Introduction to Cognitive Robotics

Module 1: Overview of Cognitive Robotics

Lecture 2: Operation of a cognitive robot; reasons for studying cognitive robotics

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What is cognition?

Why is cognition useful in robotics?

How do cognitive robots work?

Finally, we answer this question

Operation of a Cognitive Robot

Cognitive robots achieve their goals by

- Perceiving their environment
- Paying attention to the events that matter
- Anticipating the need for some action
- Planning what to do
- Anticipating the outcome as it executes the action
- Learning from the resultant interaction
- Adapting to change

Operation of a Cognitive Robot

Cognitive robots achieve their goals by

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Perception makes use of many sensory modalities, e.g. vision, audition, and haptic (tactile and kinesthetic)

(see https://www.youtube.com/watch?v=HH6QD0MgqDQ)

Operation of a Cognitive Robot

Cognitive robots achieve their goals by

- Perceiving their environment
- Paying attention to the events that matter
- Anticipat
- Plannin
- Anticip
- Learnin
- Adaptin

Selective
selecting a given feature or object

Restrictive
restricting what to look for or where to look for it

Suppressive
suppressing features, objects, or locations that are deemed to be not relevant

[Kotseruba and Tsotsos 2020]

Operation of a Cognitive Robot

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Anticipation; also referred to as prospection

The anticipated action is often associated with achieving a goal

Four modes of operation:
simulation, prediction, intention, and planning

[Szpunar et al. 2014]

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Planning is sometimes effected by reasoning about the current state of the world or anticipated futures states

Exploits memories of past experience (episodic memory) and knowledge of the world (semantic memory)

Operation of a Cognitive Robot

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Anticipating the outcome of a possible action can refer to the actions of the robot itself or the actions of other agents (people and other robots)

Operation of a Cognitive Robot

Cognitive robots achieve their goals by

- Perceiv
- Paying
- Anticip
- Plannin
- Anticipa
- Learning from the resultant interaction
- Adapting to change

Learning from actions means that future actions can be more effective or more efficient

Often based on reasoning

Sometimes referred to as meta-cognition or meta-reasoning (the focus is on improving the cognitive or reasoning process)

Operation of a Cognitive Robot

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Adaptation is also achieved through learning

In this case the result of learning is a **new** action policy rather than an **improved** action policy

Operation of a Cognitive Robot

"Cognition is the process by which an autonomous system

perceives its environment,

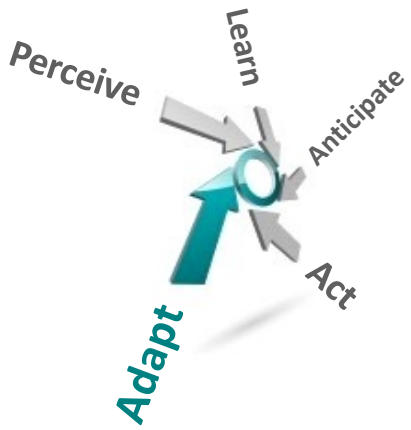
learns from experience,

anticipates the outcome of events,

acts to pursue goals, and

adapts to changing circumstances."

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



Orchestrating all this requires a cognitive architecture

Recap

A key feature of cognitive robotics is the focus on prospection to augment immediate sensory-motor experience, both when navigating and manipulating objects in the robot's environment and when interacting with people.

Cognitive robots are able to carry out tasks effectively by anticipating the effects of their own actions as well as the actions of the people around them.

Being able to view the world from another person's perspective, a cognitive robot can anticipate that person's intended actions and needs and, consequently, it can interact safely while performing tasks in everyday situations.

This applies both during direct interaction (e.g. a robot assisting a customer in a supermarket) and indirect interaction (e.g. a robot stacking shelves while customers are shopping).

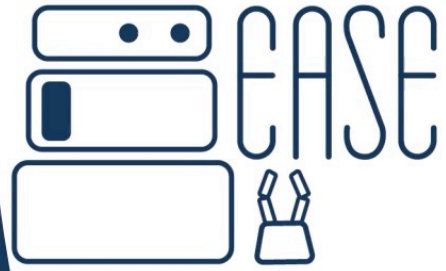
Open Knowledge for AI-Enabled Robots

OpenEASE CeBIT 2016

http://www.open-ease.org/

The Robot Household Marathon aka the EASE Robot Day Demonstrator

Gayane Kazhoyan, Simon Stelter, Ferenc Balint-Benczedi,
Franklin Kenghagho Kenfack, Sebastian Koralewski and Michael Beetz



Artificial Intelligence

Universität Bremen

EASE Milestone Meeting, September 2020

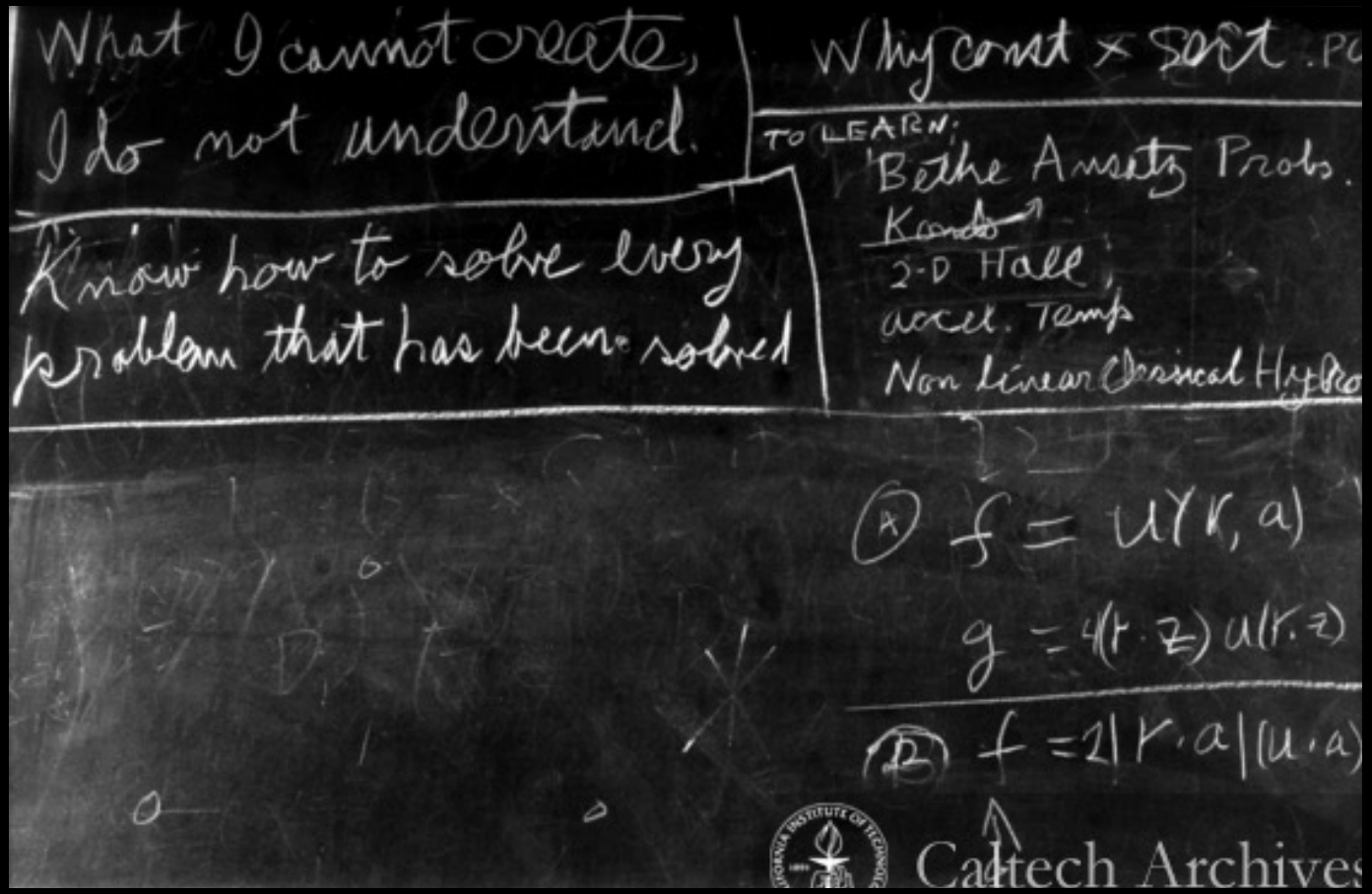
http://www.open-ease.org/

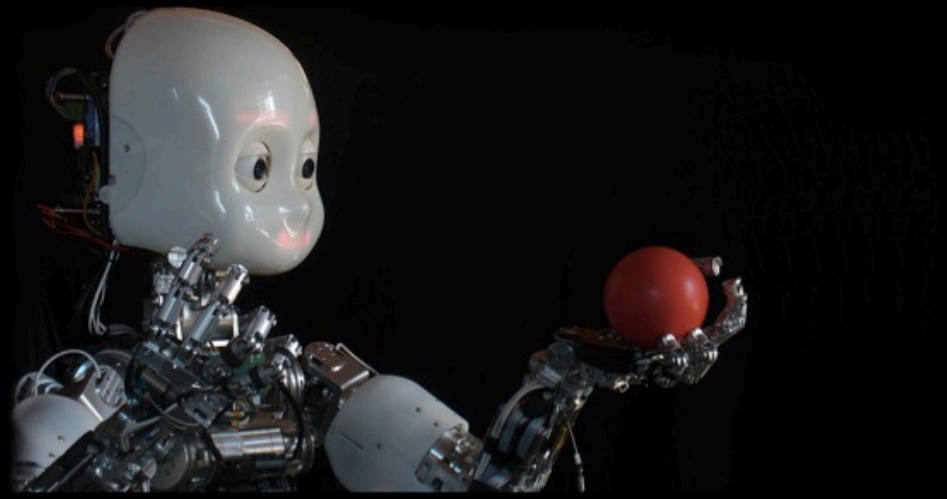
A Final Thought ...

There are two reasons people study cognitive robotics

1. They want to build smart robots
2. They want to understand cognition

Richard Feynman

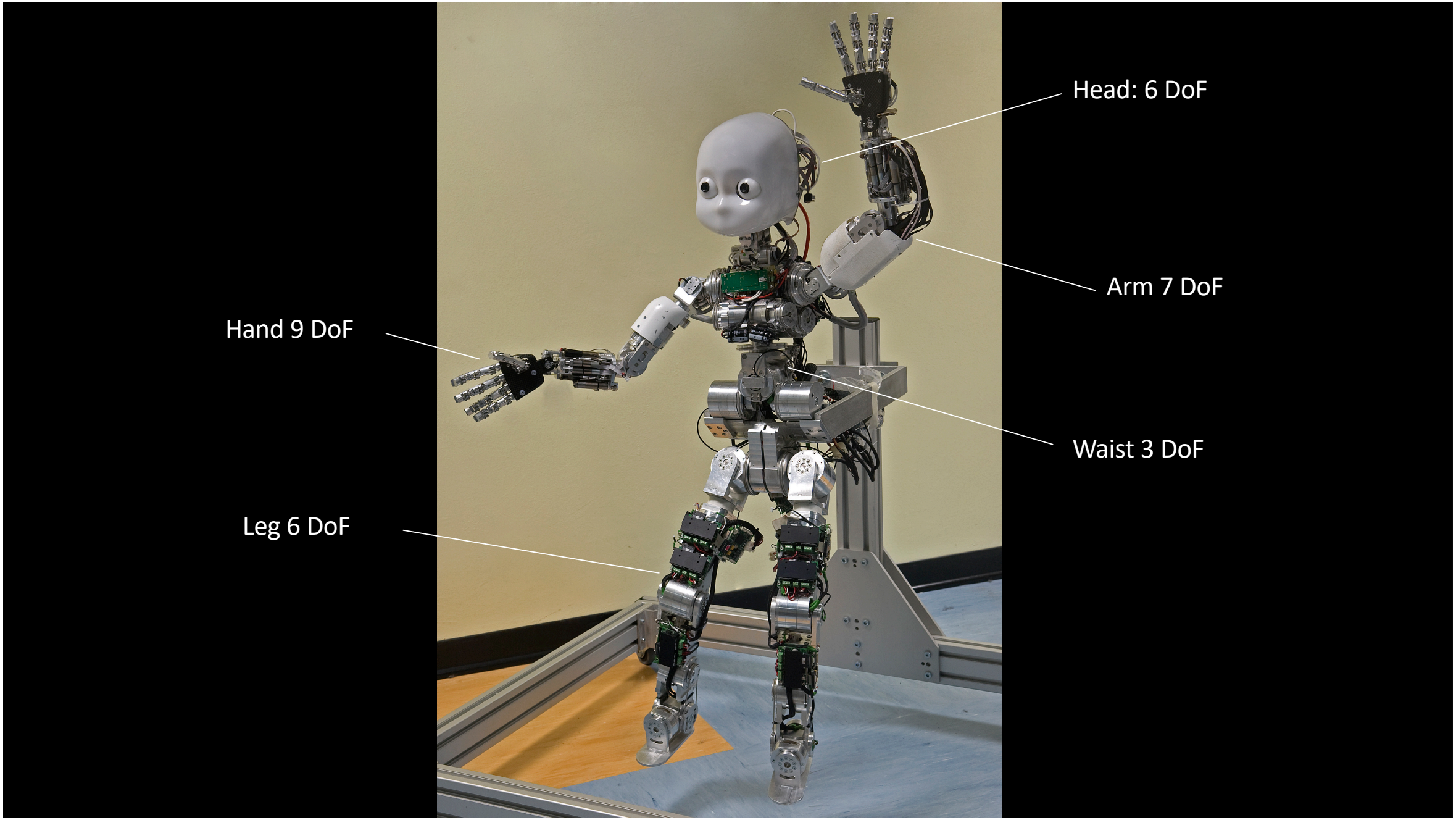




iCub.org

an open source cognitive humanoid robotic platform

Funded by The European Commission, Project IST-004370, RobotCub,
under Strategic Objective 2.3.2.4: Cognitive Systems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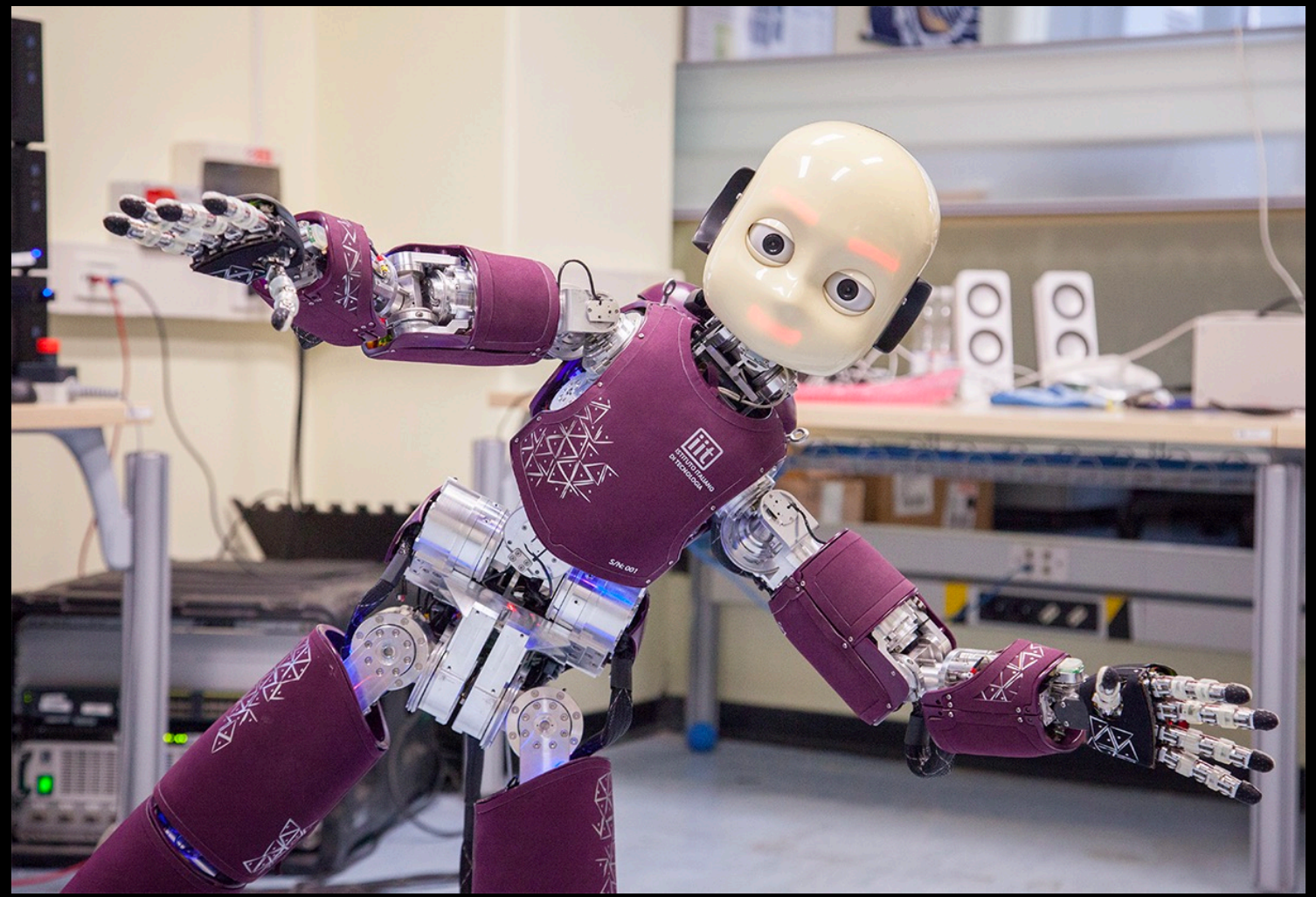
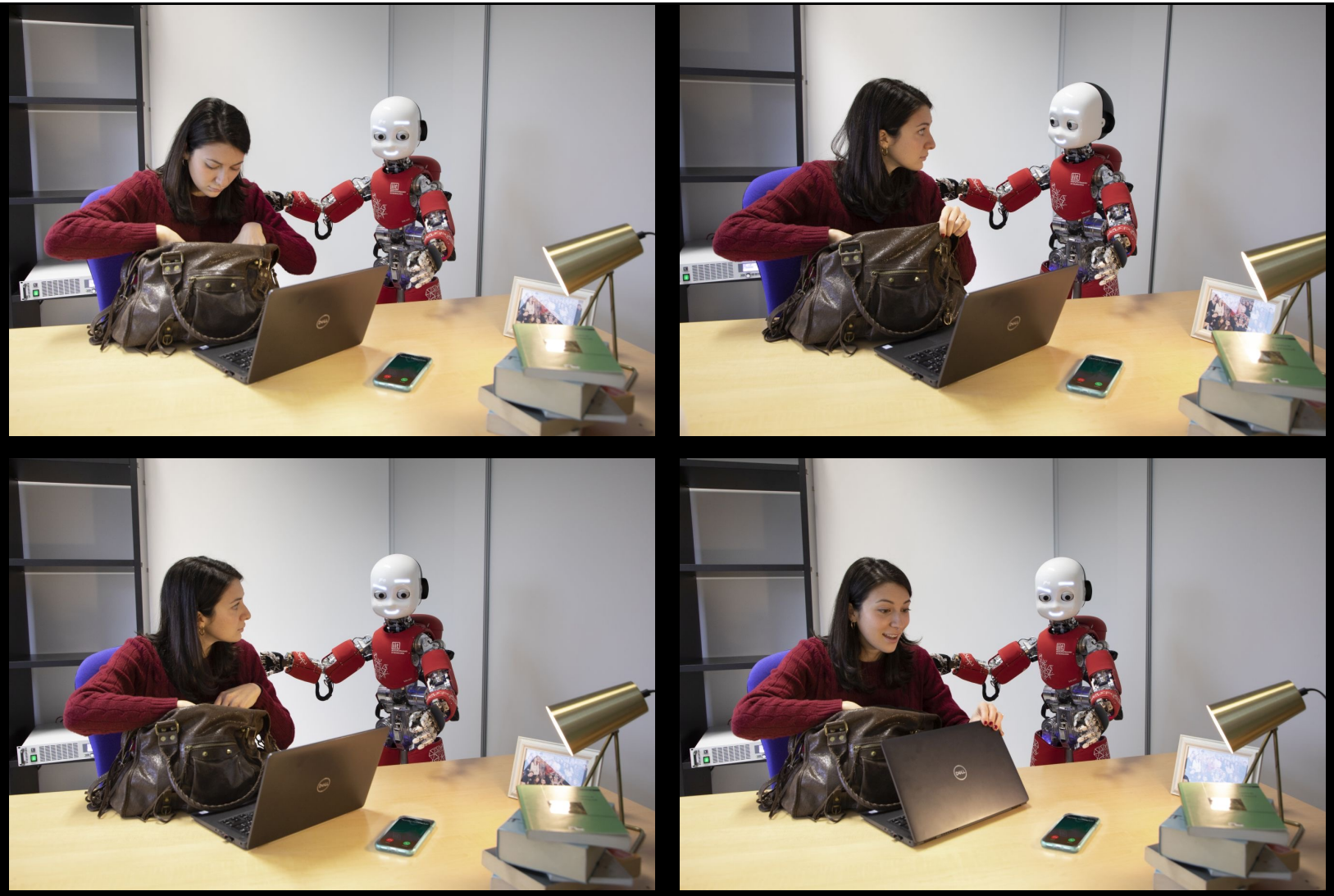
Arm 7 DoF
Hand 9 DoF
Waist 3 DoF
Leg 6 DoF



https://icub.iit.it/products/icub-robot



"This sequence of pictures depicts a situation in which the iCub humanoid robot (www.icub.org) is interacting with a human, reading her intention to get her phone from her bag, and alerting her to the fact that it is on the desk, hidden from her by the laptop.
Note that this sequence has been staged to illustrate the desired capabilities of a cognitive robot and has not yet been implemented."

Sandini, G., A. Sciutti, and D. Vernon. Cognitive Robotics. In M. Ang, O. Khatib, and B. Siciliano (Eds.), Encyclopedia of Robotics. Springer, 2021.
Images courtesy of Istituto Italiano di Tecnologia

Recommended Reading

D. Vernon. Artificial Cognitive Systems – A Primer, MIT Press, 2014; Chapter 1.