KNOWLEDGEABLE
SERVICE ROBOTS
FOR AGING

# AI for social robots

Robots and humans understanding each other

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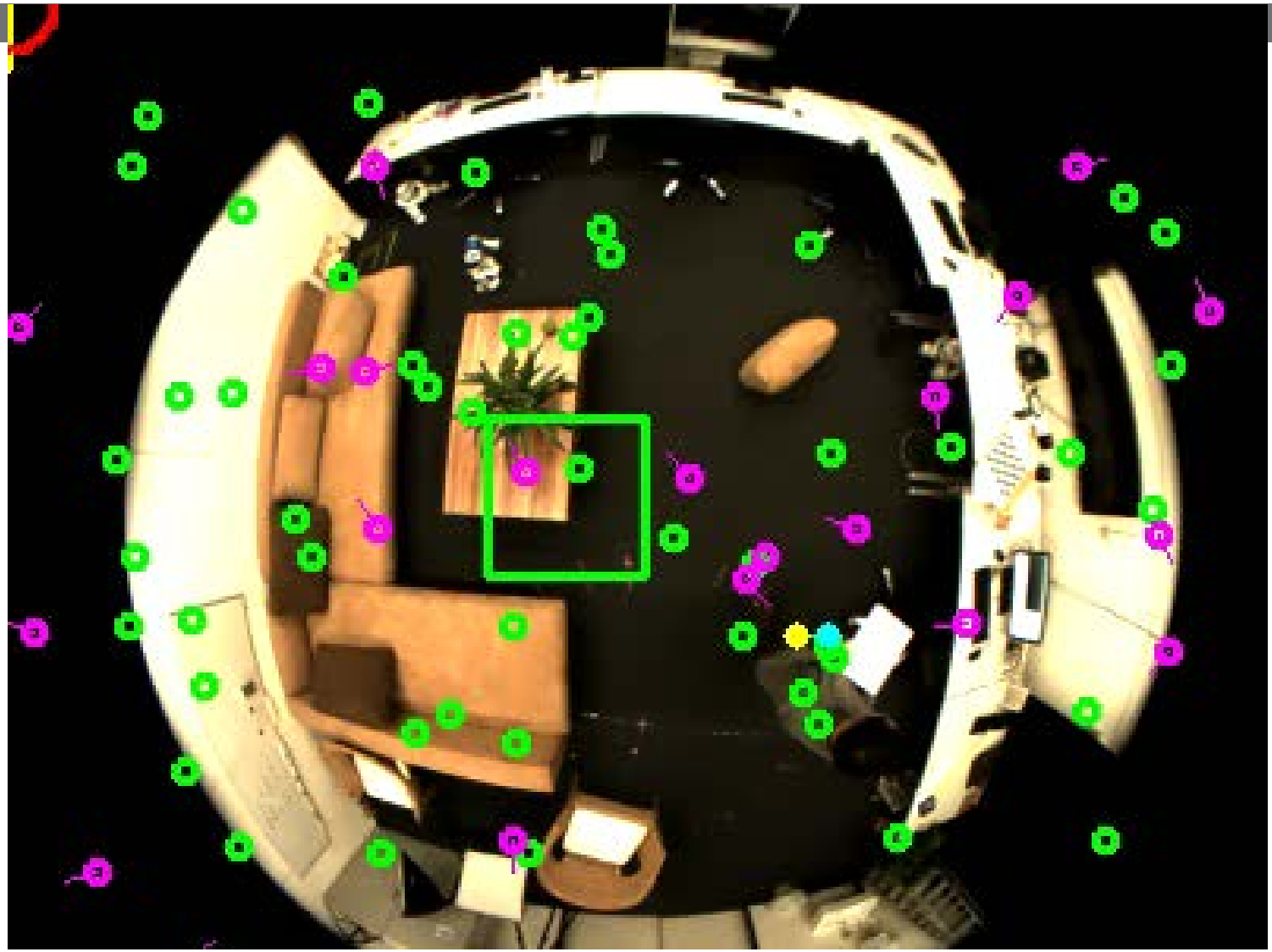
SEVENTH FRAMEWORK PROGRAMME

- As robots interact ever more closely with people, they also need to “understand” them better
- However, psychological knowledge mostly qualitative
  - Quantitative models needed to control
- Conventional AI mostly concerned with searching/inferring true statements using symbolic represention
  - Not suited for real world complexity with partial and inaccurate information

- Modern hybrid approaches have huge potential
  - Distributed knowledge representations
  - Real-time, dynamic, subsymbolic
  - Integration Bayesian probabilistic framework with machine learning and pattern recognition
  - Bayesian methods work well in psychology because of easy integration of prior knowledge with knowledge from observations
  - Online learning (batch learning infeasible and too slow)
  - Biologically inspired?
    - Still huge discrepancy between biological and artificial intelligence
    - May show the way

# Person Localisation

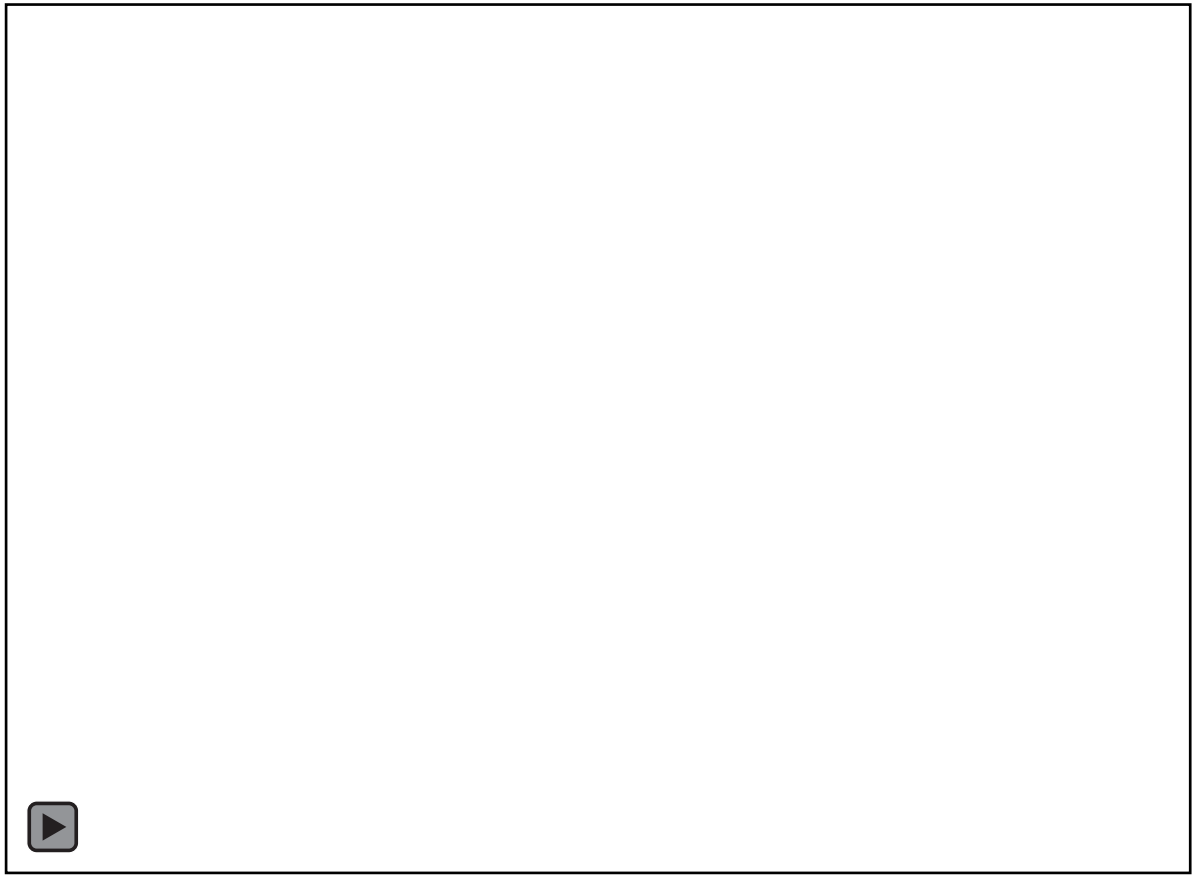


# Example

- Approaching a person to deliver a message
  - Detecting a person – computer vision, feature extraction, convolutional NN, Bayesian sensor fusion/cue integration
  - Tracking a person – tracking-learning detection (TLC), …
  - *Where* to interact – particle filters, 2D neural gas, probabilistic model of personal space/proxemics
  - *When* to interact – Bayesian decision making, stochastic processes, Dynamic neural fields, POMDPS …
  - *What* to do/say – HMM, Bayesian inferences, policy learning, …
  - *How* to behave – Social conventions? Emotional expressiveness?

# Overview

- People need to understand robots
  - Mental models and predicting robot behavior
  - Robots providing social cues
- Robots need to understand people
  - Understanding personal space
  - Understanding turn-taking



- Nomura, T., Kanda, T., Kidokoro, H., Suehiro, Y., & Yamada, S. (2017). Why do children abuse robots?. *Interaction Studies*, *17*(3), 347-369.

# PEOPLE NEED TO UNDERSTAND ROBOTS

# People need to understand robots

Social cues

- Human observer always try to interpret observed behaviours
  - "Doing nothing" also has meaning
- According to Reeves and Nass (1996) people automatically interact in a social way with artificial agents (computers):

Mental model

- 'Theory of Mind' - common sense model of human behavior which allows us to automatically attribute beliefs, goals and mental states to our human co-actors (Premack & Woodruff, 1978; Scassellati, 2002).
- 'Simulation Theory',- observer uses own action system to predict the mental processes and actions of others (Goldman, 1992).

# People need to understand robots

- When working with devices we construct accurate mental models
  - Movement of mouse ↔ movement of mouse cursor
    - Try holding the mouse upside down!
  - Steering a bicycle ↔ movement of bike

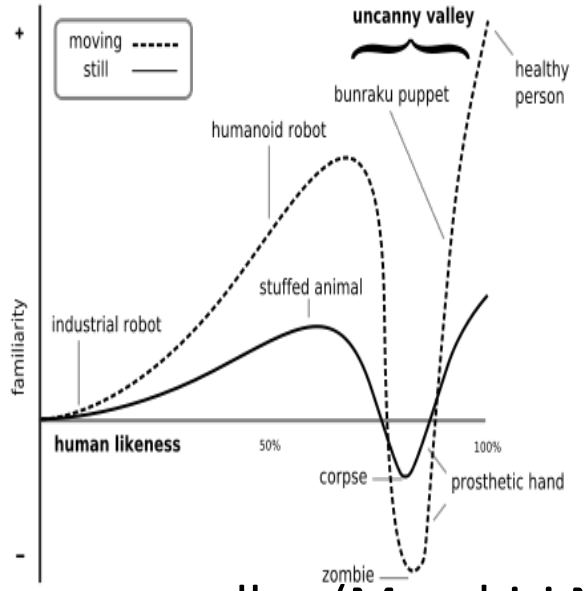
- It allows us to accurately predict behaviours, when our 'mental model' is correct
- Mental models are automatic and subconscious
- When we do not 'have' accurate mental models, we substitute:
  - Human driven car → autonomous car
  - Human → humanoid robot

# People need to understand robots

- A few simple human-like elements in the design could already make a person attribute a variety of human-like characteristics to technology

# People need to understand robots

- If robots look like humans, but do not behave like humans, they become




- Uncanny valley (Masahiri Mori)


# Summary

- We posses many mental models that allow us to predict and interpret behavior
- People anthropomorphize vehicles/robots
  - It makes the robot's behavior predictable
- Robots can take this to their advantage
  - Only a few social cues are sufficient
- However, the mental model can be wrong
  - Robot provides no social cues → unpredictable, cautious response
  - Robot provides wrong social cues → wrong predictions, uncanny!

# ROBOTS NEED TO UNDERSTAND PEOPLE

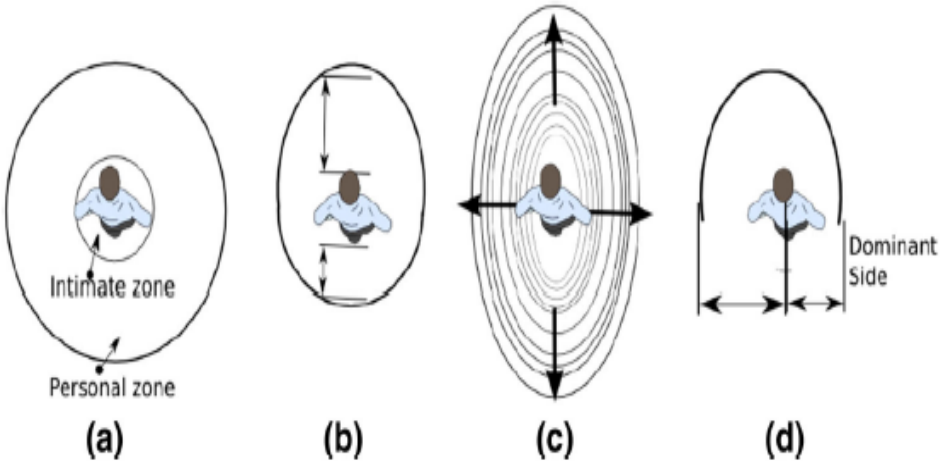
# Robots need mental models of people

- In many applications robots and autonomous vehicles need to adapt to human behavior
  - Autonomous car needs to detect whether pedestrians intend to cross the street
  - Robot assesses risk of abuse

- Robots need a mental model in order to predict human behavior
  - Personal space model
  - Turn-taking cues

# Understanding personal space

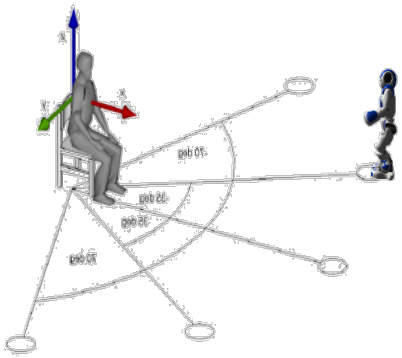
- Conventionally, personal space is a region surrounding a person

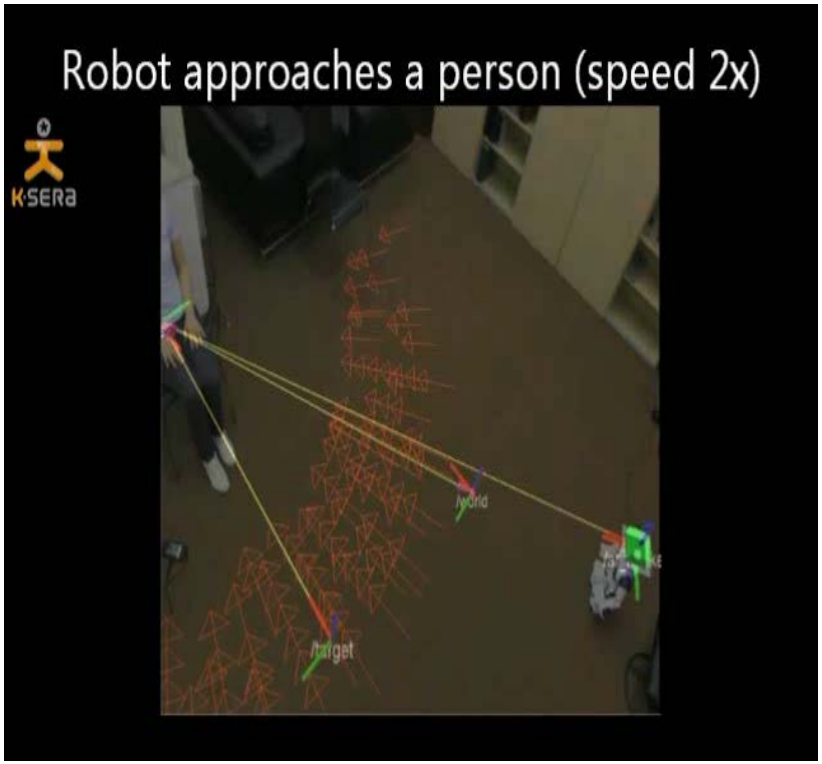


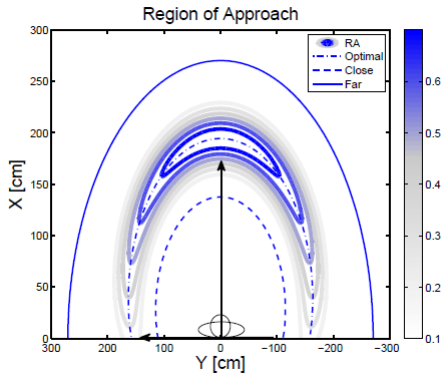

- However, optimal location depends on the environment and activity
  - Behavior based navigation towards human target
  - Dynamic updating using perception of the environment

# Understanding personal space

- Measure stopping distance and determine shape of personal space





# Understanding Turn-taking

- Robotic systems deployable for **information exchange** services

Museum tour-guide

Karreman et al. 2013

Lecturer

Huang & Mutlu, 2013

Receptionist


Michalowski, 2006

# Understanding Turn-taking

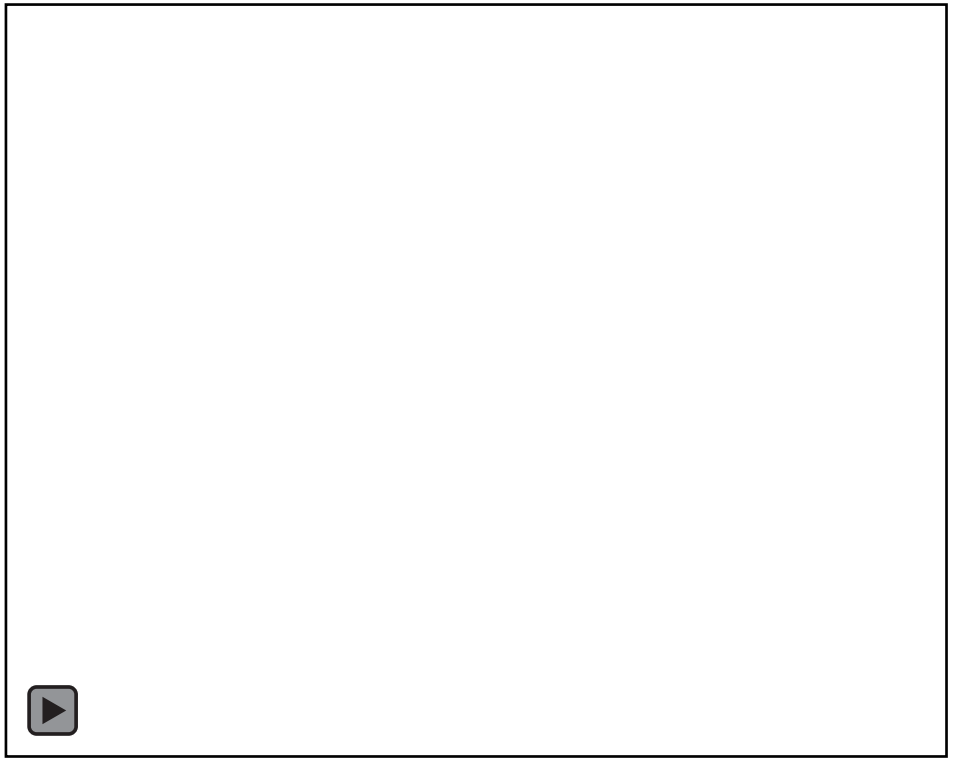
- Eye contact is important for regulating verbal communication
- In order for a robot to make eye contact it must
  - Look at the human observer
  - Monitor the gaze direction of the human looker
- During a conversation
  - Listener looks at speaker
  - Speaker looks at audience (but not always)

- Good turn-yield: speaker stops and looks at person receiving the turn
- Good turn-take: listener waits for silence and gaze cue

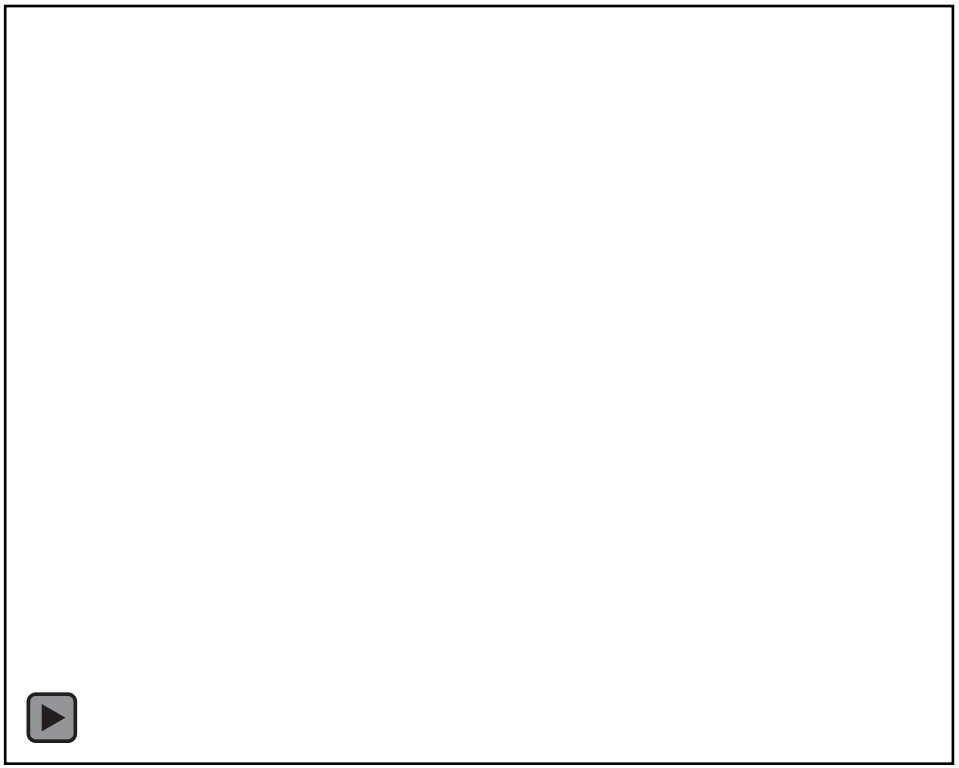
# Understanding Turn-taking

- When the robot understands turn yielding cues,
- And its timing of turn yielding cues is correct

➢ Interaction with robot is very natural and fluent



# Understanding Turn-taking



- However, when the timing is wrong ….

# Summary

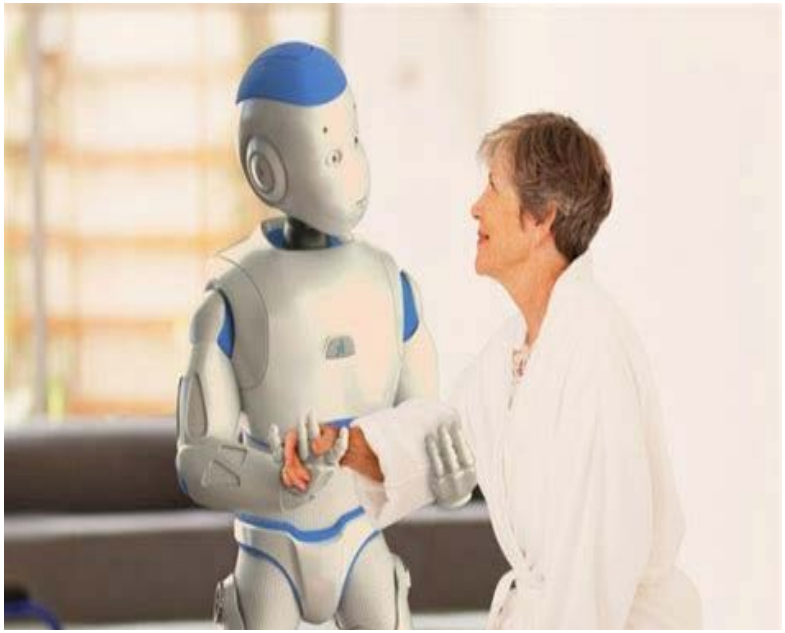
- People have mental models of machines
  - based on experience or expectations(!)
  - Provides opportunity for robots
- Robots need mental models of people
  - Improves predictability and quality of interaction
- When there is a mismatch (either way)
  - Interaction is inefficient and user acceptance is poor

# Future perspectives

- Robots for educational support
- Robots for health care support
- Robots in public places

- AI under the hood
  - Robots are able to detect more and more social cues
  - Robots can adapt to the human context
  - Human-robot collaboration with multiple persons

# Robot companion: still a dream?



**Thank you for your attention!**