



*There is no intelligence, without action.*

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# Neurorobotics - Intro

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Lab Neurotrónica  
Departamento de Ingeniería Informática

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# Neurorobotics

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## Outline



**Block 1:** Mechatronics / Agents / Sensing / Actuation / Robotics Intro



**Block 2:** Neuroscience / Neurons / Action Potential / Modelling / Wearables / Brain-Computer Interfaces



**Block 3:** Human-Centred Robotics / Human Augmentation



**Block 4:** Real World Robots / Simulation and Combat

# Neurorobotics

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## Objectives

-  **Obj 1:** General idea of this innovative approach to solve digital transformation problems.
-  **Obj 2:** Have a general idea what are the available technologies to solve them.
-  **Obj 3:** How we can find inspiration in cognitive architectures to solve these issues? Understand the intrinsic connections between robotics and neuroscience.
-  **Obj 4:** Being able to touch a “problem”, understand their capacities and limitations.

# Neurorobotics

## Outline

-  Day 1:Introduction to Neurorobotics
-  Day 3:Reinforcement Learning
-  Day 5: Practical Internet of Robotic Things
-  Day 7: Robot Simulation Practice

-  Day 2: Robotics and Mechatronics
-  Day 4: Brain-Computer Interfaces
-  Day 6: Rehabilitation Robotics
-  Day 8: Robot Simulation Arena

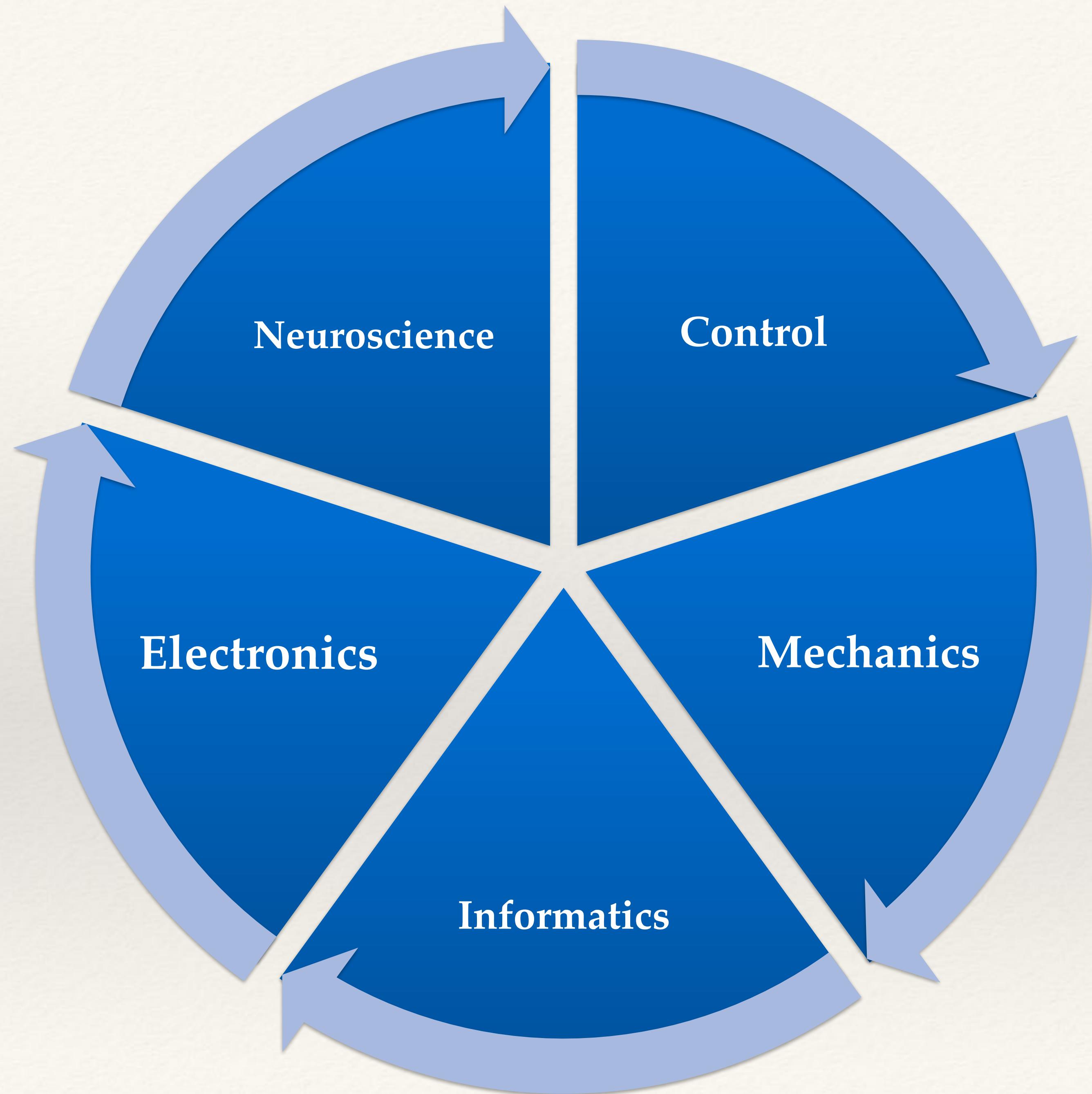
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# Marking and Passing

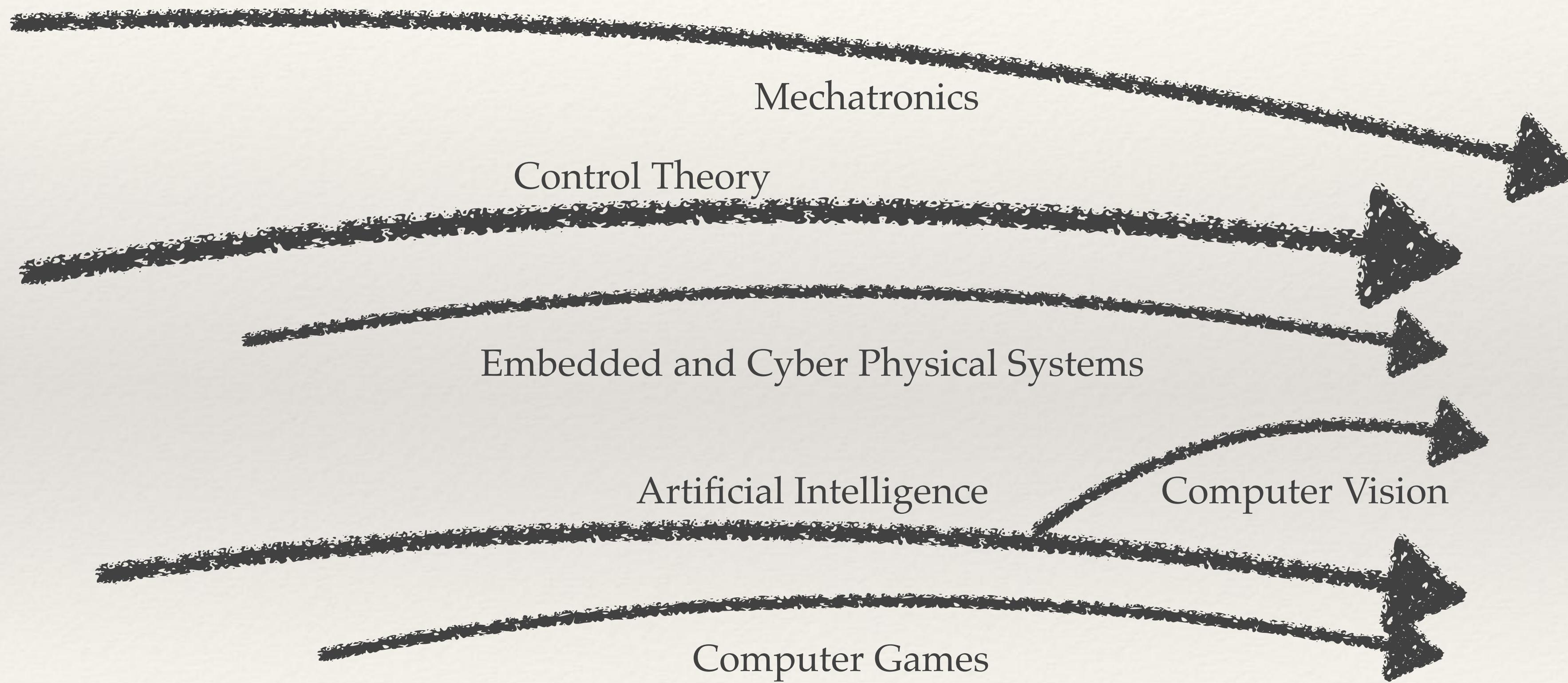
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## Objectives

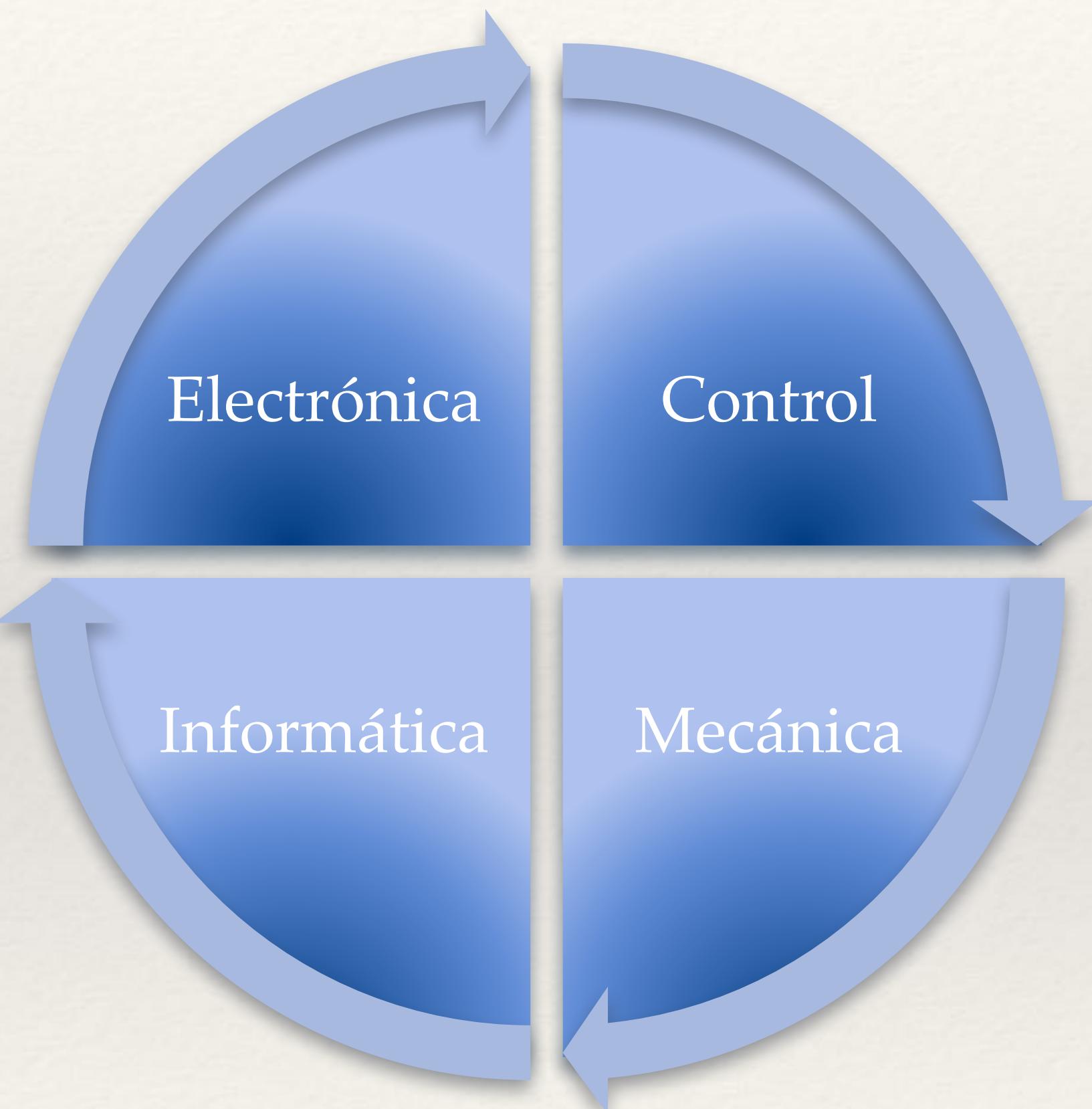
**Beat the other mobile robots in the Robot Simulator. Winner takes all !**



# Paths to Robotics



# Mechatronics



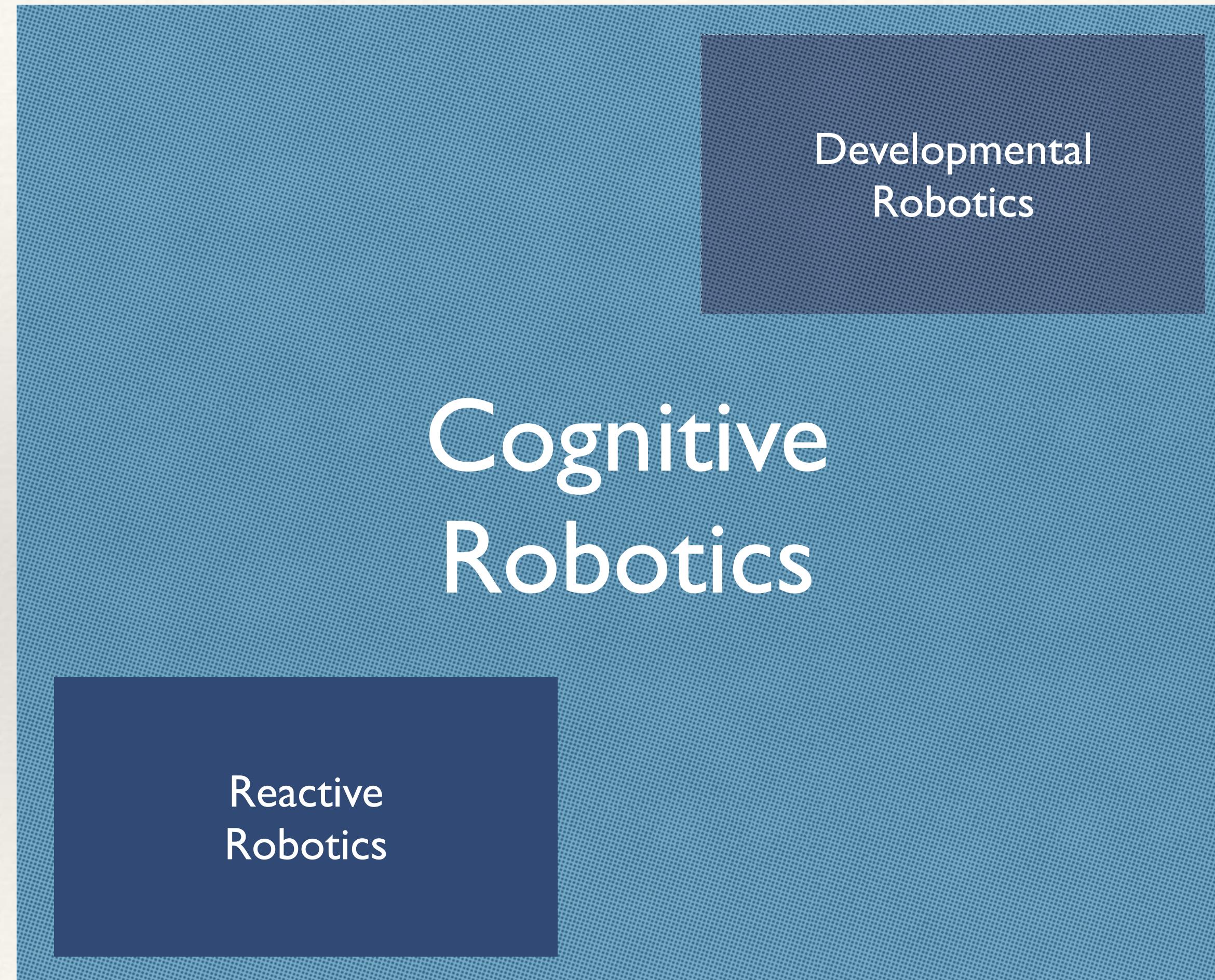
(1) 安川電機, 1969

# Washing Machine

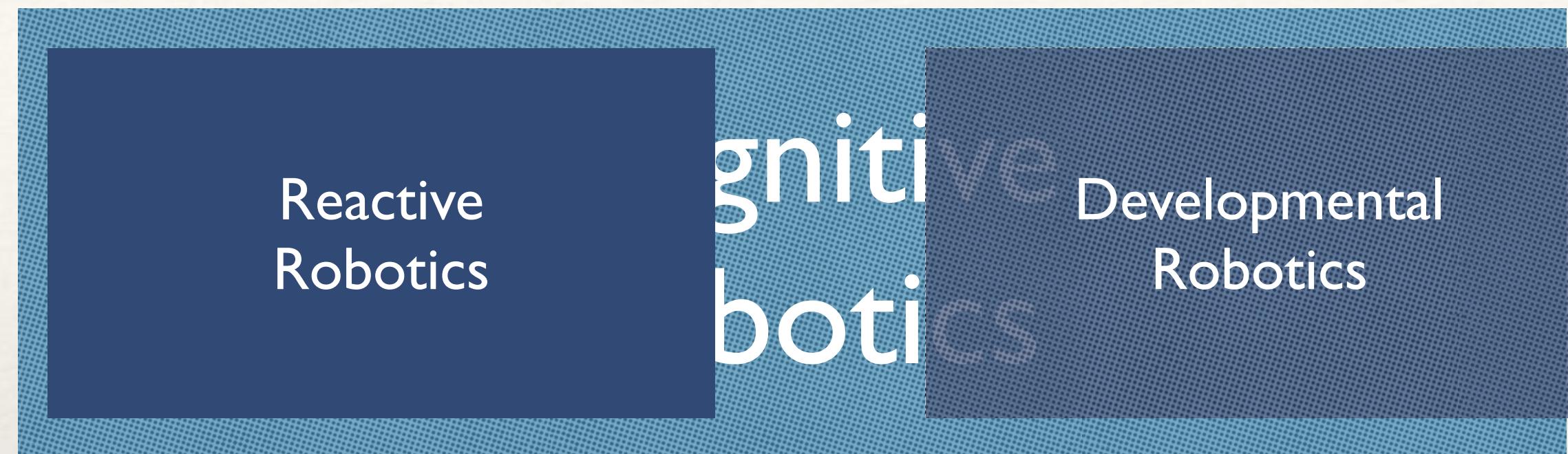


- ❖ Tienen que reinventarla de cero. ¿Cómo sería el paso a paso en el desarrollo de este producto?

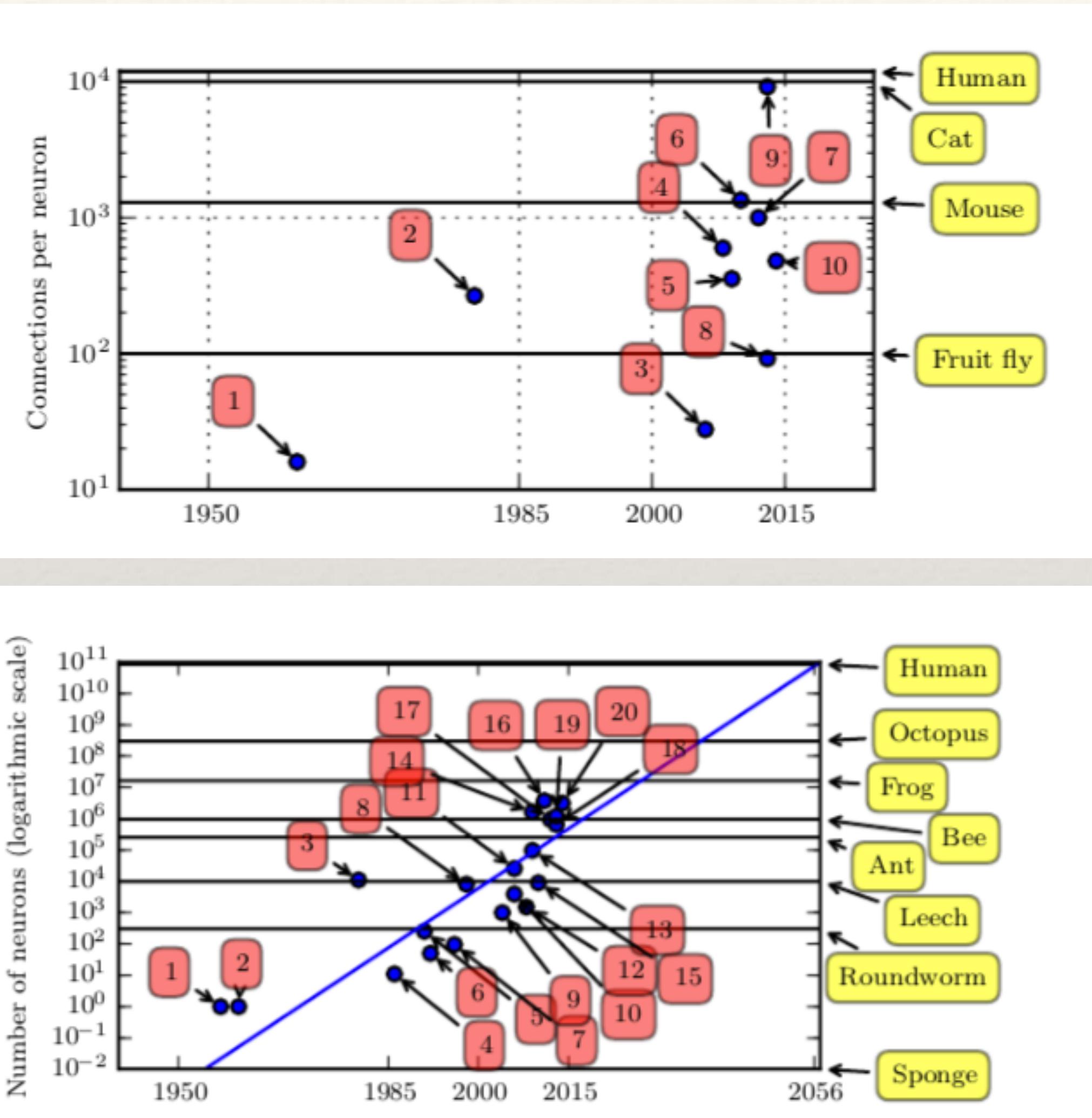
# Neurorobotics



# Neurorobotics



# Biomimesis

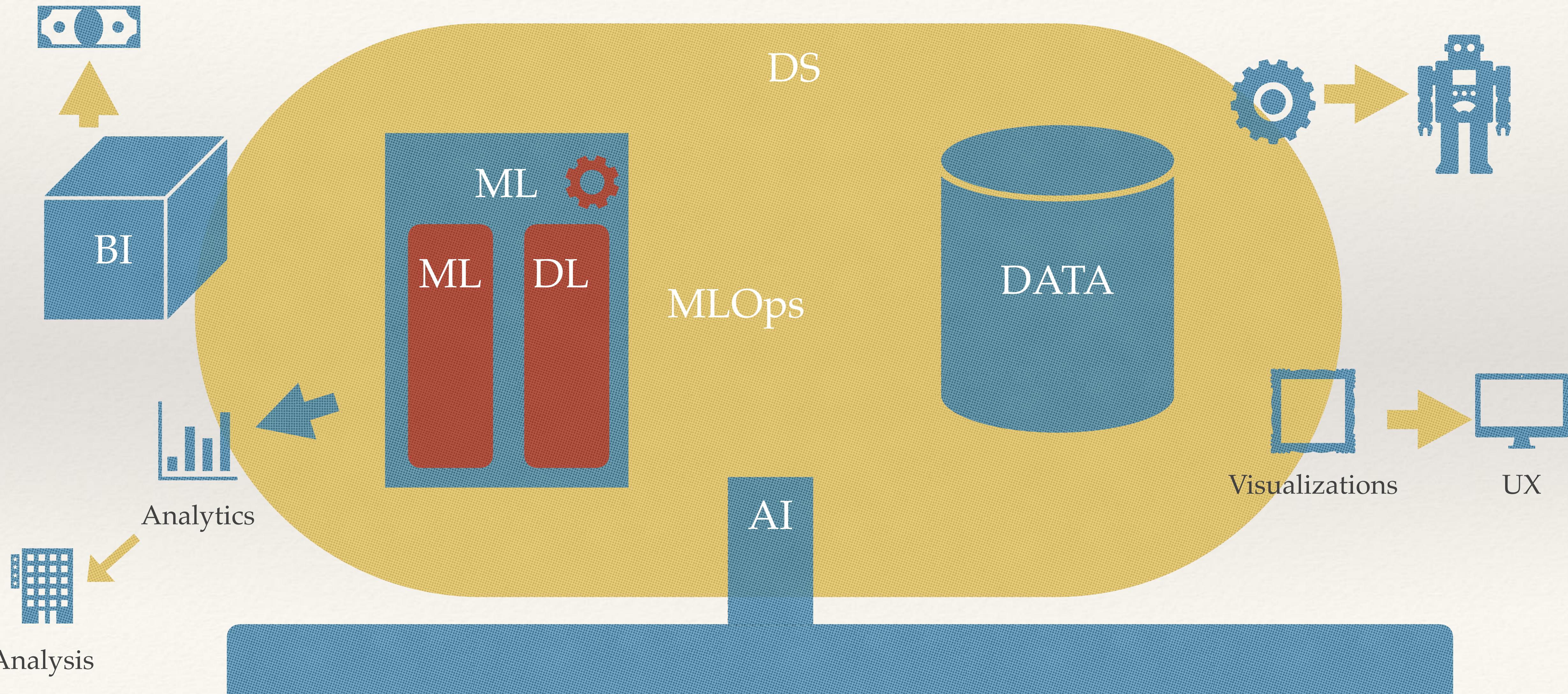


**Figure 2.1**

The number of neurons and synapses in different organisms. Adapted from [http://en.wikipedia.org/wiki/List\\_of\\_animals\\_by\\_number\\_of\\_neurons](http://en.wikipedia.org/wiki/List_of_animals_by_number_of_neurons).

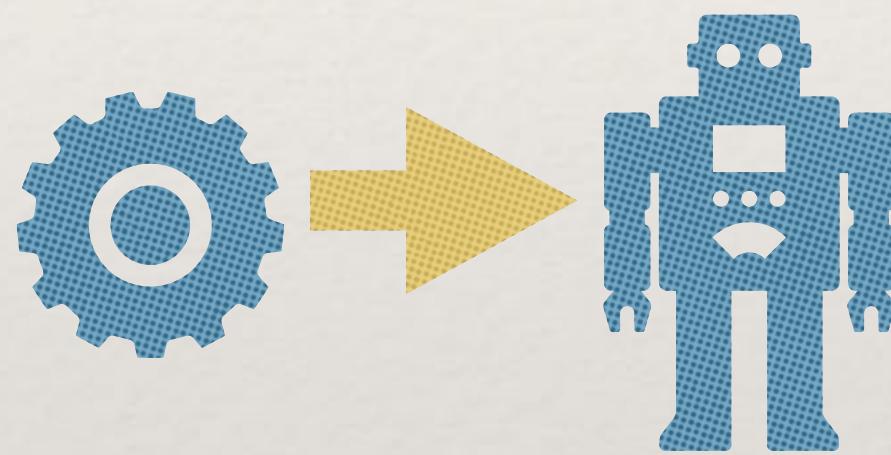
# Data Actuation

Business



# Automation

Industrial  
Automation



Dynamical  
Systems

Industrial  
Manipulators

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# Ejercicio

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- ❖ Piensen en un escenario sobre cómo resolverían una situación de cómo localizar autos en los estacionamientos gigantes de una fábrica automotriz en pleno pico de producción.
- ❖ ¿Qué característica tiene el problema que lo vuelve un escenario donde una solución de este estilo parecería tener sentido?

# Internet of Robotic Things

# Internet Of Things

- ❖ IoT, Internet Of Things es la conceptualización del armado de redes de intercambio de información, basada en protocolos de Internet, entre sensores y dispositivos electromecánicos computacionales, de forma coordinada para proveer servicios específicos que interrelacionan el mundo virtual con el mundo físico.
- ❖ Además es un buzzword, con mucho auge y catalogado en Gartner Hype Cycle en el pico de las expectativas (circa 2017). Existen un sinfín de términos similares asociados como Internet Of Everything, cuando incluye personas (social), Industrial Internet Of Things, la incepción de las tecnologías Web2.0 al mundo de la Automatización, y hasta Internet Of Living Things, cuando incluye plantas y animales (e.g. una Smart Home que abre la puerta cuando el gatito, que tiene un collar tracker, se acerca a la casa).
- ❖ El desarrollo de IoT es la confluencia de varias disciplinas en auge en los años anteriores: System On a Chip, Single Board Computer, Cyber-physical systems, Wireless Sensor Networks y Mobile.

# Internet Of Robotic Things

- ❖ Los **Cyber Physical Systems** pueden combinarse con robots con capacidad de comunicación, procesamiento, integración en la nube, proveyendo la capacidad de **actuación**.



# Internet of Robotic Things

Application

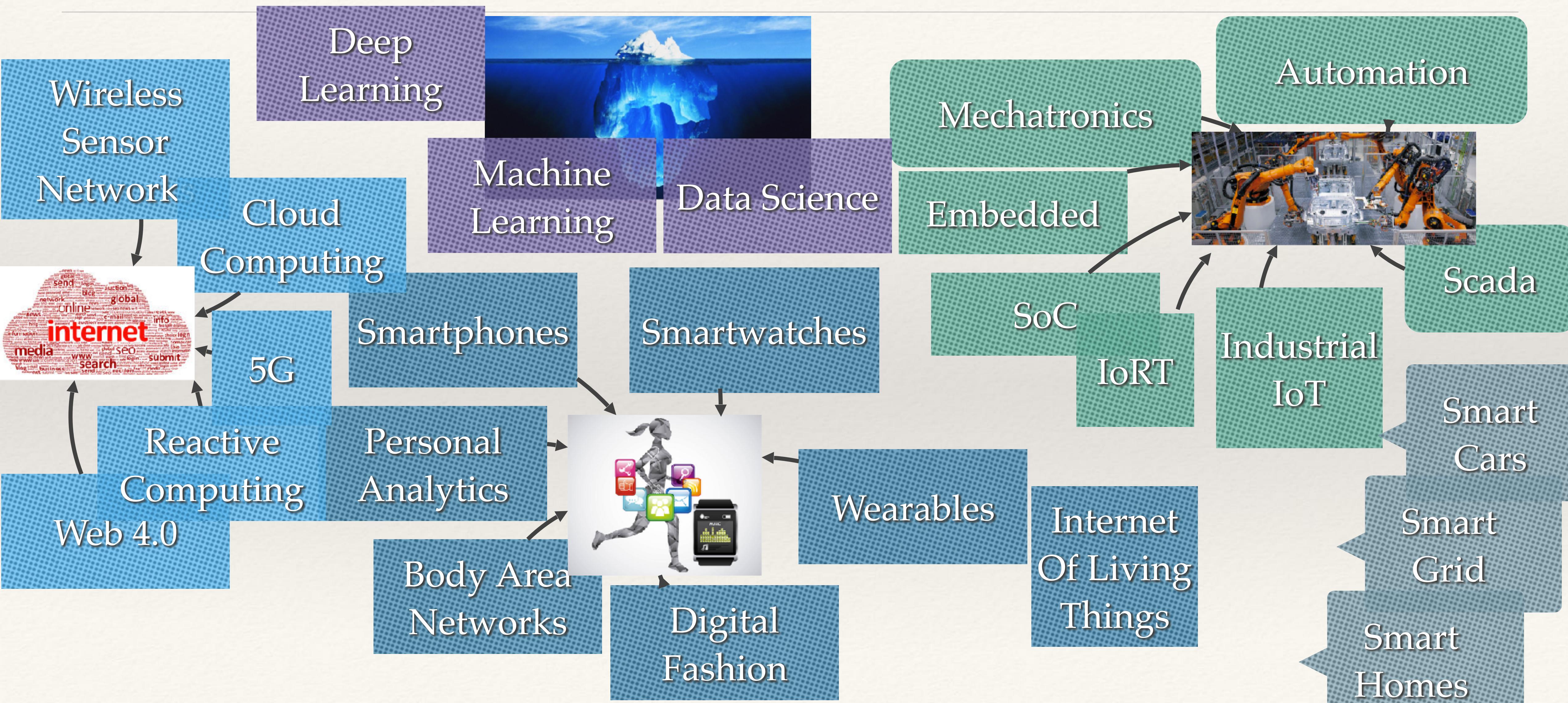
Infrastructure

Internet

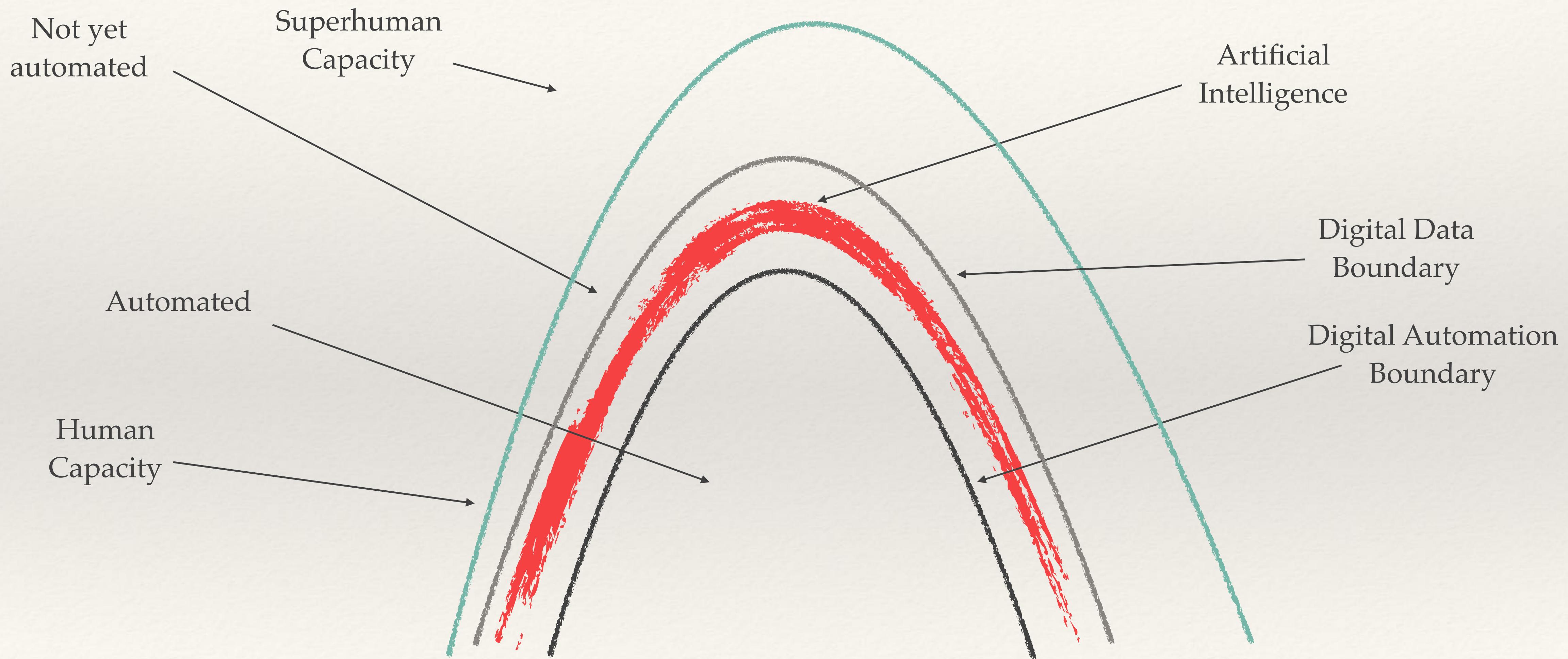
Network

Hardware

# Massive Digitalization of the Society



# Digital Automation



# Wearables and Digital Fashion



Smart clothes



Soomi Park LED-based eyelashes



Wearable Mobile Device



J'Lo OLED Dress



Heart Spark Eric Boyd



mHealth

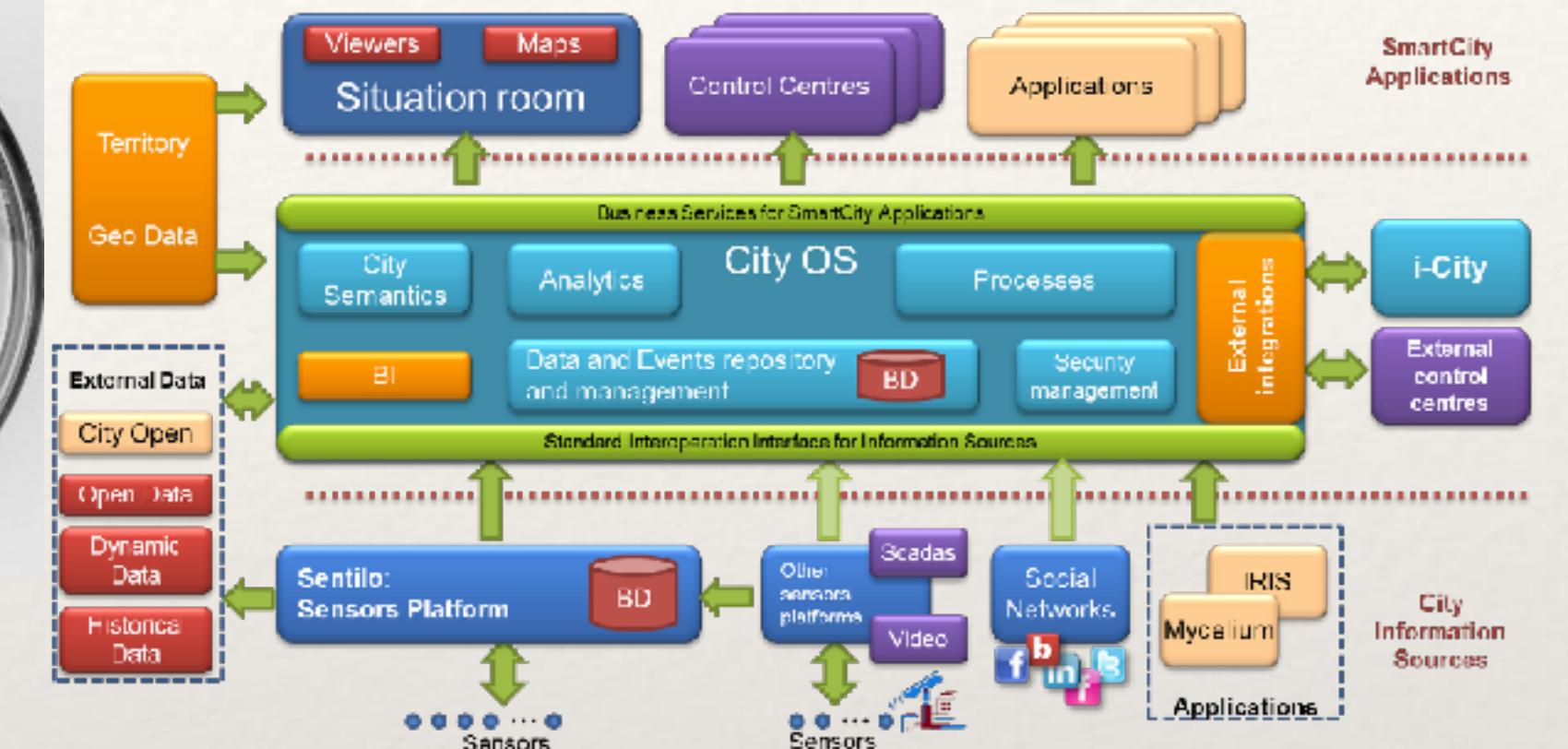
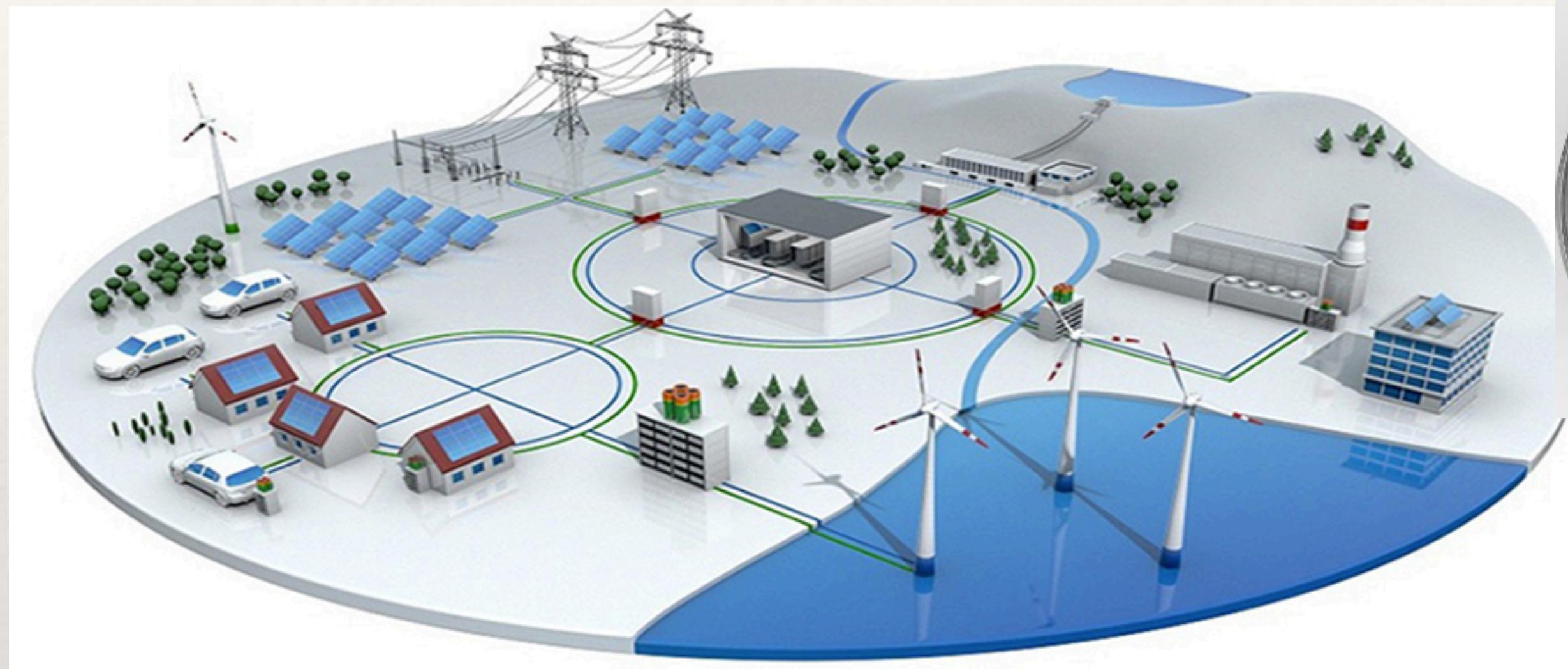


SmartWatch

# Metaverse



# Smart-Grids, Smart-Cities, Smart-Homes

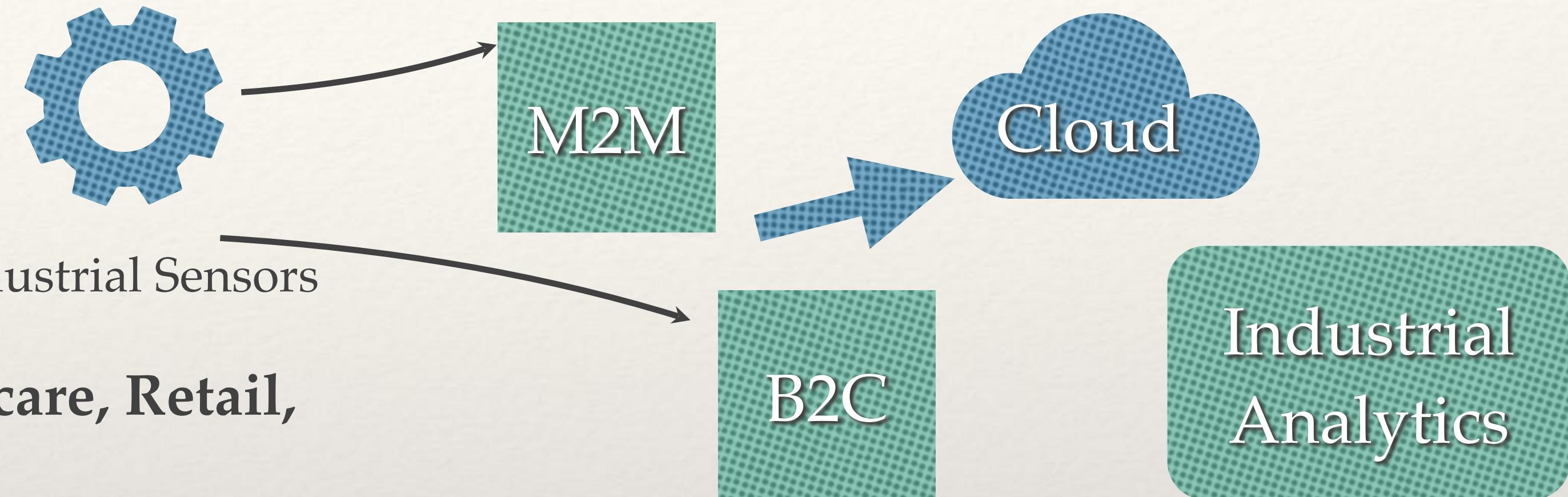


- San Francisco Park
- Barcelona's CityOS
- Villa La Angostura Paraíso Inteligente
- QMAX Instalaciones off-grid Cloud



# Industry 4.0

- ❖ IIoT or Industrial Internet
- ❖ Energy, Manufacturing, Agriculture, Healthcare, Retail, Transportation, Logistics, Aviation
- ❖ U\$D 151.01 Billons Market Size 2020: The Power of 1%



- Standardisation
- Security
- Work force skills

Outcome Economy

Selling Light, instead of Light Bulbs

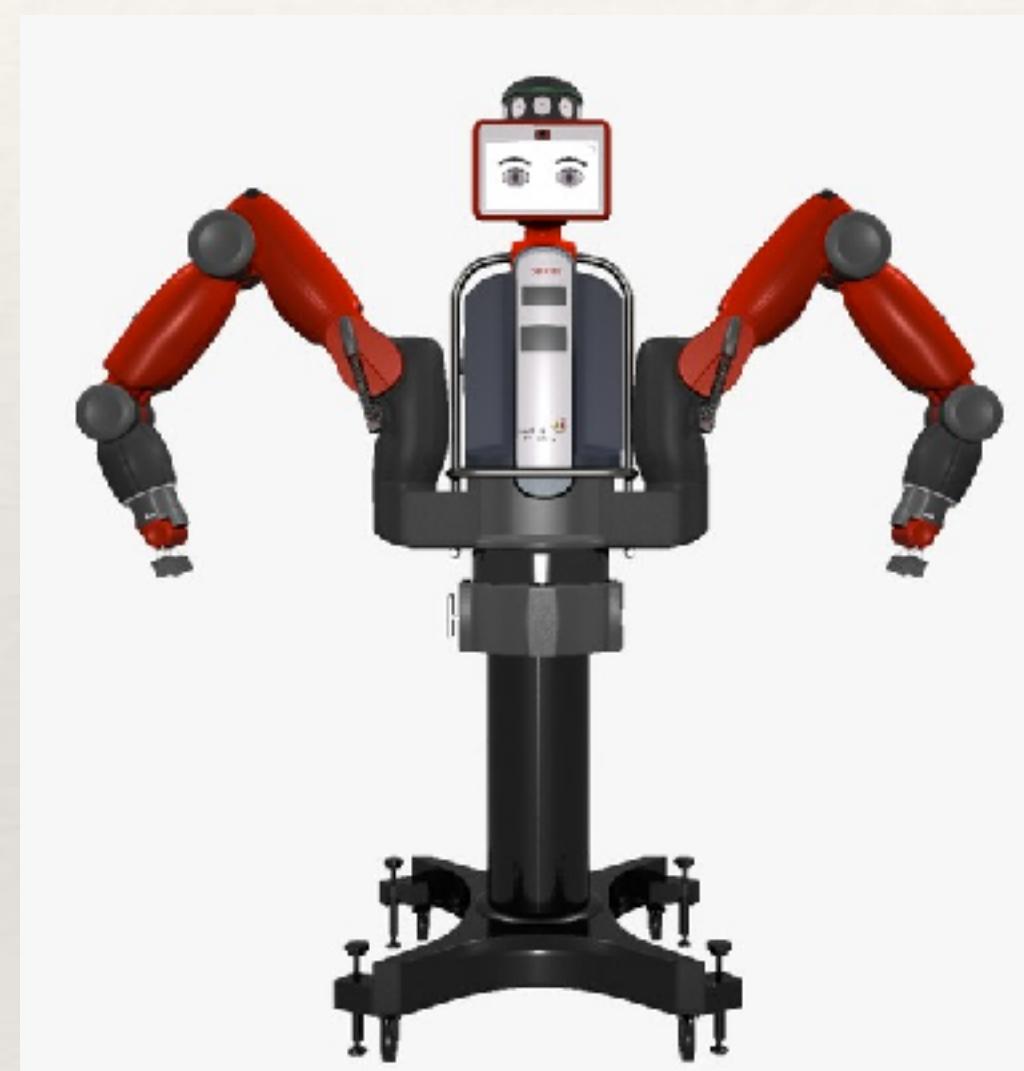
# Smart-Cars Robótica y Drones



Alexa y Apple's HomeKit



Google Autonomous Car



Baxter Robot

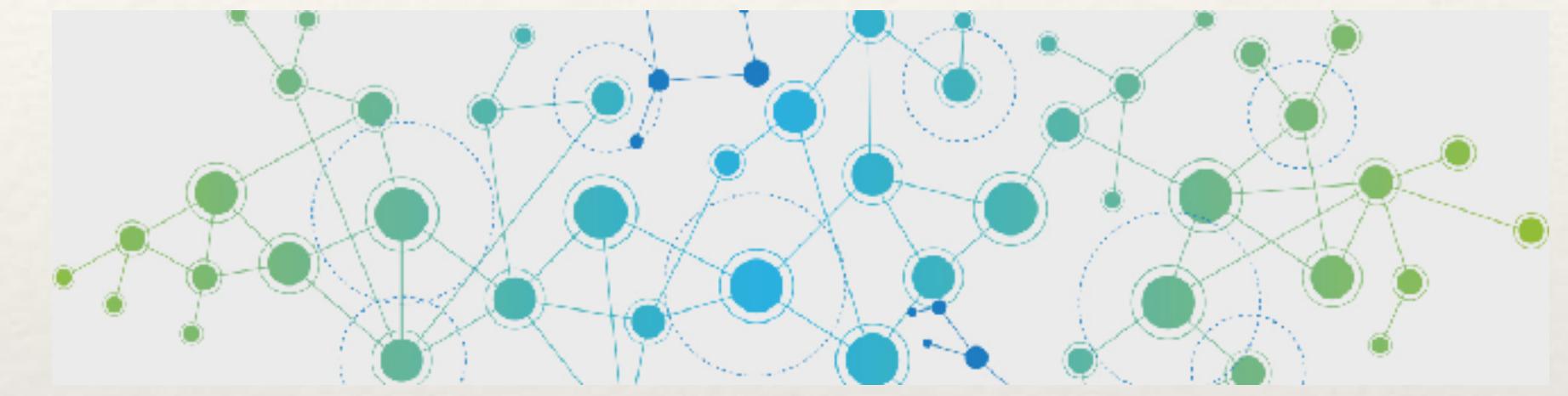
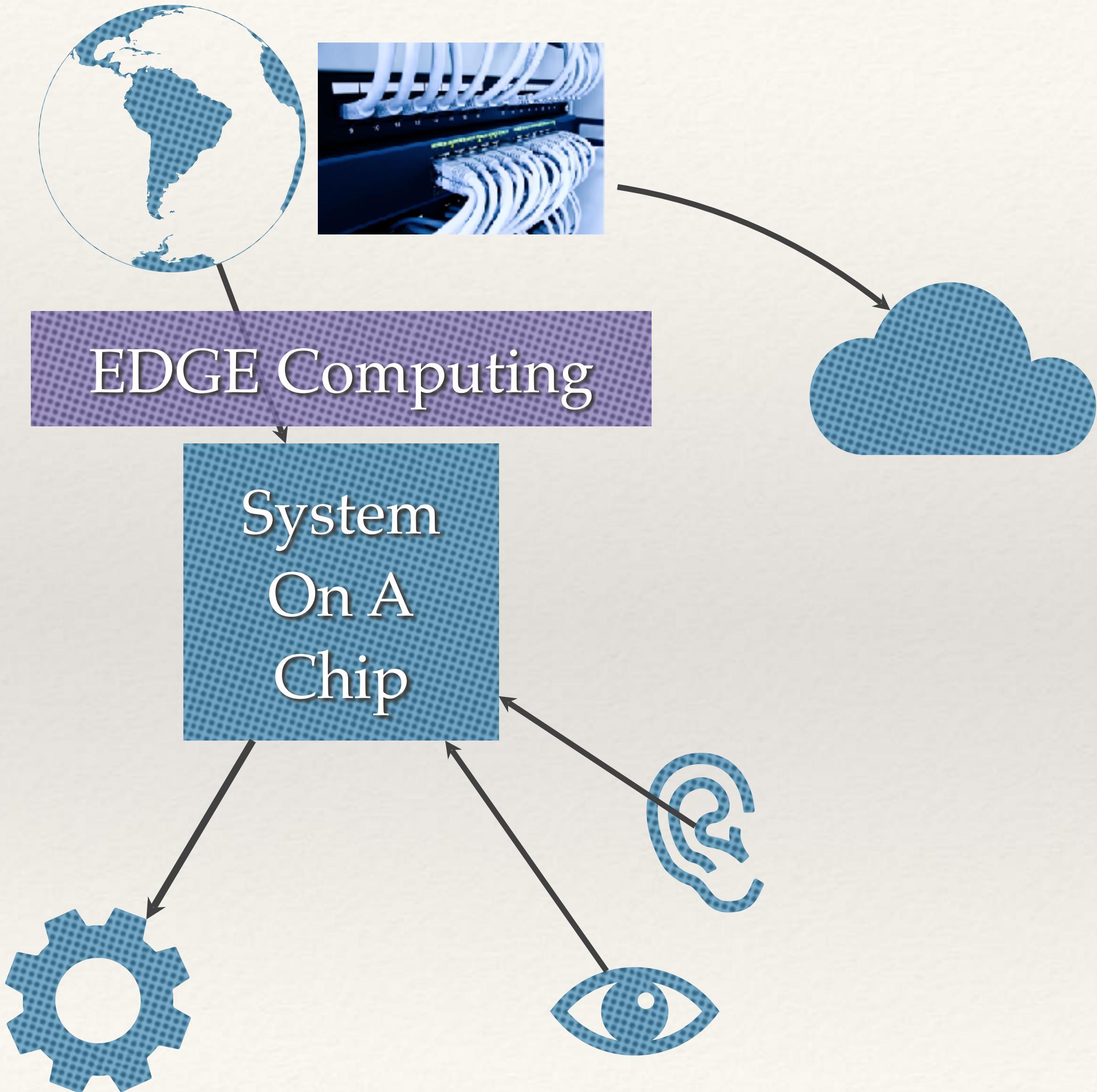


Tesla Model 3 Autopilot



DIY Roomba

# Several Levels of Intelligence



Emergent Properties

LoB  
Line Of Business

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# Use cases

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- ❖ **Telemetry:** Access data and control anything virtually from anywhere.
- ❖ **Surveillance y Sousveillance:** Digital Society
- ❖ **Tracking:** Monitoring and control devices
- ❖ **Remote controlling:** Telepresence, Haptic Interfaces, Surrogates
- ❖ **Digital Twins:** digital proxy of real objects
- ❖ **M2M/M2C:** Machine to Machine y Machine To Consumer. Ubiquitous interaction between devices.

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# Ejercicio

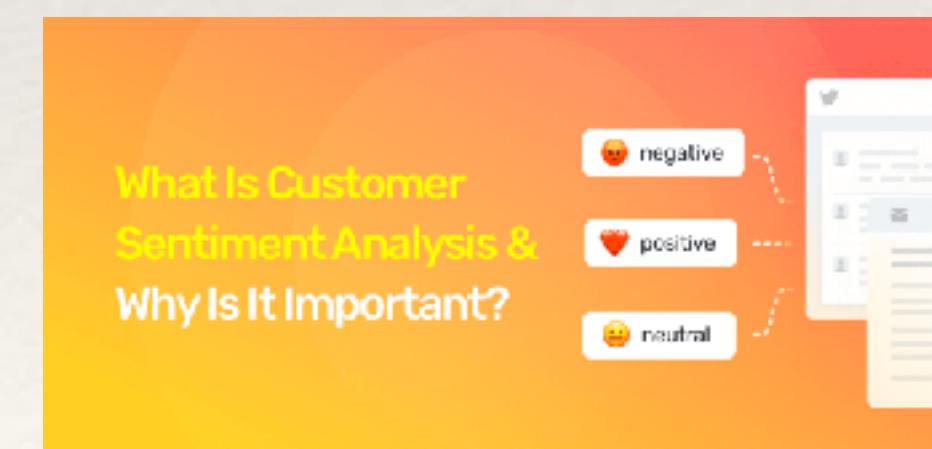
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- ❖ Asimov et al se imaginó hace 70 años el mundo actual dominado por máquinas inteligentes. ¿Creen ustedes que si siguiese vivo, consideraría que su profecía se materializó?

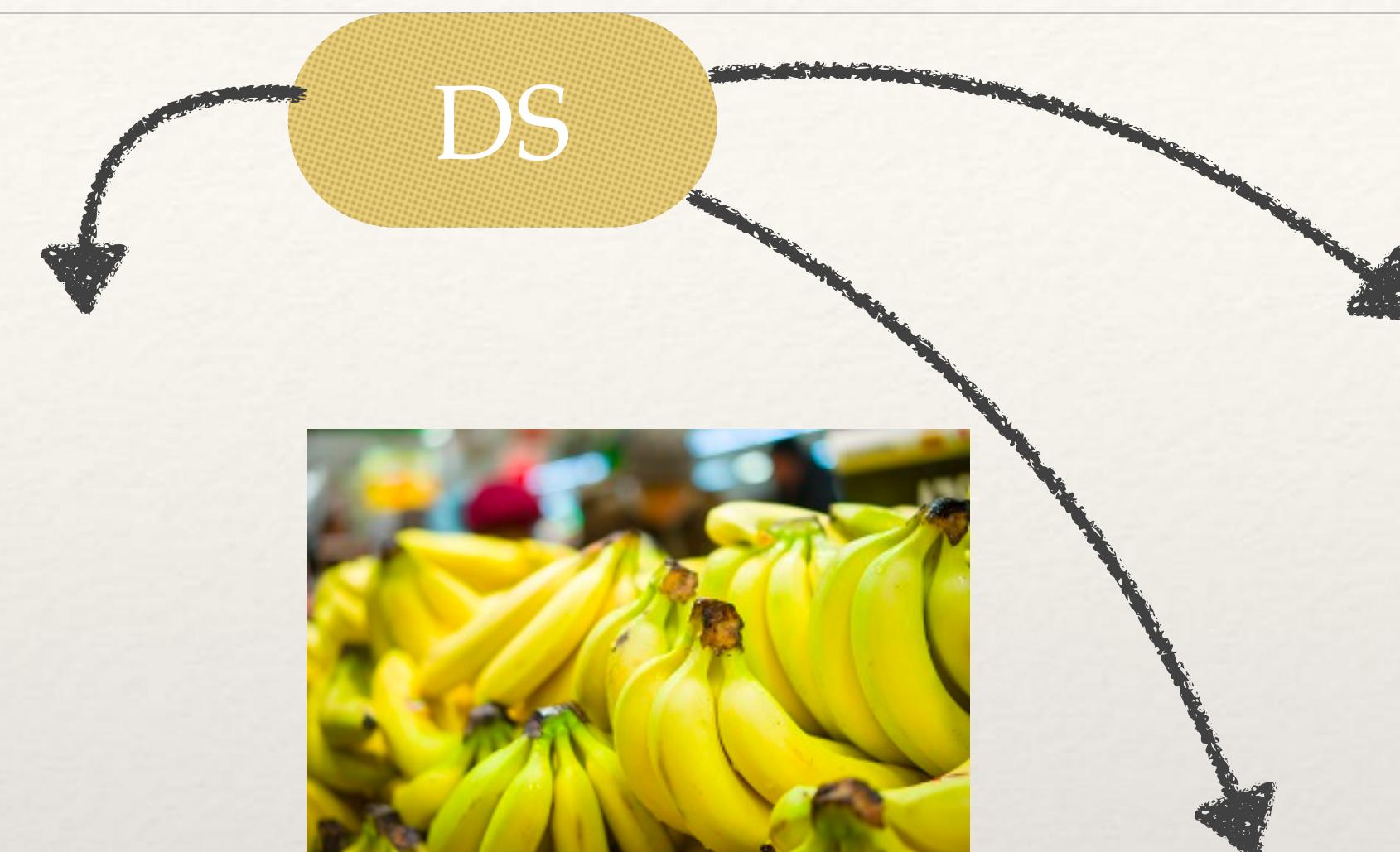
# Applied AI



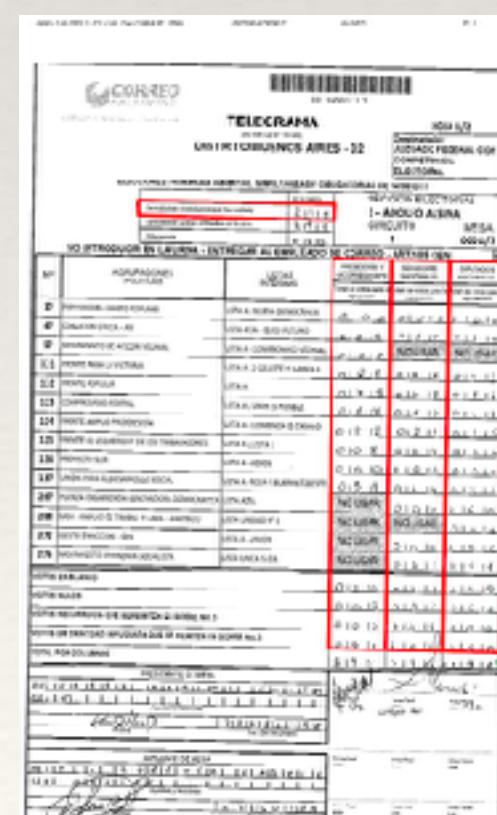
Liveness Detection



Customer Satisfaction  
NLP



Estado de la fruta  
Seguros de Exportaciones



OCR de los Telegrama Electorales

# Human Augmentation

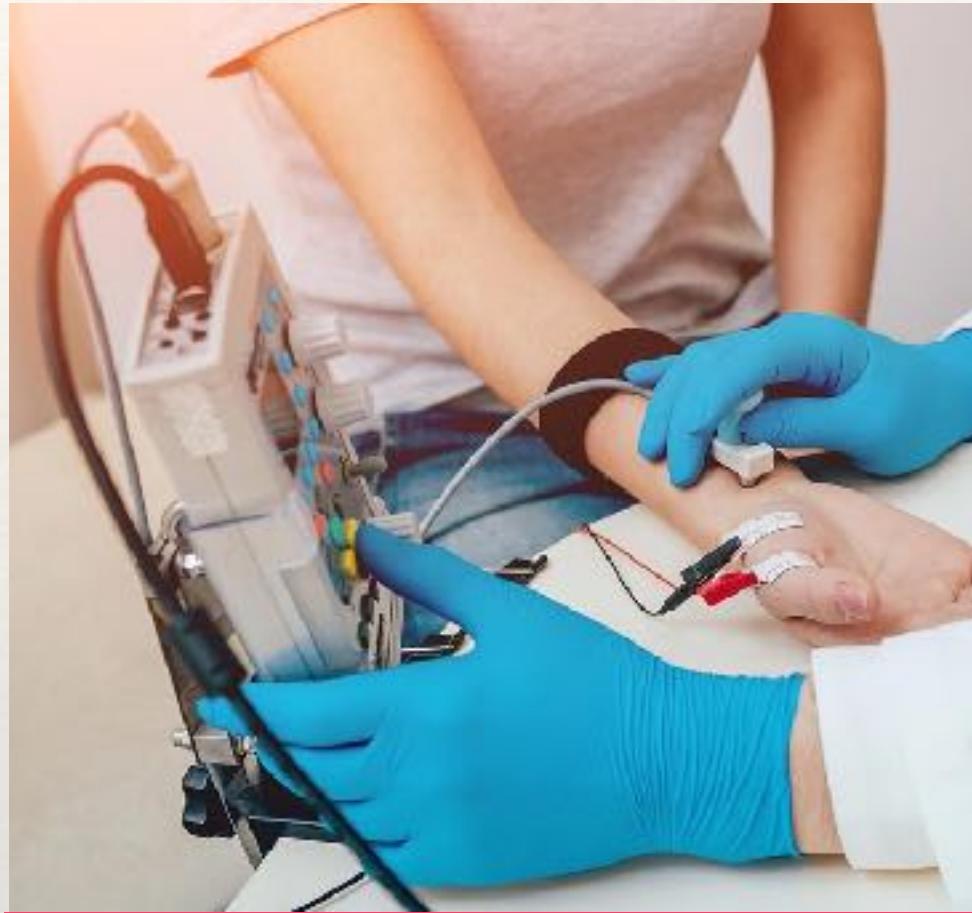


# Tecnología y Accesibilidad



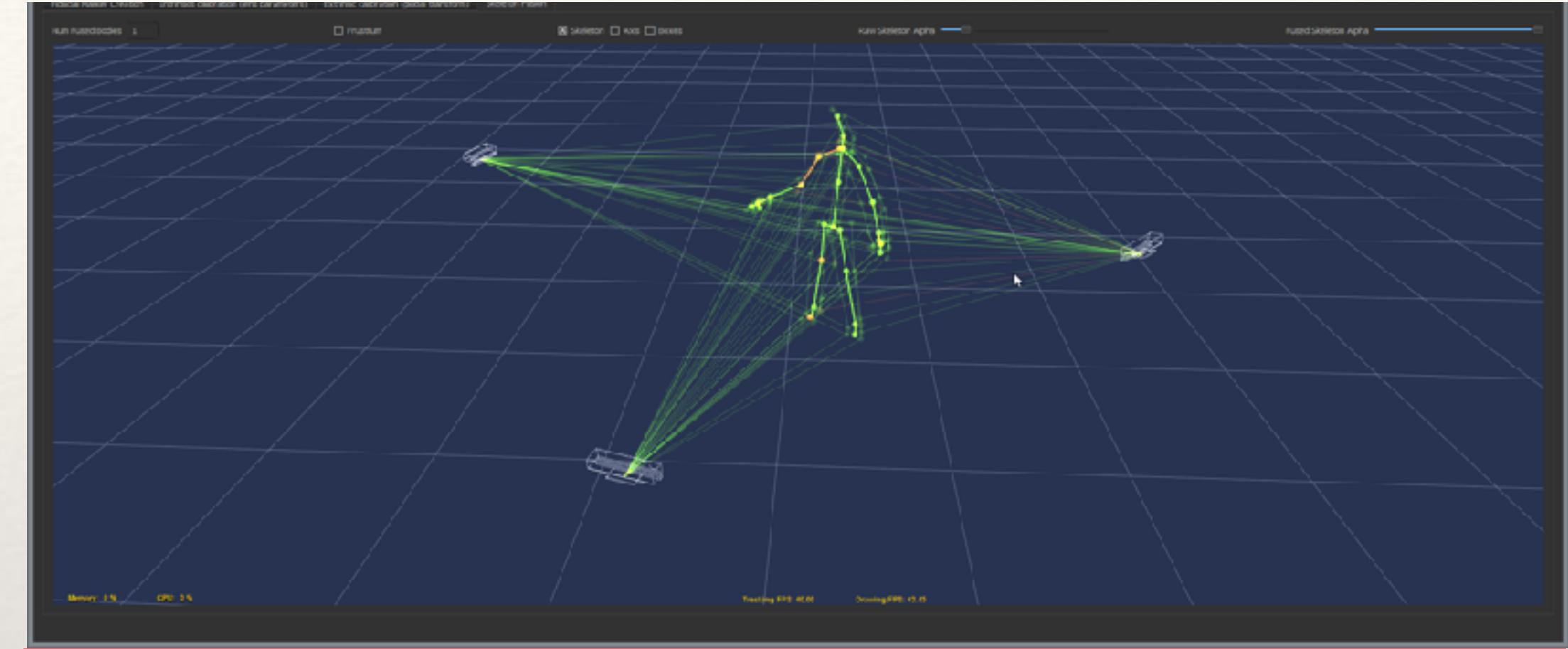
## EEG Neuroheadset

Sacar las señales del cerebro y usarlas para transmitir a una computadora, eventualmente controlar algo.



## EMG

Usar información del movimiento muscular detectándola con sensores de miografía.

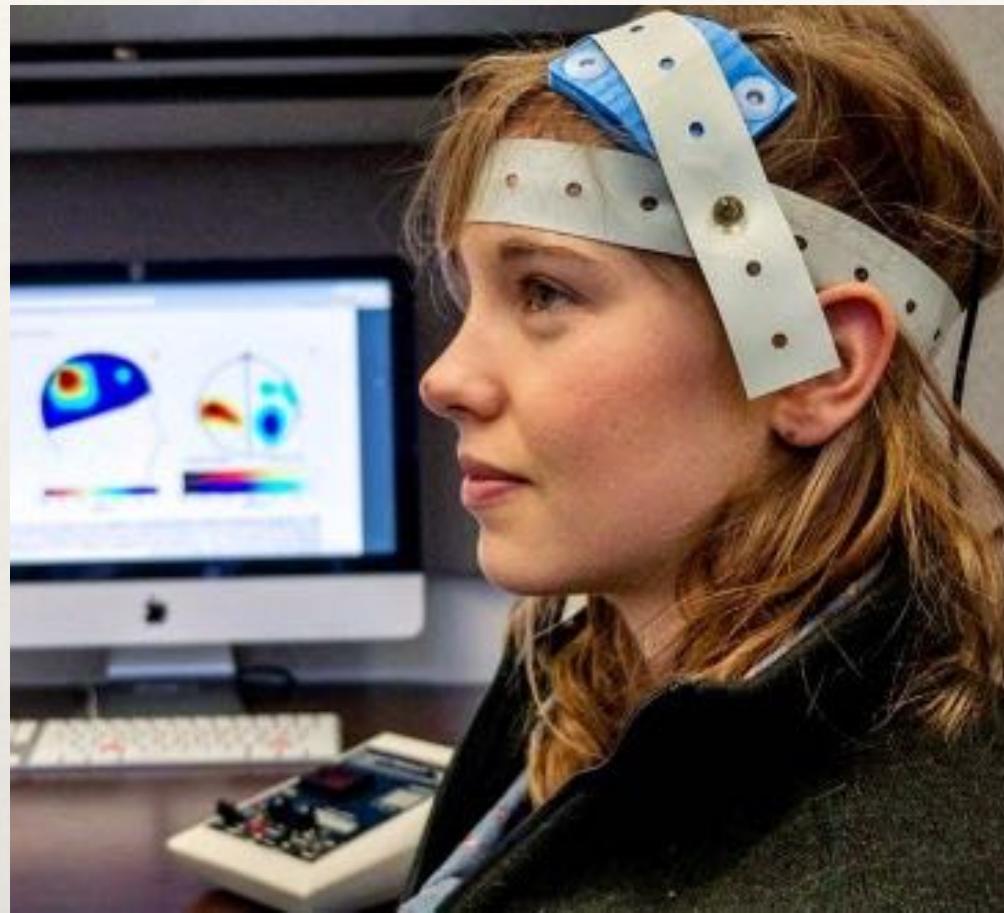


## Kinect/Fiducials/Motion Capture

Detección de movimiento. Se puede hacer usando Fiducials (marcadores que se detectan con computer visión) o con una sala o sistema de Motion Capture.

# Tecnología y Accesibilidad

WORKSHOP ILA 2021



## tDCS

Estimulación y TX de información al Cerebro por estimulación de corriente directa.



## Eyetracker

Detección de información y seguimiento de donde se mira.



## AKAT (AAC)

Sistema de Intel que usaba Stephen Hawking. Es un Augmented Alternative Communication device.

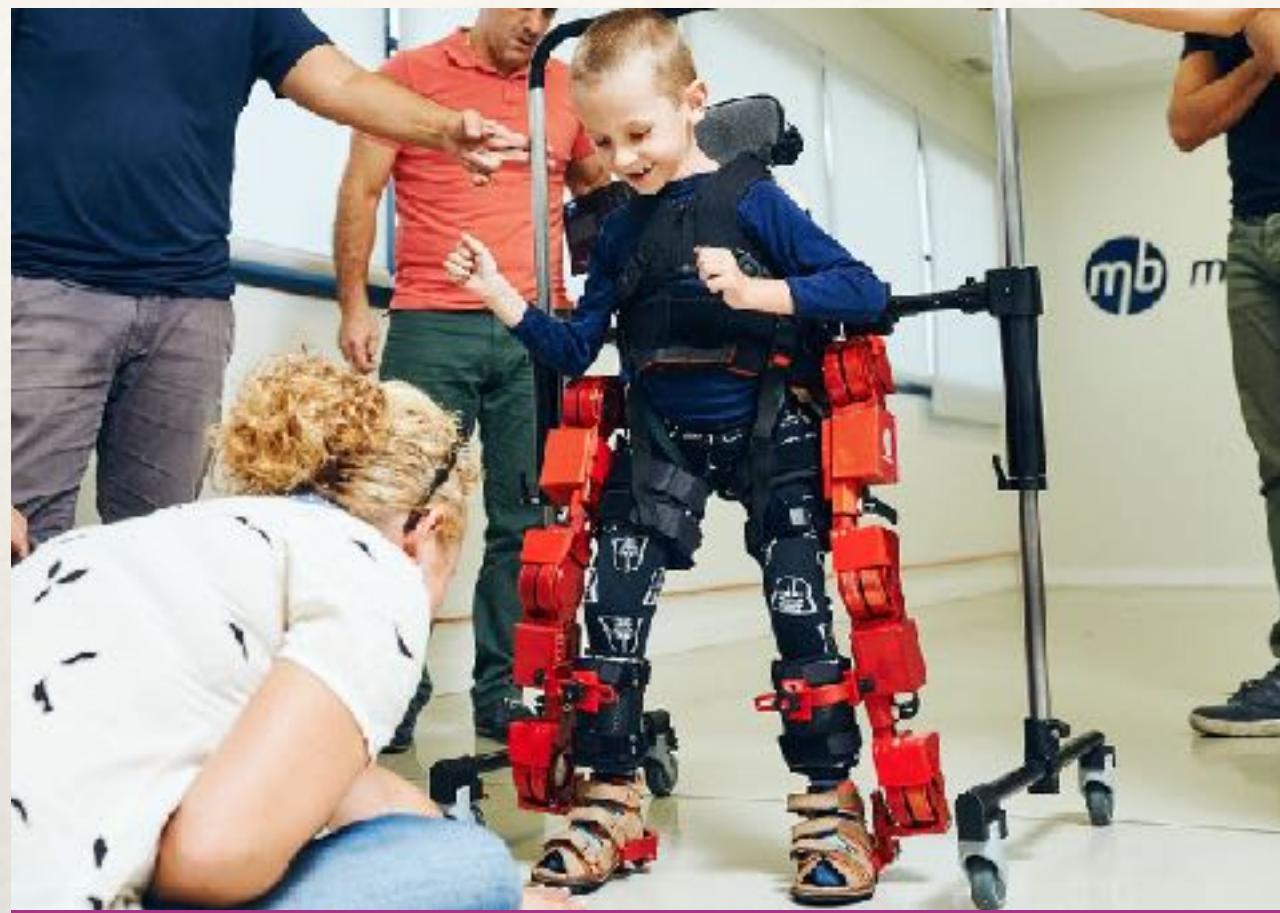


## Botones

Se usan en personas con parálisis o problemas de movimiento. Por los espasmos o la espasticidad no pueden moverse bien, pero pueden apretar un botón.

# Tecnología y Accesibilidad

WORKSHOP ILA 2021



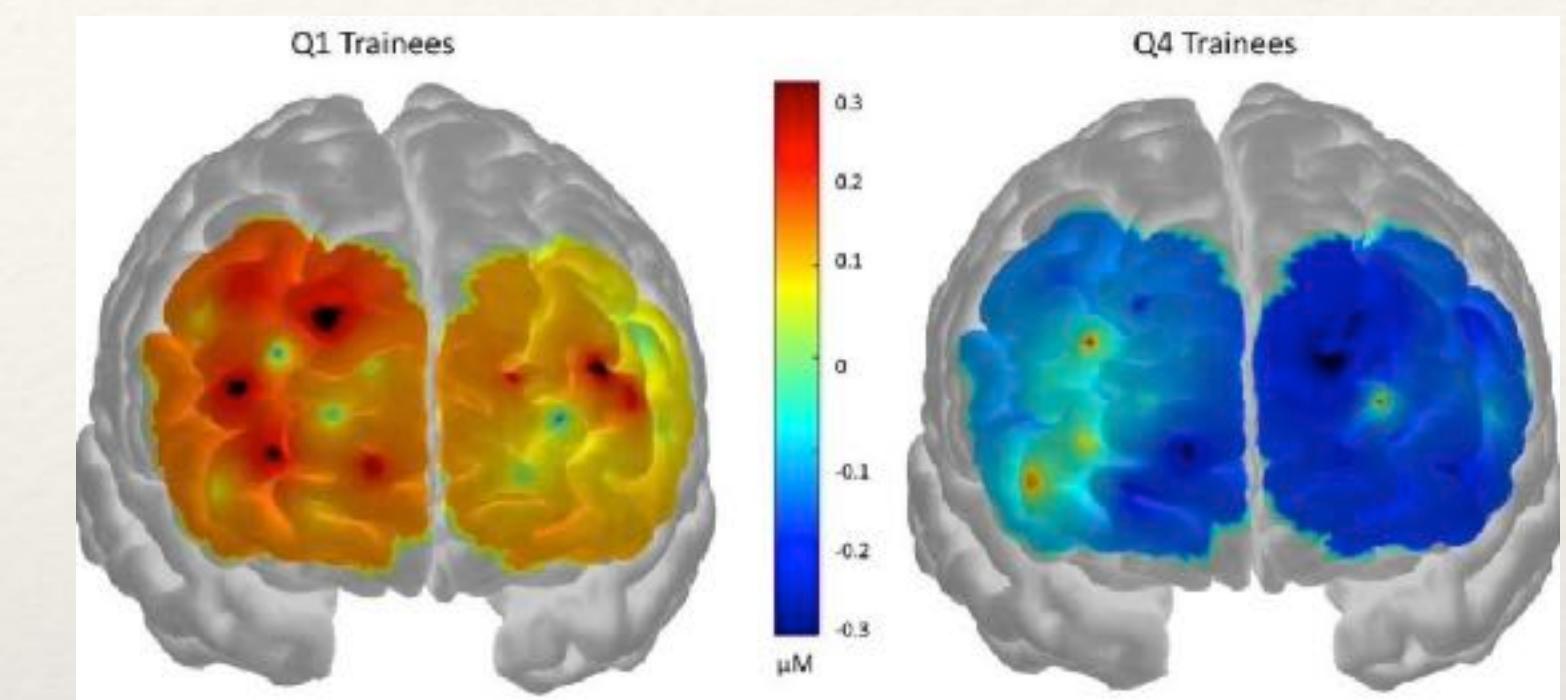
## Exoesqueleto

Predicen, acompañan, detectan el movimiento y ayudan a completarlo. Sirven para hacer rehabilitación.



## Affective Computing

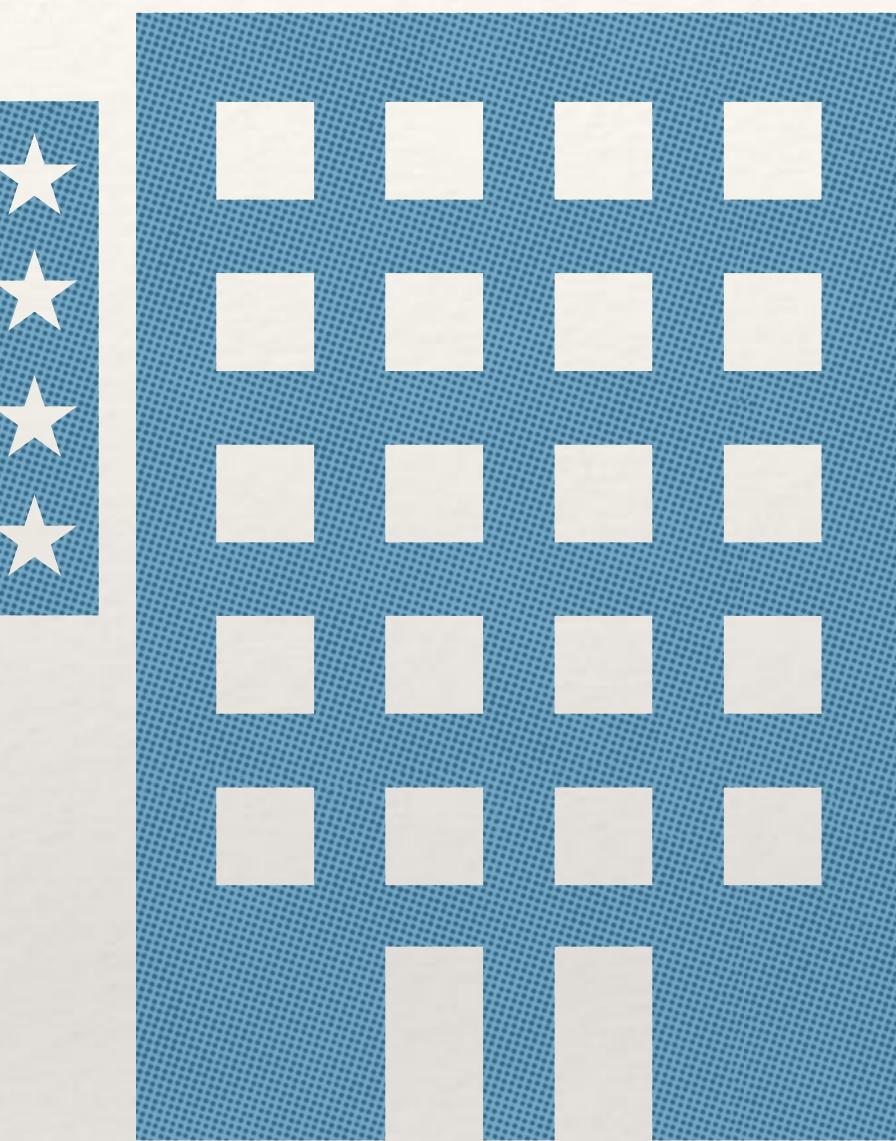
Análisis de características faciales u otras para determinar emociones.



## Neuroergonomics

Adaptación del workload en base a análisis de biopotenciales.

# Corporate Augmentation



# IoT Security

- Identity and Data Thief
- Device Manipulation
- Server/Network Manipulation
- Increasing exposure to blurred Line of Business
- Critical Safety Risks

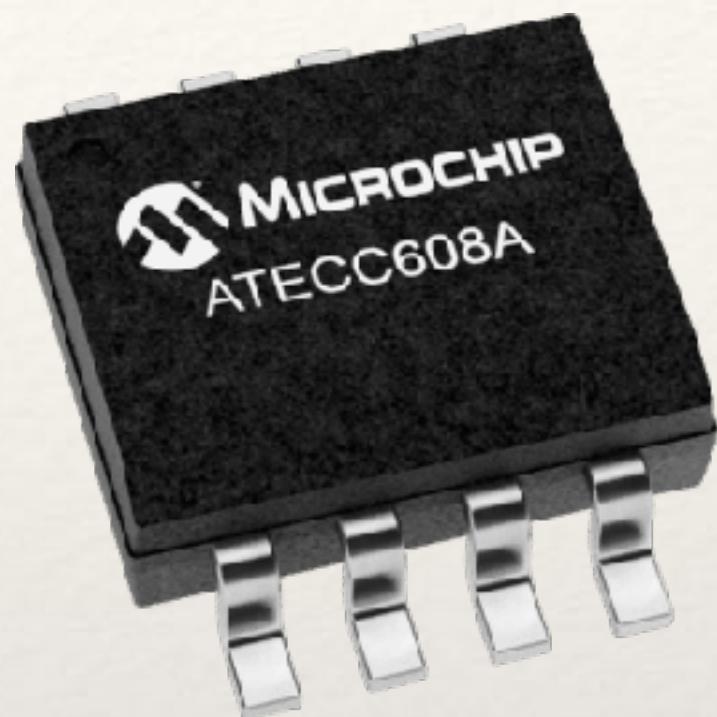
Three Layers:

- \* Perception Layer: Cryptochips and Abnormal sensor readings
- \* Application Layer: Authentication, data protection and recovery. Vulnerabilities.
- \* Network Layer: traditional Network Security

Privacy, Reliability and Availability. Compliance

Embedded Security

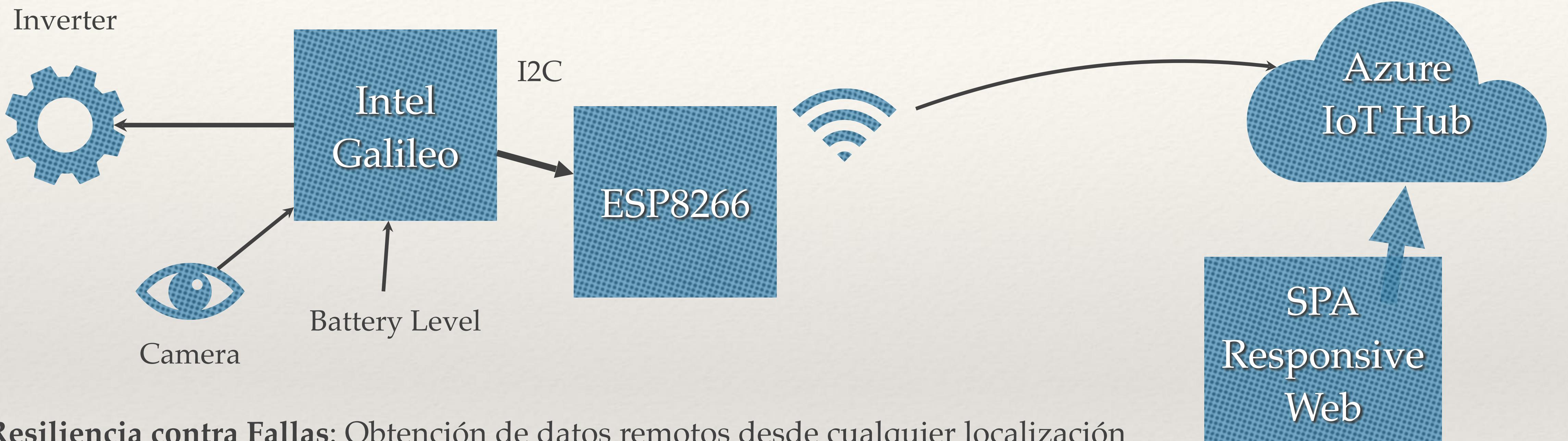
Physical Threat: reverse engineering, jamming, radio interference, tampering (tamper proof housing)



## Intrinsic Characteristics

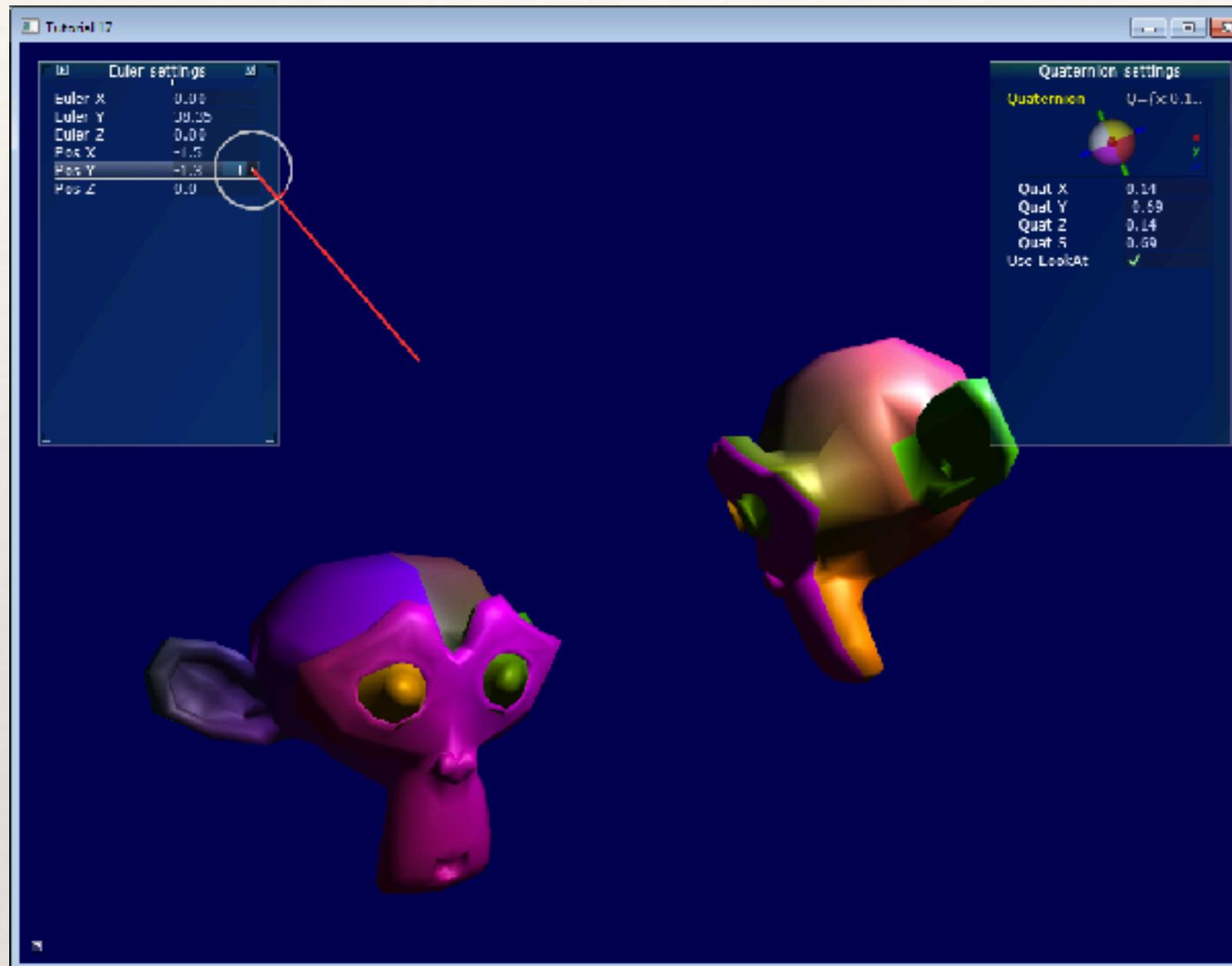
- Open Architecture
- Tampering-with is easier.
- Balance between feasibility and security
- Mobility, Wireless
- Diversity
- Scale

# IoT Architecture: Example app

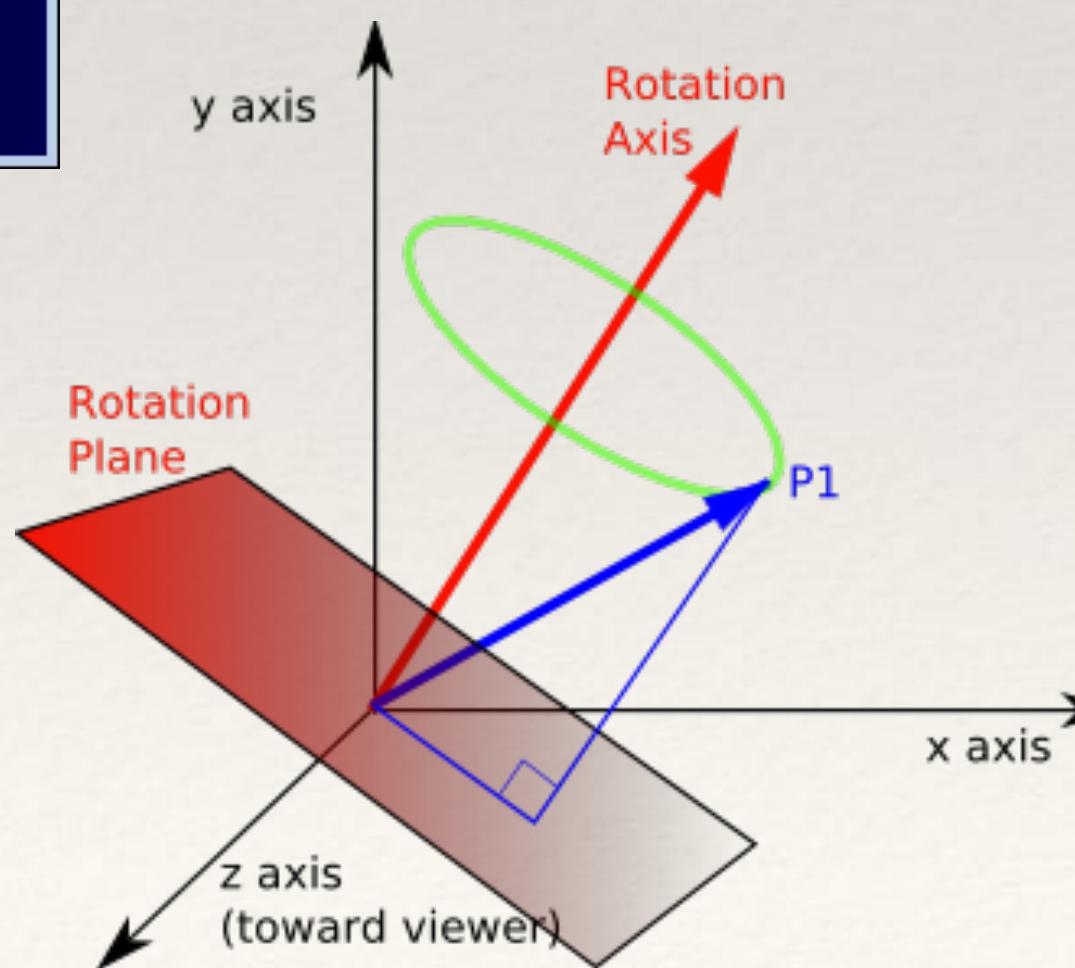


- ❖ **Resiliencia contra Fallas:** Obtención de datos remotos desde cualquier localización
- ❖ **Conectividad:** Bluetooth, NFC, RFID, Zigbee, Zwave, WiFi, LoRaWAN, GPRS, LTE, Serie, CANBUS, I2C, SPIO, GPIO
- ❖ **Seguridad:** Este es el mayor DESAFIO de IoT
- ❖ **Provisioning:** Control Operacional

# Gaming and Computer Graphics



- ❖ **Simulated World:** an agent needs to be able to play alongside humans, even beat them in a controlled environment.
- ❖ **3D Motion:** Gaming share the problem of direct kinematic, dynamics, translations and rotations.



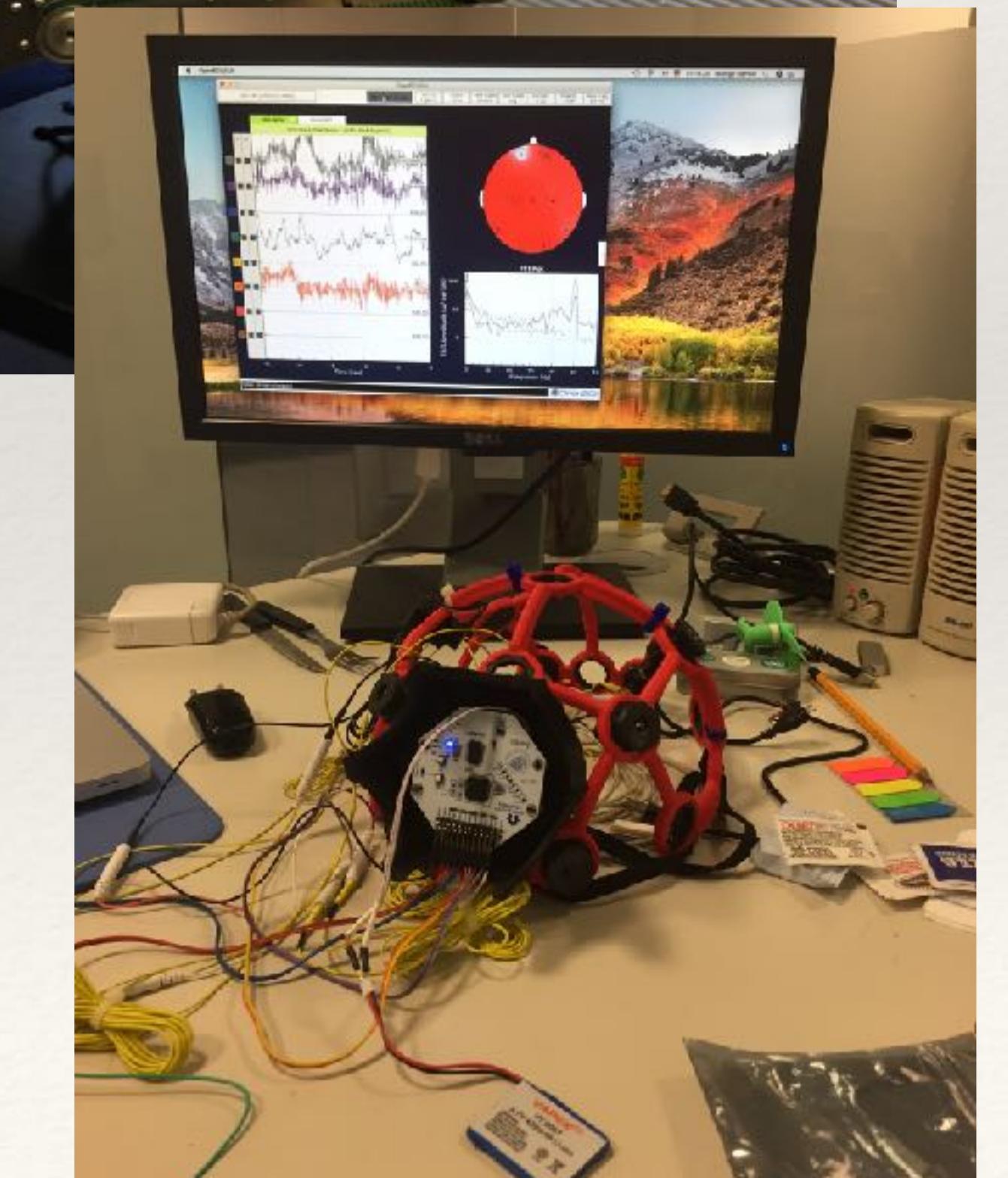
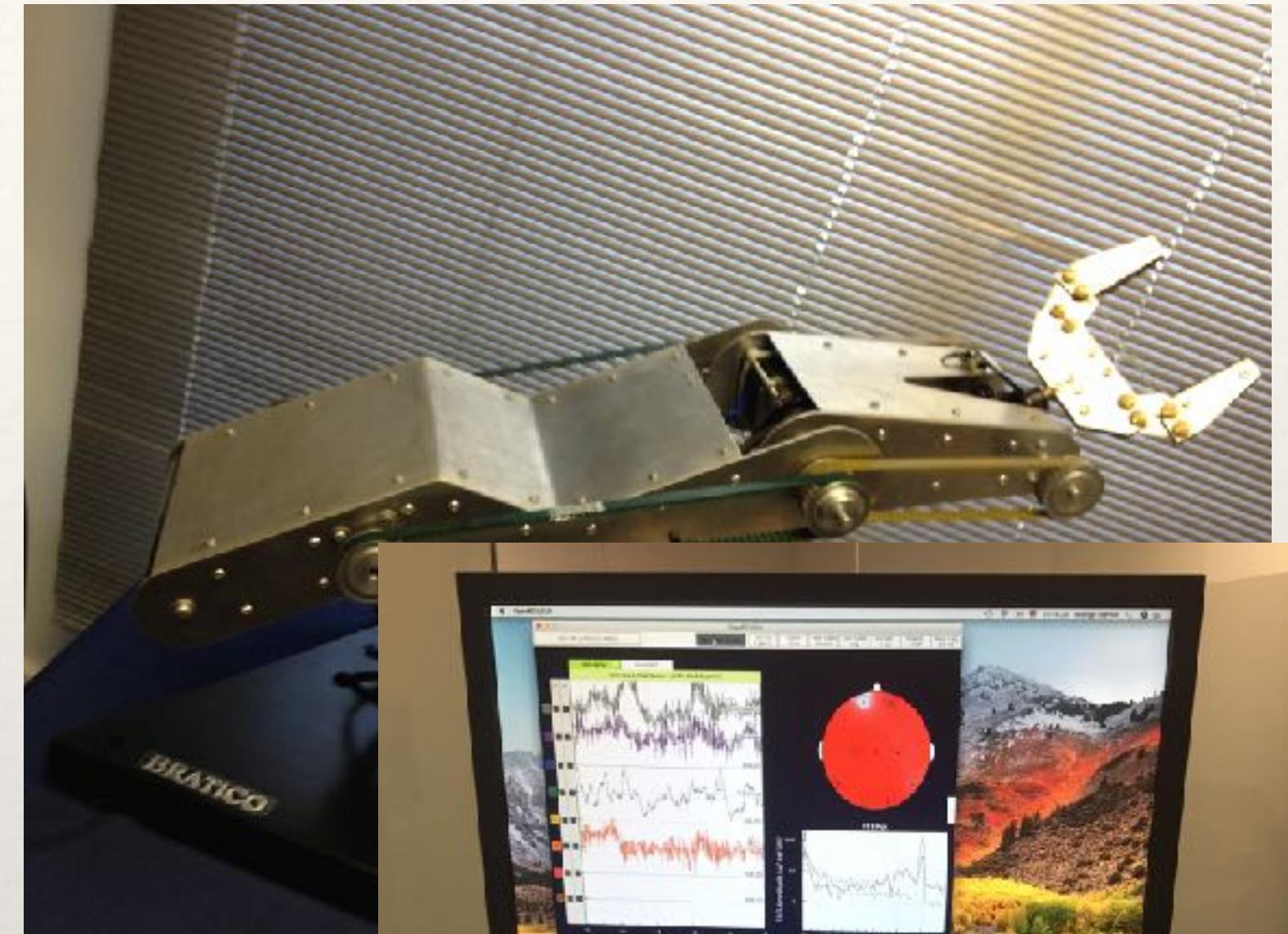
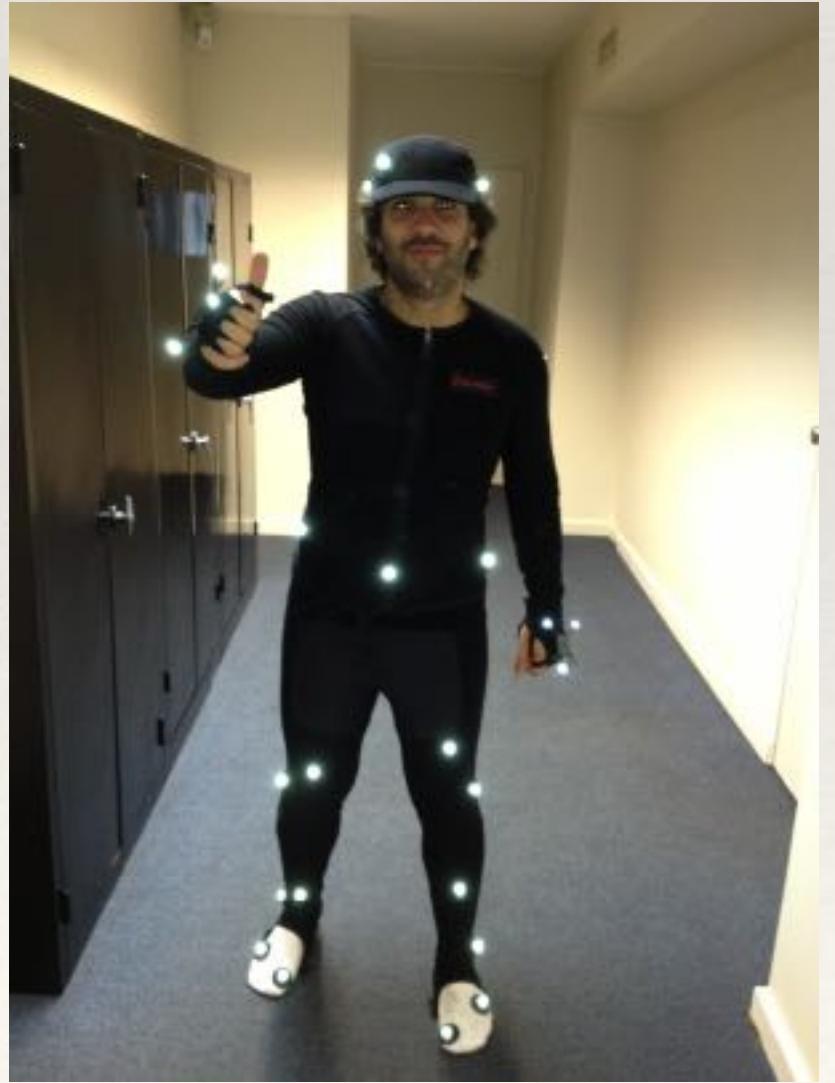
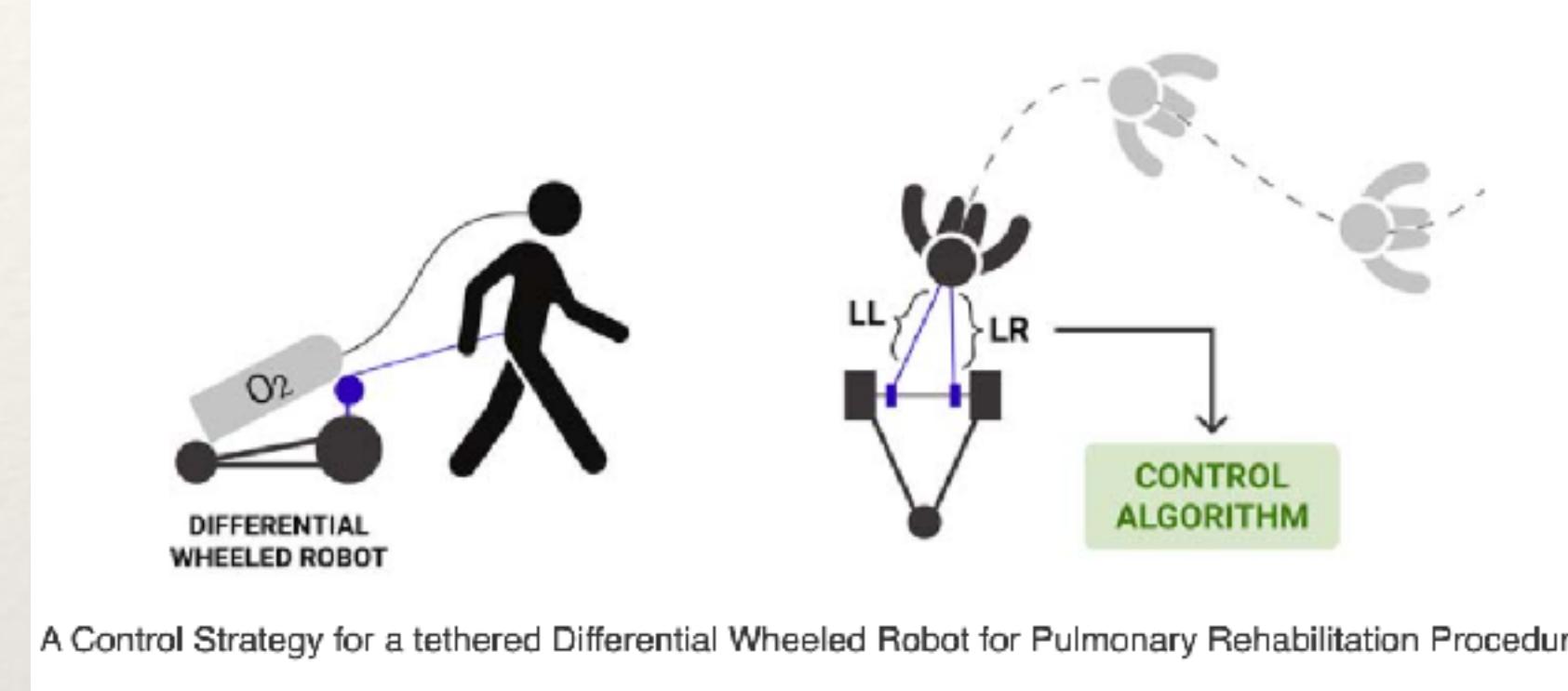
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# Ejercicio

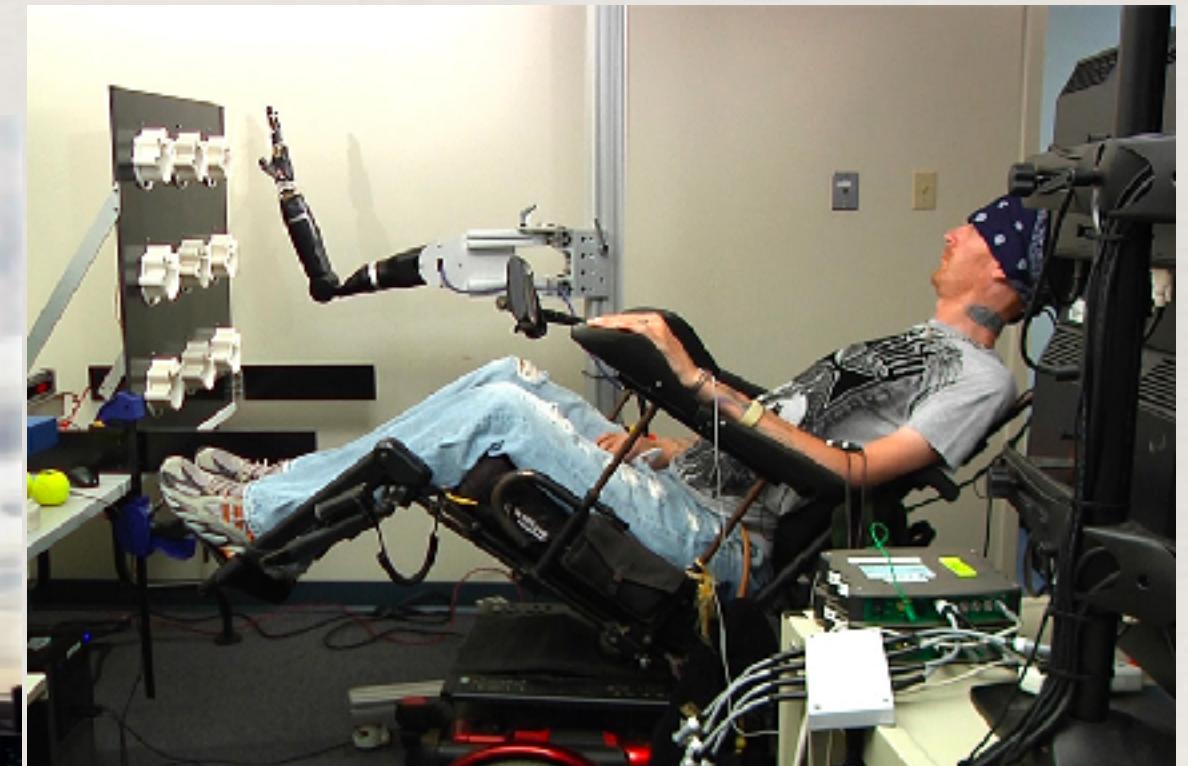
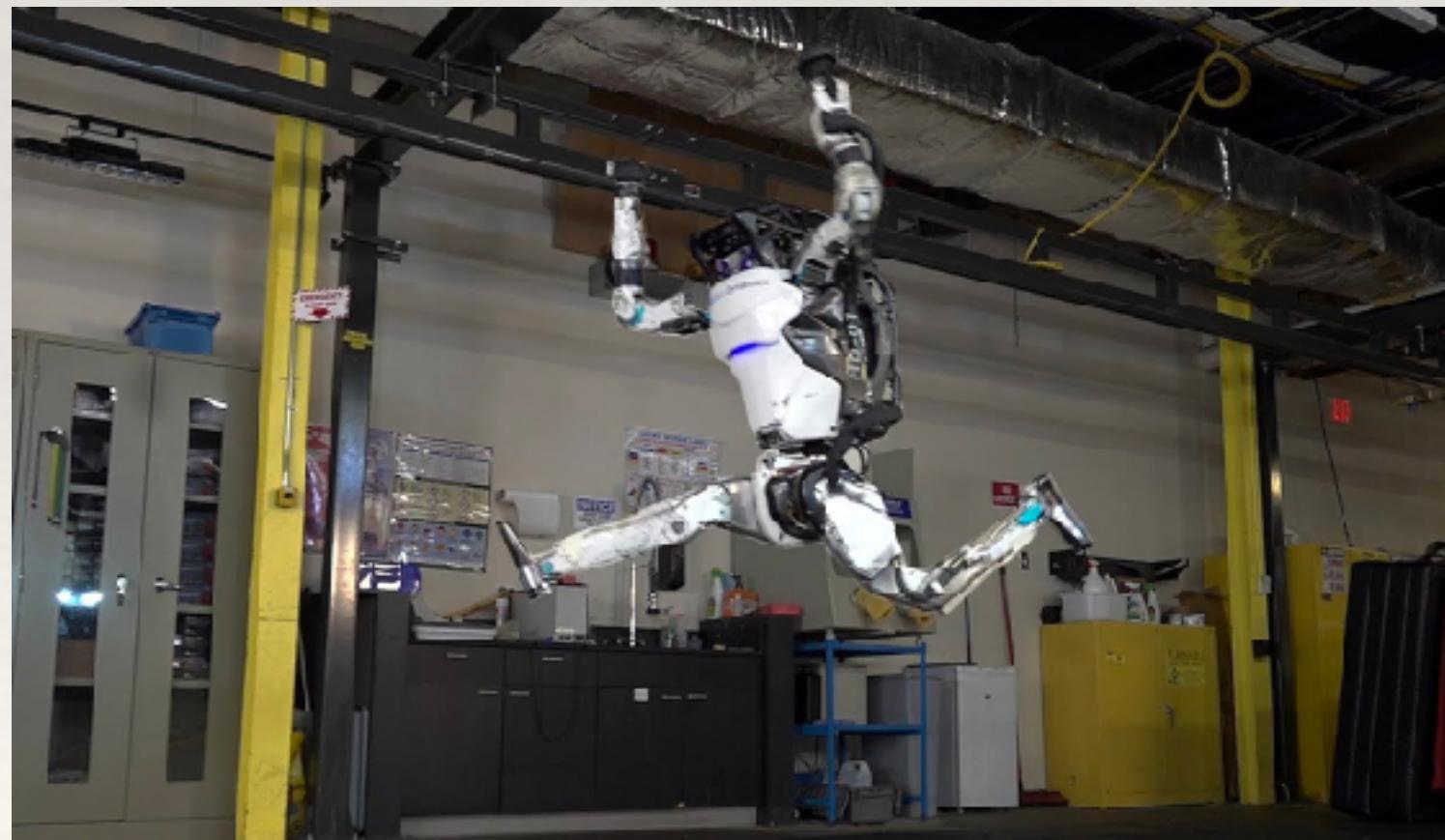
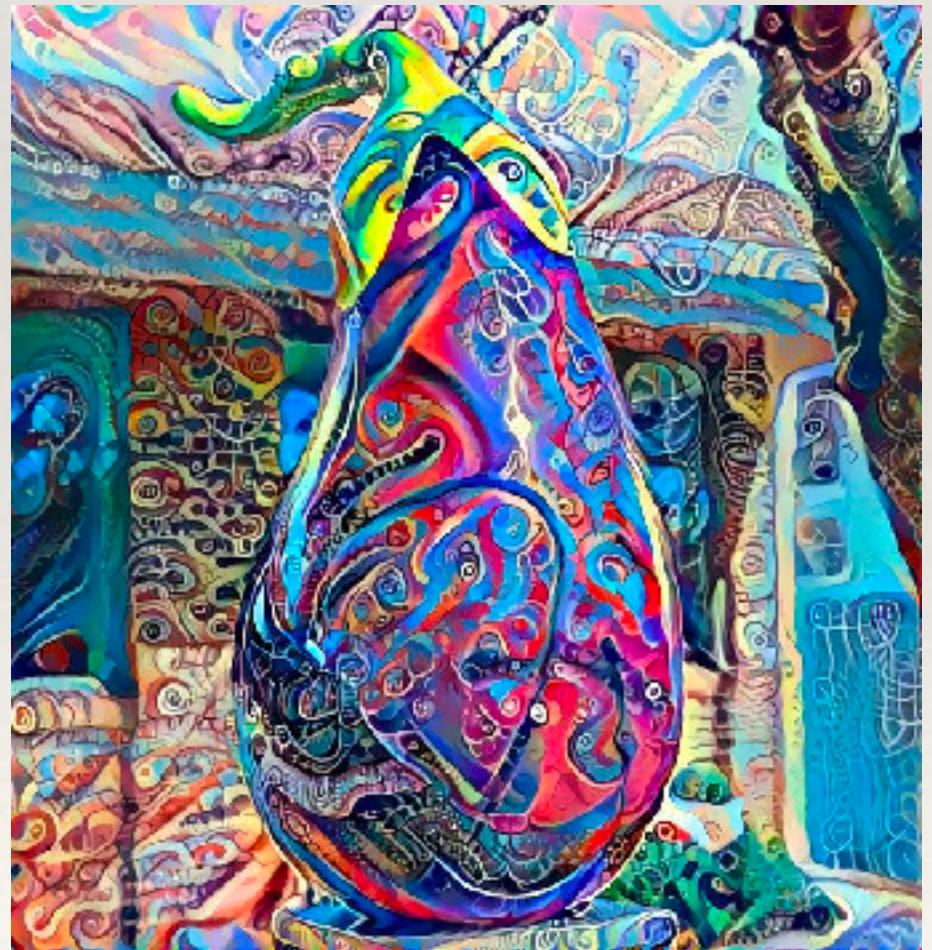
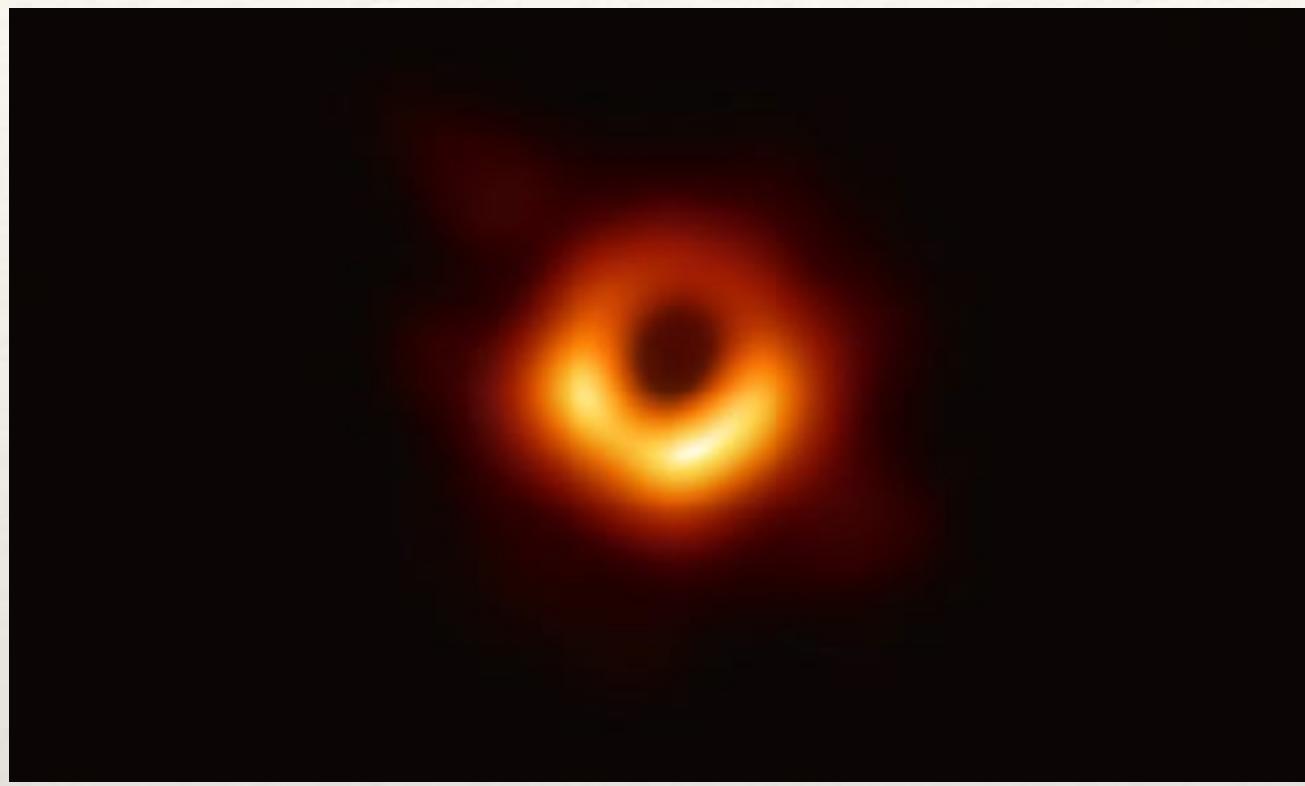
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- ❖ Quieren hacerse un robot que les alcance la sal en la mesa, que ese sea el propósito de su existencia.  
¿Cómo automatizarían todo el proceso? Definirlo paso a paso, incluyendo cómo harían con el software.

# Interdisciplinary Engineering



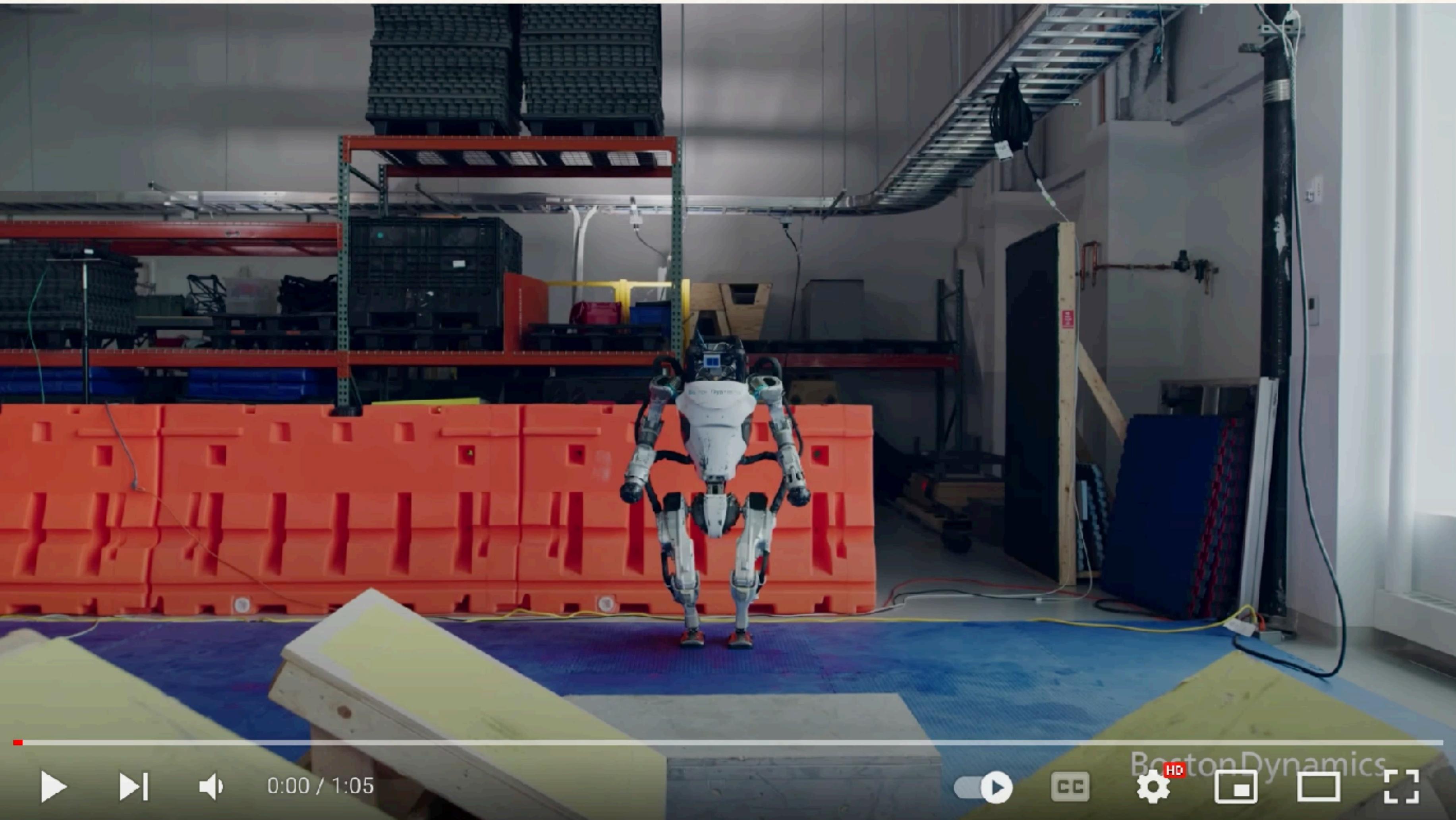
# XXI Century Global Projects

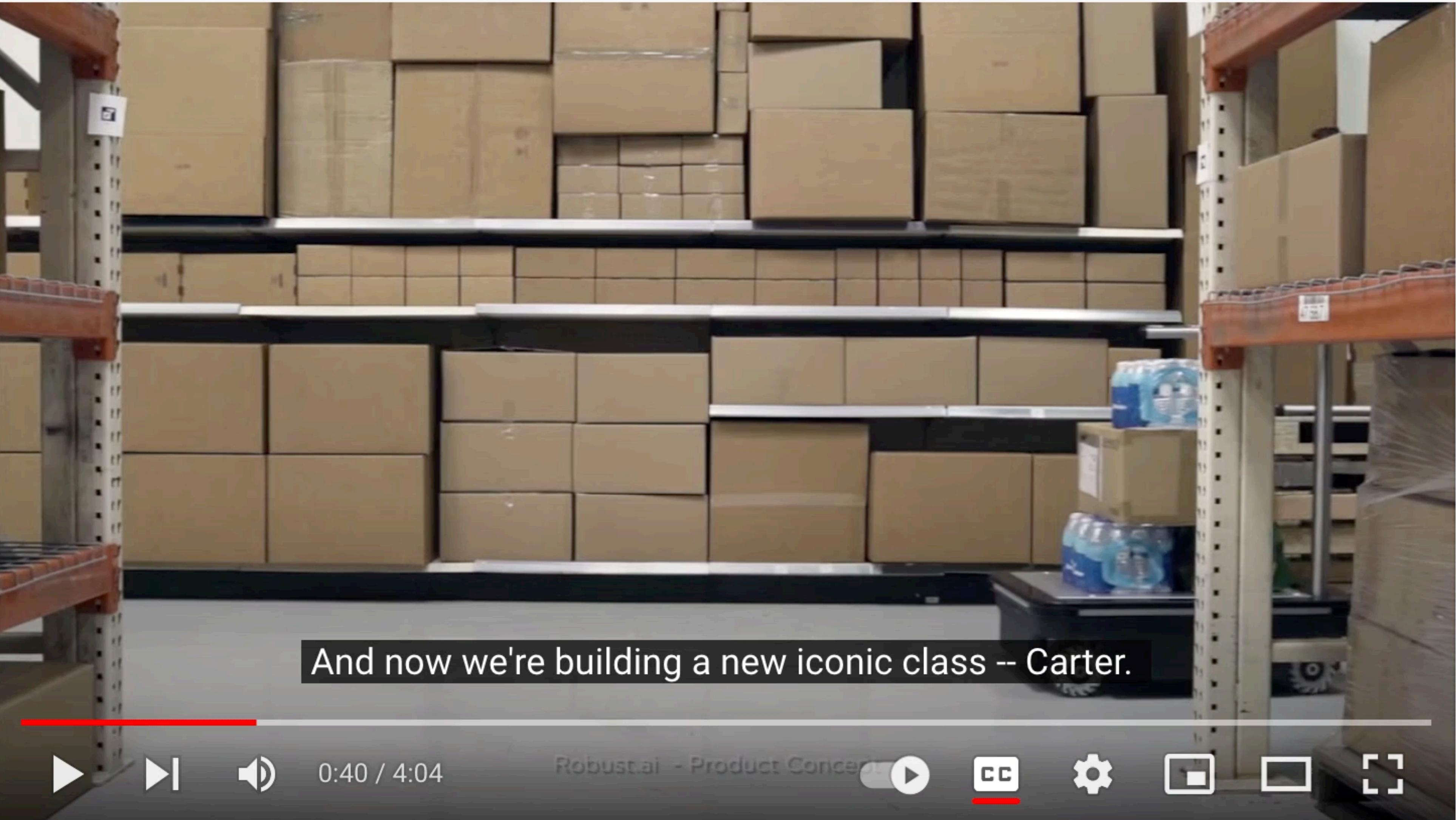


# Manufacturing



# Robotics





And now we're building a new iconic class -- Carter.



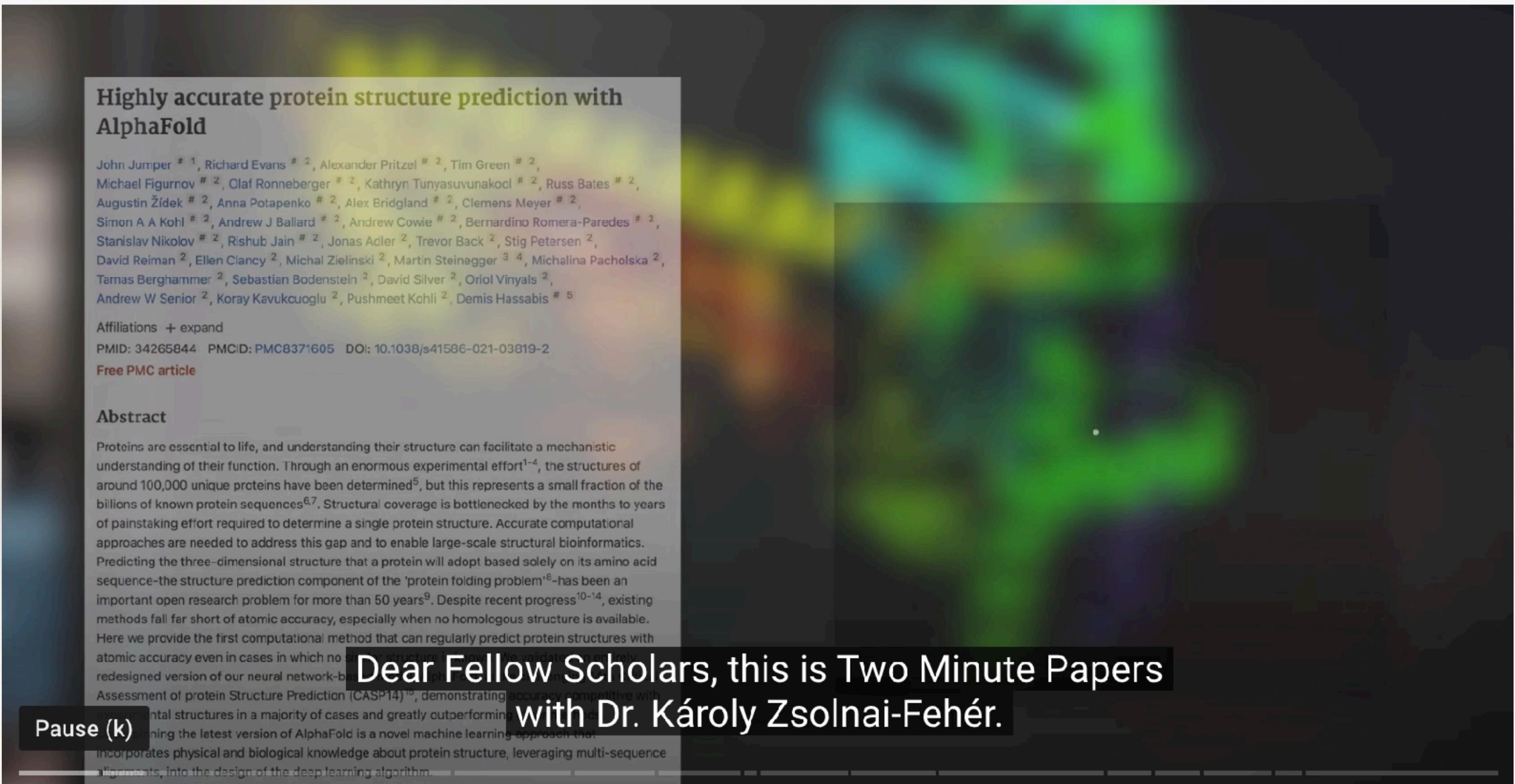
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Robust.ai - Product Concept



Robust.AI on Collaborative Productivity

# AlphaFold



**Highly accurate protein structure prediction with AlphaFold**

John Jumper <sup># 1</sup>, Richard Evans <sup># 2</sup>, Alexander Pritzel <sup># 2</sup>, Tim Green <sup># 2</sup>, Michael Figurnov <sup># 2</sup>, Olaf Ronneberger <sup># 2</sup>, Kathryn Tunyasuvunakool <sup># 2</sup>, Russ Bates <sup># 2</sup>, Augustin Žídek <sup># 2</sup>, Anna Potapenko <sup># 2</sup>, Alex Bridgland <sup># 2</sup>, Clemens Meyer <sup># 2</sup>, Simon A A Kohl <sup># 2</sup>, Andrew J Ballard <sup># 2</sup>, Andrew Cowie <sup># 2</sup>, Bernardino Romera-Paredes <sup># 2</sup>, Stanislav Nikolov <sup># 2</sup>, Rishabh Jain <sup># 2</sup>, Jonas Adler <sup>2</sup>, Trevor Back <sup>2</sup>, Stig Petersen <sup>2</sup>, David Reiman <sup>2</sup>, Ellen Clancy <sup>2</sup>, Michał Zieliński <sup>2</sup>, Martin Steinegger <sup>3 4</sup>, Michalina Pacholska <sup>2</sup>, Tamás Berghammer <sup>2</sup>, Sebastian Bodenstein <sup>2</sup>, David Silver <sup>2</sup>, Oriol Vinyals <sup>2</sup>, Andrew W Senior <sup>2</sup>, Koray Kavukcuoglu <sup>2</sup>, Pushmeet Kohli <sup>2</sup>, Demis Hassabis <sup># 5</sup>

Affiliations + expand

PMID: 34265844 PMCID: PMC8371605 DOI: 10.1038/s41586-021-03819-2

[Free PMC article](#)

**Abstract**

Proteins are essential to life, and understanding their structure can facilitate a mechanistic understanding of their function. Through an enormous experimental effort<sup>1–4</sup>, the structures of around 100,000 unique proteins have been determined<sup>5</sup>, but this represents a small fraction of the billions of known protein sequences<sup>6,7</sup>. Structural coverage is bottlenecked by the months to years of painstaking effort required to determine a single protein structure. Accurate computational approaches are needed to address this gap and to enable large-scale structural bioinformatics. Predicting the three-dimensional structure that a protein will adopt based solely on its amino acid sequence—the structure prediction component of the ‘protein folding problem’<sup>8</sup>—has been an important open research problem for more than 50 years<sup>9</sup>. Despite recent progress<sup>10–14</sup>, existing methods fall far short of atomic accuracy, especially when no homologous structure is available. Here we provide the first computational method that can regularly predict protein structures with atomic accuracy even in cases in which no similar structure is known. We validate it entirely on a redesigned version of our neural network-based protein structure prediction system, AlphaFold. AlphaFold’s performance on the latest version of AlphaFold is a novel machine learning approach that

**Dear Fellow Scholars, this is Two Minute Papers with Dr. Károly Zsolnai-Fehér.**

Pause (k)

Incorporates physical and biological knowledge about protein structure, leveraging multi-sequence alignments, into the design of the deep learning algorithm.

# Dall-e 2





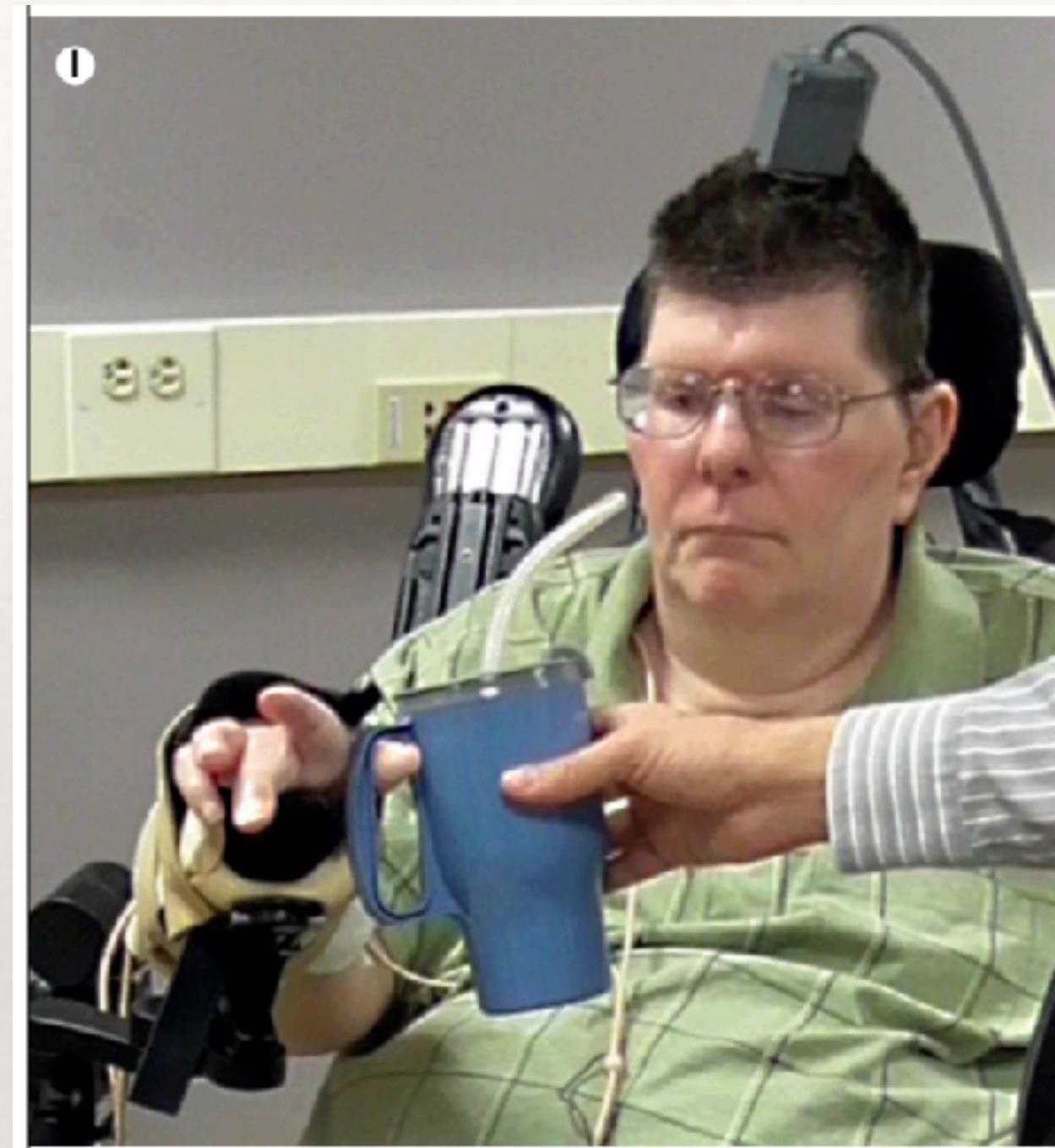
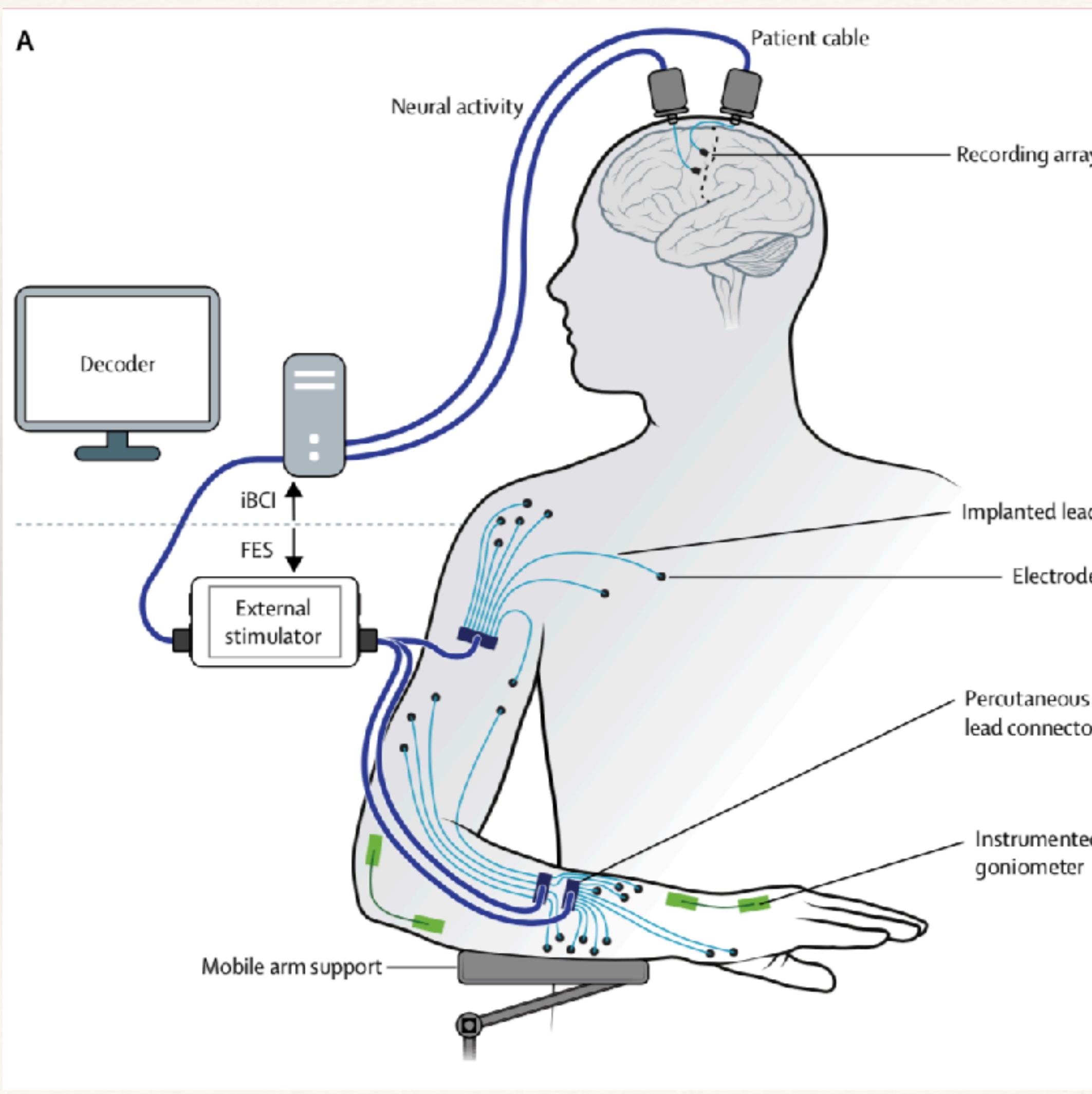
Next  
WITH KYLE CLARK

# XXI eSports



Unreal Engine 4

# Assistive Technologies



# Neuralink

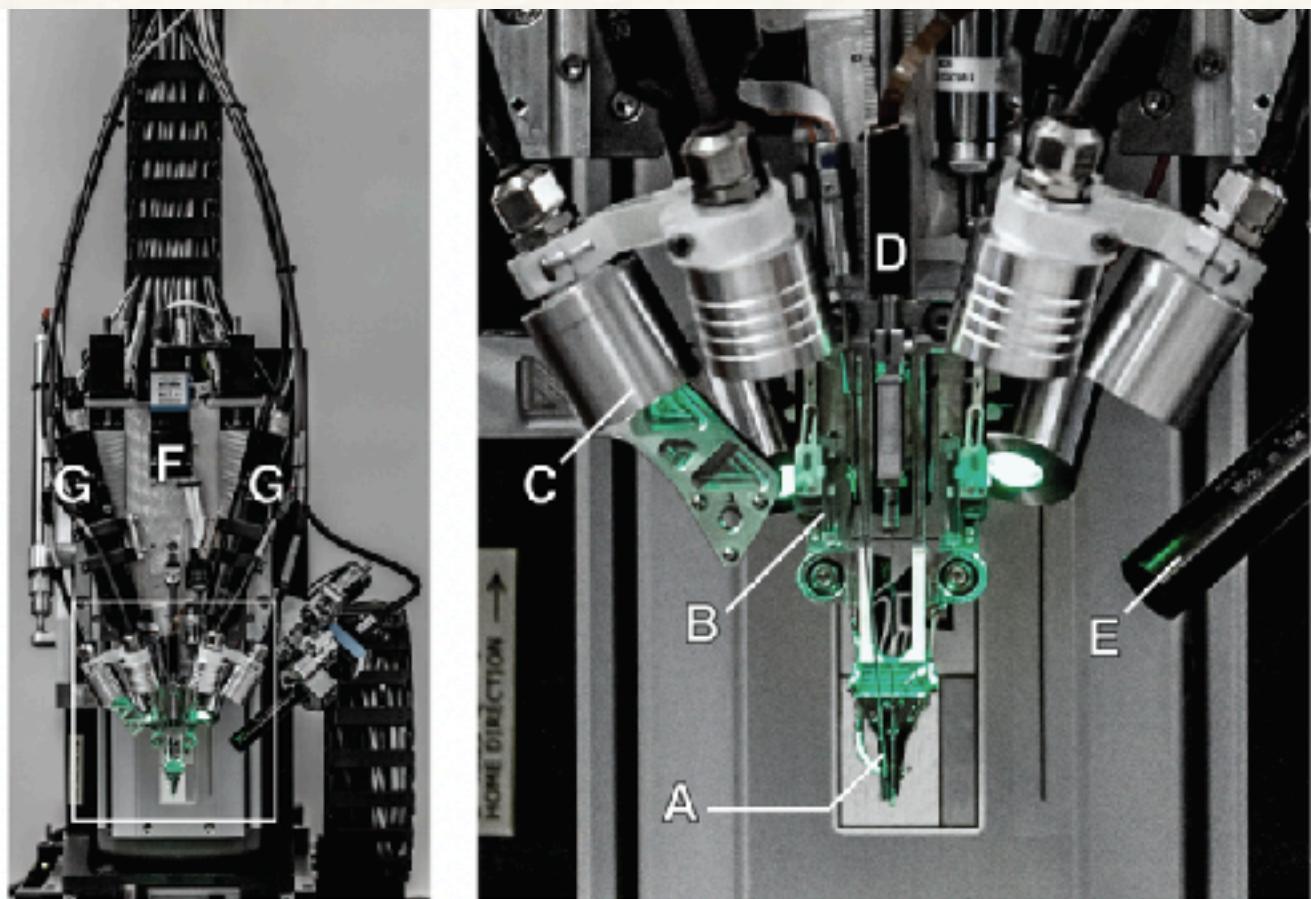
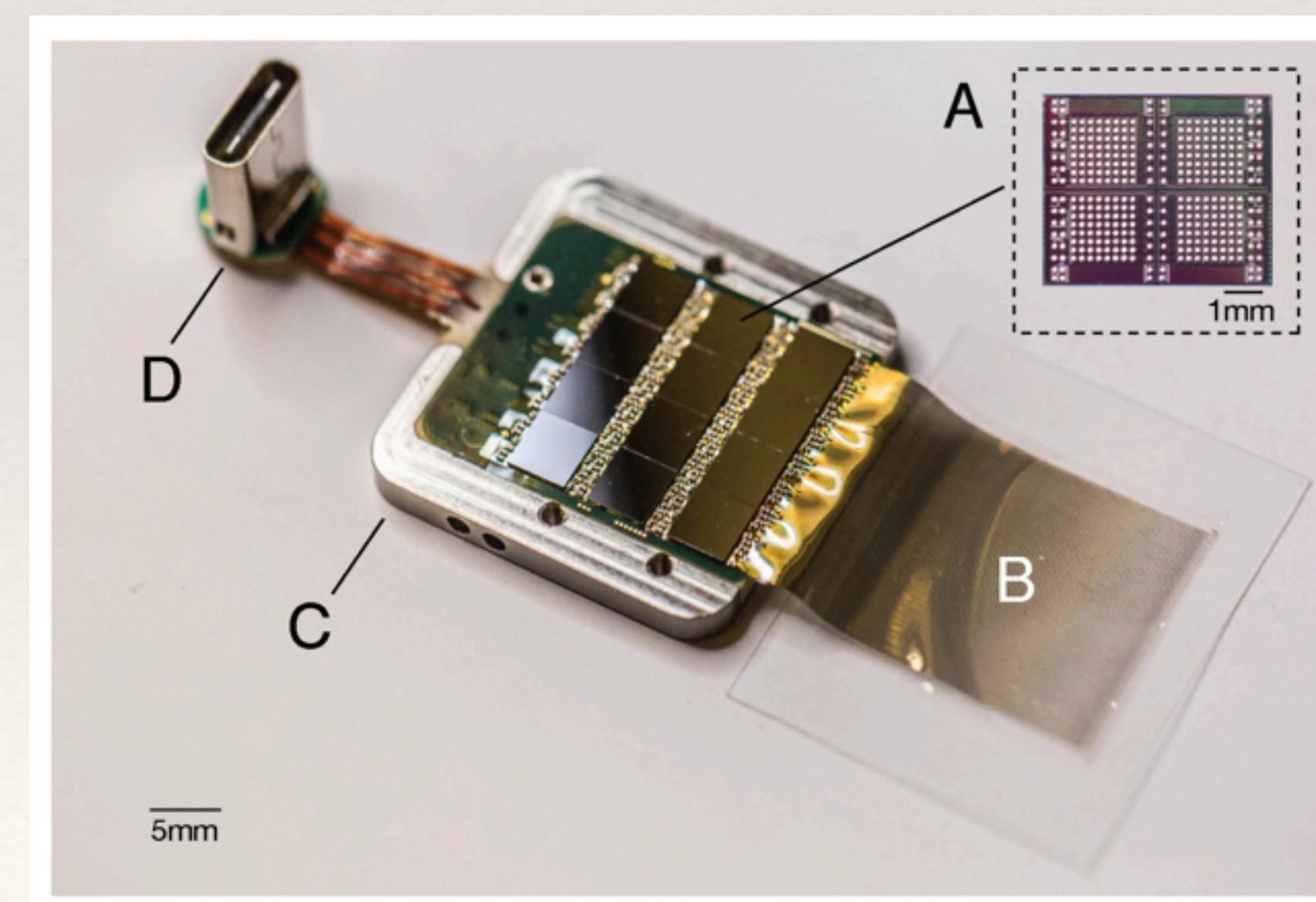
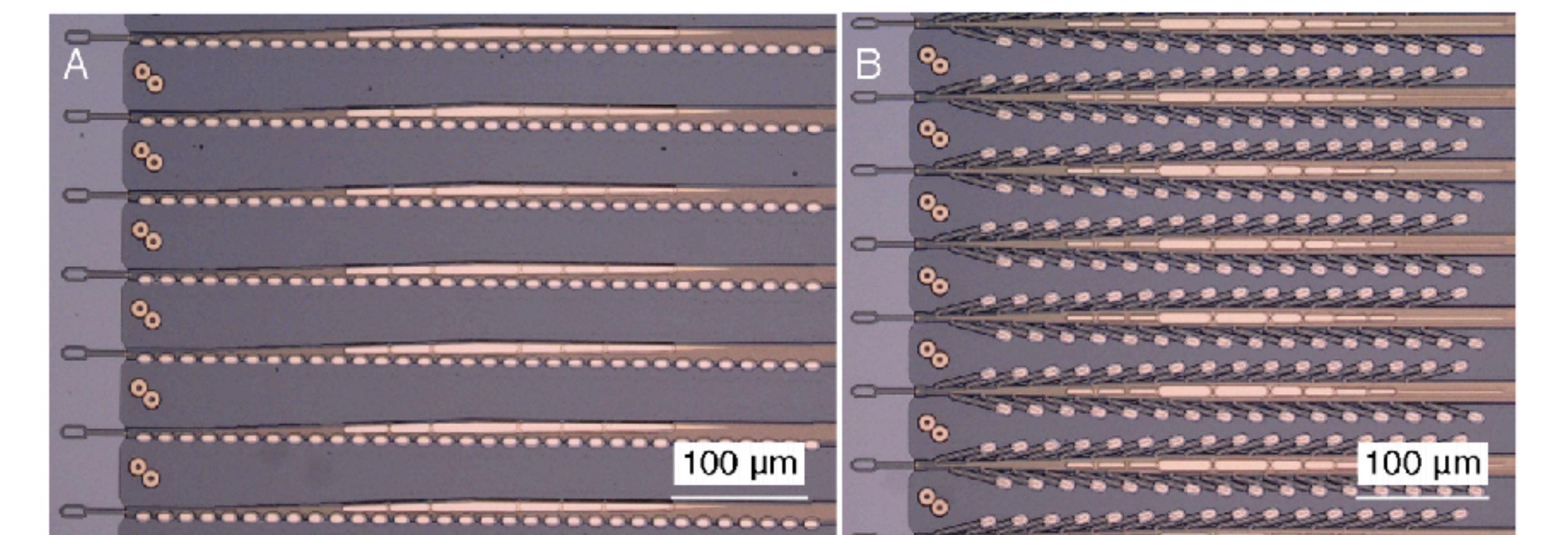
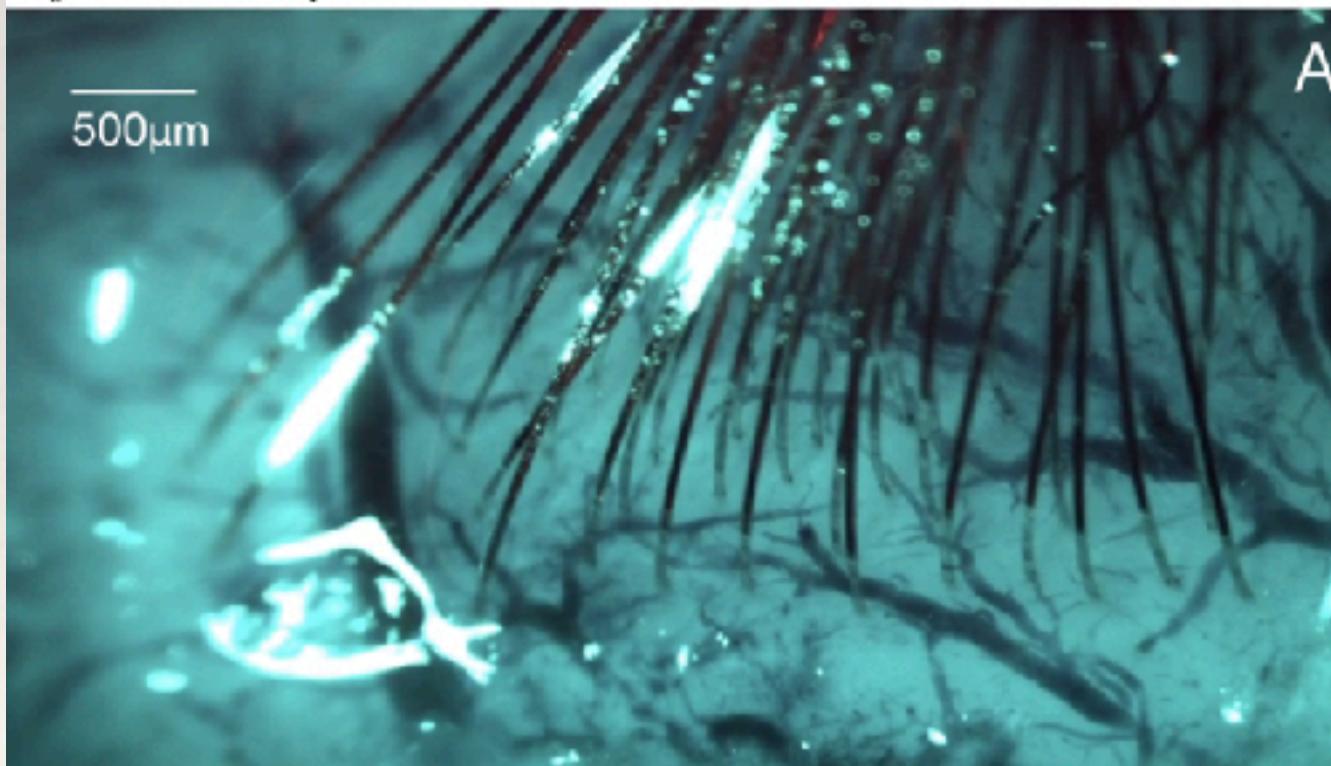
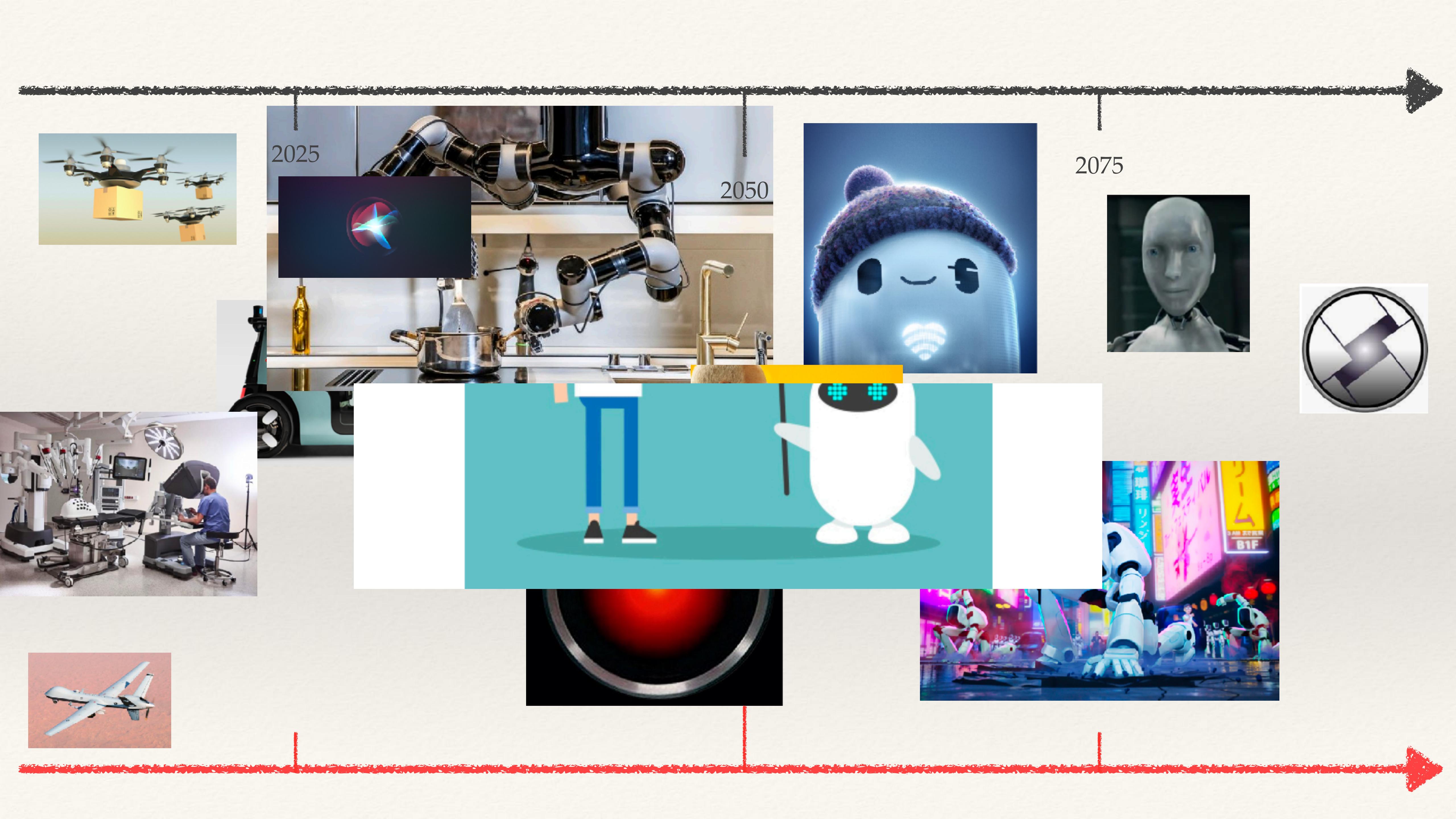


Figure 3: The robotic electrode inserter; enlarged view of the inserter-head shown in the inset. A. Loaded needle pincher cartridge. B. Low-force contact brain position sensor. C. Light modules with multiple independent wavelengths. D. Needle motor. E. One of four cameras focused on the needle during insertion. F. Camera with wide angle view of surgical field. G. Stereoscopic cameras.





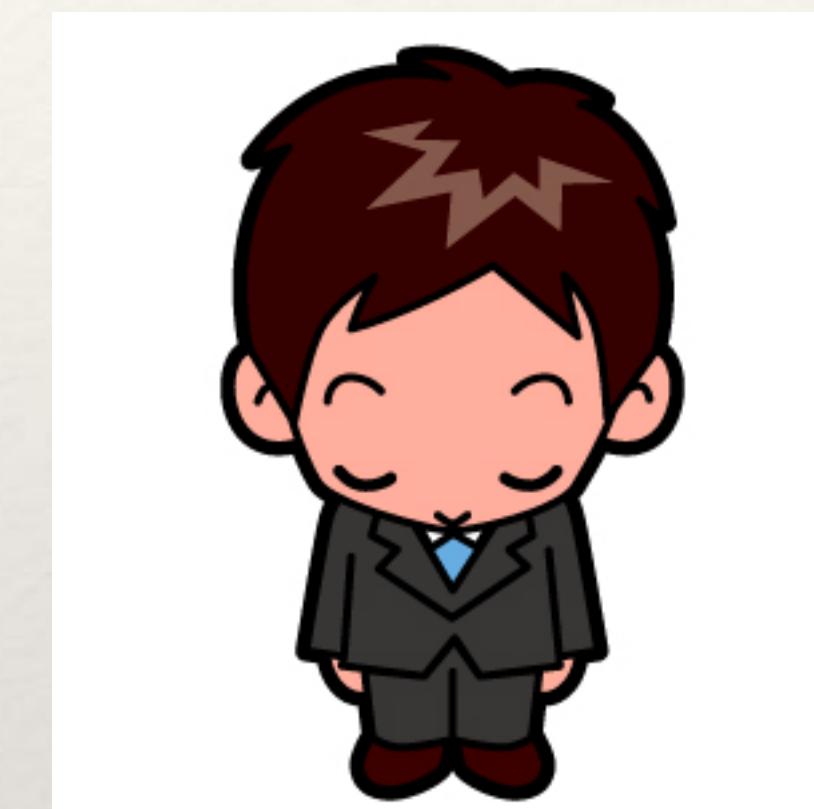
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# Conclusions

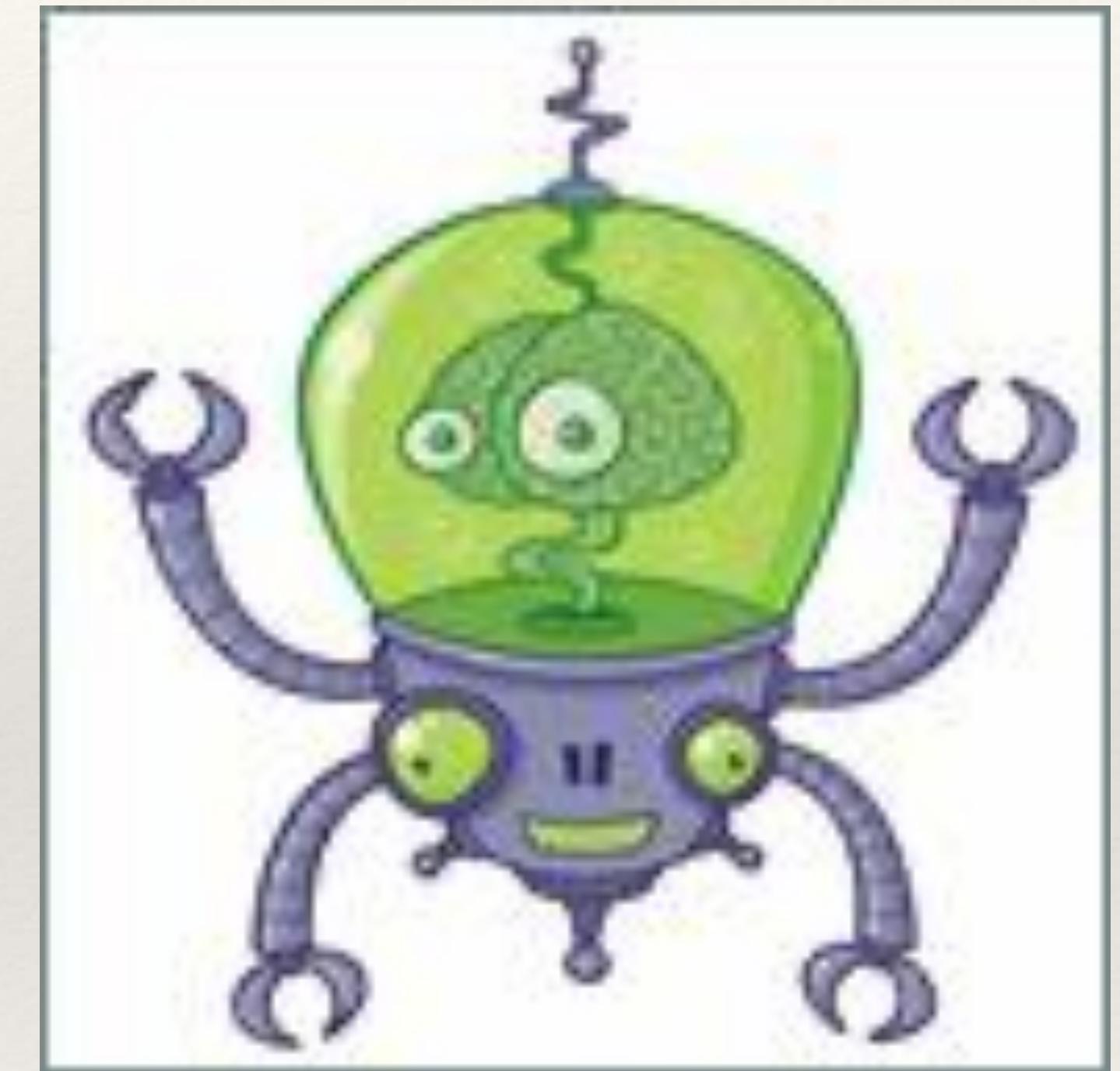
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- ❖ Robotics is Data Actuation. IoRT is a way to forward to implement this actuation.
- ❖ Pushes ahead the digital frontier.
- ❖ Can be used as a human-augmentation strategy.
- ❖ Security is a major concern, but properly handled they can be overcome.

どうもありがとう

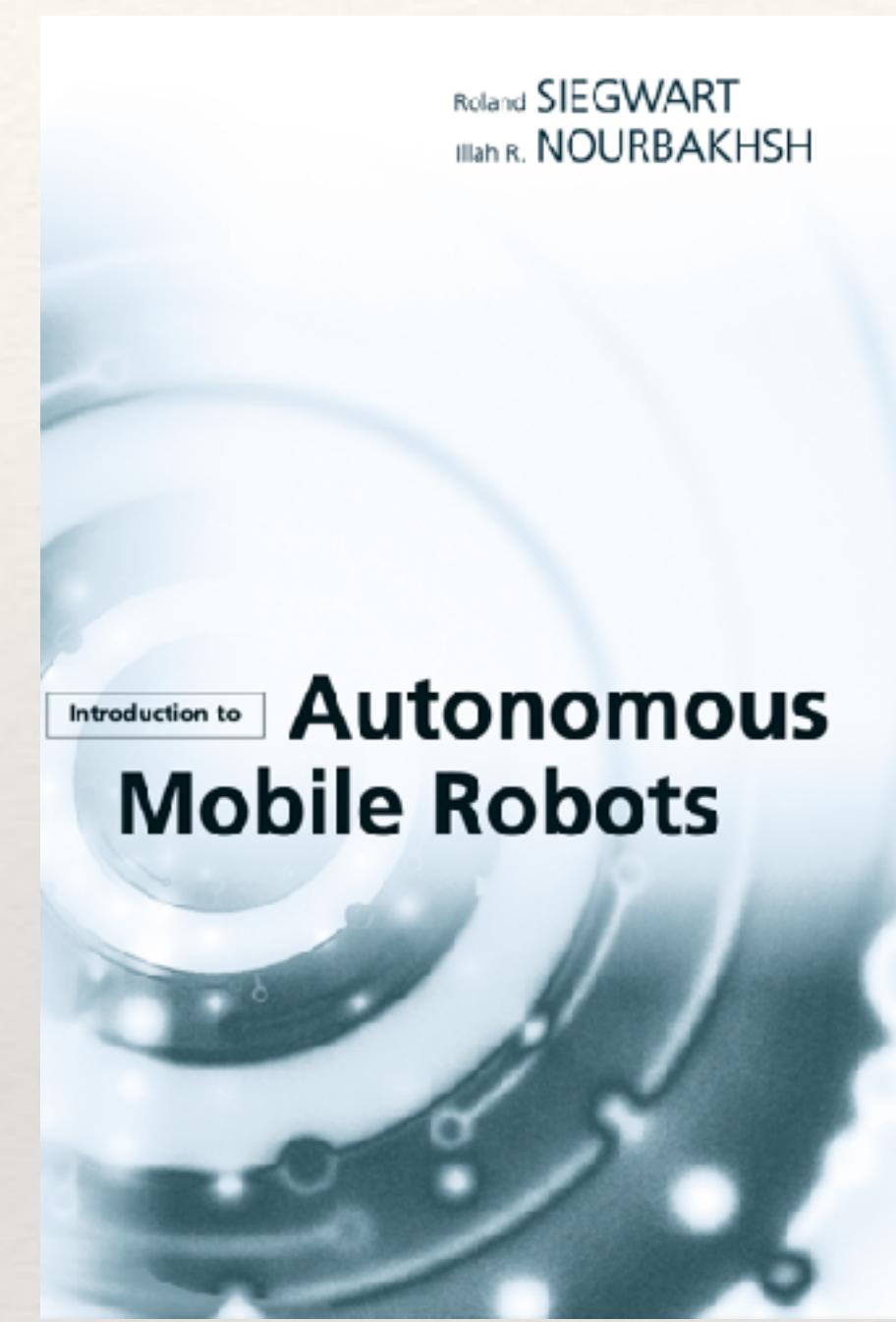
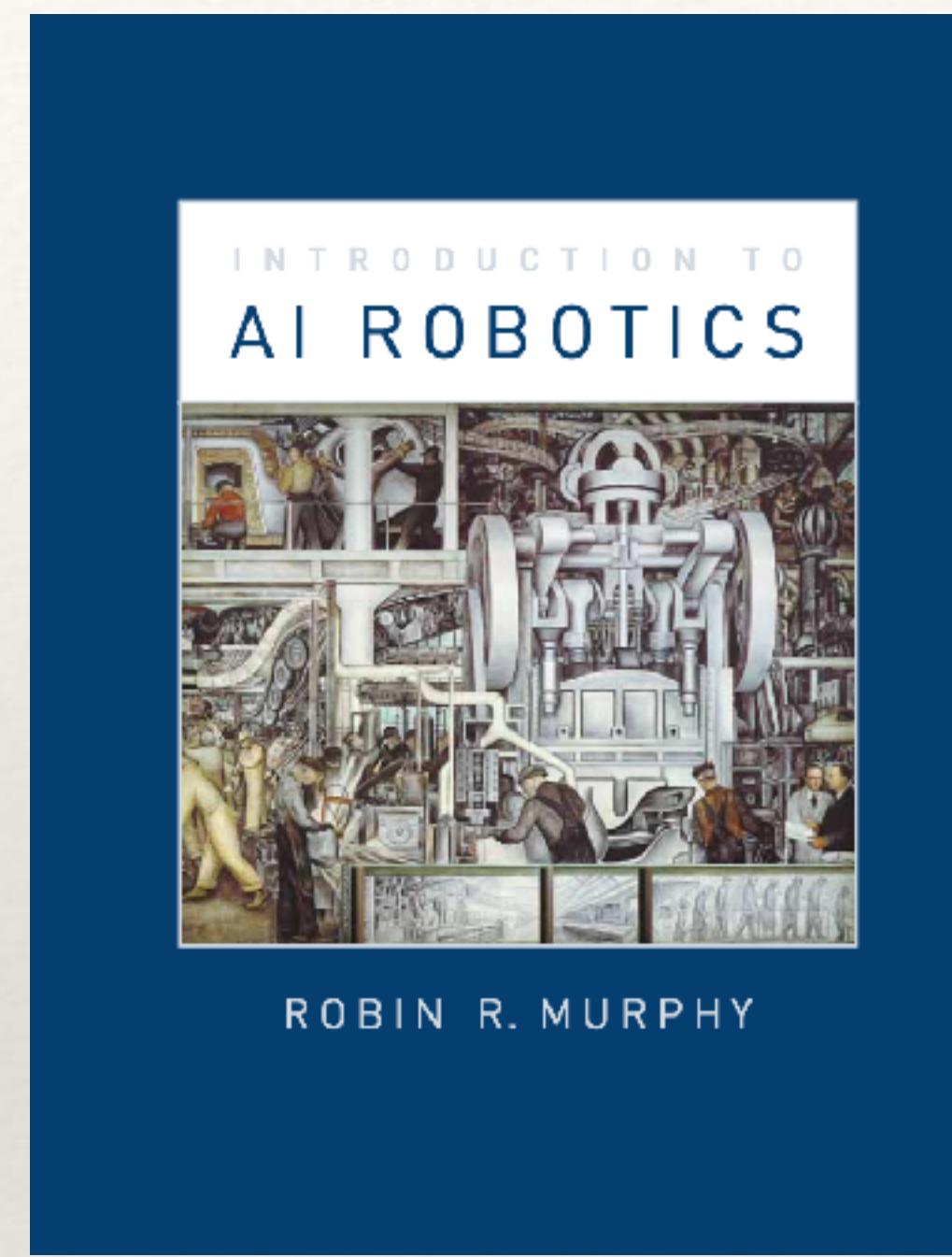
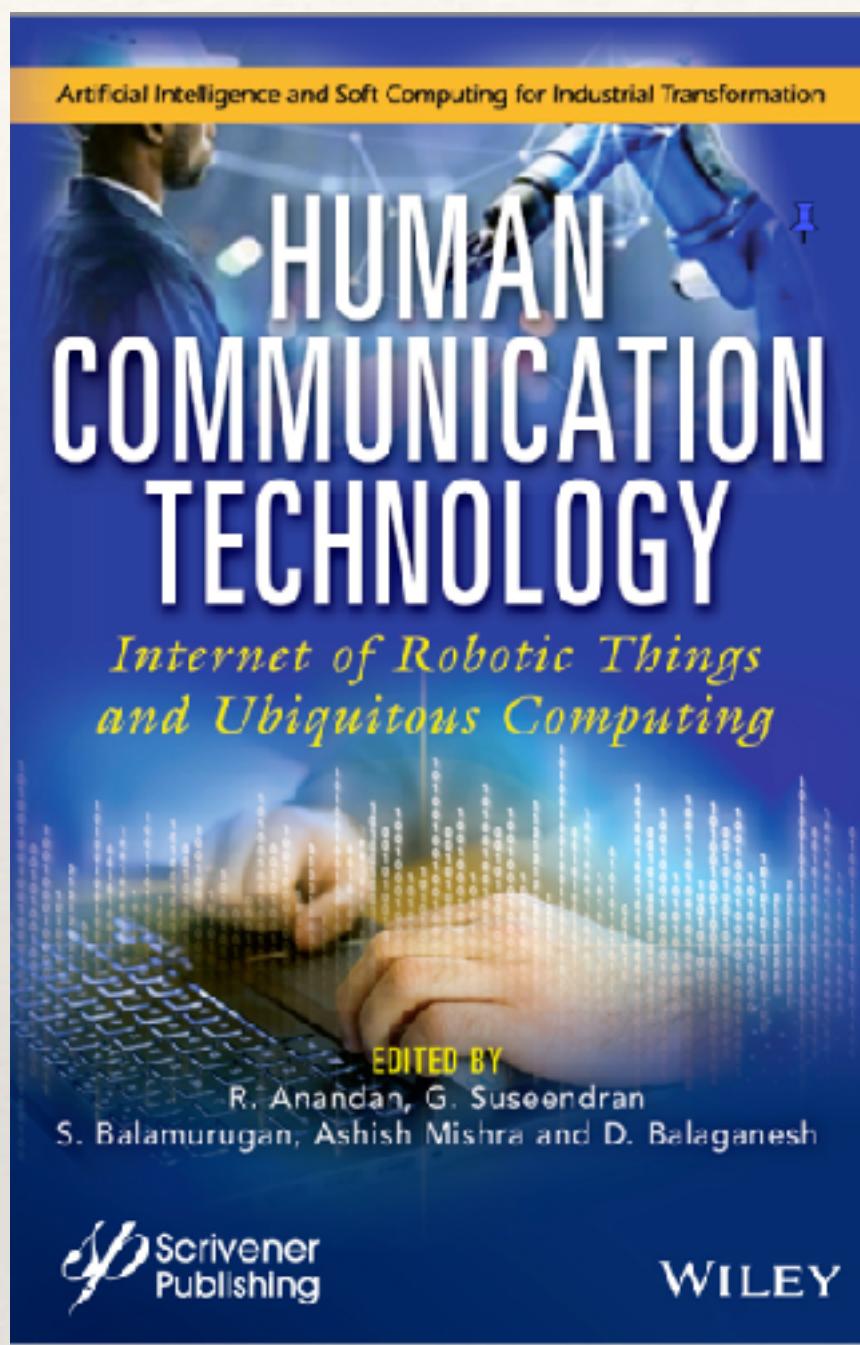
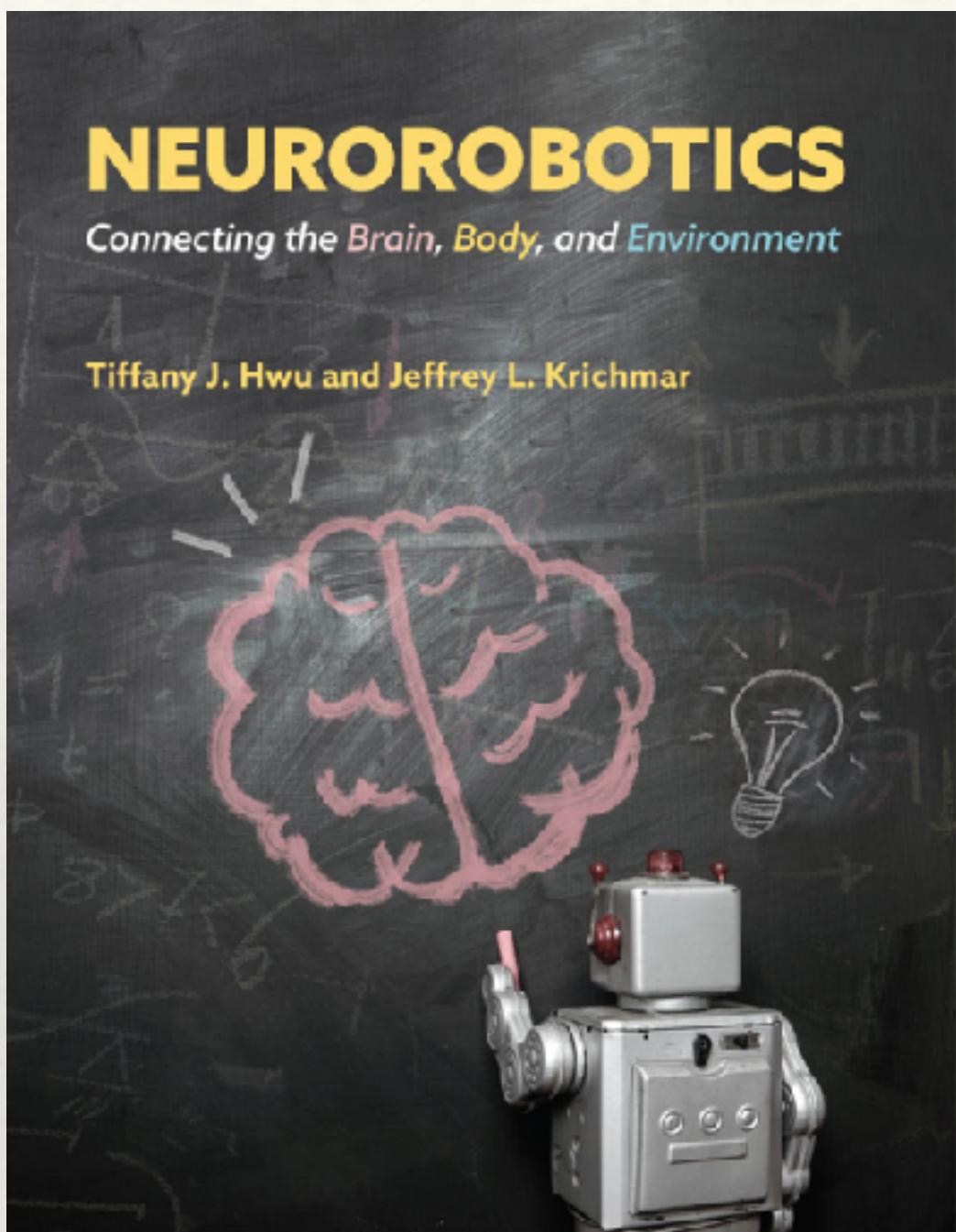


*Gracias !*

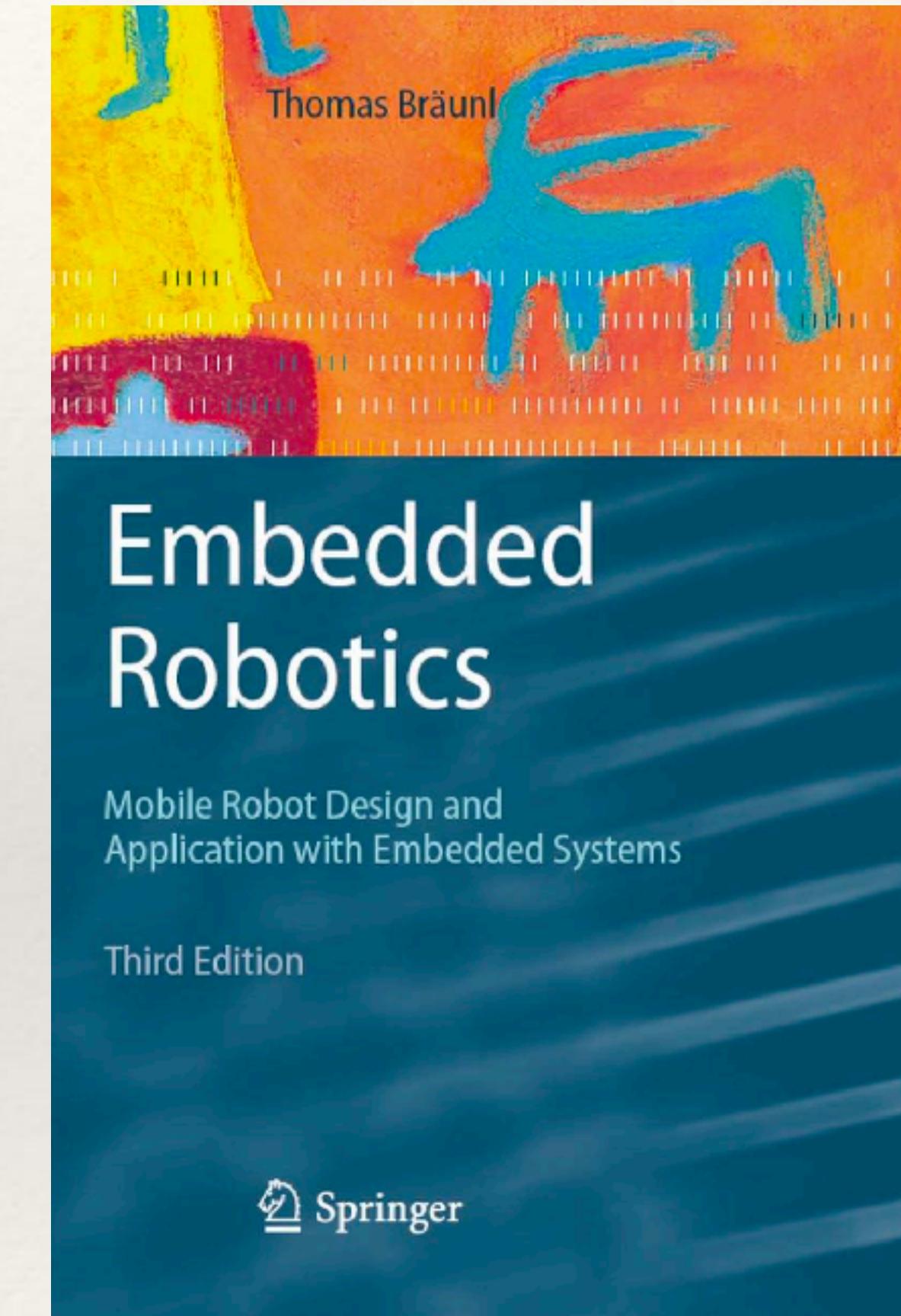
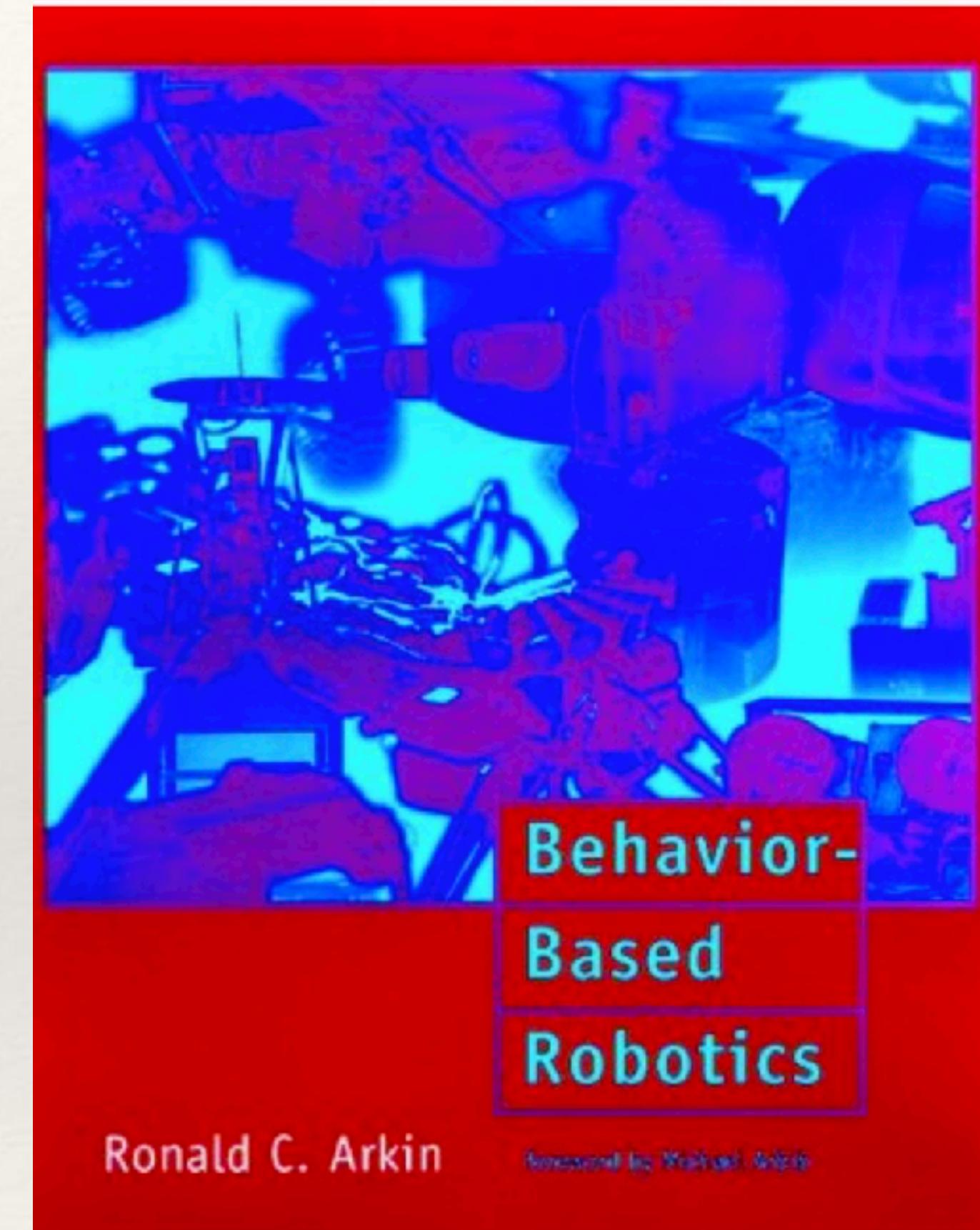
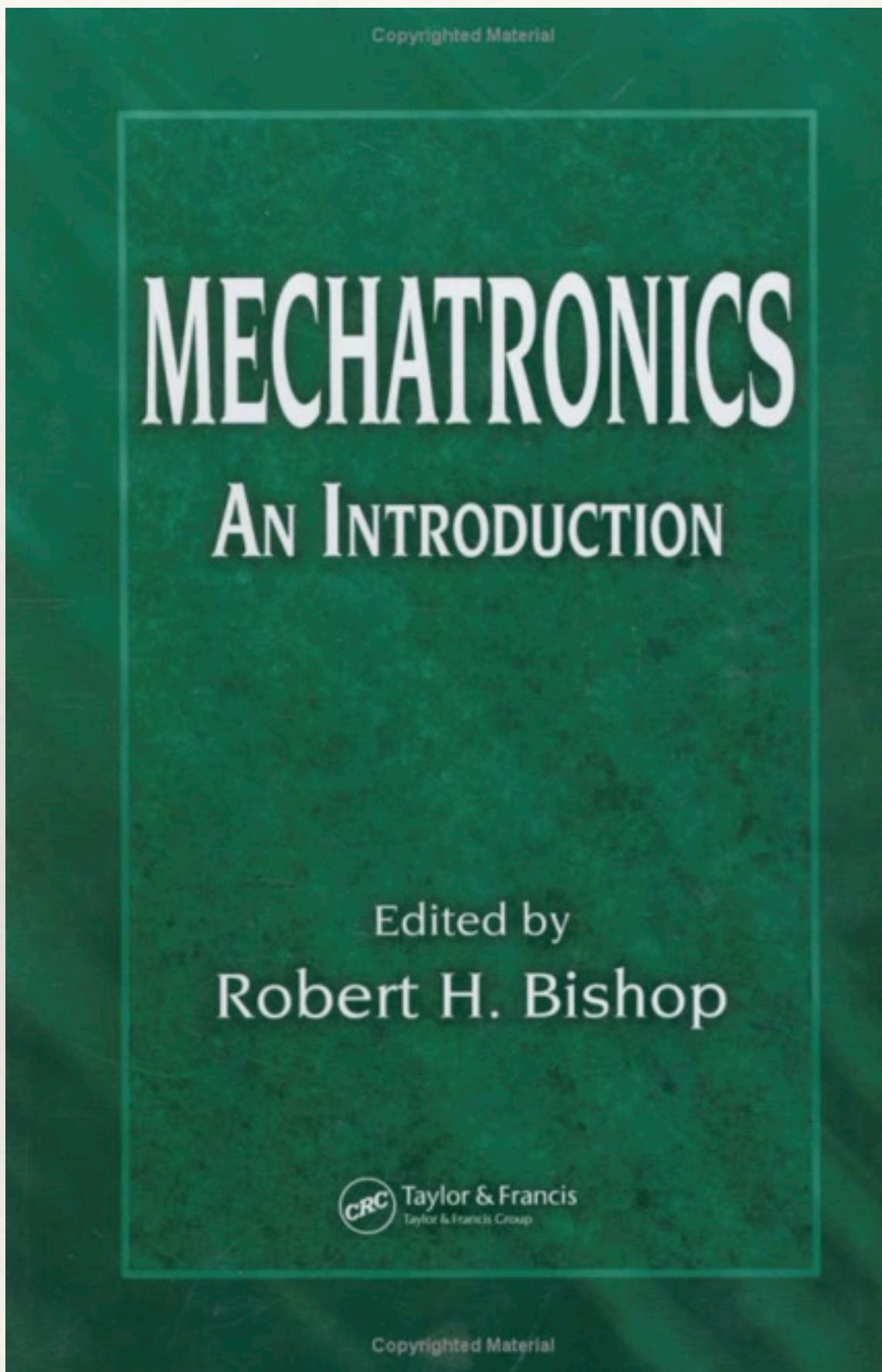


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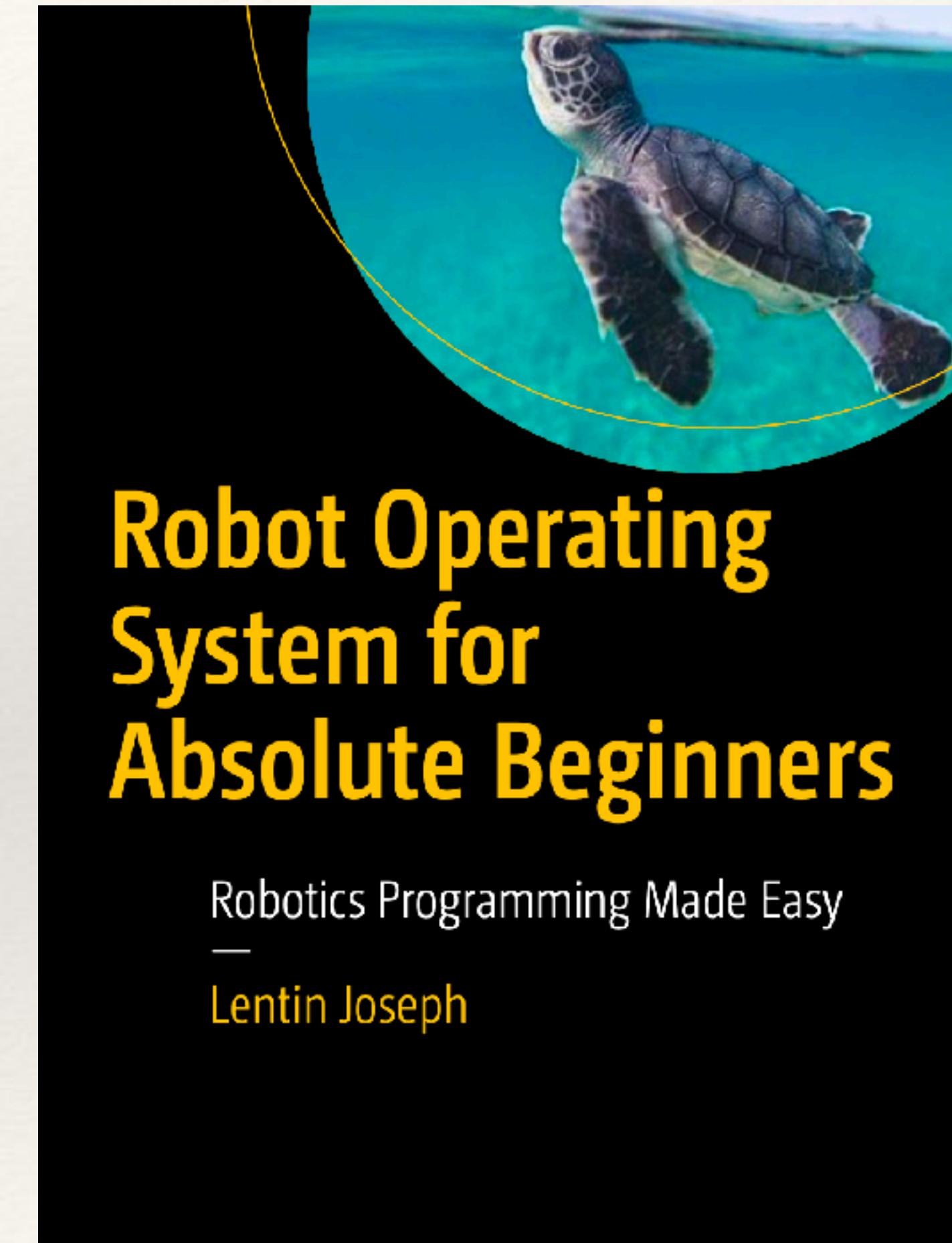
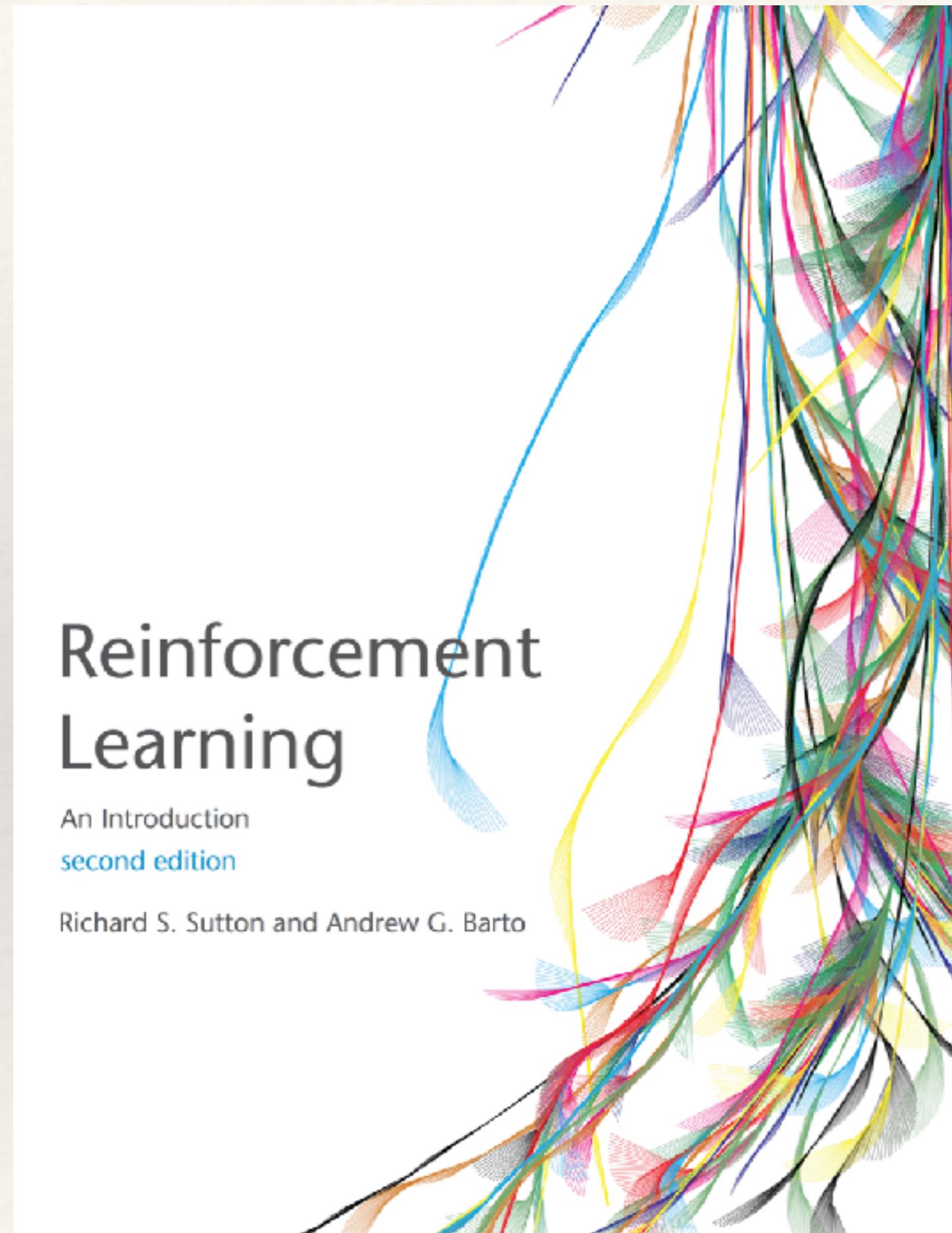
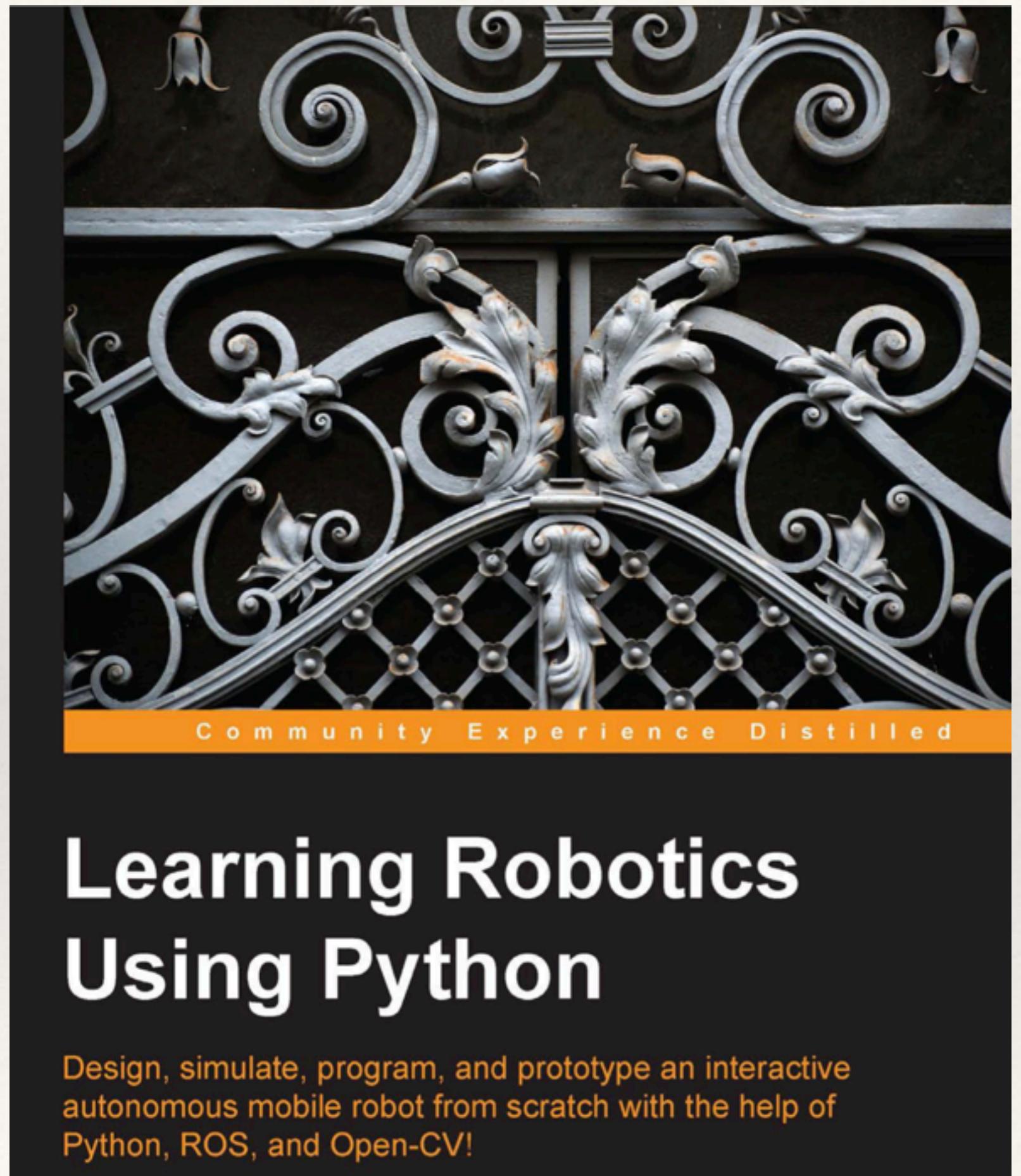
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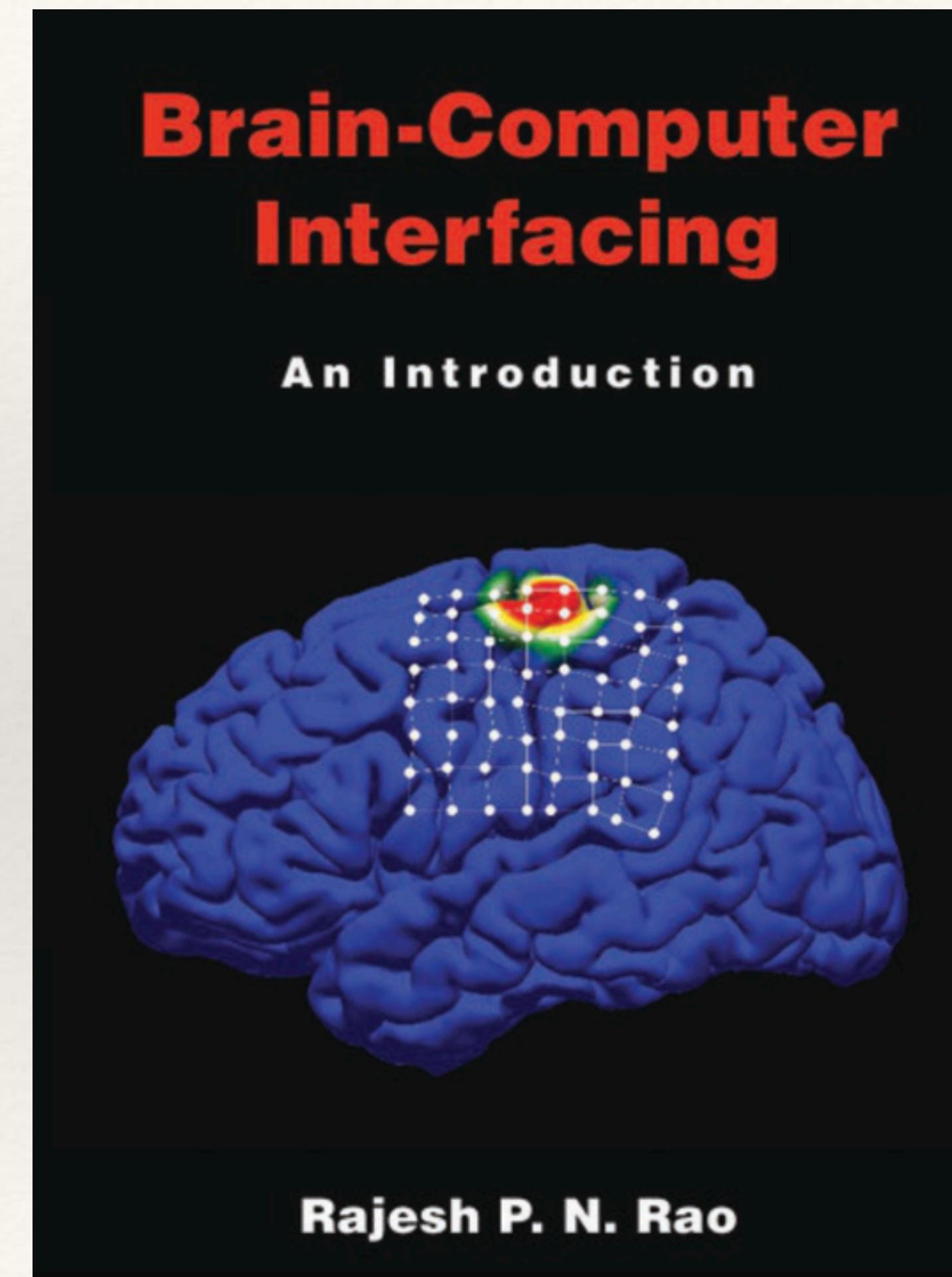
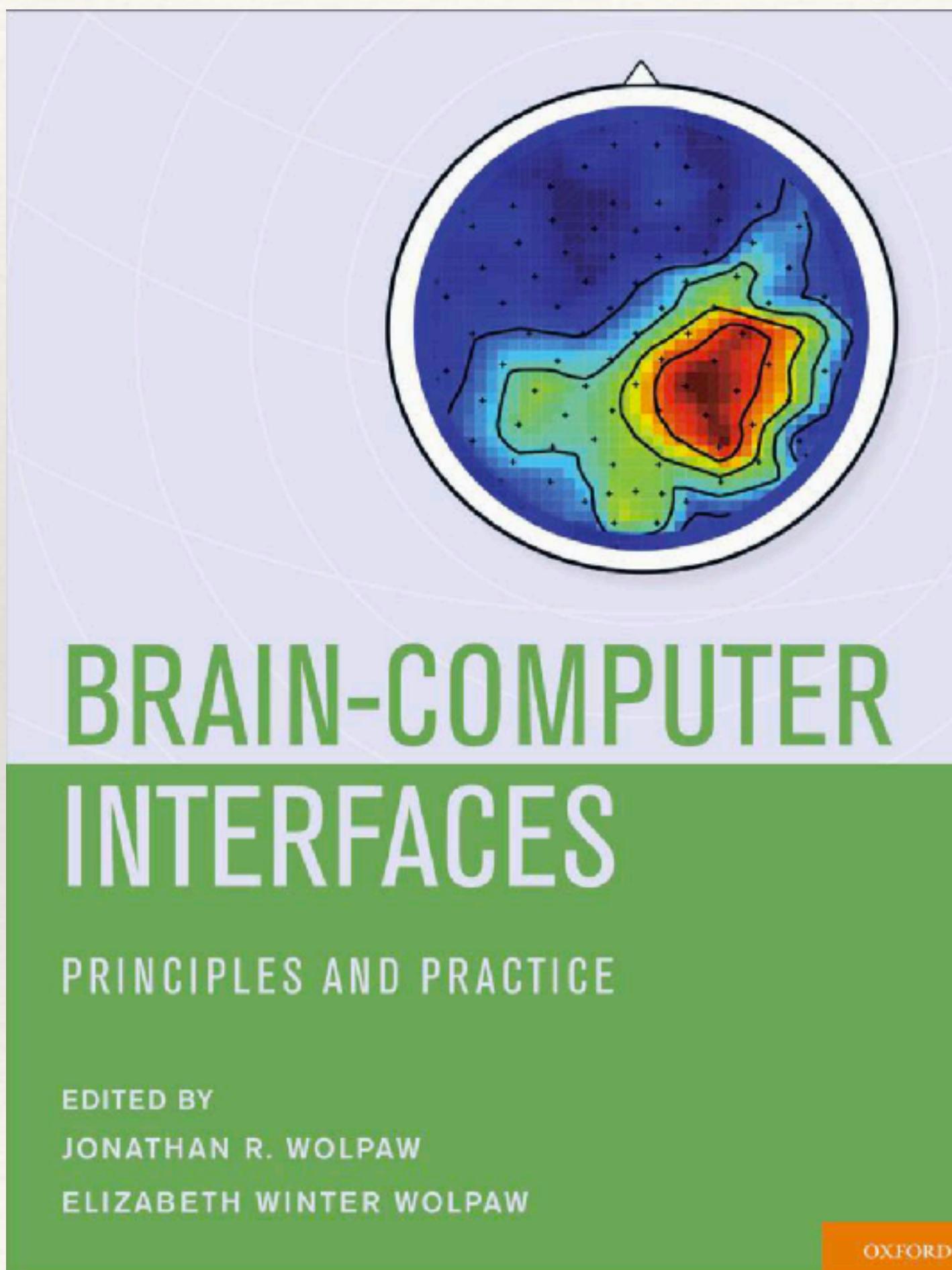
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