Introduction to Cognitive Robotics

Module 6: Artificial Cognitive Systems

Lecture 6: Interaction and Social Cognition

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Interaction

Cognition so far:

- Agent-centred
- “Lonely” activity
- Explore and interact with the world: adaptation and autonomy
- Not collective social activity

Interaction

- But …

  Other cognitive agents playing a major role in the cognitive activities of an individual cognitive agent

- Cognitive systems in a collective setting

  – How cognition in an individual agent takes place in a **social milieu**

Interaction

- Two of the essential characteristics of cognitive interaction
  - **Action**
  - **Goals**
- Two others
  - **Intention**
  - **Perception**

Interaction

Two of the essential characteristics of cognitive interaction

- **Intention**...the prospective aspect of action and goals
  - **An intention includes both a goal and the means of achieving it**
  - An agent may have
    - A goal for some state of affairs to exist and
    - An intention to do something specific in pursuit of that state of affairs

Interaction

Two of the essential characteristics of cognitive interaction

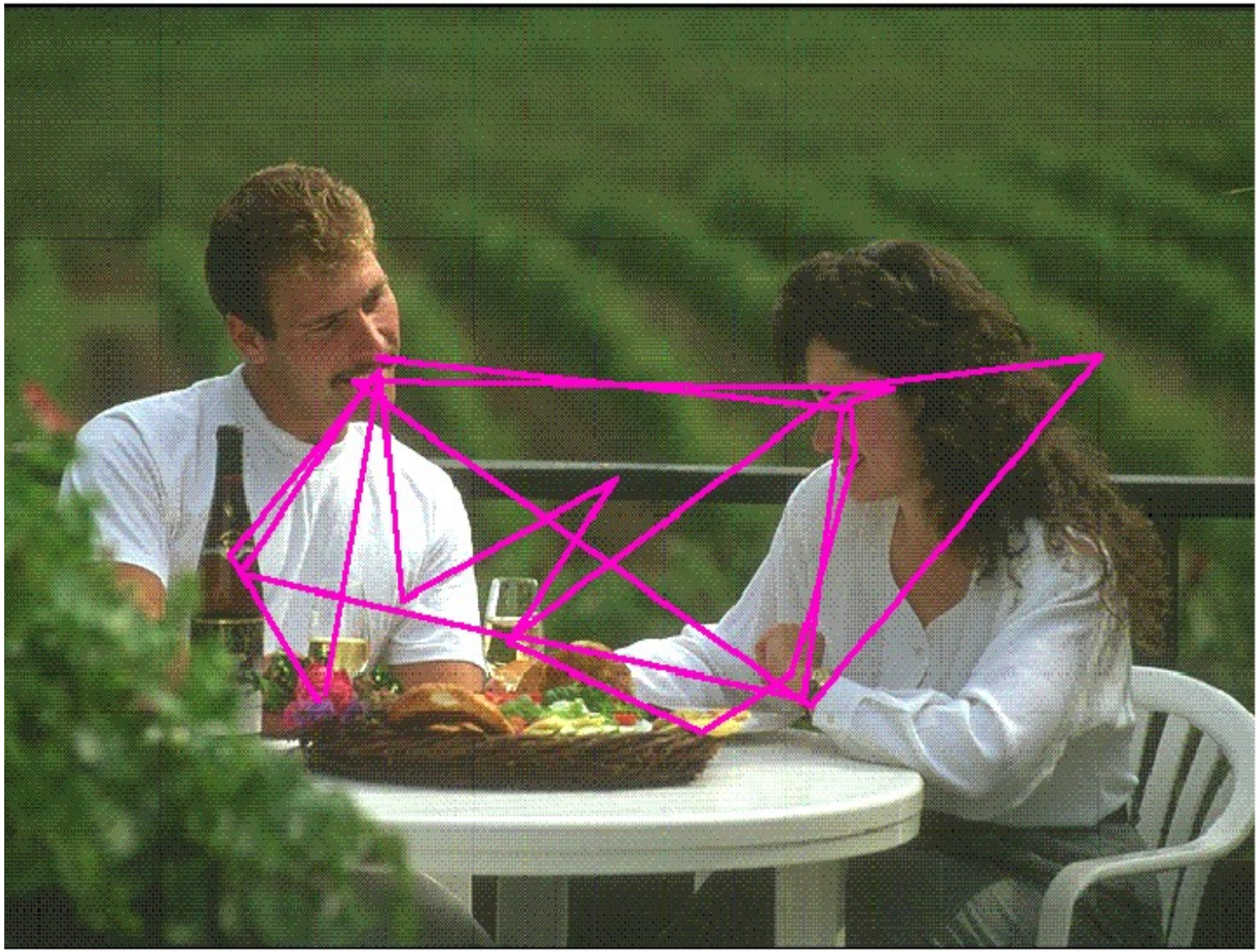
- **Perception**
  - Directed
  - Focussed on goals
  - Influenced by expectations
  - **Attentive**

Interaction

Attention

- **Spatial** attention: where we direct our gaze
- **Selective** attention: what sort of things are most apparent to our gaze
- "the temporally-extended processes whereby an agent concentrates on some features of the environment to the (relative) exclusion of others."

(Kaplan and Hafner 2006)



[K. O'Regan and A. Noë 2000]

Interaction

Attention

"Intentionally-directed perception"

We focus our attention on what matters to us in pursuit of our goals

"When performing movements or observing someone else performing them, subjects fixate goals and sub-goals of the movements [Johansson et al. 2001]. However, this is only done if an action is implied: when showing the same movements without the context of an agent, subjects fixate the moving object instead of the goal [Flanagan and Johansson 2003]."

Claes von Hofsten

Interaction

Attention

The video that follows has three cases:

1. an agent (the subject) stacks blocks
2. another agent (an actor) stacks blocks, and
3. a hidden agent (an actor with hidden hands) stacks blocks.

In cases 1 and 2, the subject's gaze saccades to the goal position in advance of the hand movement, i.e., it predicts the intention when it is an action (which requires the presence of an agent and a goal)

In case 3, the subject's gaze just follows the block because no agent is apparently present, and therefore there is no intention, no action, and no implied goal: it is just a movement

See: J. R. Flanagan, G. Rotman, A. F. Reichelt, and R. S. Johansson, "The role of observers' gaze behaviour when watching object manipulation tasks: predicting and evaluating the consequences of action," Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences, vol. 368, no. 1628, 2013.

Block stacking

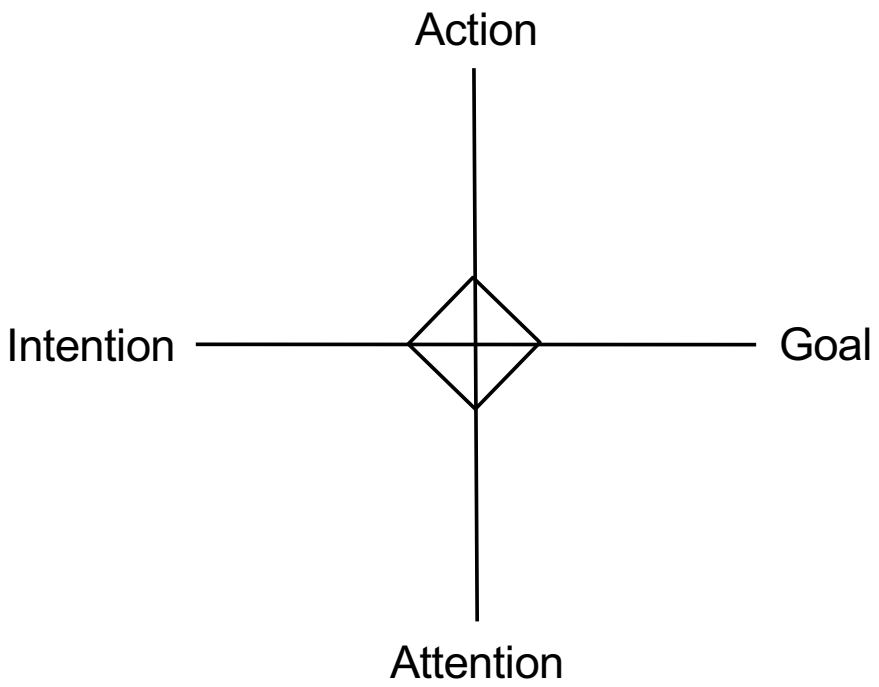
- ***subject performs***
- *actor performs*
- *"blocks just move"*
  (actors hand hidden)

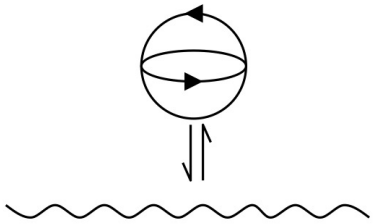
Interaction

Four characteristics **of interaction of an individual** cognitive agent

1. Action
2. Goals (or commitment)
3. Intention
4. Attention (intention-guided perception)

All of which have an element of prospection


Action
Intention
Goal
Attention

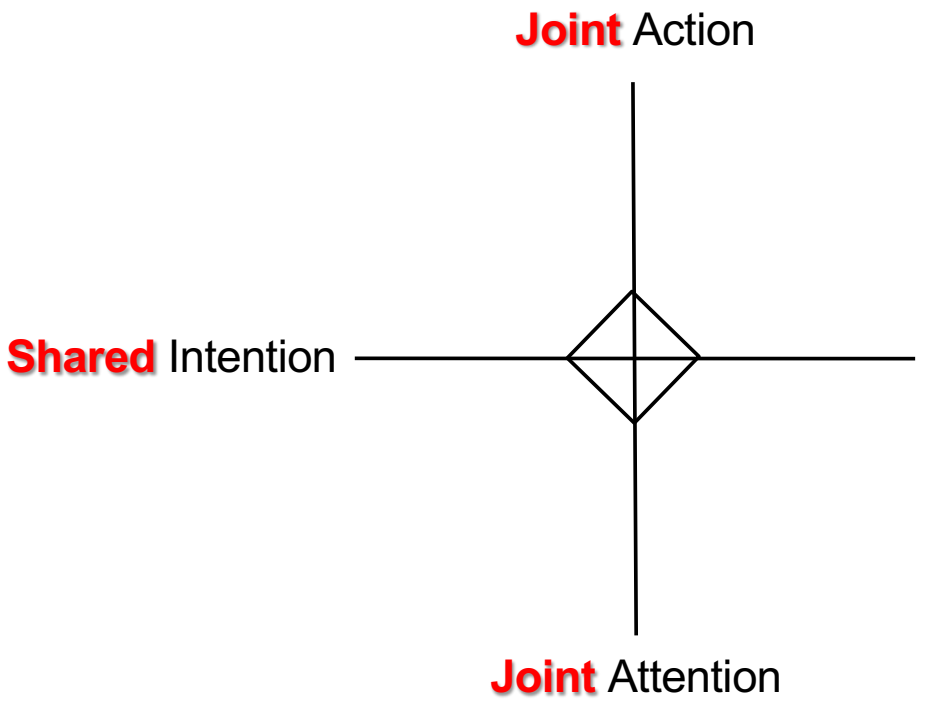


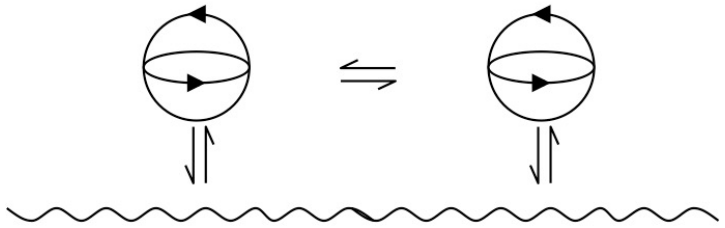
Interaction

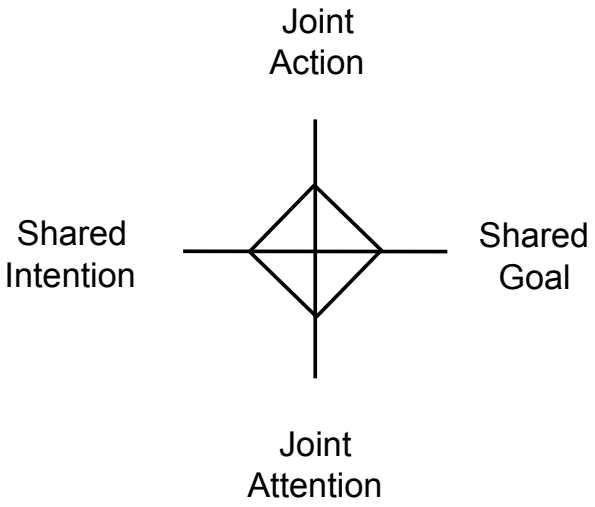
Social interaction between two (or more) cognitive agents

1. **Joint** action
2. **Shared** goals
3. **Shared** intentions
4. **Joint** attention

Not just a simple superposition of the notions of individual action, goals, intentionality, and attention


Joint Action
Shared Intention
Shared Goal
Joint Attention




Joint
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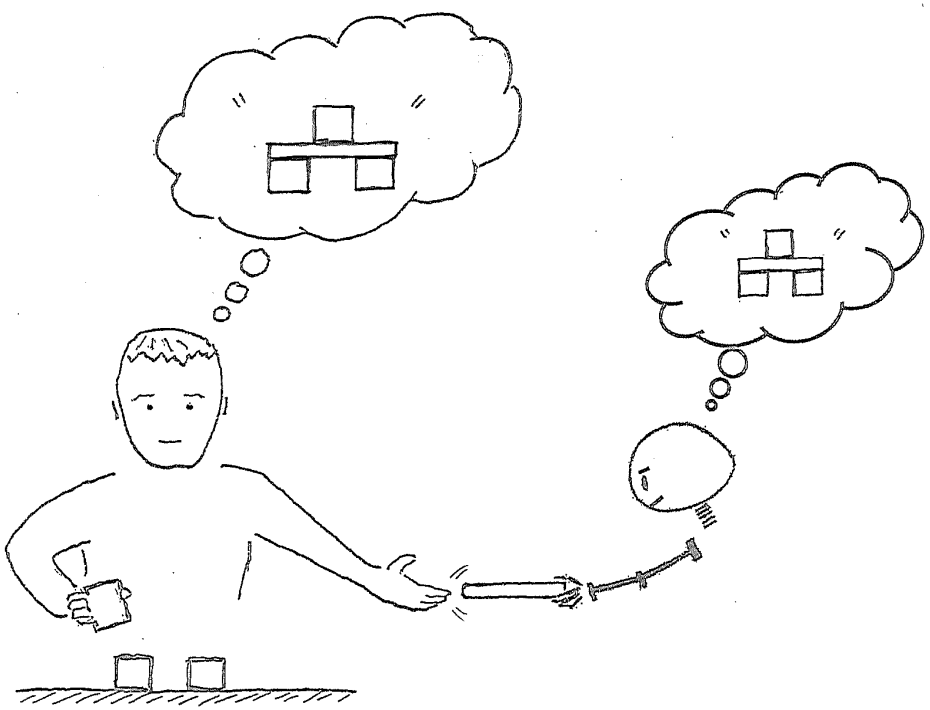


Social Interaction

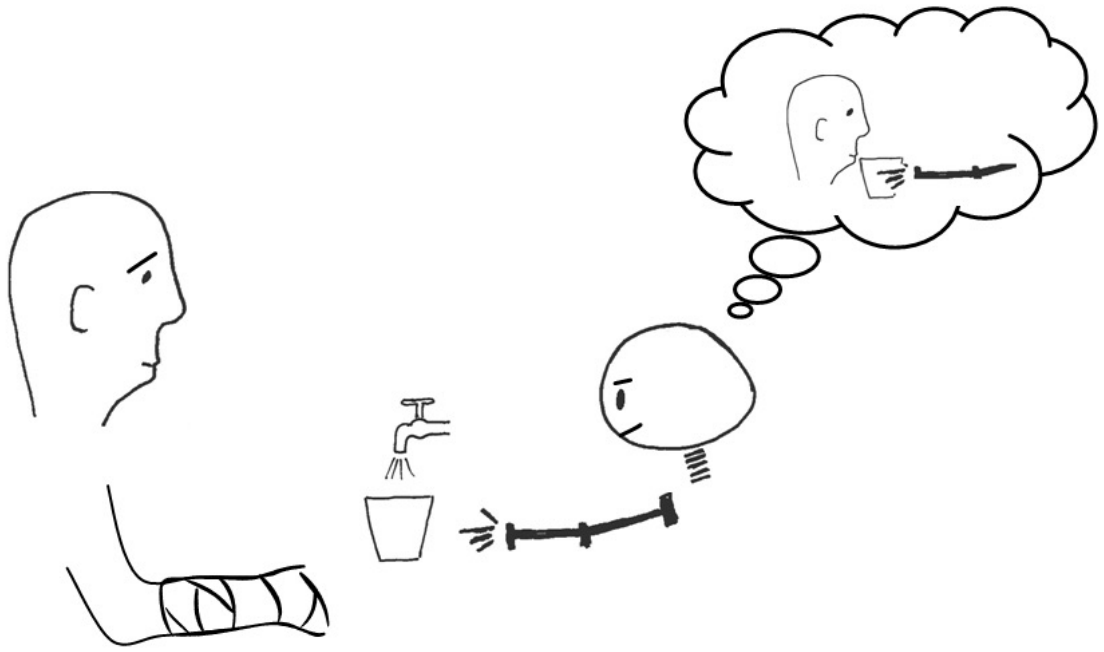
Required abilities

- Reading faces
- Detecting eye gaze
- Recognizing emotional expressions
- Perceiving biological motion
- Paying joint attention
- Detecting goal-directed actions
- Discerning agency, imitation, deception, empathy, ...

- ...

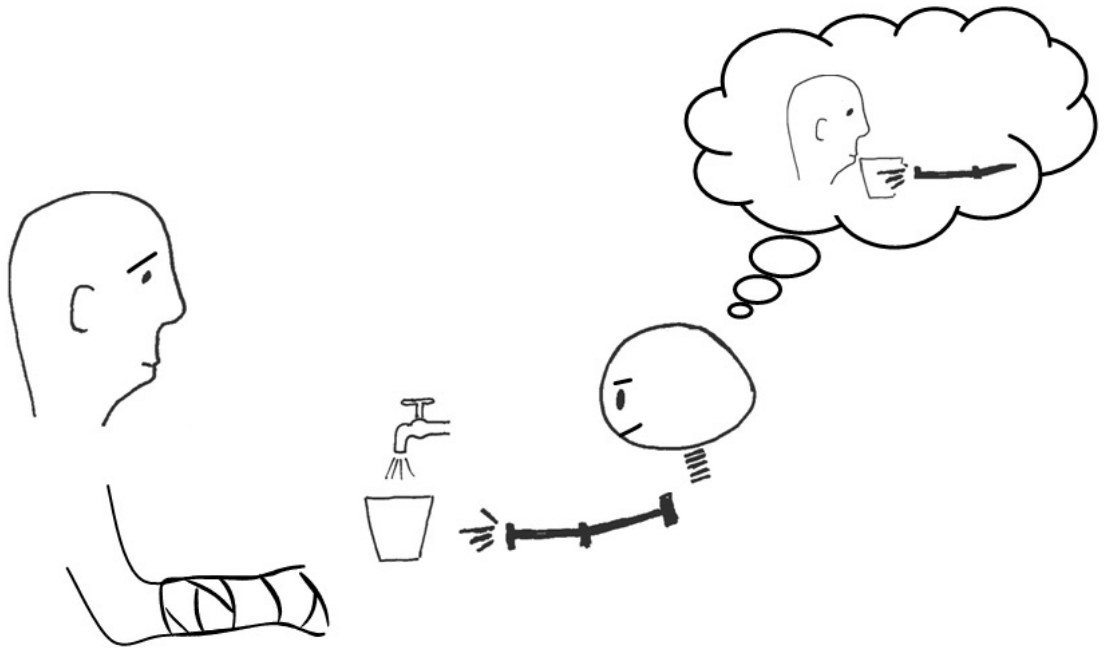
- Need to be aware of the cognitive state of the other agent

Social Cognition



Inferring Intentions & Theory of Mind
Instrumental Helping
Collaboration

Social Cognition



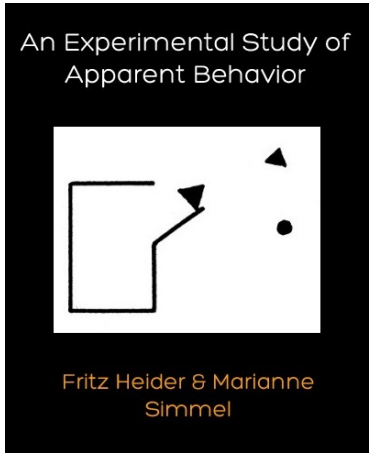
Inferring Intentions & Theory of Mind
Instrumental Helping
Collaboration

Inferring Intentions and Theory of Mind

- Prospection is the essence of cognition
- Social interaction is complex because …
  - **A cognitive agent's act must anticipate the actions of an agent that itself is already anticipating what it is going to do**
- That is, an agent must anticipate the intentions of other agents
  - Predict what they will do
  - Possibly, why they want to do it

Inferring Intentions and Theory of Mind

- Theory of Mind:
  - To have the ability to infer what someone else is thinking and wants to do
- Young children differentiate between the behaviour of inanimate and animate objects
  - attributing mental states to the animate objects
- Attribute agency to inanimate objects that exhibit biological motion
  - Intentions
  - Emotions
  - Personality traits



Fritz Heider and Marianne Simmel, 1944

https://www.youtube.com/watch?v=n9TWwG4SFWQ
and
http://vimeo.com/48908599

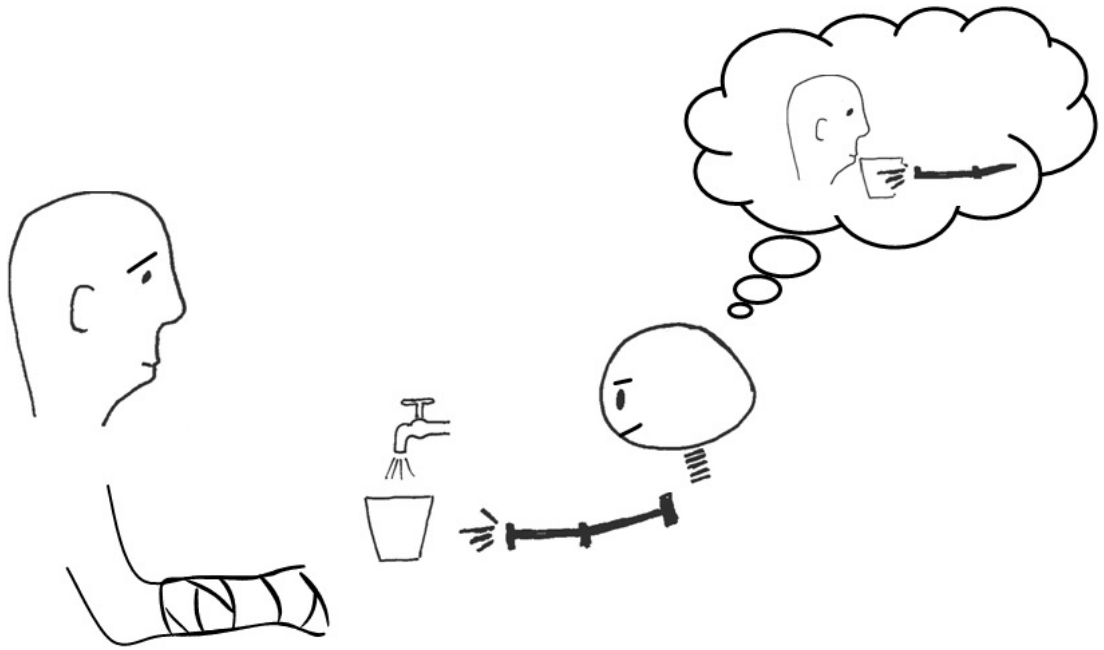
Inferring Intentions and Theory of Mind

Humans infer different types of intention

- Interpreting movements (lower level intentions) … **what** is the desired state
- Interpreting actions (higher level) … **why** is it desired (underlying motive)
- Grasp a cup *vs.* he is thirsty

Inferring Intentions and Theory of Mind

- How do human infer the intentions of others from their actions?
- **Internal simulation**
  - A mechanism that predicts the consequences of the agent's own actions based on its own intentions by internal simulation using forward models
    - Input: overt or covert motor commands
    - Output: the likely sensory consequences of carrying out those commands
  - When observing another agent's actions, the same mechanism can be used
    - Associate **observed** movements with likely, i.e. intended, sensory consequences



Inferring Intentions & Theory of Mind
Instrumental Helping
Collaboration

Learning to Help and Be Helped

It takes several years for human infants to develop the requisite abilities

- 14 to 18 months: **instrumental helping behaviour**
- 2 years: start to solve **simple cooperation** tasks with adults
- 2-3 years: ability to **cooperate** with peers
- 3 years: complex **collaboration**
  - Sharing of intentions
  - Joint coordination of complementary actions
- 3 ½ years: Roles in the task can be reversed; & can teach new partners

Instrumental Helping

Instrumental helping

- Assist the other individual achieve their goals
- Even in the absence of any benefit from doing so
- Sometimes because there is no benefit in doing so

Instrumental Helping

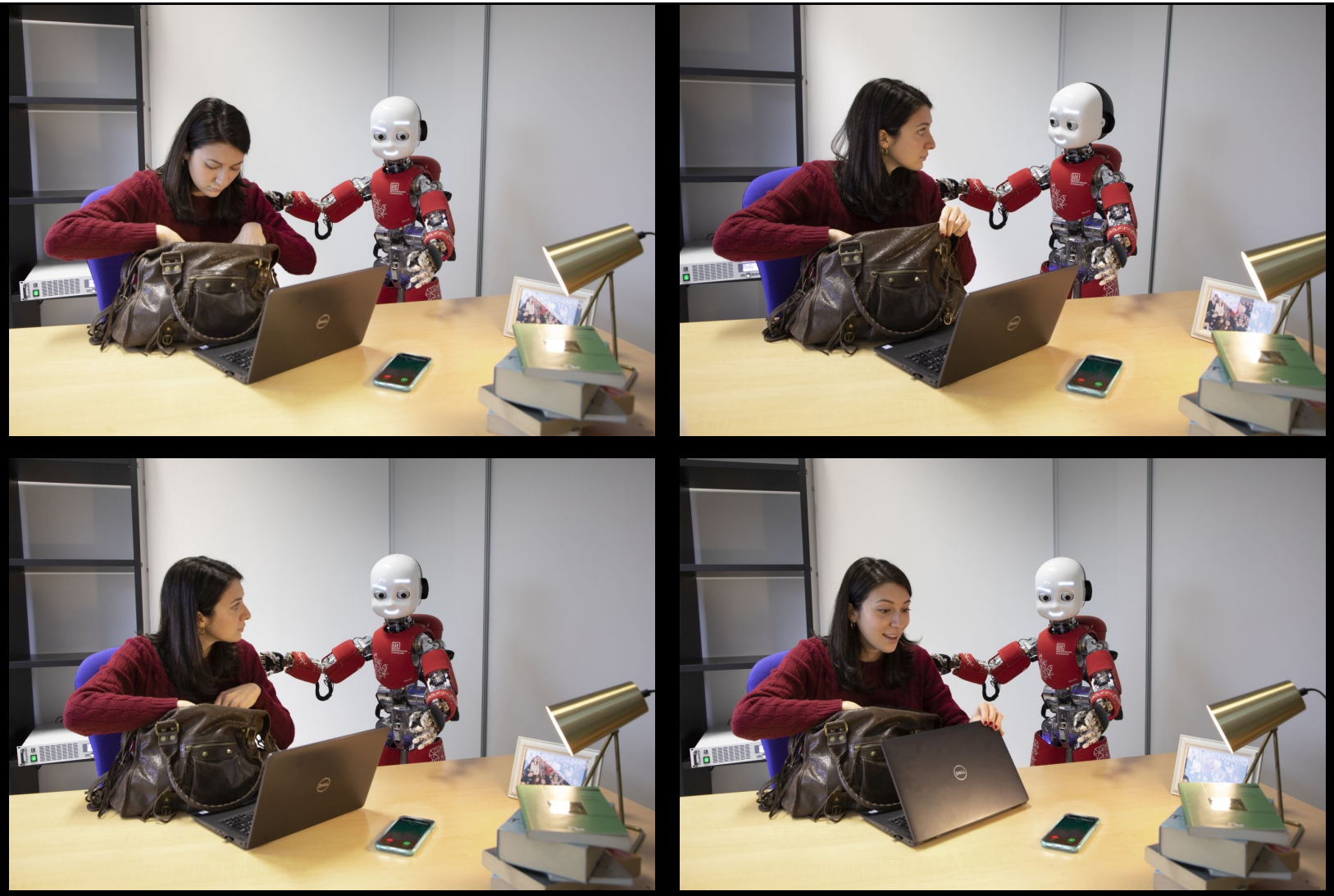
The Prospective Nature of Helping

- **Instrumental helping** requires one agent to understand the goal of another agent
  - Inferring its intention
  - Recognizing that it can't achieve it without assistance
  - Acting to provide the necessary help

    (e.g., picking up something for a person whose hands are full).

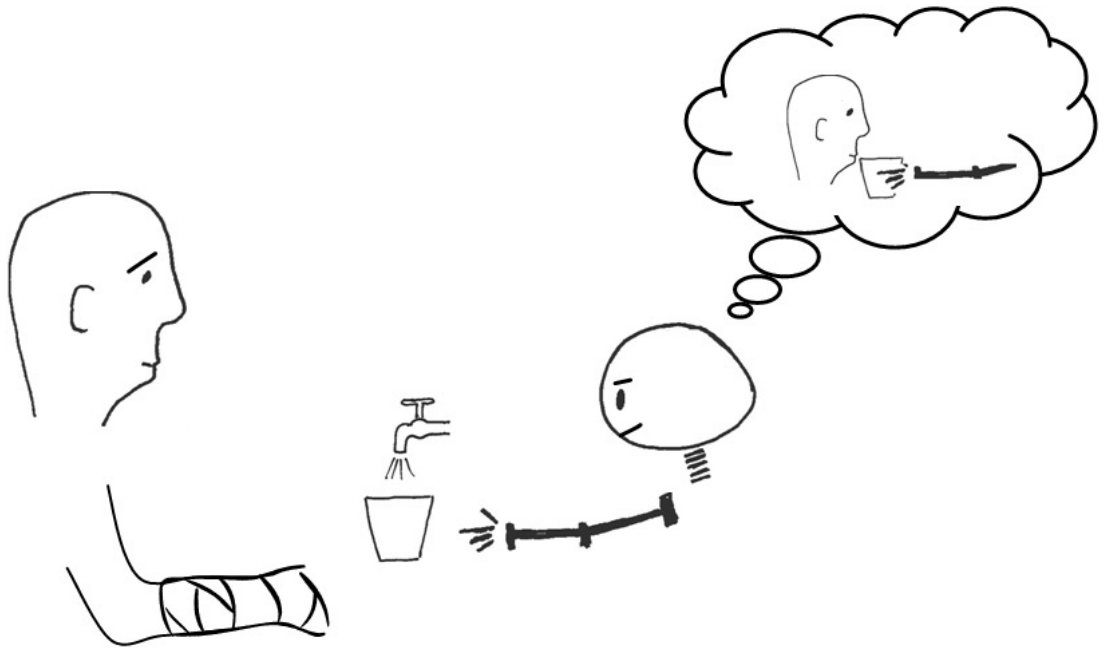
Instrumental Helping

- Two components
  - Cognitive
    - Recognizing what the other agent's goal is
    - Recognizing the reason they can't achieve it on their own
  - Emotional
    - Desire to see the second agent achieve the goal
    - Desire to see the second agent exhibit pleasure at achieving it
- Prosocial behaviour (in contrast to anti-social behaviour)
  - Directed at benefitting another person



"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."

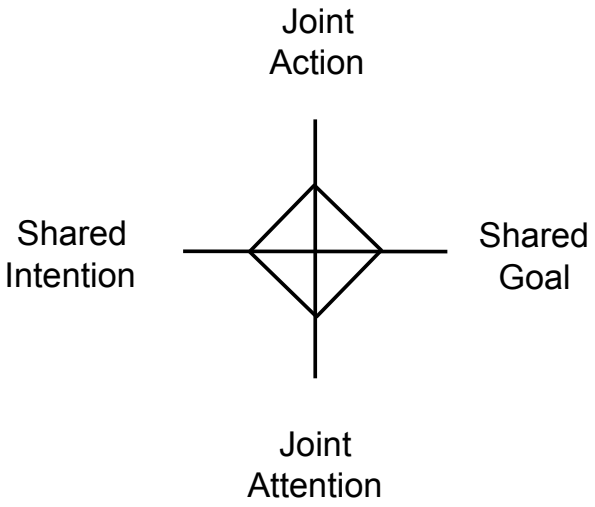
Sandini, G., A. Sciutti, and D. Vernon (in press). Cognitive Robotics. In M. Ang, O. Khatib, and B. Siciliano (Eds.), Encyclopedia of Robotics. Springer.
Images courtesy of Istituto Italiano di Tecnologia



Inferring Intentions & Theory of Mind
Instrumental Helping
Collaboration

Collaboration

- More complicated than instrumental helping
- **Joint cooperative action**
  - **Joint action**
  - **Shared cooperative activity**
- Agents that engage in joint action
  - **Share** the **same goal, intend** to act together, c**oordinate** their actions to achieve their shared goal through **joint attention**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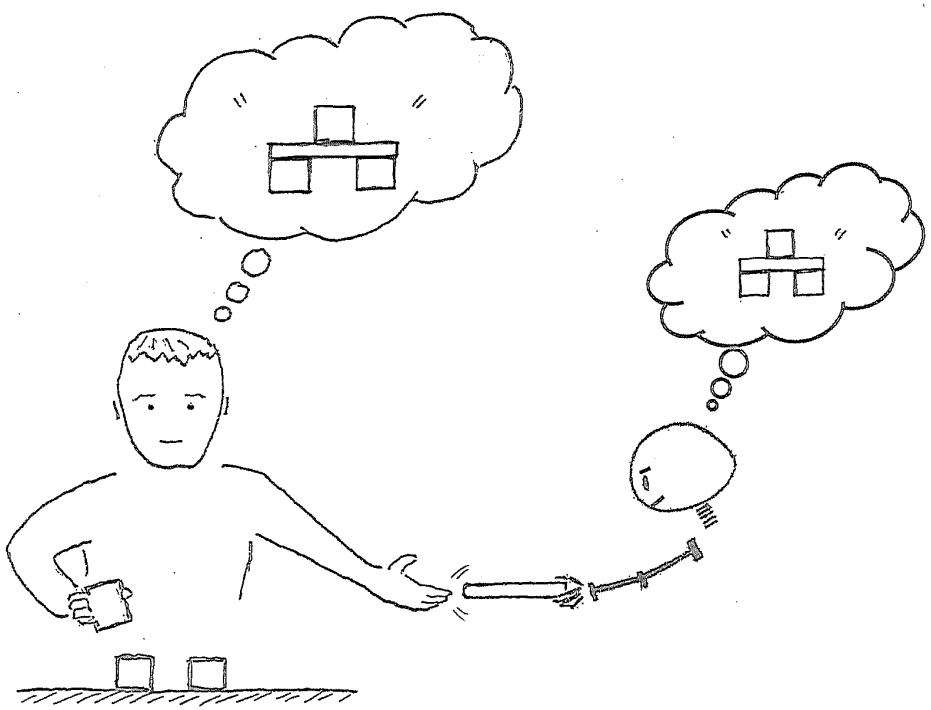

Collaboration

- To take part in collaborative activities requires
  - An ability to read intentions
  - An ability to infer goals
  - A unique motivation to share psychological states with other agents
- Shared intentionality:

"Collaborative actions in which participants have a shared goal (shared commitment) and coordinated action roles for pursuing that shared goal."

(Tomasello et al. 2005)

Collaboration

- The goals and intentions of each agent is a mix of their own goals & intentions and the goals and intentions of the other agent
  - The intention is a joint intention
  - The associated actions are joint actions
- This differentiates collaboration from instrumental helping

Collaboration

- Furthermore, each agent understands both roles of the interaction and so can help the other agent if required

- Critically

  - agents not only choose their own action plan

  - but also in its own motor system to enable coordination represent the other agent's action plan in the sense of who is doing what and when

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