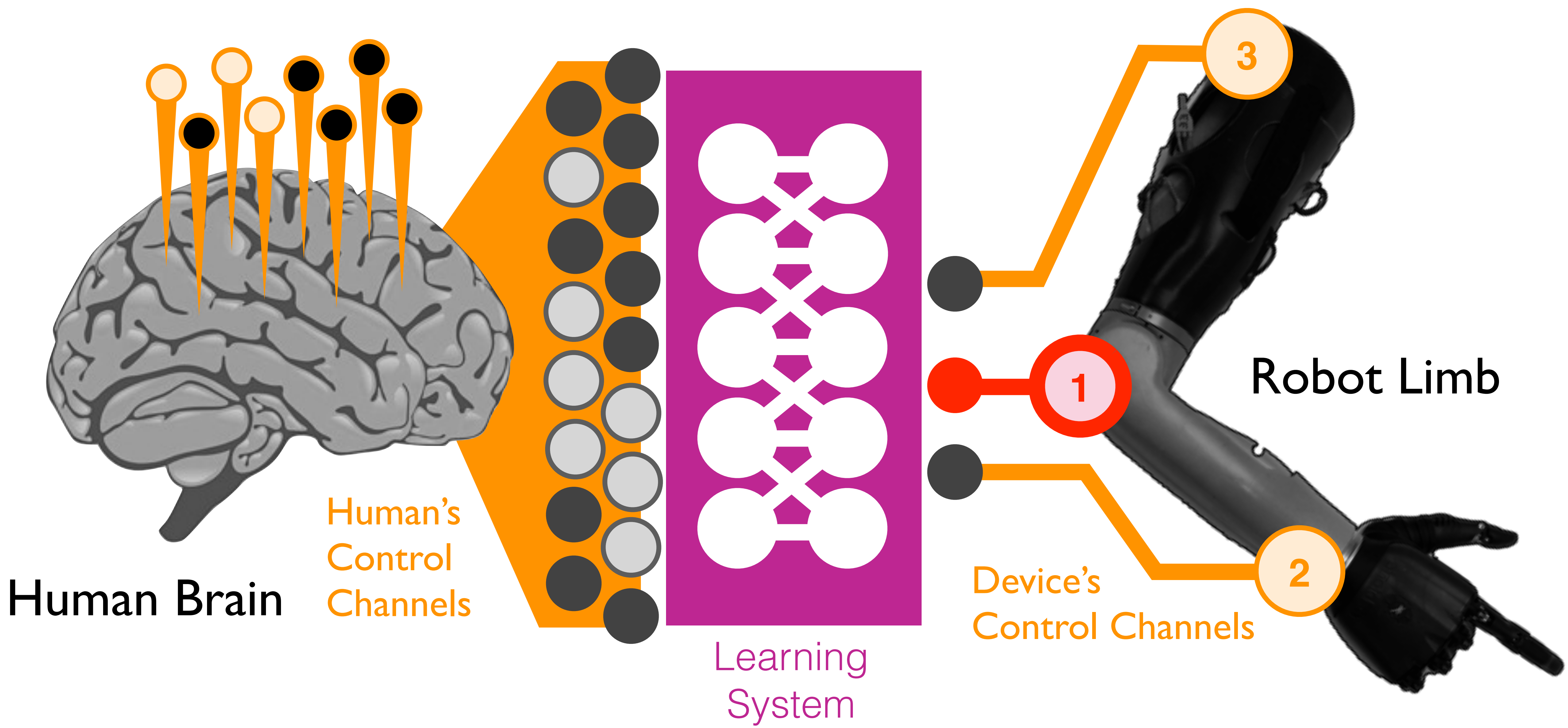
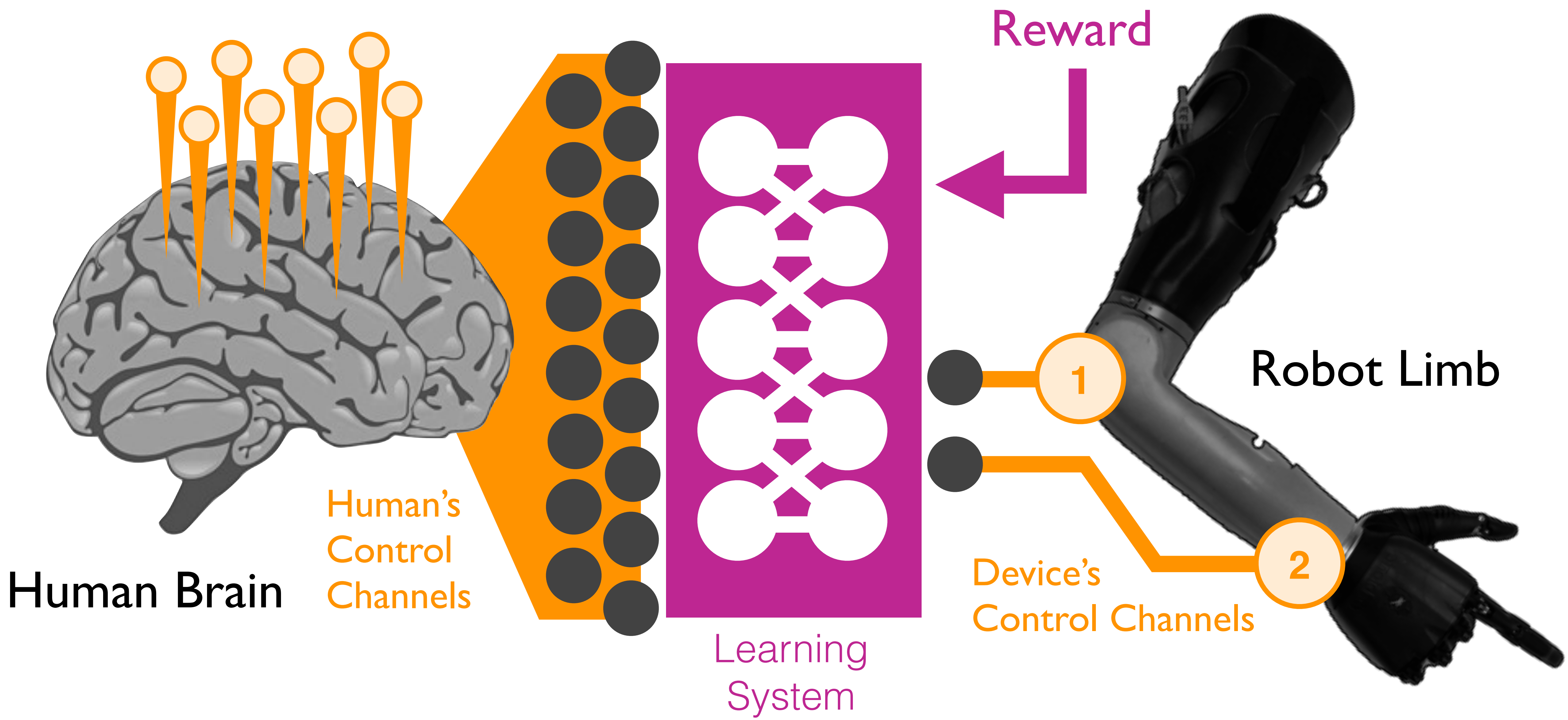


KEY IDEA

Learning from labeled examples can be effective when a domain is well known but very complex.
(often done *offline* or *batch*)

Learning to Actuate (through trial and error)



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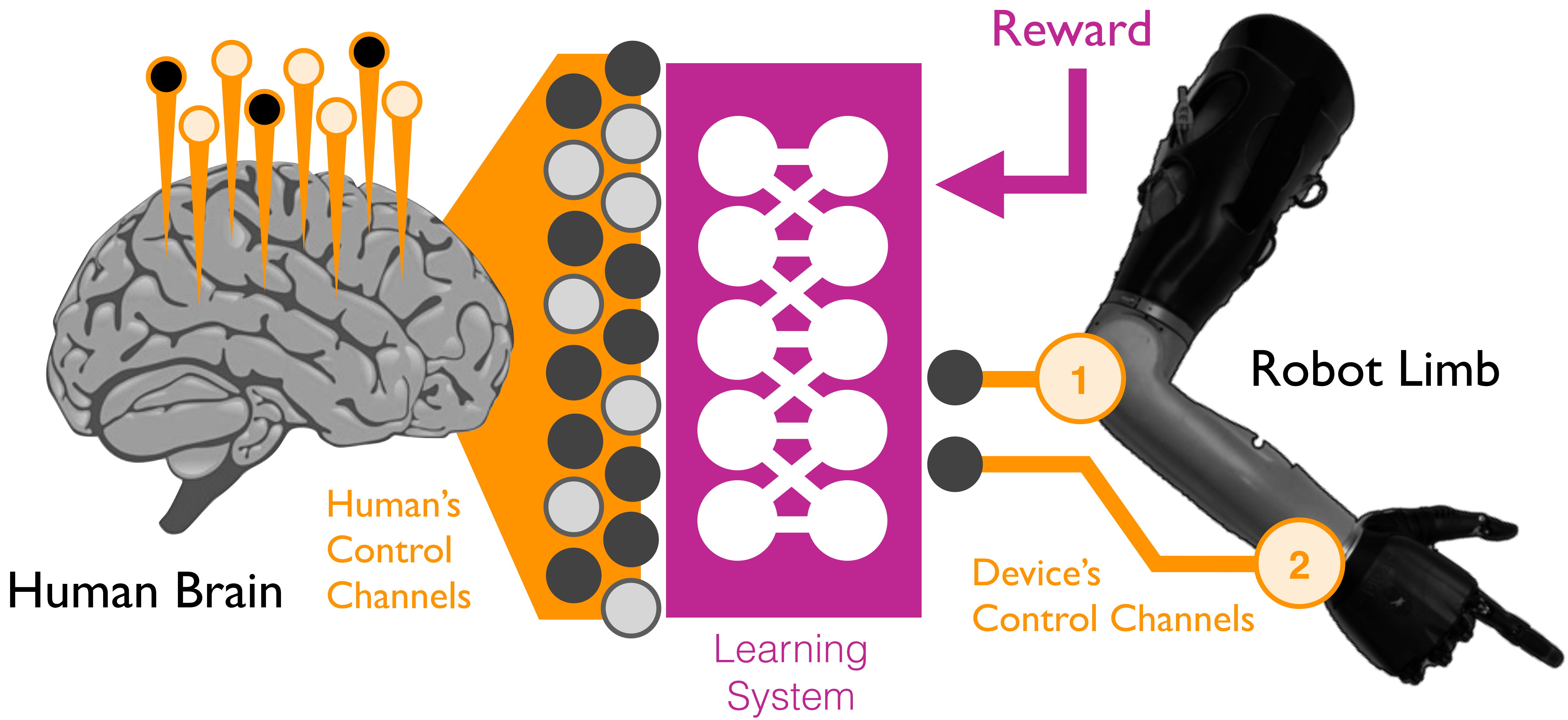
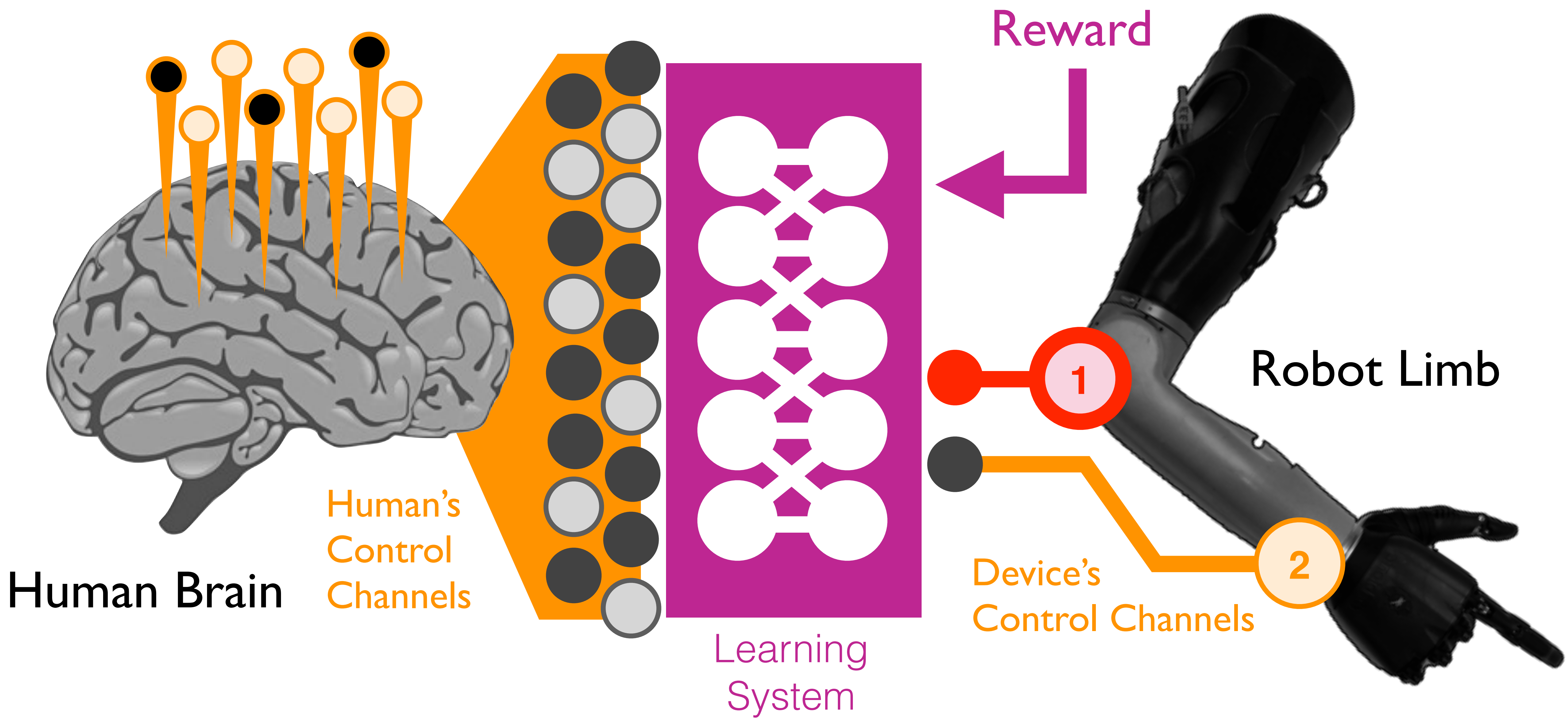
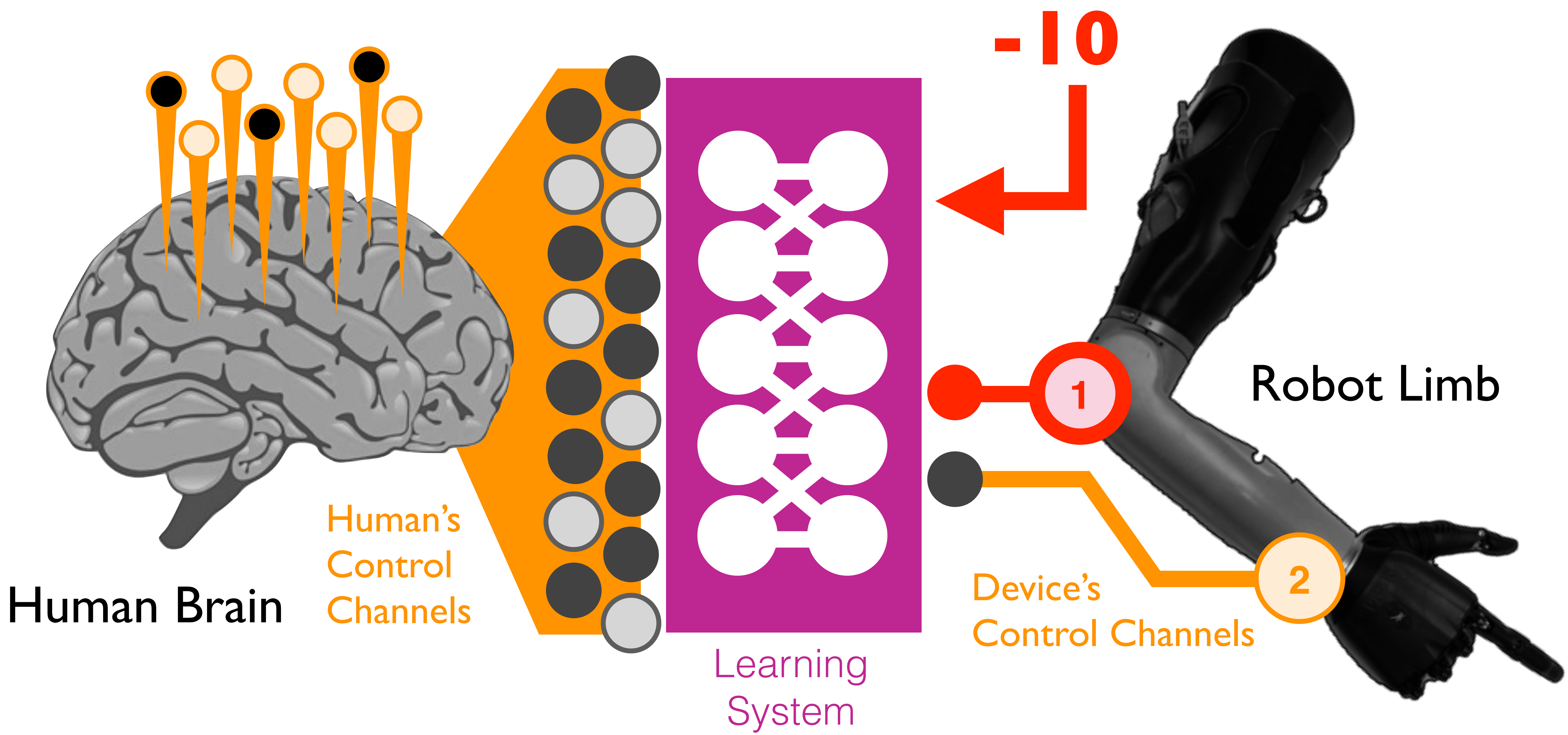


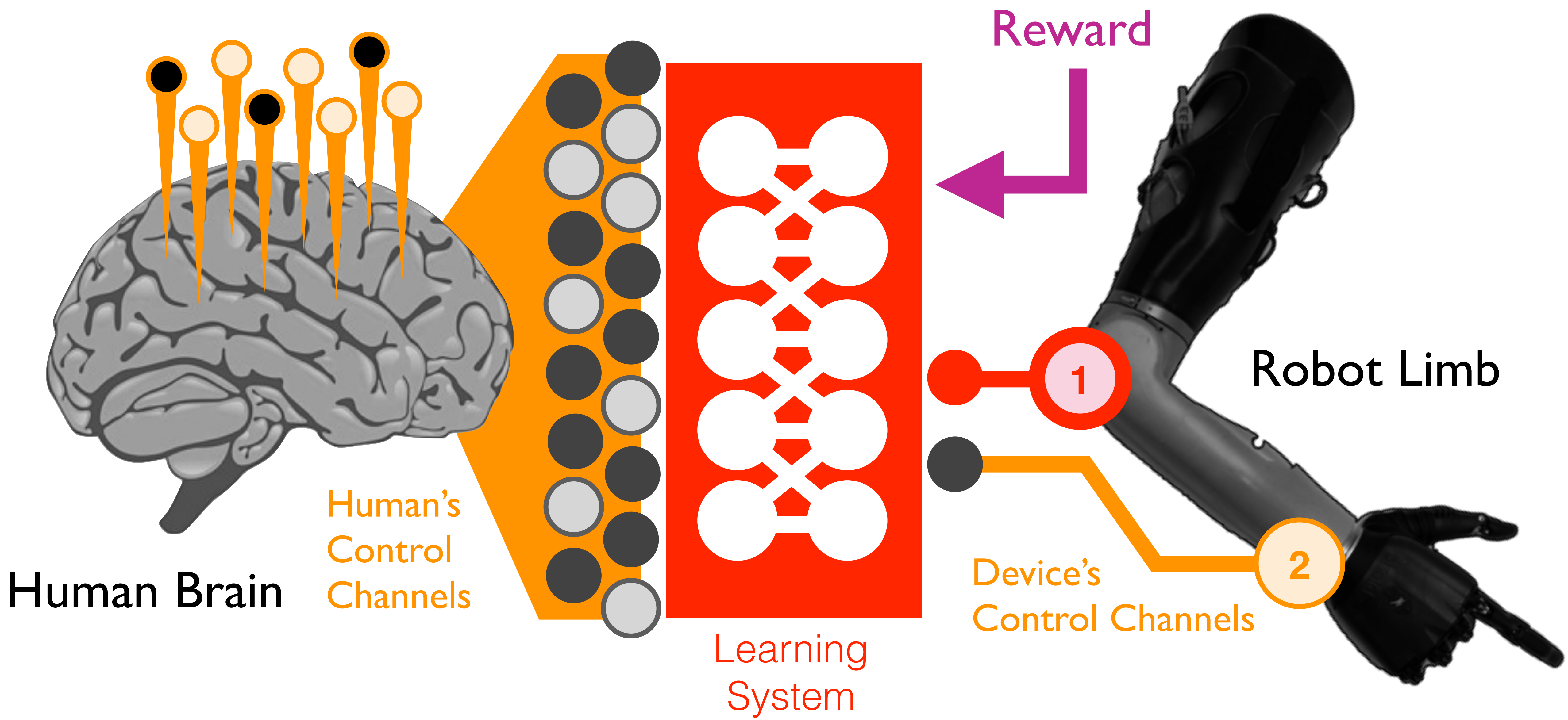
Learner Picks Action 1



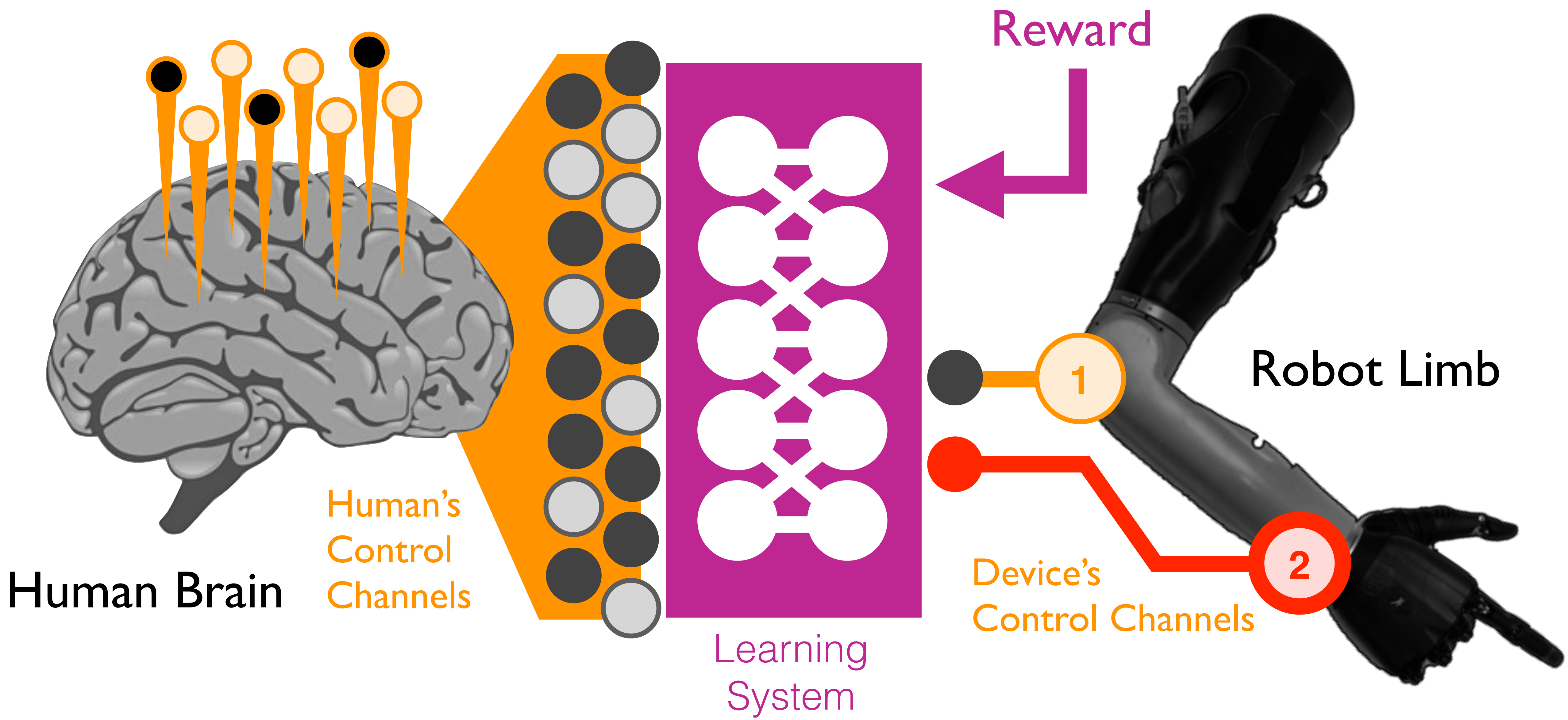
Feedback is Given "Bad"



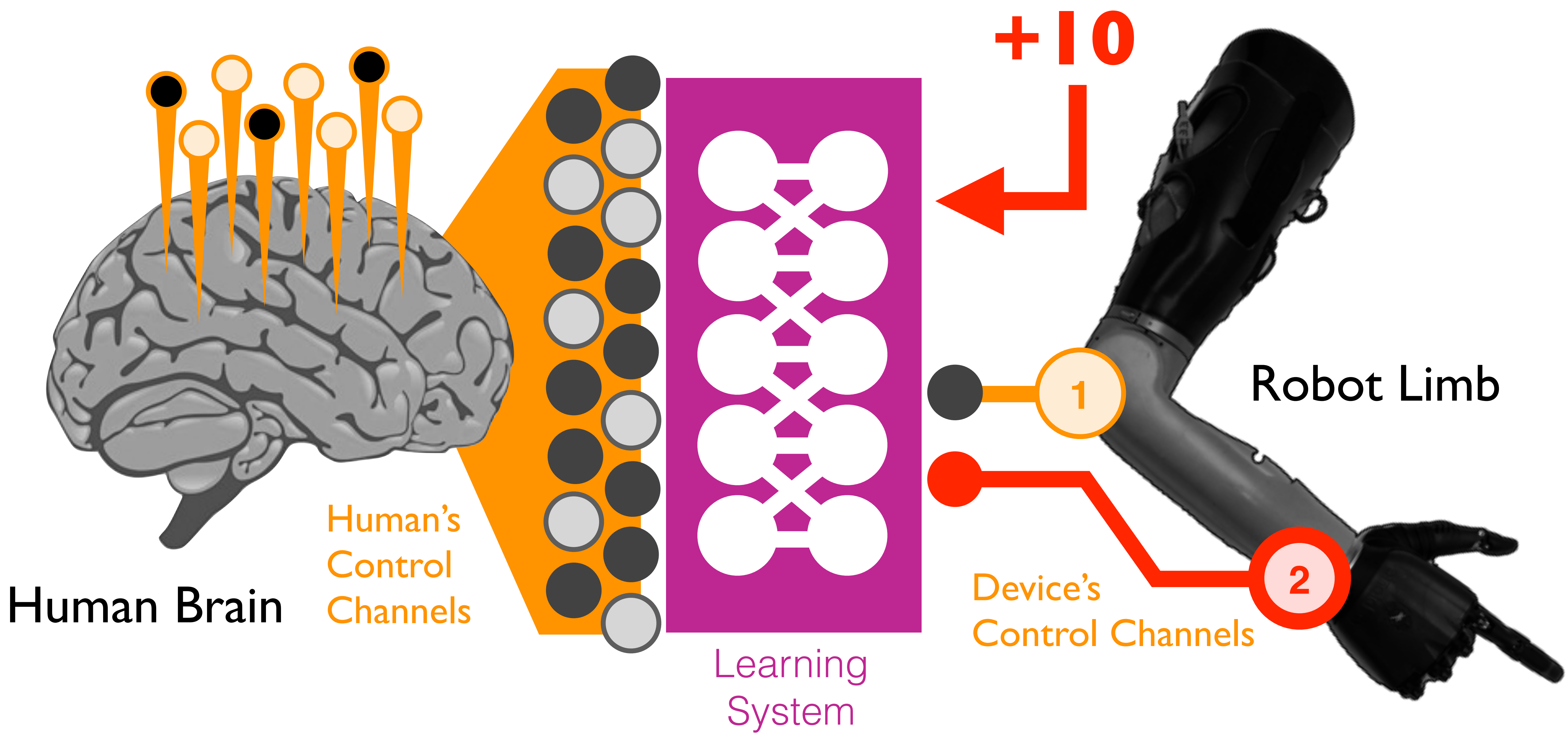
Learner Updates Its Control Policy



Learner Picks Action 2



Feedback is Given “Good”



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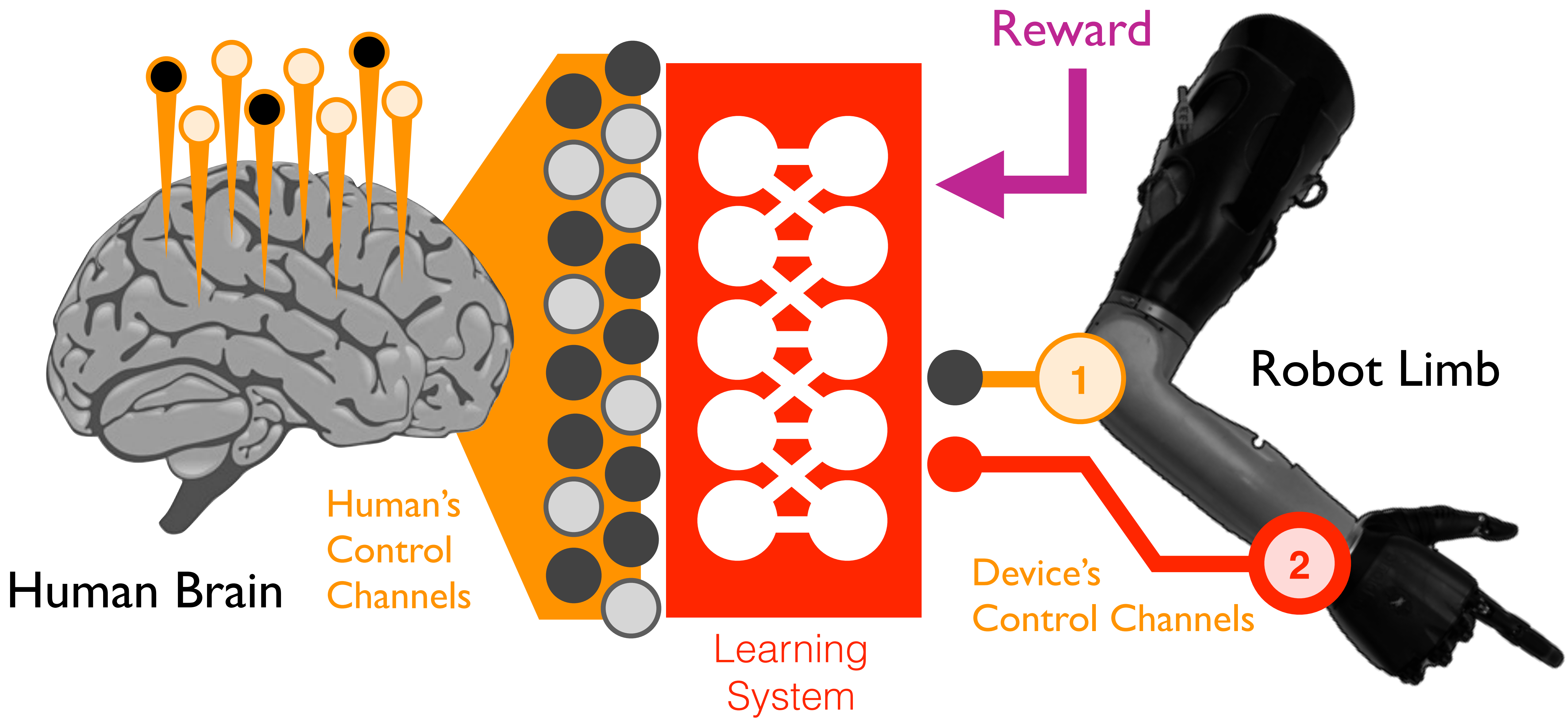
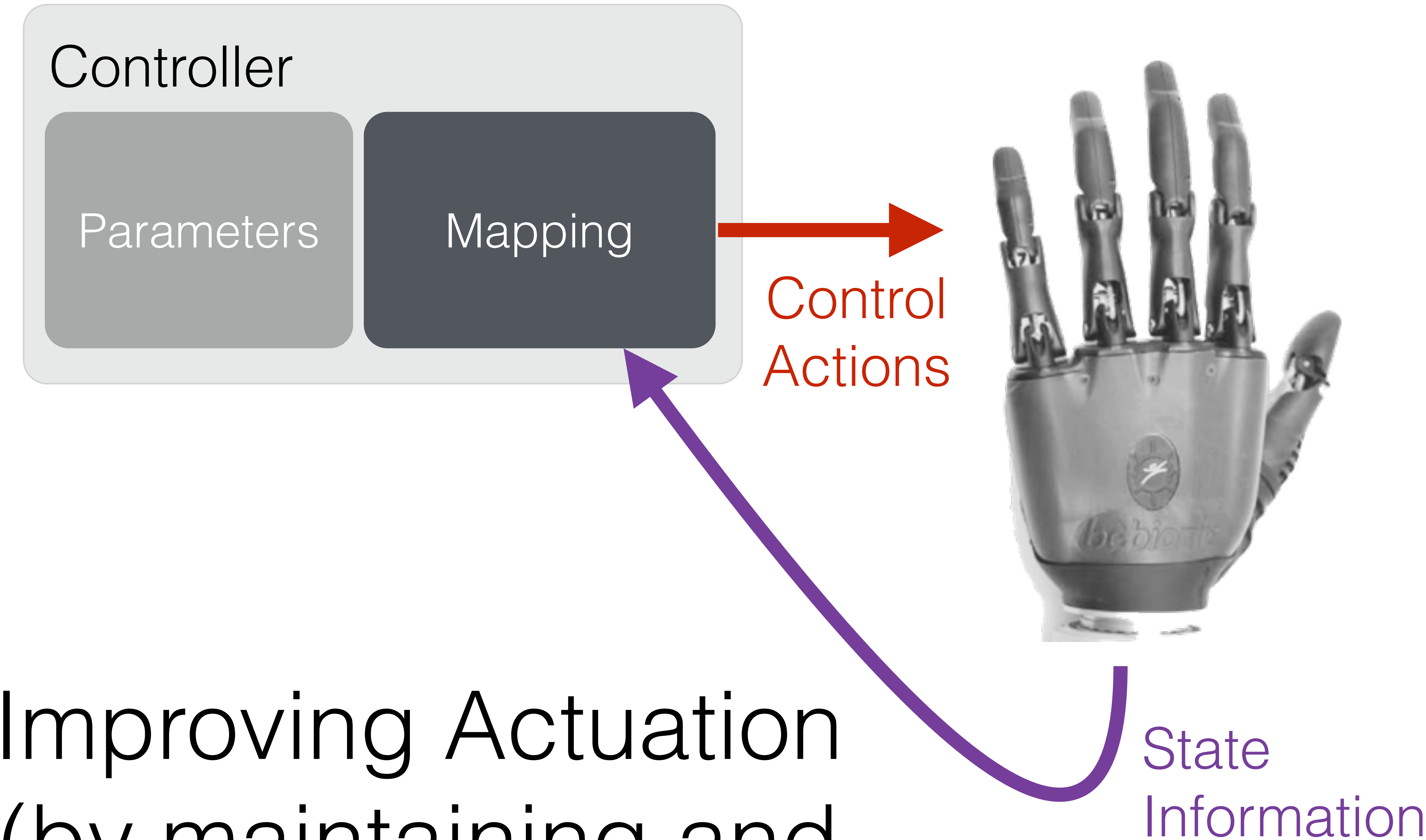
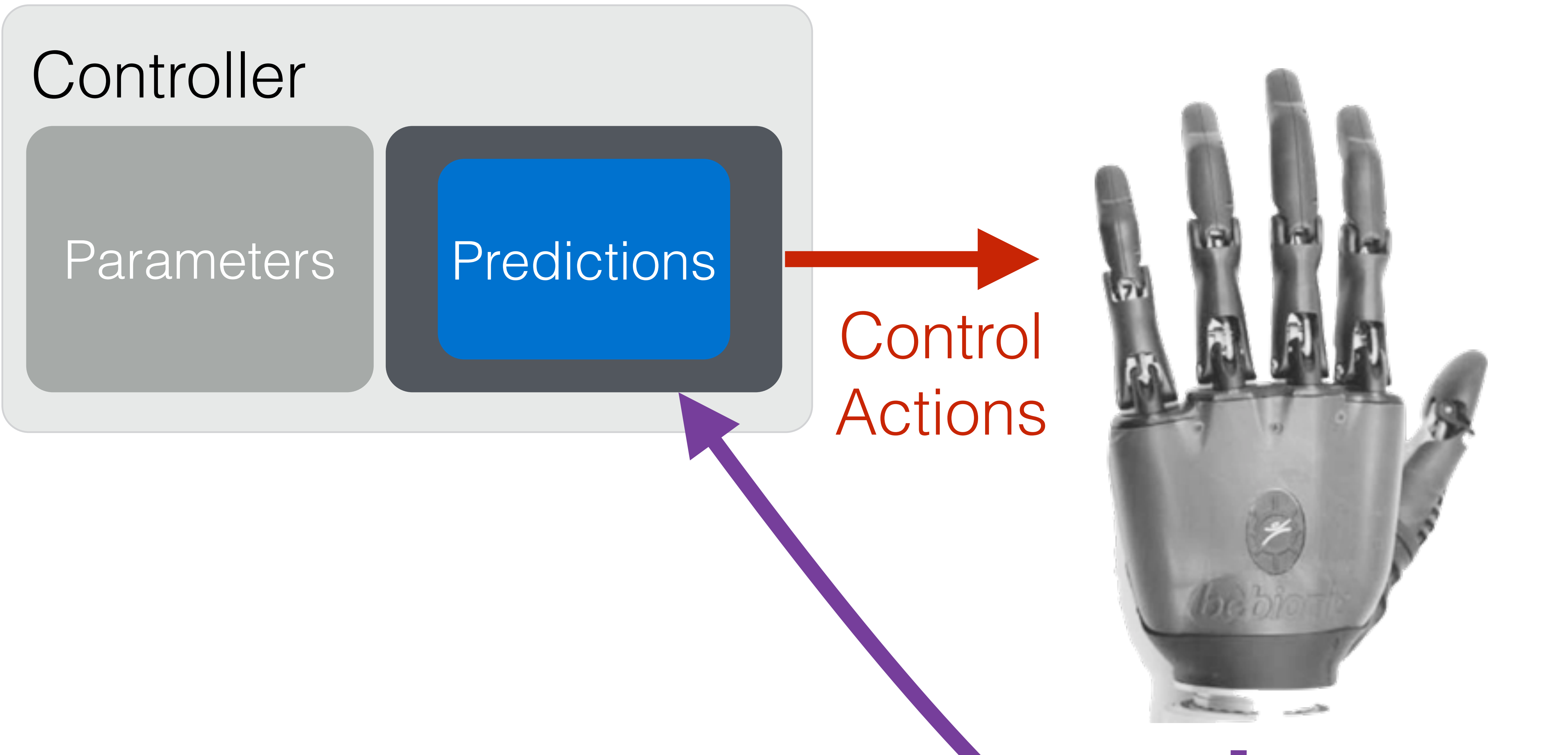


KEY IDEA

Learning through <u>trial and error</u> can be effective when a domain is unknown or poorly specified. (often done in *real time*)



Improving Actuation (by maintaining and using knowledge)



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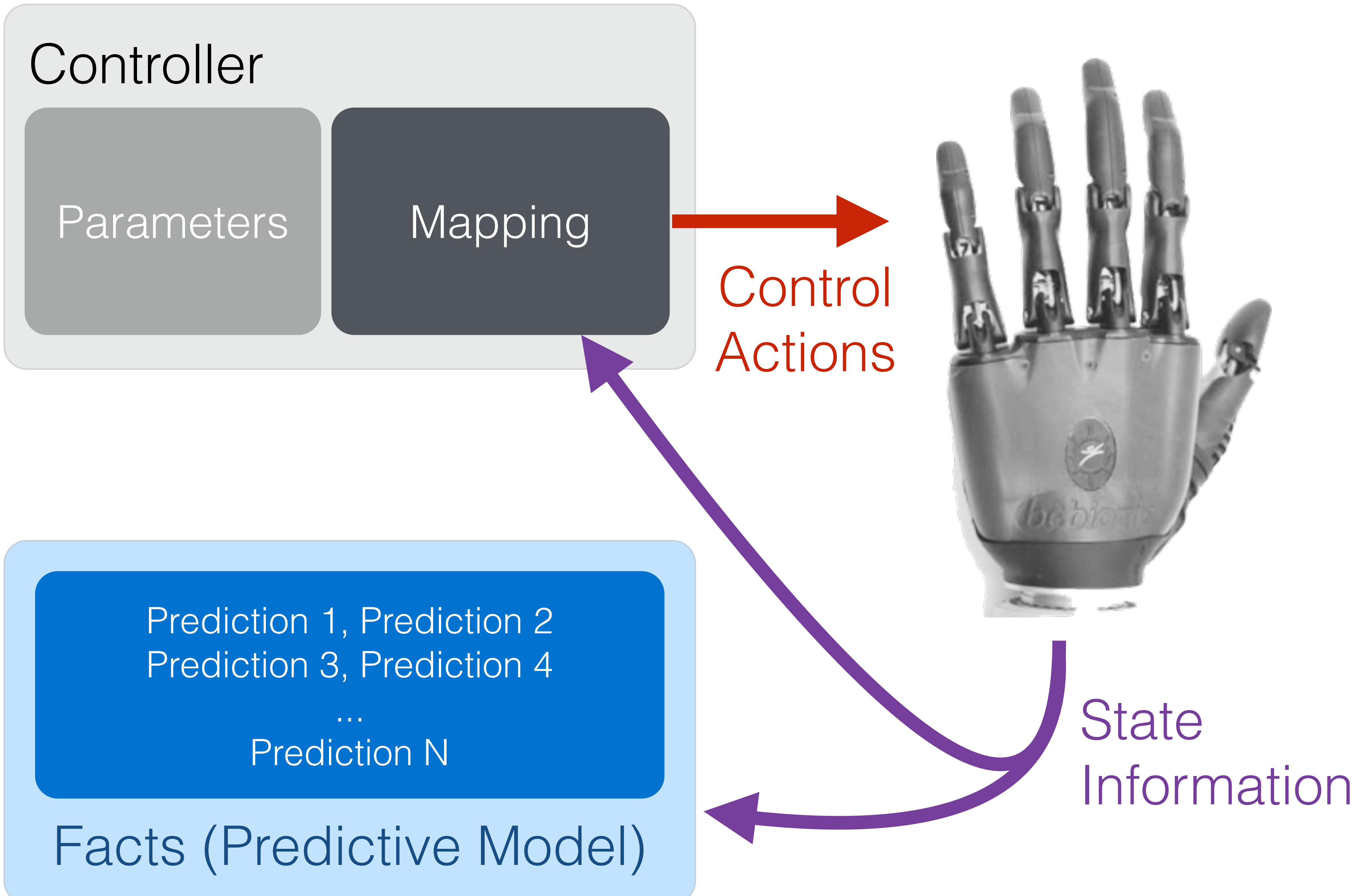
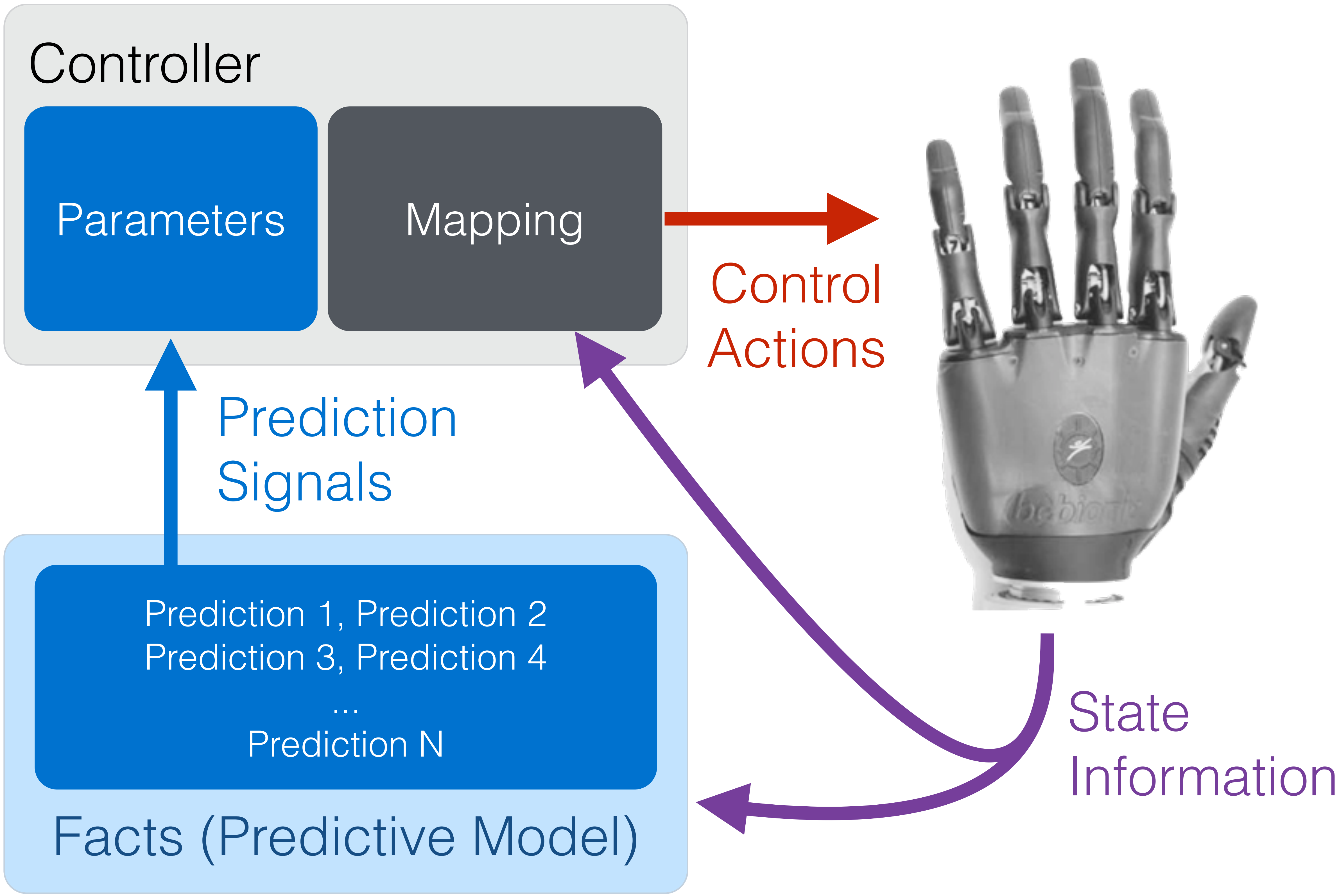

Controller
Parameters
Mapping
Control Actions
Prediction 1, Prediction 2
Prediction 3, Prediction 4
...
Prediction N
Facts (Predictive Model)
State Information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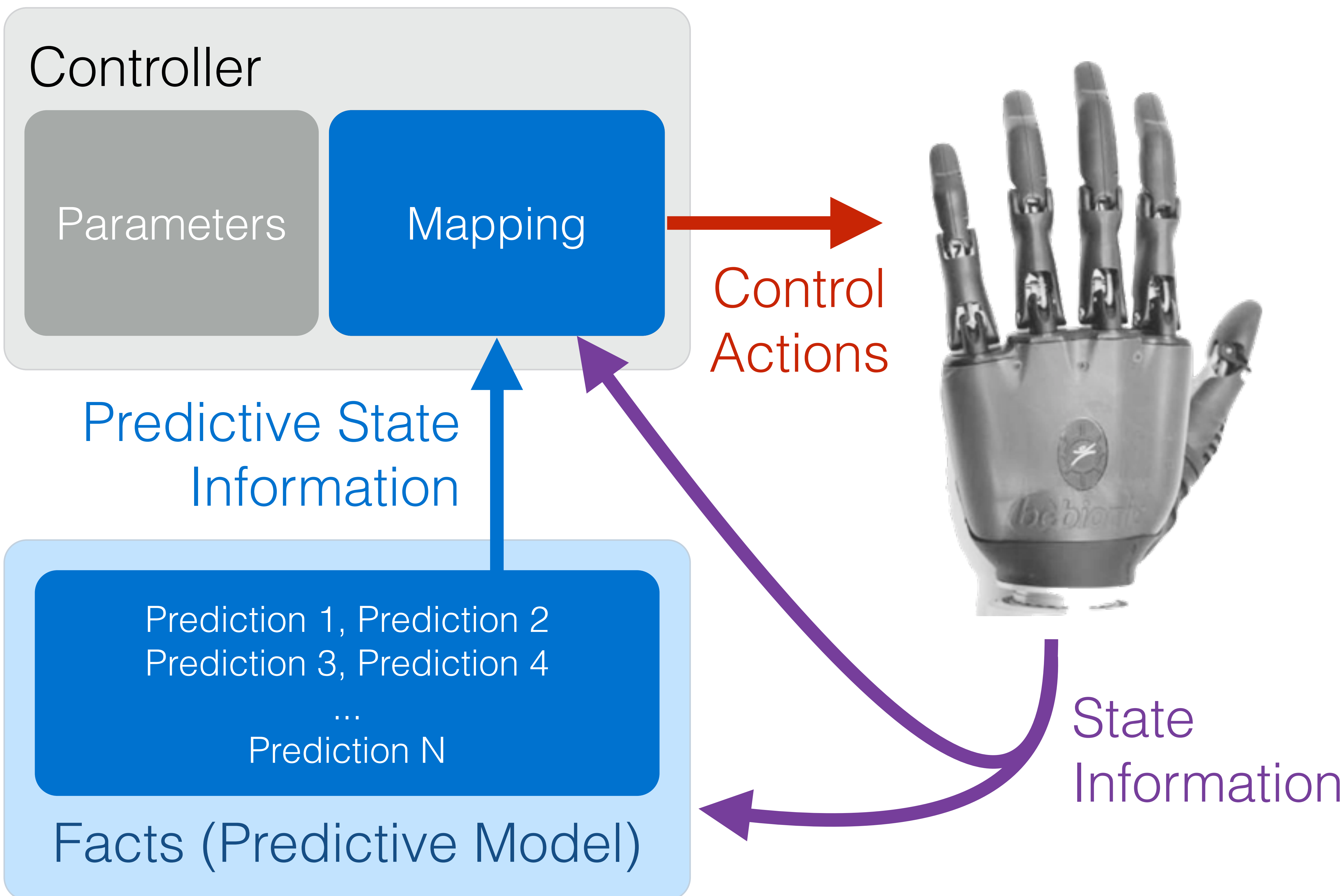
Controller
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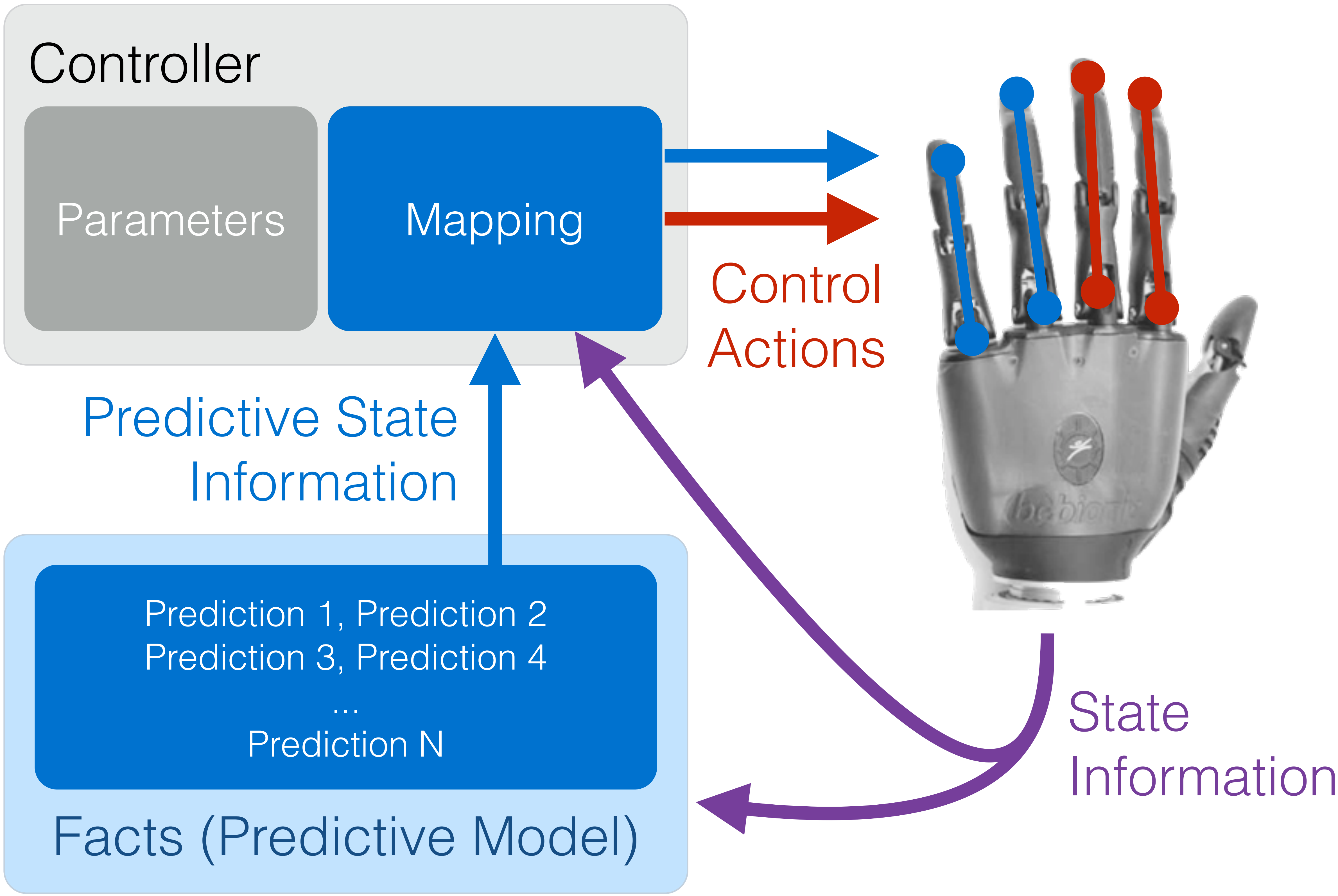
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KEY IDEA

Finding structure in the data (maintaining up-to-date knowledge) can be useful when a domain is in changeable or non-stationary.

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

Open Questions

- **When signals and information are plentiful:** how to gain function without losing function?

  “how would I intuitively control a prehensile tail, a pair of wings, or an internet spider?”

- **When signals and information are scarce:** how to gain extra information from limited data?

  “how could I fly an airplane with one hand, or drive a race car using only a single button?”

POSSIBLE SOLUTION

Maintaining and using knowledge (representation, prediction, control) in a purposeful way.

POSSIBLE SOLUTION

Machine intelligence.

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QUESTIONS

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