IJCAI 2026 Co-Located Event in Bremen

Robot Expo @ AICO

Artificial Intelligence Powered Cognition-Enabled Robotics

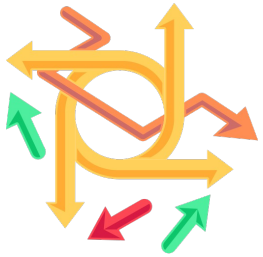
18th August 2026

Cognitive Architectures for Autonomous Robots

David Vernon

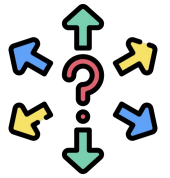
www.vernon.eu

Physical actions and social interaction
can produce unexpected outcomes



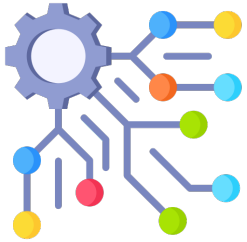
The world is complicated:
Ill-defined objects
Unpredictable humans

Perception is noisy:
inferred knowledge
is uncertain



Robotics is Hard
Why?

Autonomy is complex:
Need to self-assess &
adapt to the unexpected



People give instructions in
vague, underdetermined ways

People's goals
can be hard to infer

images: Flaticon.com

How Do We Deal With This?
Cognition

"Cognition is the process by which an autonomous system

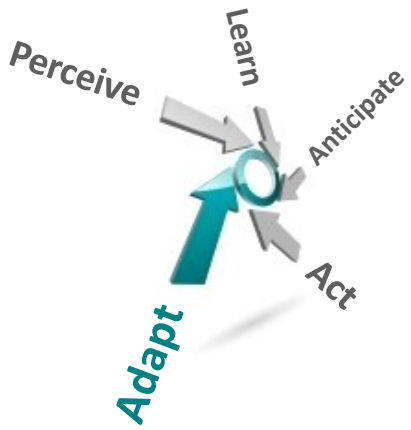
perceives its environment,

learns from experience,

anticipates the outcome of events,

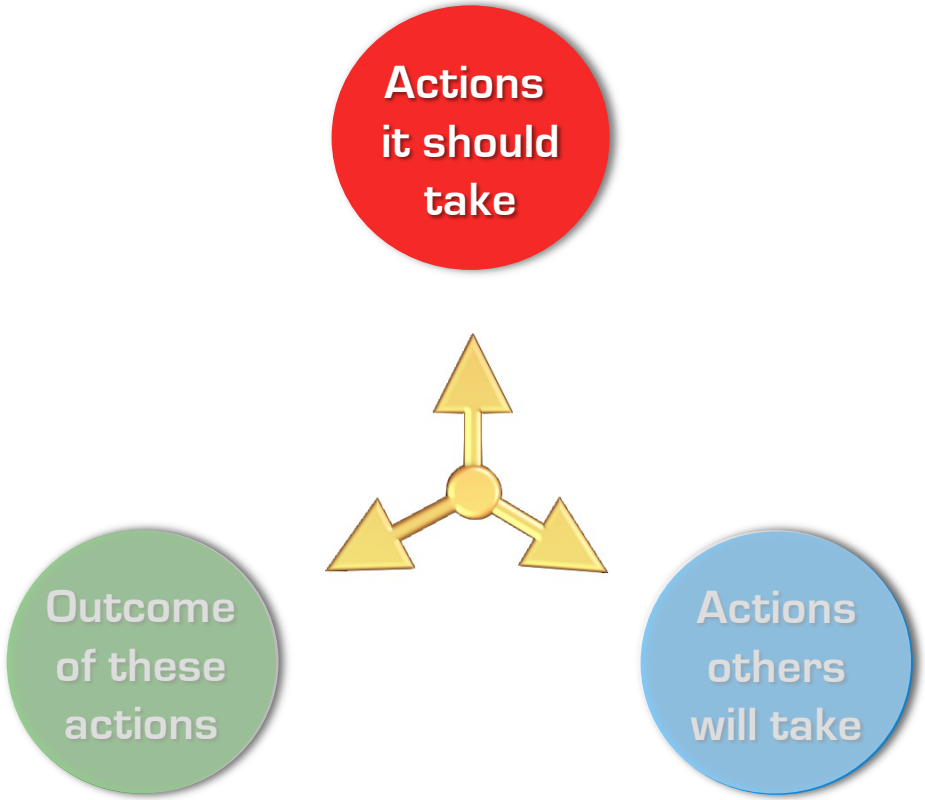
acts to pursue goals, and

adapts to changing circumstances."



D. Vernon, Artificial Cognitive Systems – A Primer, MIT Press, 2014

An Autonomous Cognitive Robot Continually Predicts ...



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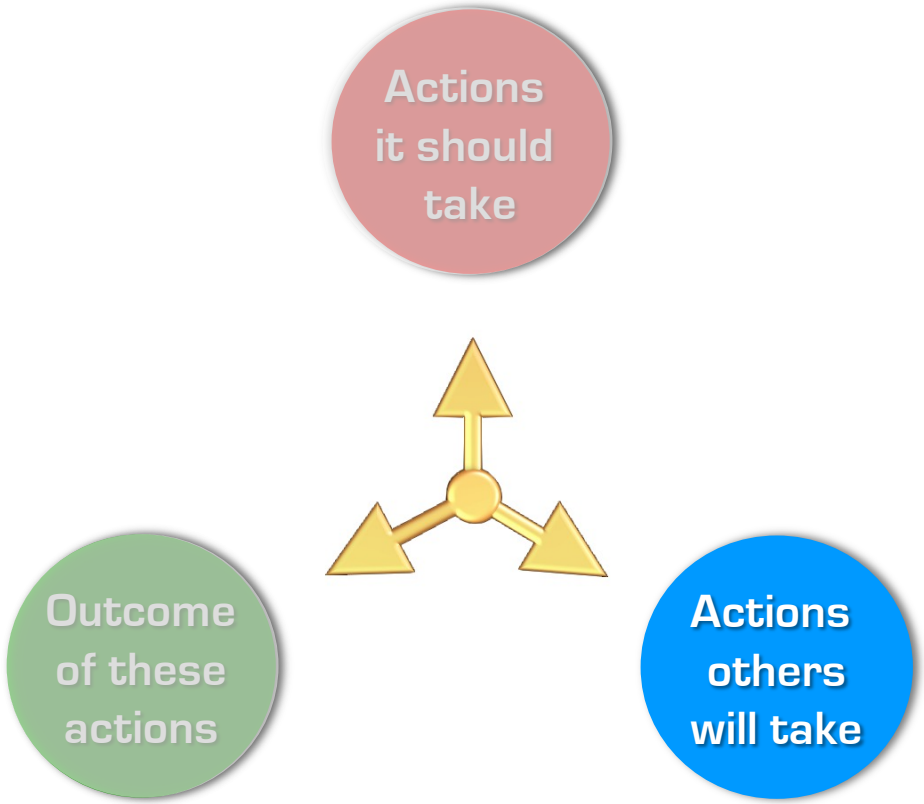

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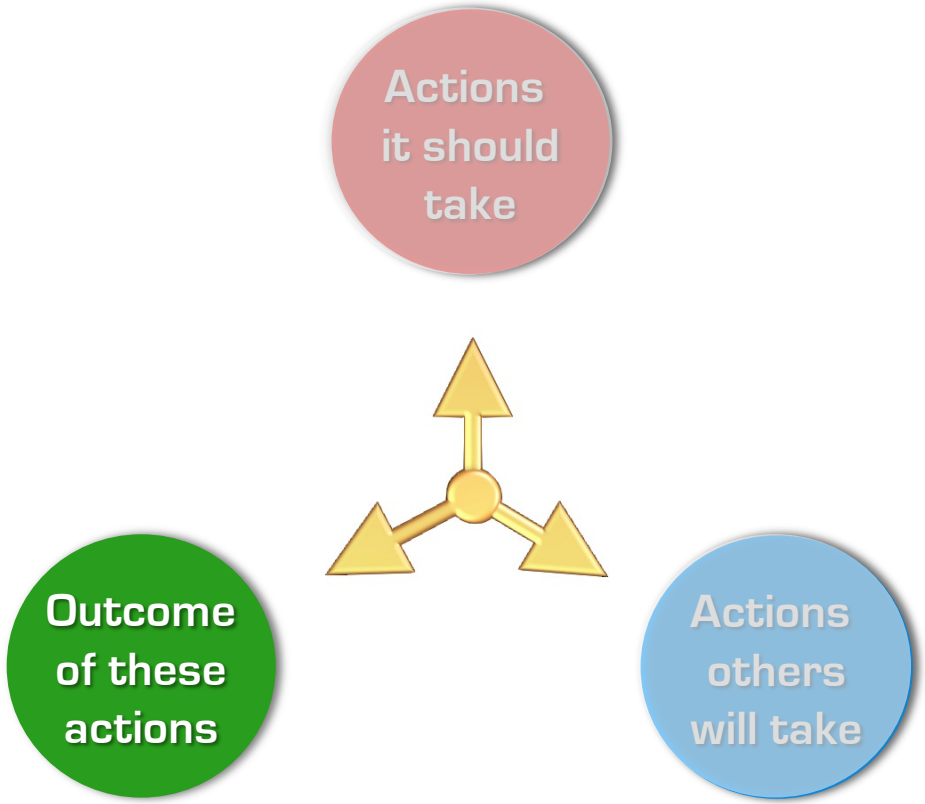

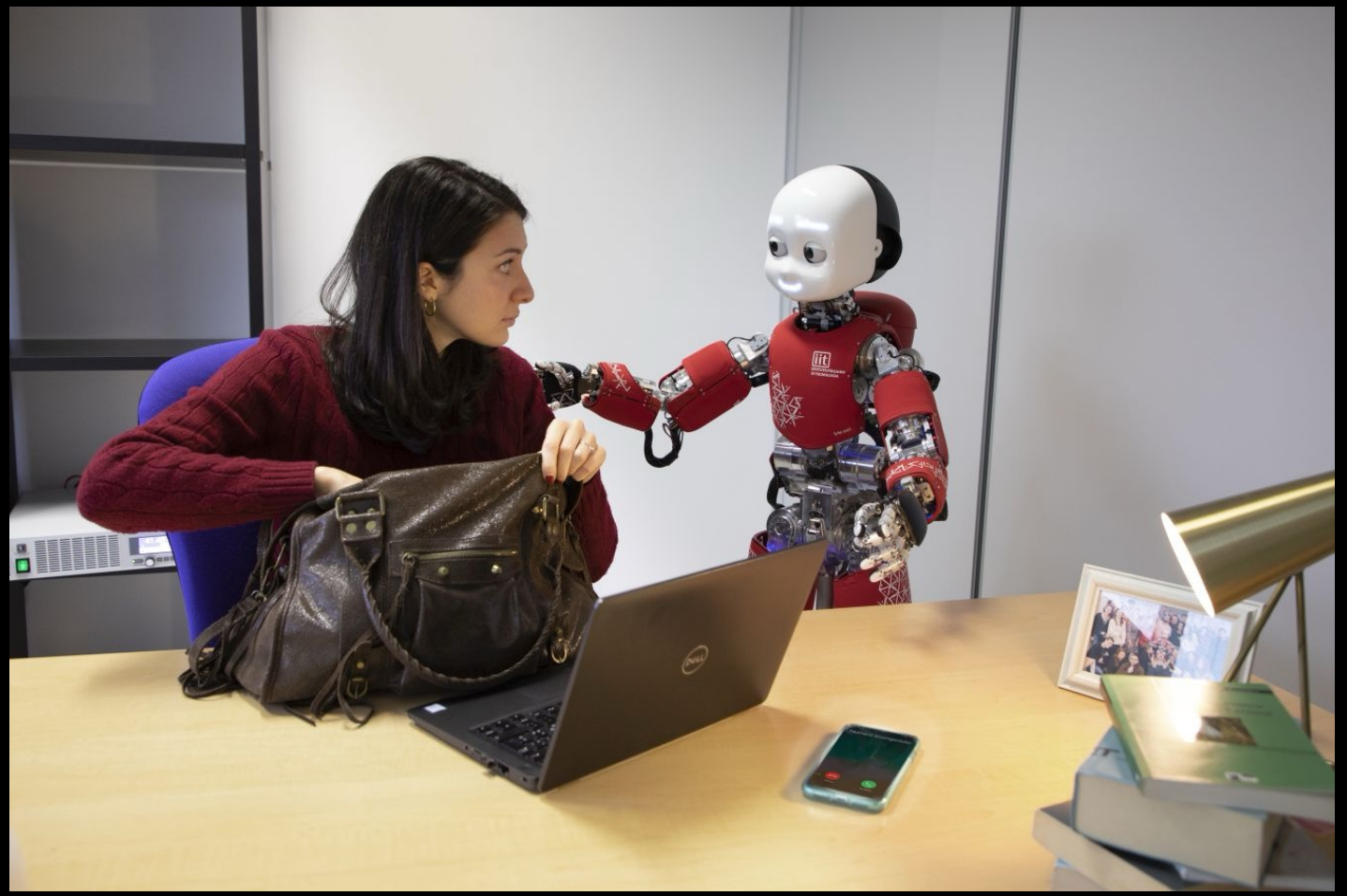

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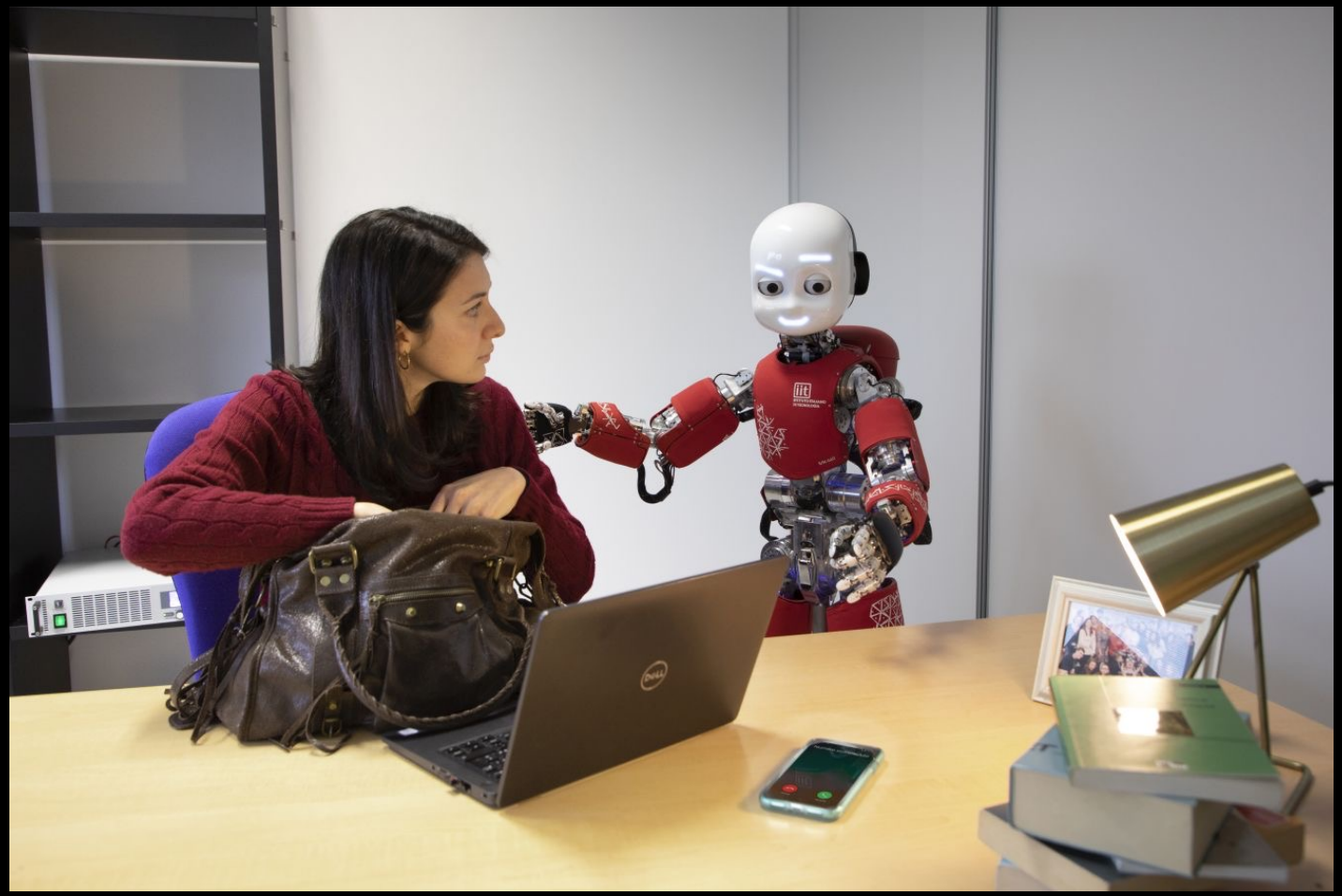

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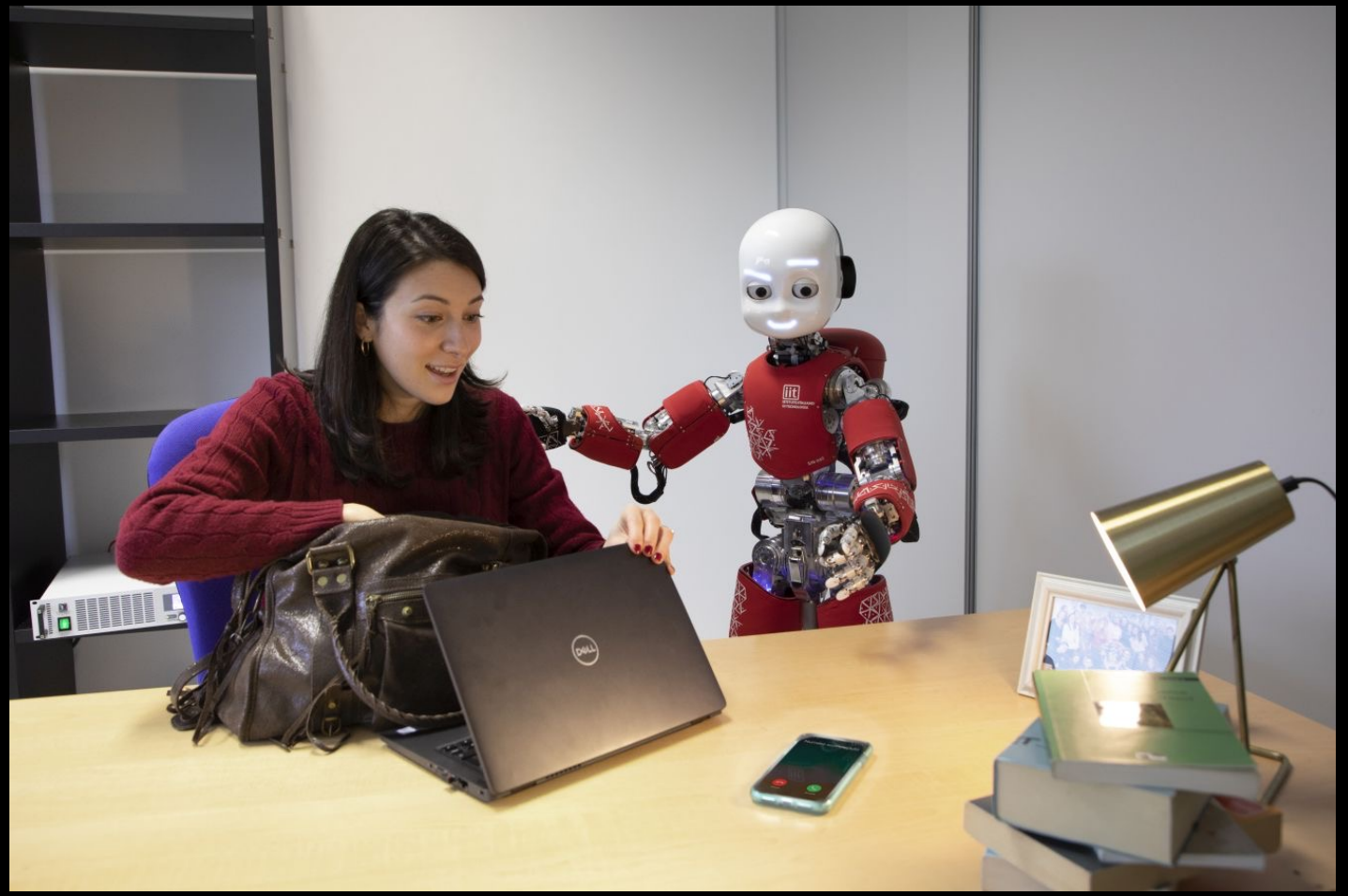

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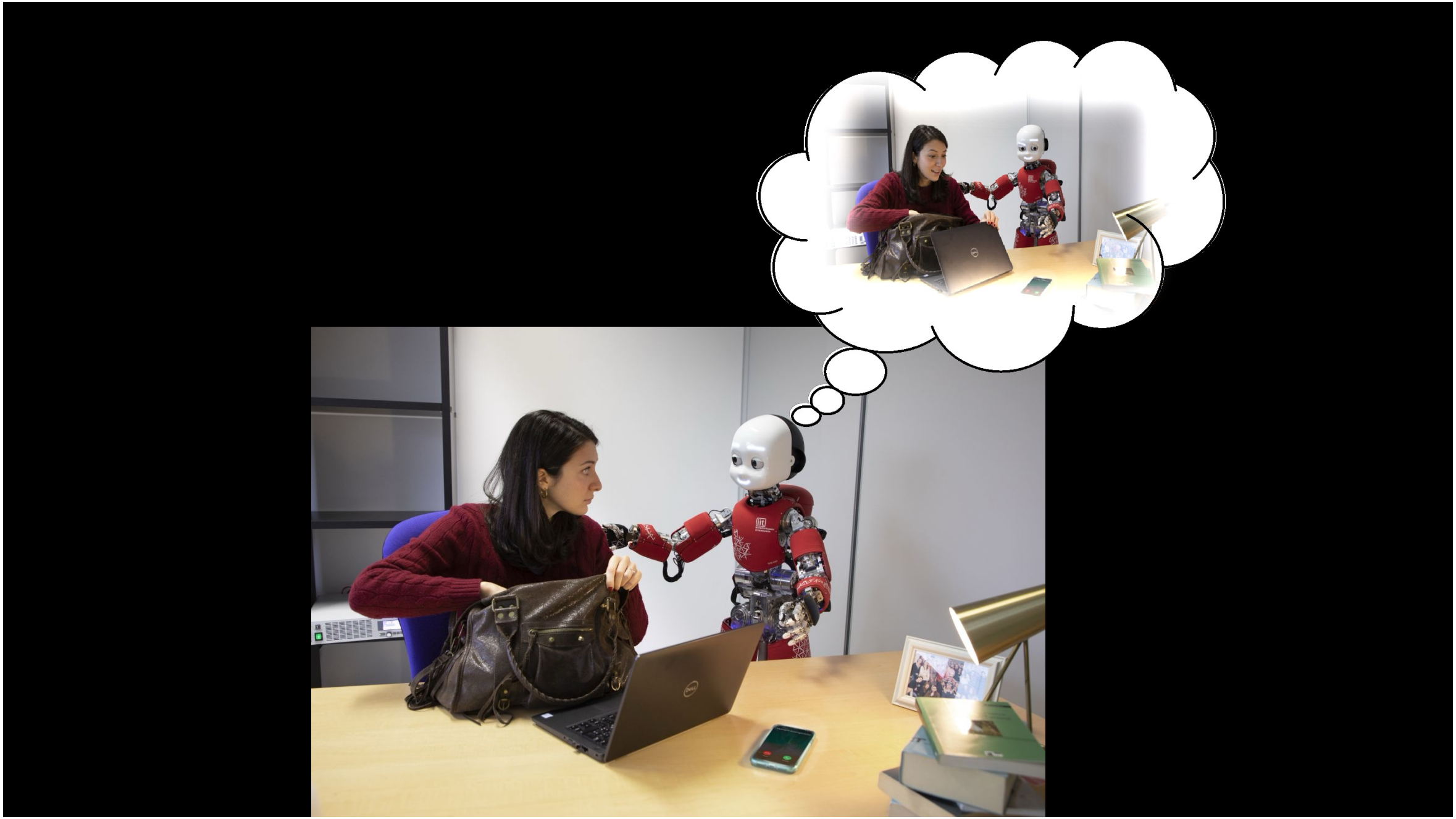


Cognition: Prospective, Goal-directed Action

https://stock.adobe.com/ie/search?k=5+pillars

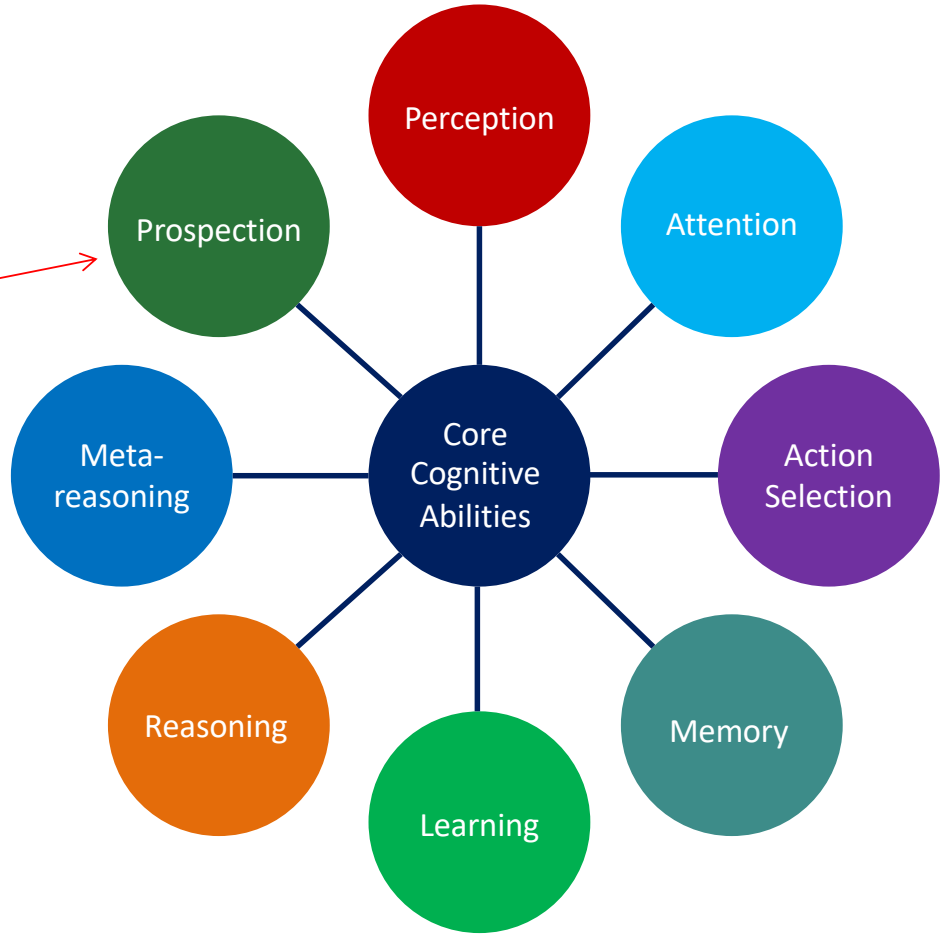
To achieve goals adaptively and robustly in these circumstances requires a complex system that can

- Construct models of the way the world works
- Use them to guide actions prospectively
- Update them as the system continually learns through its interactions

A cognitive architecture is the way we specify how to achieve this

Core Cognitive Abilities

Not included in (Kotseruba and Tstotsos, 2020)



A cognitive architecture allows these core abilities to be dynamically orchestrated

I. Kotseruba and J. Tsotsos (2020). 40 years of cognitive architectures: core cognitive abilities and practical applications. Artificial Intelligence Review, Vol. 53, No. 1, pp. 17-94.

Elements of a Cognitive Architecture

Perception

Attention

Action selection

Memory

Learning

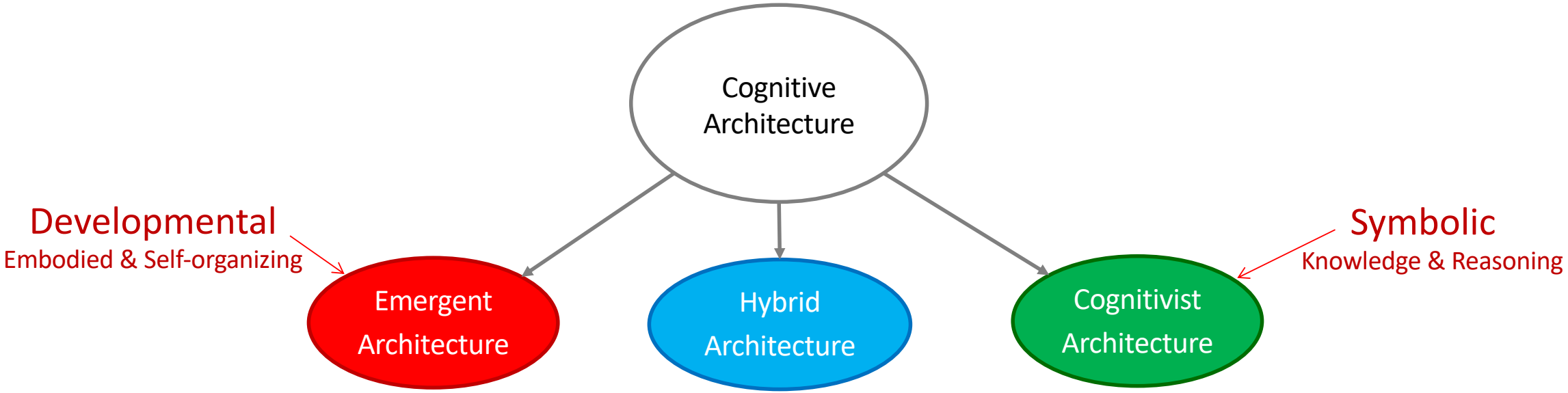
Reasoning

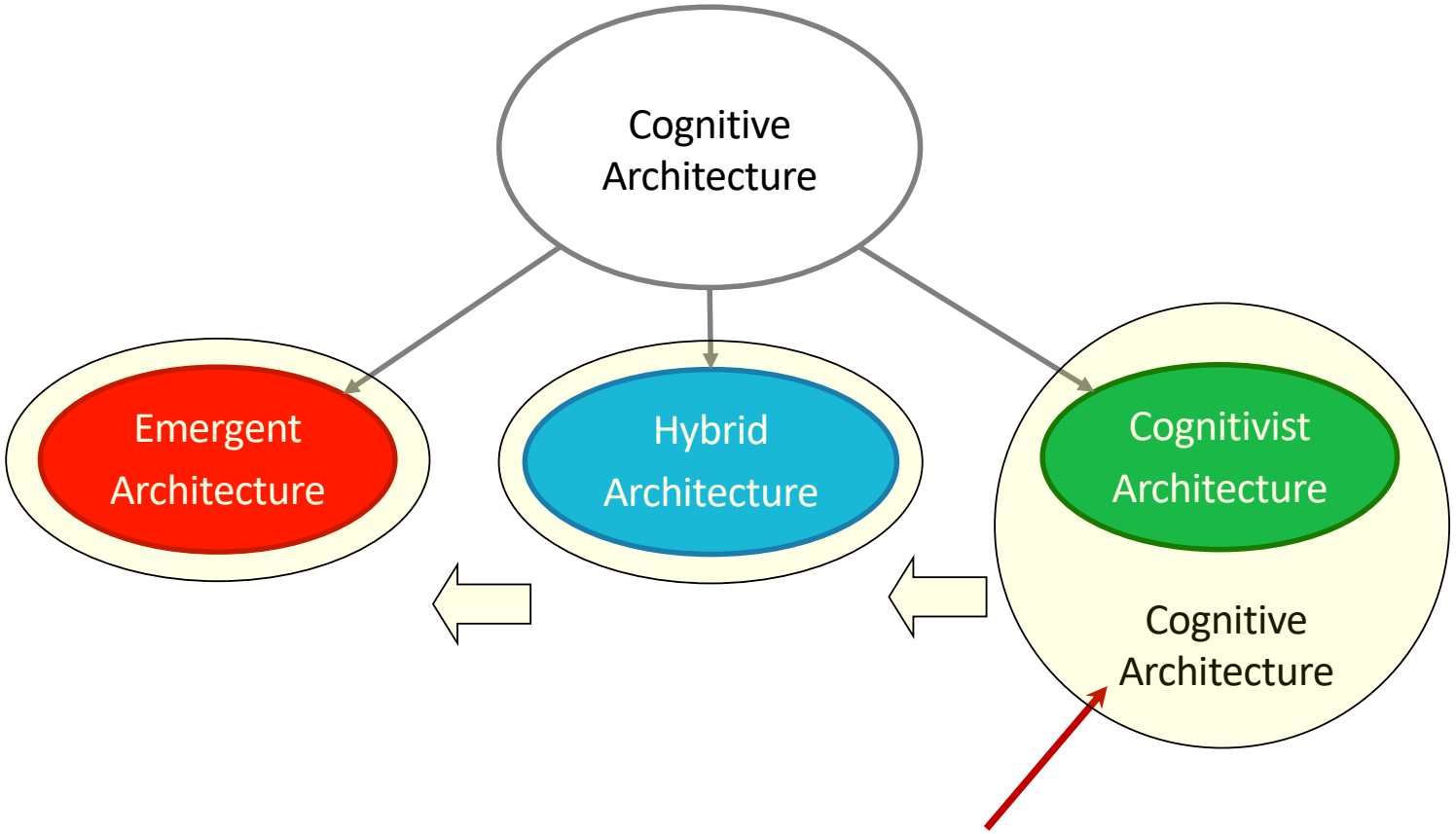
Meta-reasoning

Prospection

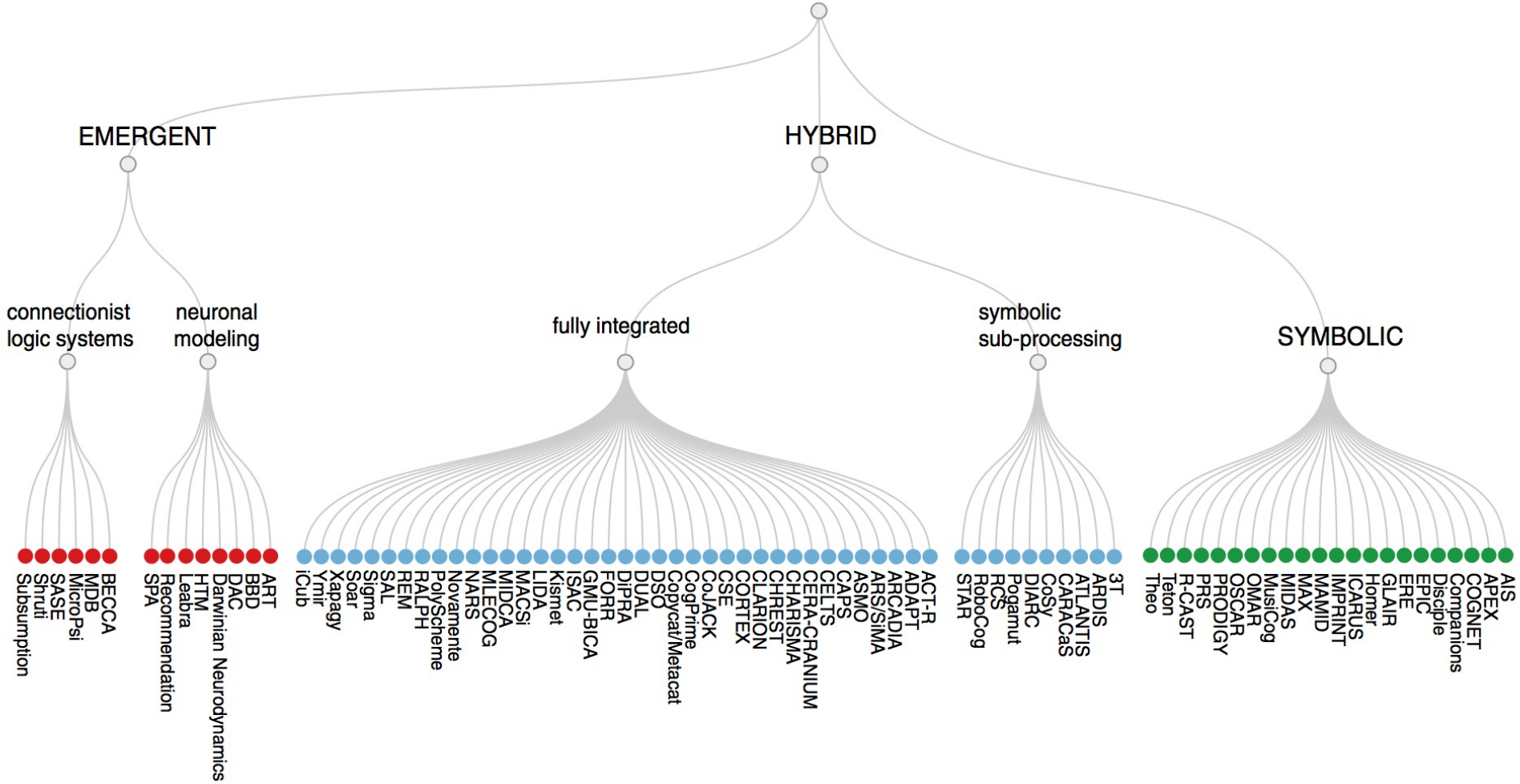
https://fashion-history.lovetoknow.com/fabrics-fibers/weave-types

Cognitive Robot:
Prospective, goal-directed action


Cognitive Architecture
Developmental
Embodied & Self-organizing
Symbolic
Knowledge & Reasoning
Emergent Architecture
Hybrid Architecture
Cognitivist Architecture



The term "cognitive architecture" originated with the work of Allen Newell (1987, 1990)
inspired to some extent by the title of John Anderson's 1983 book *The Architecture of Cognition*



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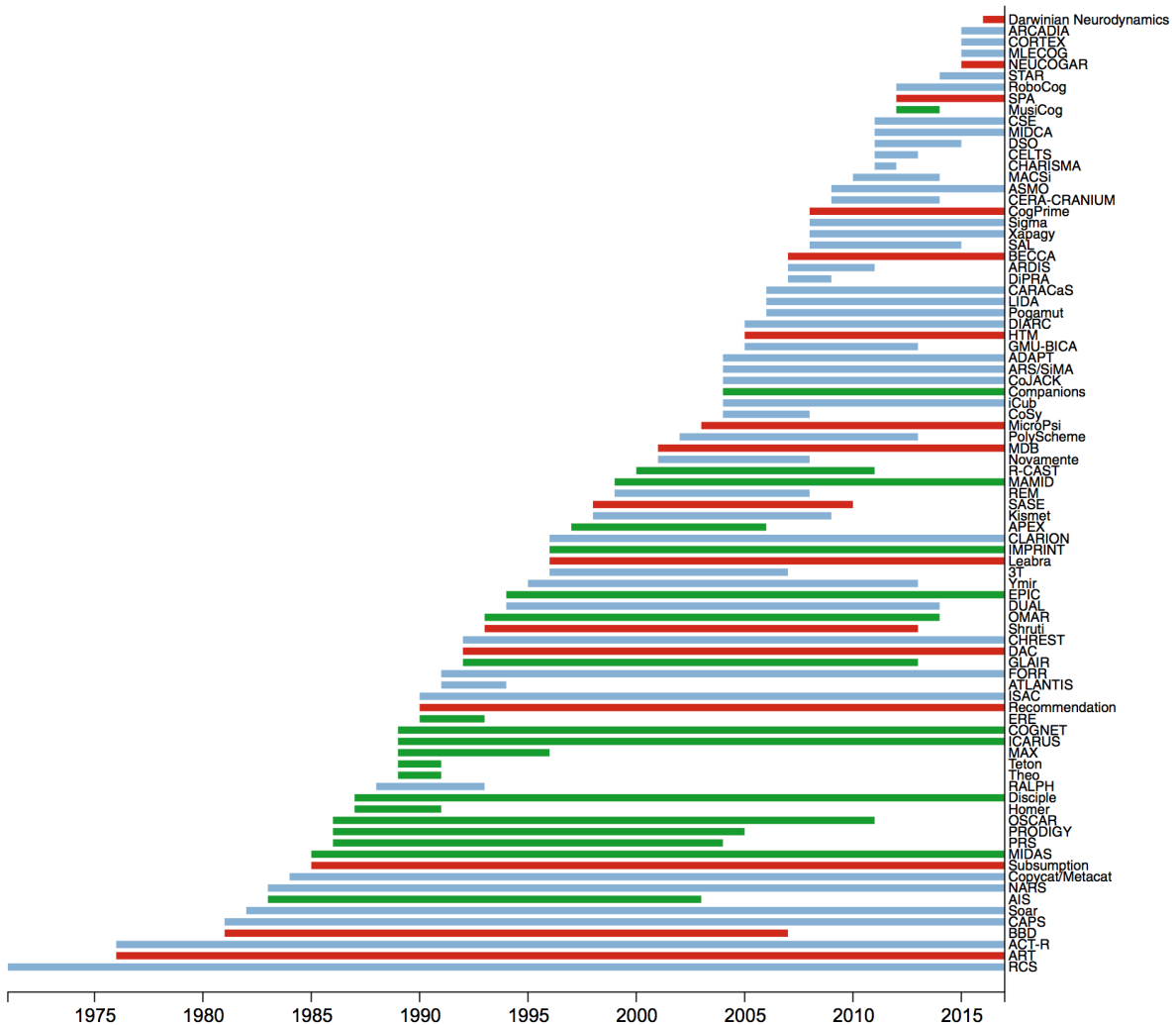
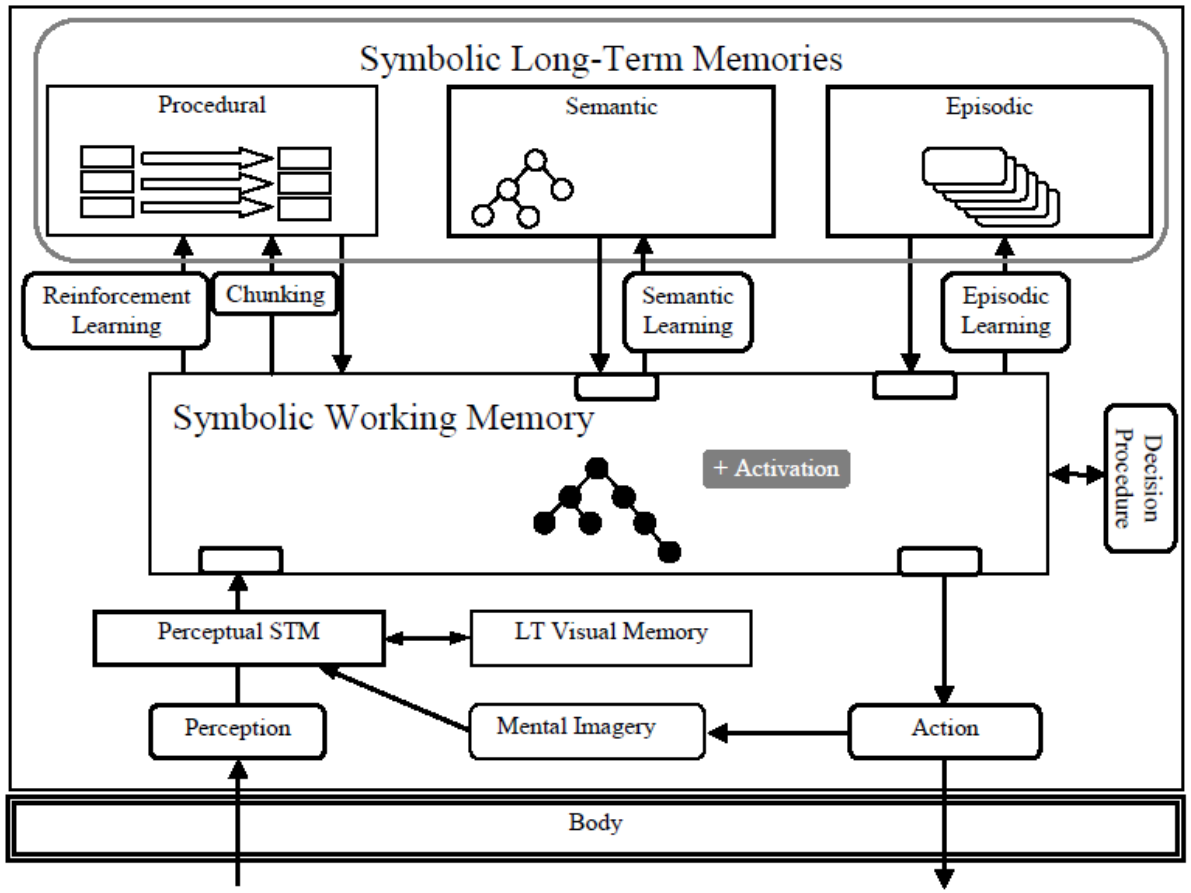


I. Kotseruba and J. Tsotsos. 40 years of cognitive architectures: core cognitive abilities and practical applications. Artificial Intelligence Review, Vol. 53, No. 1, pp. 17-94, 2020.

Soar

(Laird et al., 2012)



A short video by John Laird on Soar can be found at the
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https://transair-bridge.org/workshop-2021/

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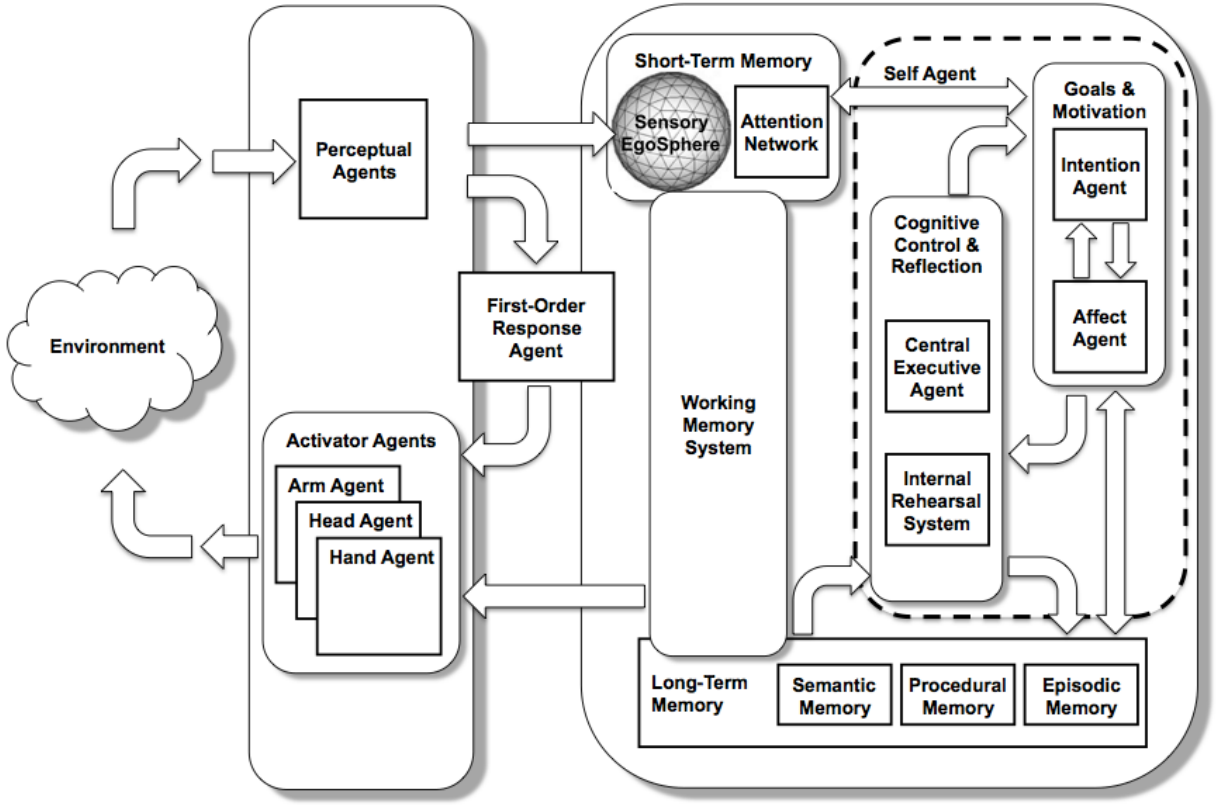
ISAC

(Kawamura et al., 2008, 2024)



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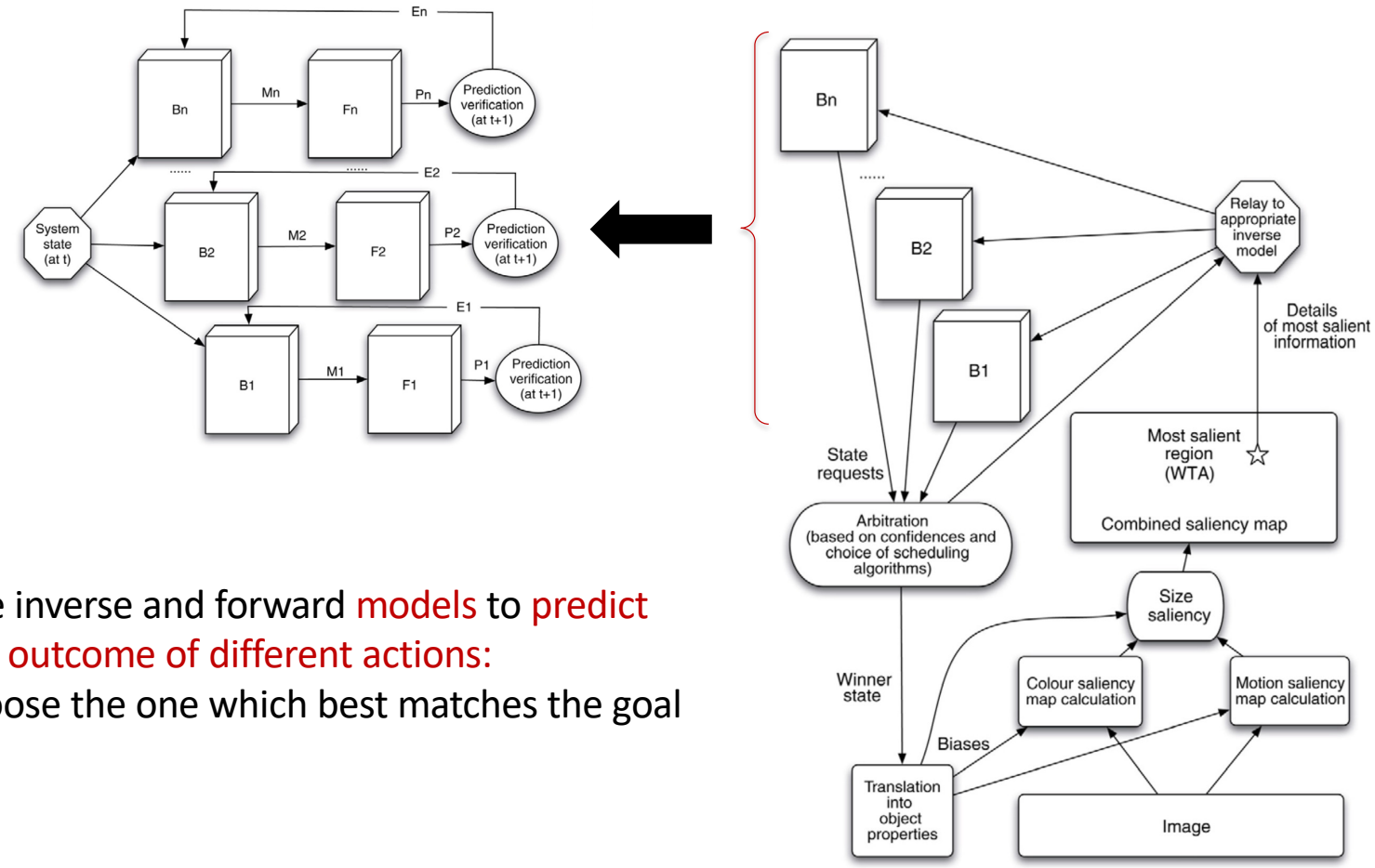
HAMMER

(Demiris and Khadhouri, 2006)



Use inverse and forward models to predict the outcome of different actions:
choose the one which best matches the goal

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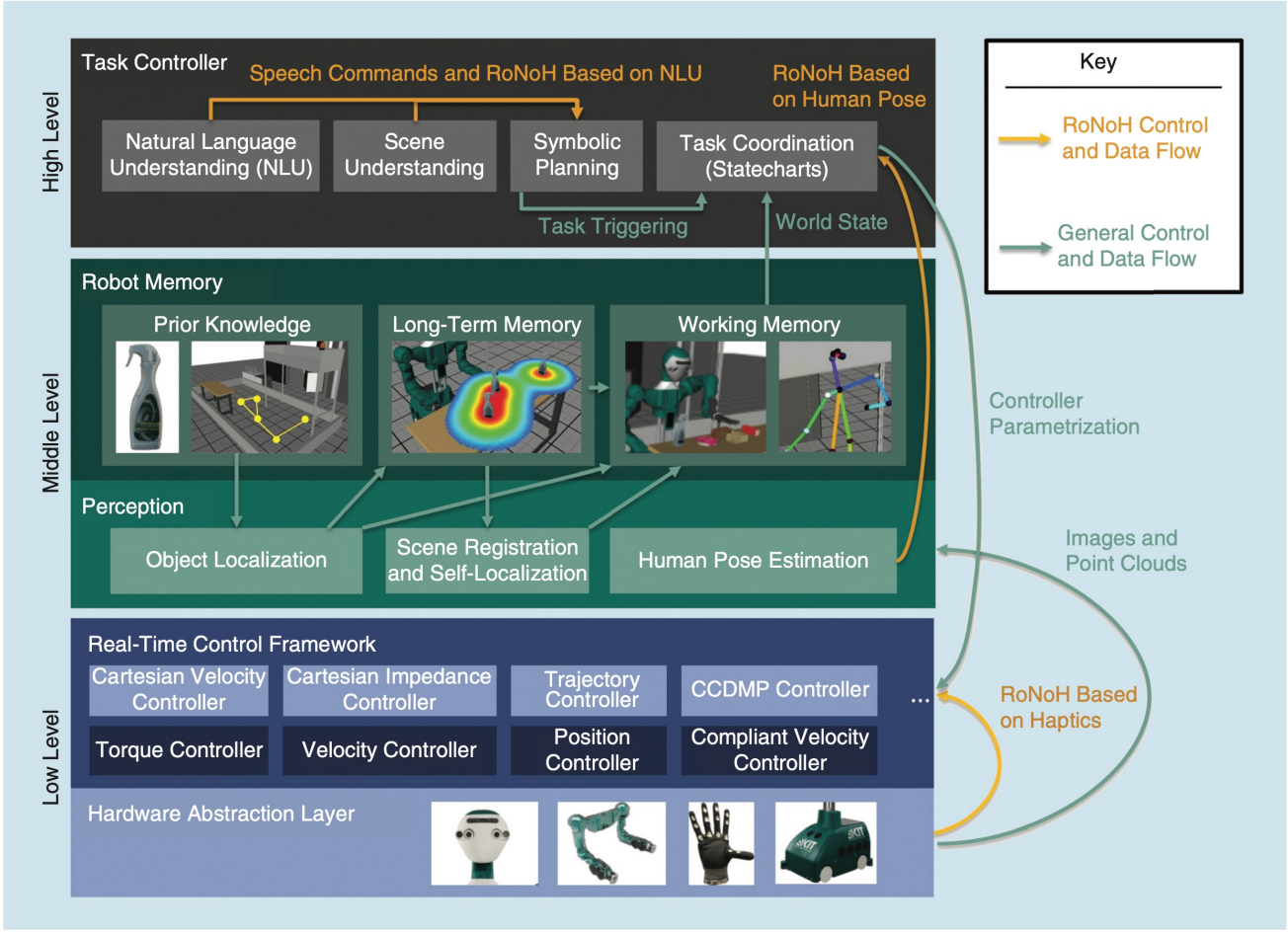
ArmarX

(Vahrenkamp et al., 2015; Asfour, 2019; Peller-Konrad et al., 2023)



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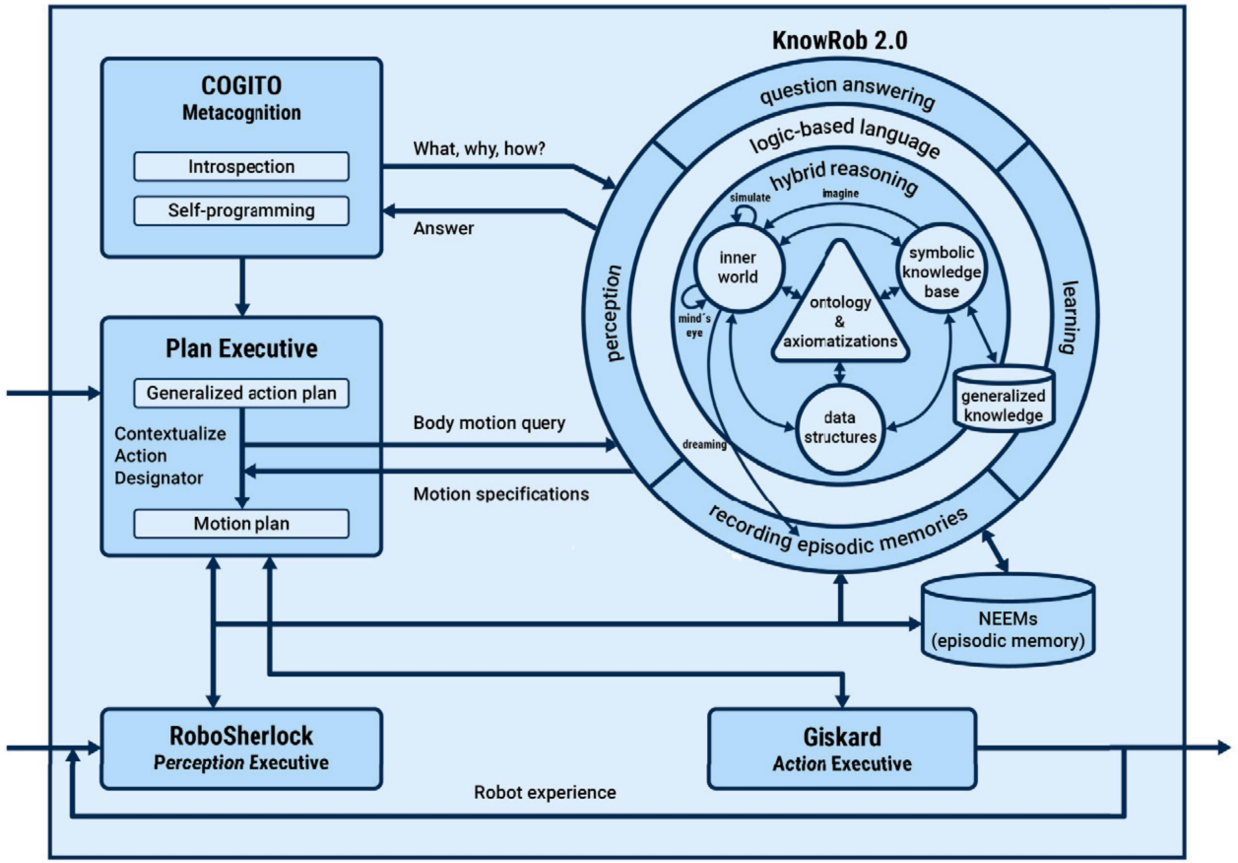
CRAM 2.0

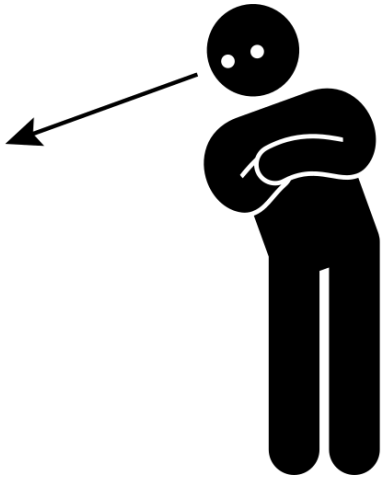
(Beetz et al., 2025)



Designed to address robot manipulation tasks in everyday activities based on **underdetermined instructions**

Observation 1

Cognitive architectures need world models

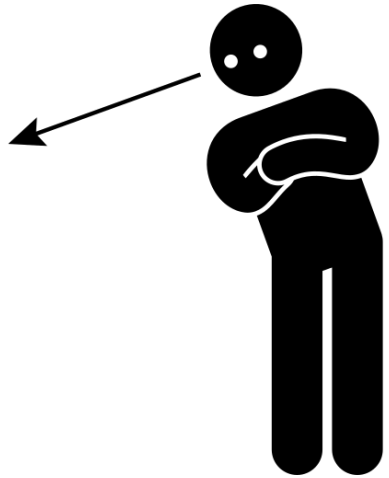


- "Any agent capable of generalizing to multi-step goal-directed tasks must have learned a predictive model of its environment"
  Richens et al. (2025)

- Good regulator theorem: "Every good regulator of a system must be a model of that system"
  Conant & Ashby (1970)

Observation 2

If our focus is exclusively on robot cognitive architectures, we can make some pragmatic choices

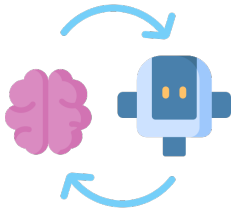


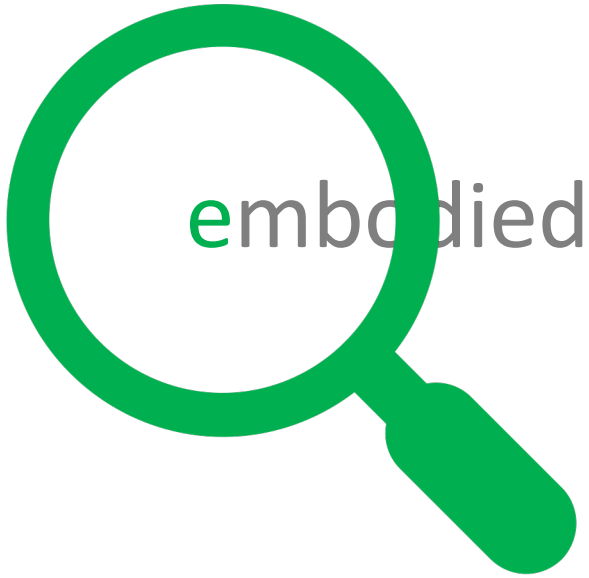
- What it means to be autonomous
- What it means to be embodied
- What it means to be bio-inspired

Autonomic, homeostatic, allostatic, i.e., self-maintaining

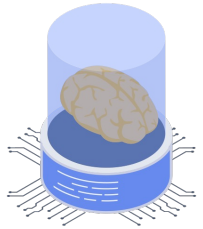
Capable of operating without human intervention

The body is a constitutive element of the cognitive process

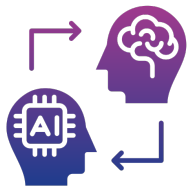




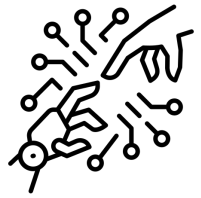
Cognition controls the body



Cognitive robots allows us to test hypotheses about human cognition

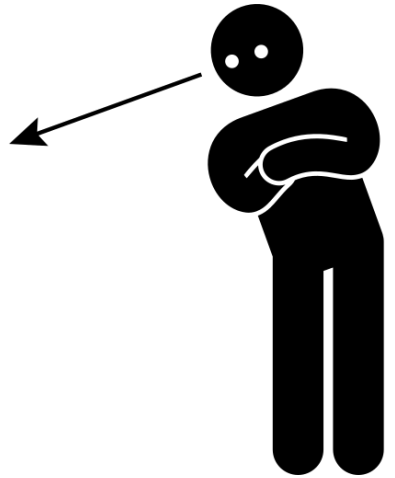


Cognitive architecture: informed by human cognition but not emulate it



Observation 3

Foundation models (LLMs & VLMs) are having a major impact



- Modules for hybrid cognitive architectures
  e.g., Clarion (Sun, 2024)

- Replacing cognitive architectures
  e.g., generative end-to-end Vision-Language-Action (VLA) models

- New forms of cognitive architecture
  e.g., energy-based Joint-Embedding Predictive Architecture (JEPA)
  (LeCun, 2022; Dawid & LeCun, 2024)

Question 1

Based on foundation models, aka. LLMs & VLMs

Are Vision-Language-Action (VLA) models the answer?

– RT-2, RT-X, OpenVLA, CogACT, GROOT N1, RFM-1, π_0 ...

– Difficulties

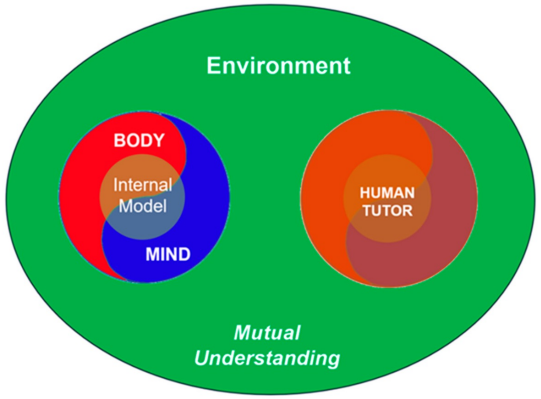
- Obtaining internet-scale training data
- Dealing with variability of physical environments, robot morphologies, and tasks
- Guaranteeing trustworthiness
- Achieving real-time performance

D. Vernon, "The Future of Research in Cognitive Robotics: Foundation Models or Developmental Cognitive Models?", Advanced Robotics Research, 2025.

Question 1

Are Vision-Language-Action (VLA) models the answer?

"Generative AI cannot cooperate with humans,
because it does not really understand humans and,
thus, is unable to support mutual understanding"



G. Sandini, A. Sciutti, and P. Morasso, “Collaborative Robots with Cognitive Capabilities for industry 4.0 and beyond,” AI 5 (2024): 1858–1869.

Question 1

Are Vision-Language-Action (VLA) models the answer?

"Let's all take a moment of silence for our dear friend VLAs. They've served us well. Rest in peace."

Jim Fan
Leader of the embodied autonomous research group at Nvidia

Robotics' End Game
Talk at AI Ascent 2026
https://sequoiacap.com/article/ai-ascent-2026/

Question 1

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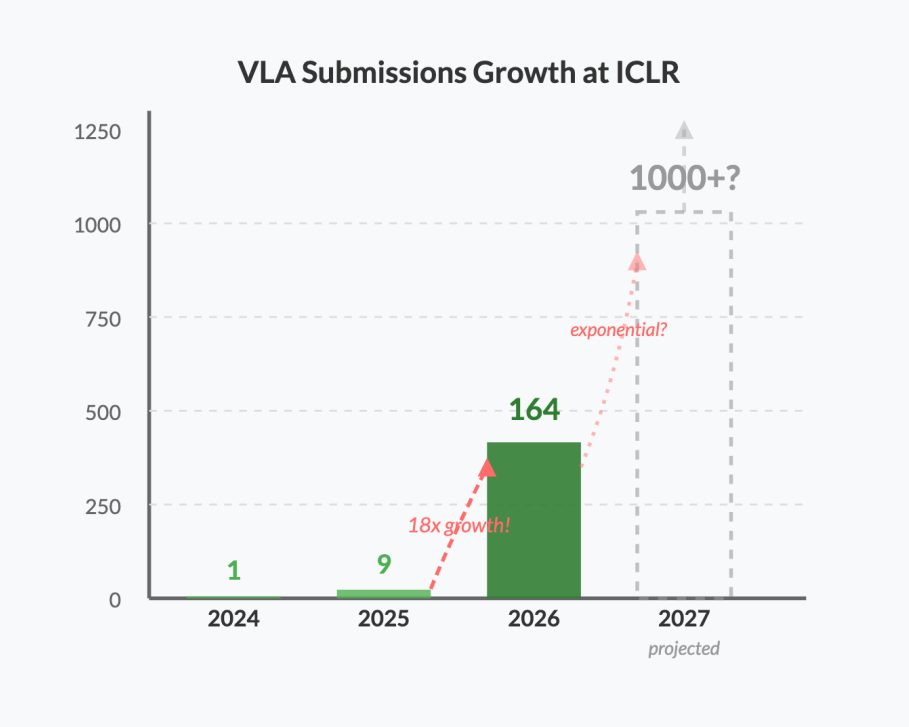

One the other hand ...

M. Reuss

State of VLA Research at ICLR 2026

https://mbreuss.github.io/blog_post_iclr_26_vla.html

Question 2

Are there any other approaches we should be aware of?

"Let's all take a moment of silence for our dear friend VLAs. They've served us well. Rest in peace.
Long live world action models."

Jim Fan
Leader of the embodied autonomous research group at Nvidia

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https://www.youtube.com/watch?v=3Y8aq_ofEVs&t=1181s

Question 2

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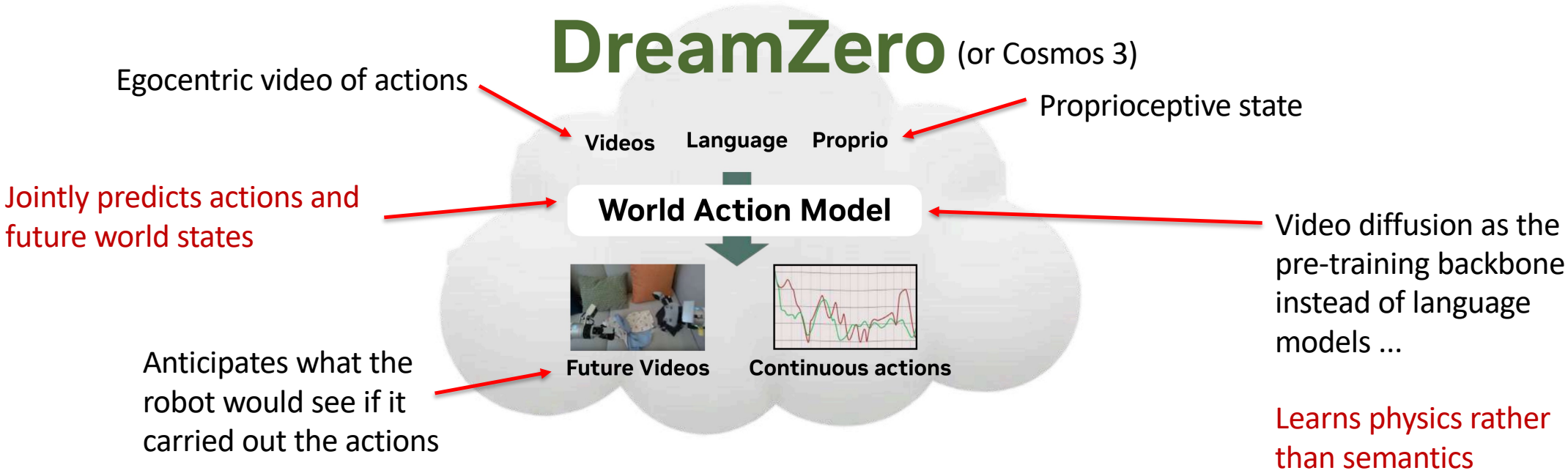


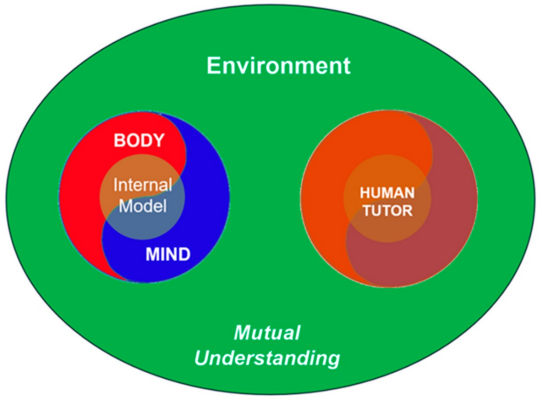
Ye et al., World Action Models are Zero-shot Policies, 2026, arXiv:2602.15922

Question 1b

Are World Action Models (WAM) the answer?

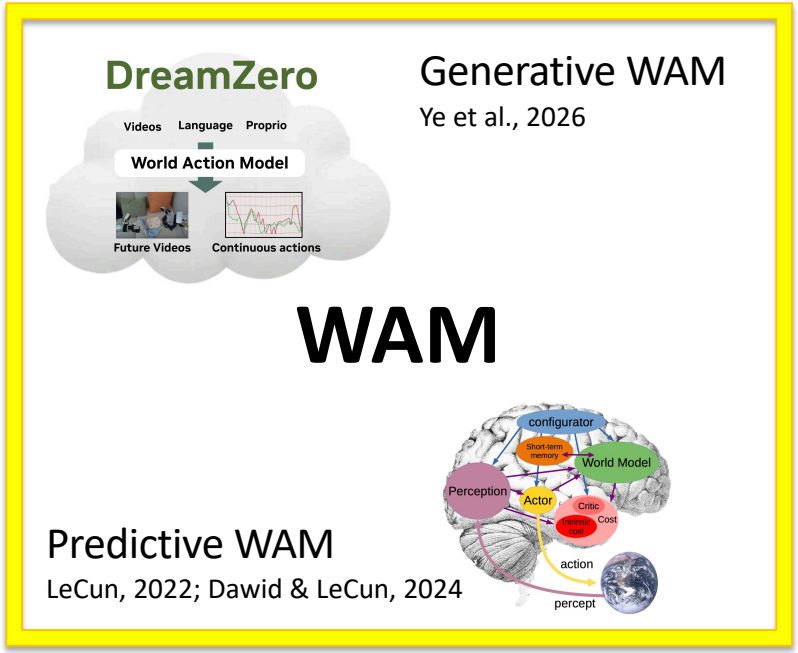
~~Are Vision-Language-Action (VLA) models the answer?~~

"Generative AI cannot cooperate with humans, because it does not really understand humans and, thus, is unable to support mutual understanding"



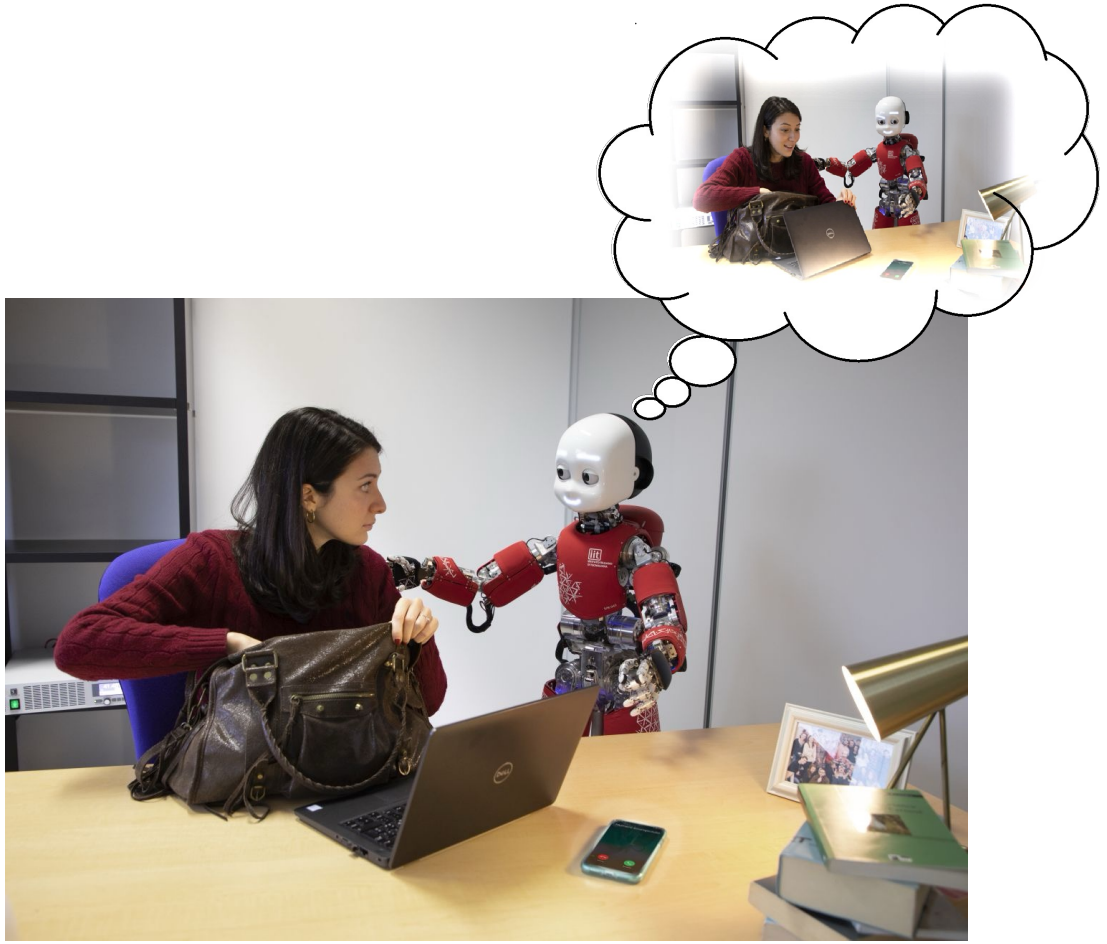
G. Sandini, A. Sciutti, and P. Morasso, “Collaborative Robots with Cognitive Capabilities for industry 4.0 and beyond,” AI 5 (2024): 1858–1869.

Conclusion



Watch this space

e.g., V-JEPA 2 (Assran et al., 2025)



Incremental, few-shot, continual learning;
not dependent on internet-scale datasets

But keep on building developmental robot cognitive architectures with world models for prospective goal-directed action & interaction

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