Humanoid robots - Social human-robot interaction

Doc. Mgr. Matěj Hoffmann, Ph.D.

Safe design for social HRI

Be so small and weak that you cannot possibly harm anyone…

Note: for iCub and Pepper, this is already not entirely true…

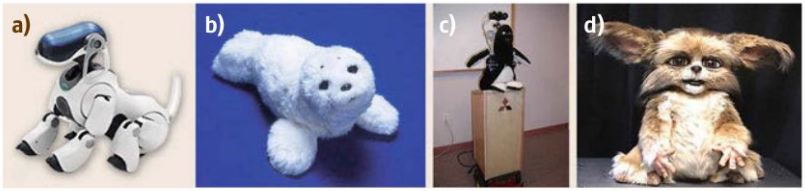
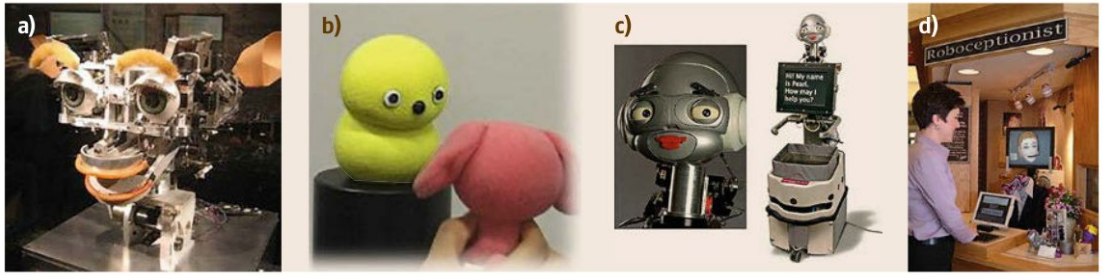


Fig.72.3a–d Examples of social robots inspired by animals with anthropomorphic qualities: **(a)** AIBO, the robotic dog developed by Sony (after [72.30]), **(b)** Paro, the therapeutic seal robot developed at AIST (after [72.31]), **(c)** Mel, the conversational robotic penguin developed at MERL (after [72.32]), and **(d)** Leonardo developed at the MIT Media Lab (after [72.33])



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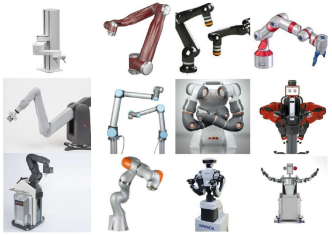
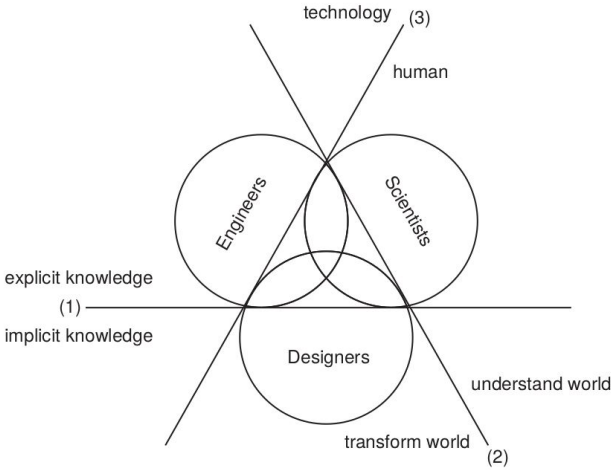
Breazeal, C., Dautenhahn, K., & Kanda, T. (2016). Social robotics. *Springer Handbook of Robotics*, 1935-1972.

HRI - physical or social (cognitive)?

- Physical HRI is about
  - robots doing **physical work** around / with humans
  - safety
- Social HRI
  - physical assistance too - e.g. household chores
  - social interaction with human
  - engineering is only ⅓ of the picture…



A selection of collaborative robots. Image credit: Robotiq.



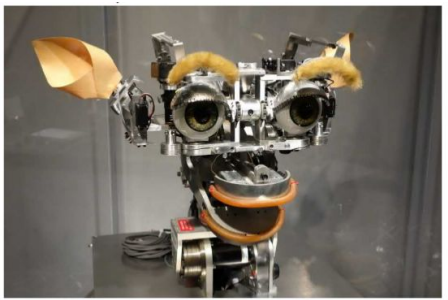
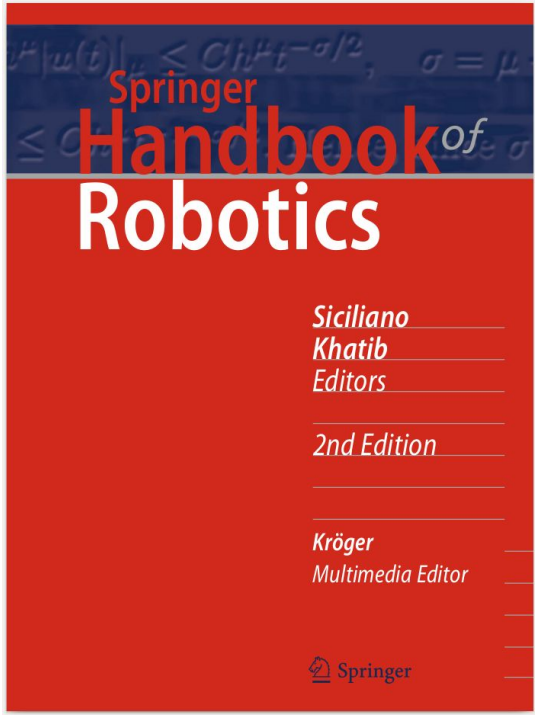


Figure 2.3 Kismet (1997–2004), an early example of social human–robot interaction research from the Massachusetts Institute of Technology. (Source: Daderot)

Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). *Human-robot interaction: An introduction*. Cambridge University Press.



Multimedia Contents

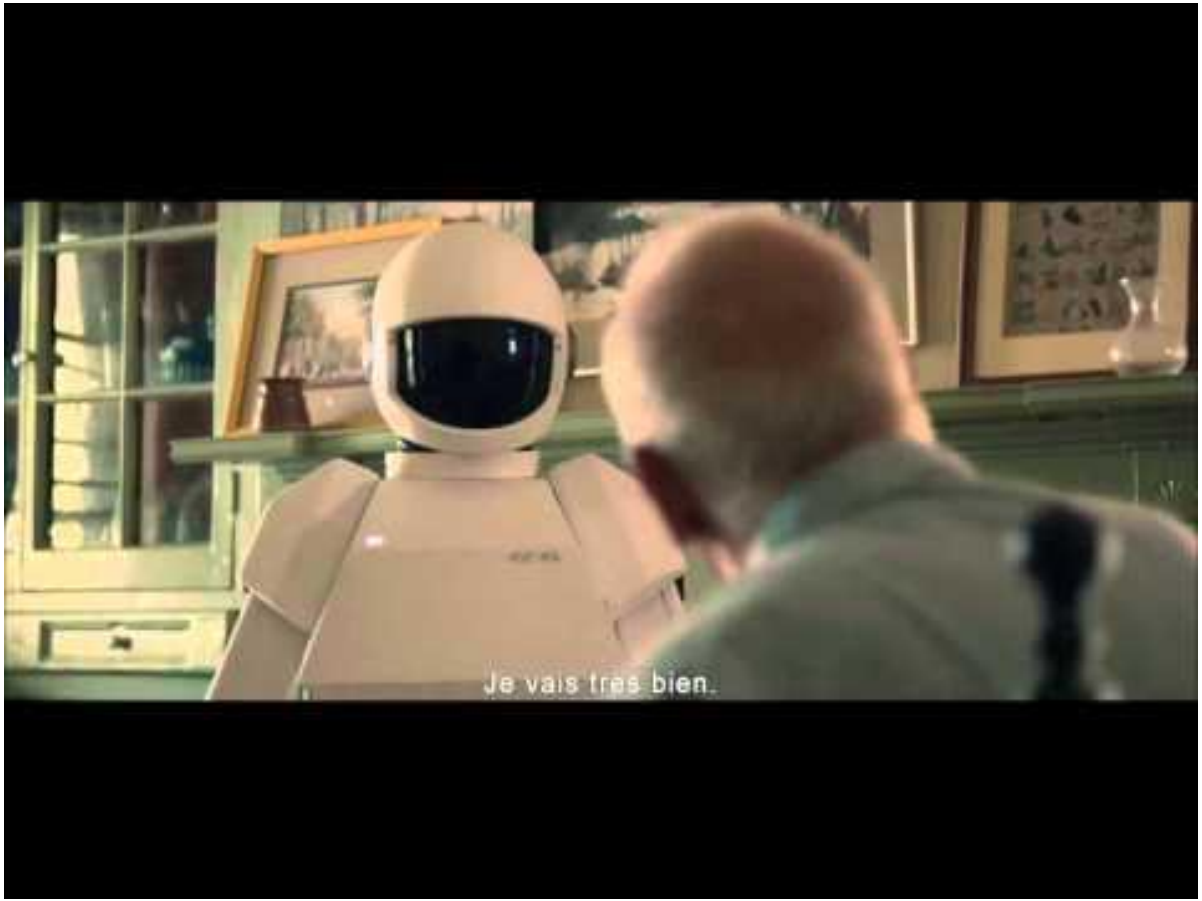
Part G Robots

Part G Robots and Humans

Ed. by Daniela Rus

Robots at home

Robot and Frank, 2012
https://youtu.be/PKJcLnjky3s



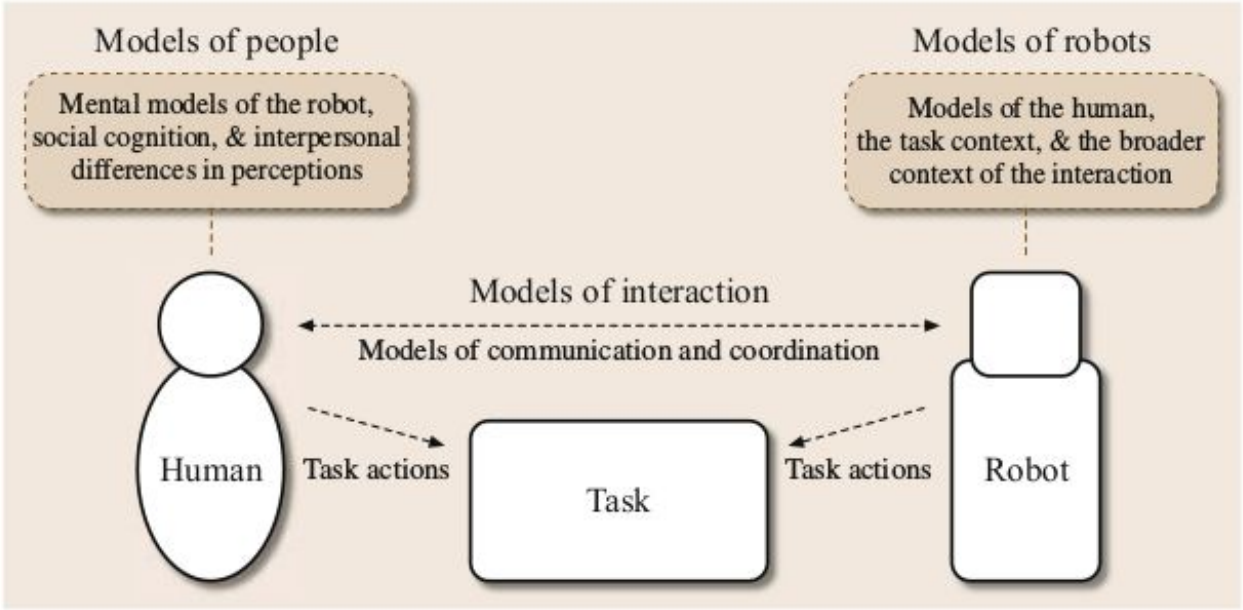
Robocup@home

2012 overview
https://youtu.be/YpjeNa8BAYg

2021 Poster – Team Tidyboy,
https://youtu.be/4GZAo41-pws

https://athome.robocup.org/
RoboCup@Home Youtube official channel

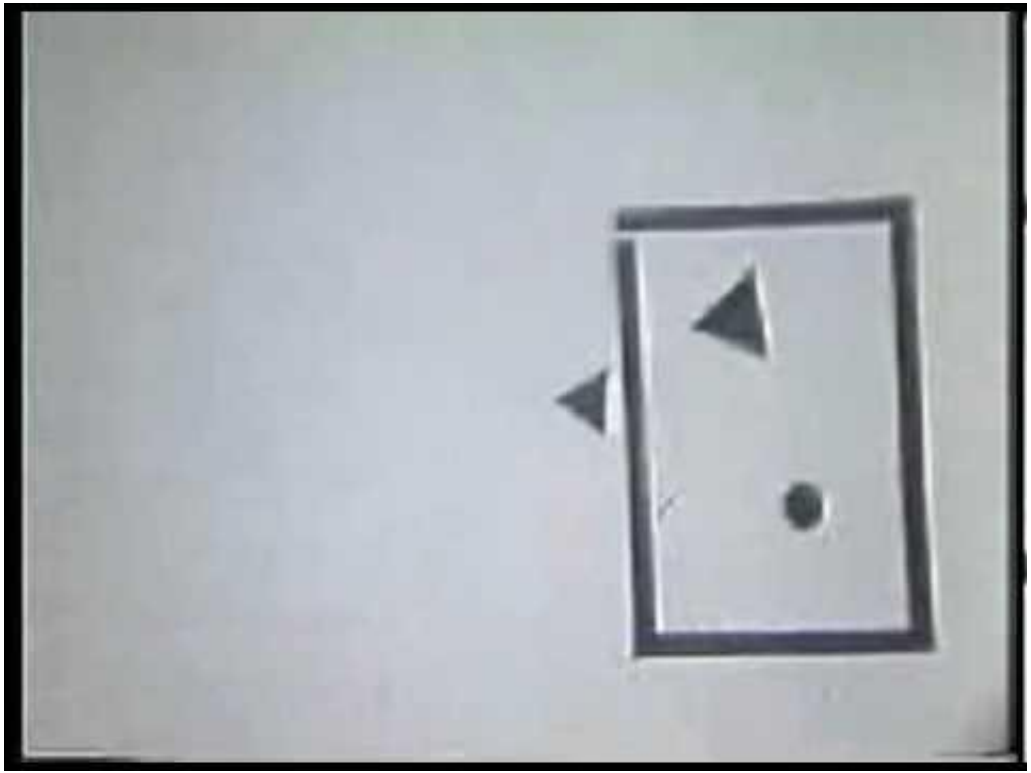
Cognitive HRI



Mutlu, B., Roy, N., & Šabanović, S. (2016). Cognitive human–robot interaction. *Springer Handbook of Robotics*, 1907-1934.

Heider, F., & Simmel, M. (1944) An experimental study in apparent behavior. The American Journal of Psychology, 57, 243-259.

- What did you see?
- Anthropomorphize - to ascribe human characteristics to things not human.
- “People do not treat robots as an assembly of plastic, electronics, and code but, rather, as humanlike entities.” Bartneck et al. (2020)
- Anthropomorphization, the incurable disease.” David McFarland, Ethologist, Oxford University



https://youtu.be/VTNmLt7QX8E

(a more modern example - Pepper awakening https://youtu.be/8HXhsKpETXE)

Design for HRI

How would you describe these robot types?

android and humanoid

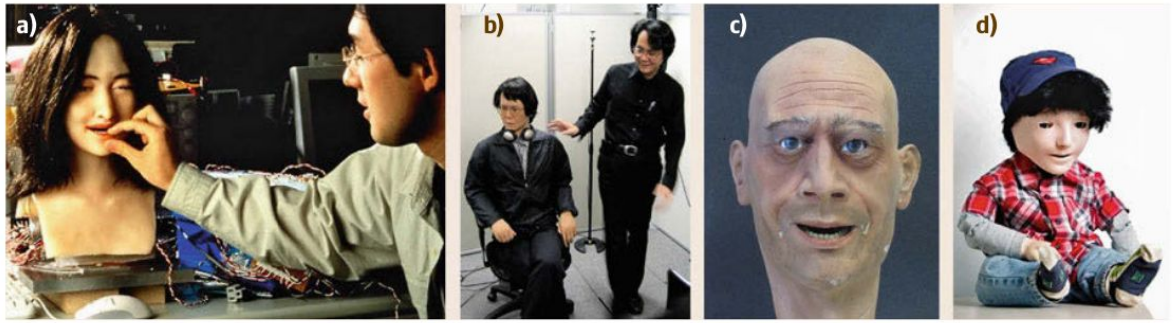
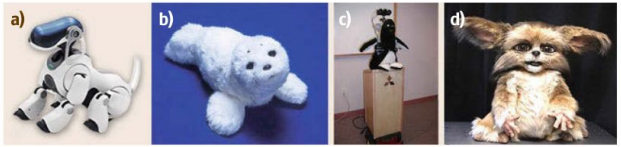


Fig.72.2a–d Some examples of androids: **(a)** One of the earliest face robots developed at the Science University of Tokyo (after [72.18]); **(b)** Geminoid developed at ATR (after [72.19]); **(c)** ROMAN developed at the University of Kaiserslautern (after [72.20]); **(d)** KASPAR developed at the University of Hertfordshire is a child like robot used during therapeutic interventions to help children with autism (after [72.21])

zoomorphic



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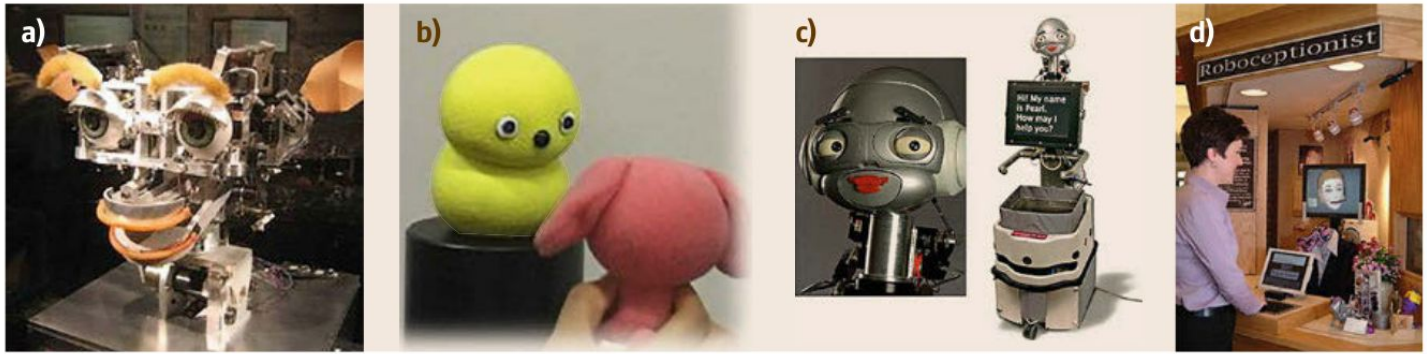
"minimalist"



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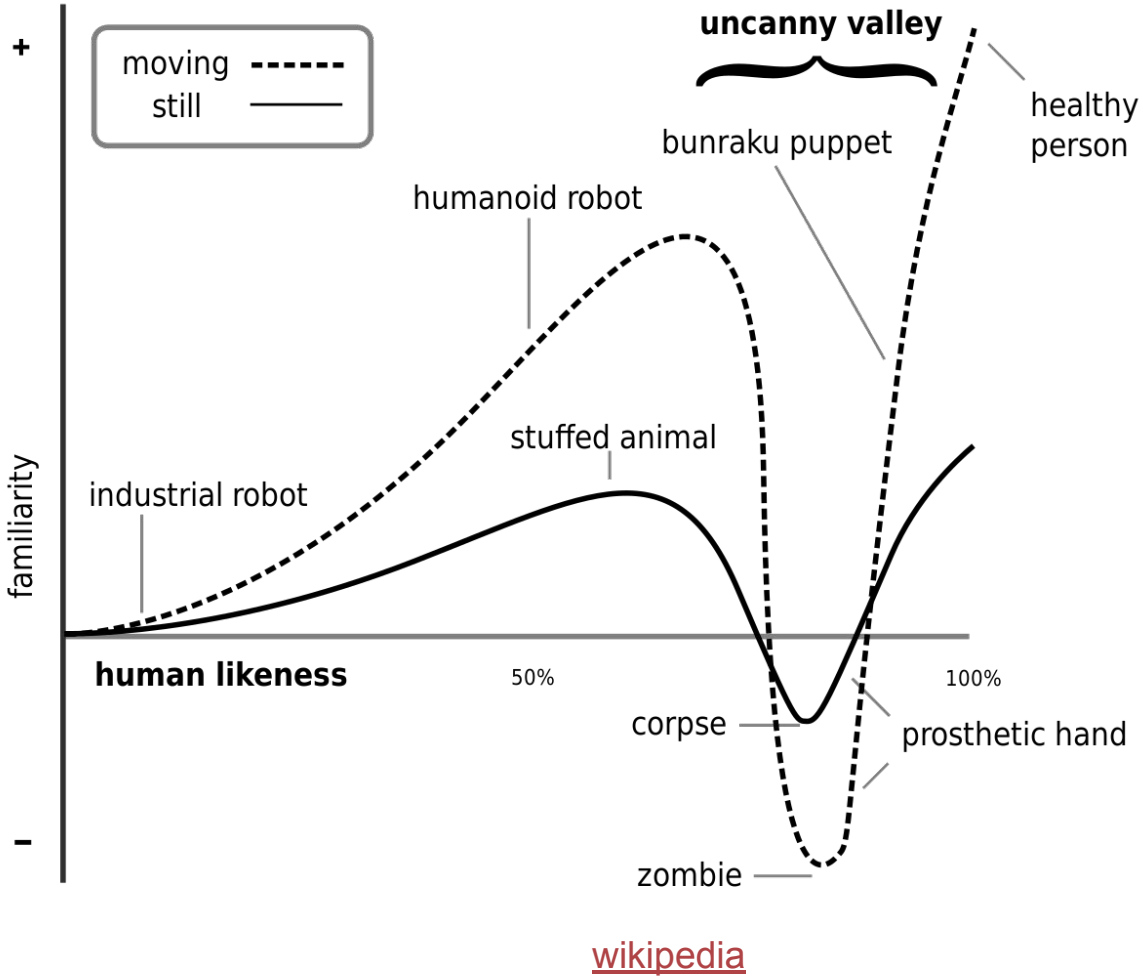
Breazeal, C., Dautenhahn, K., & Kanda, T. (2016). Social robotics. *Springer Handbook of Robotics*, 1935-1972.

Uncanny valley

- Masahiro Mori, 1970
- The problem of human-likeness
- Relevant also for animation



wikipedia

Uncanny valley in 3D

"A robot with a very high degree of human-likeness coupled with some remaining non-human qualities will make users uncomfortable. This hypothesized effect essentially describes what happens when a person's mental model of the robot as human is not born out by its interactive capabilities."

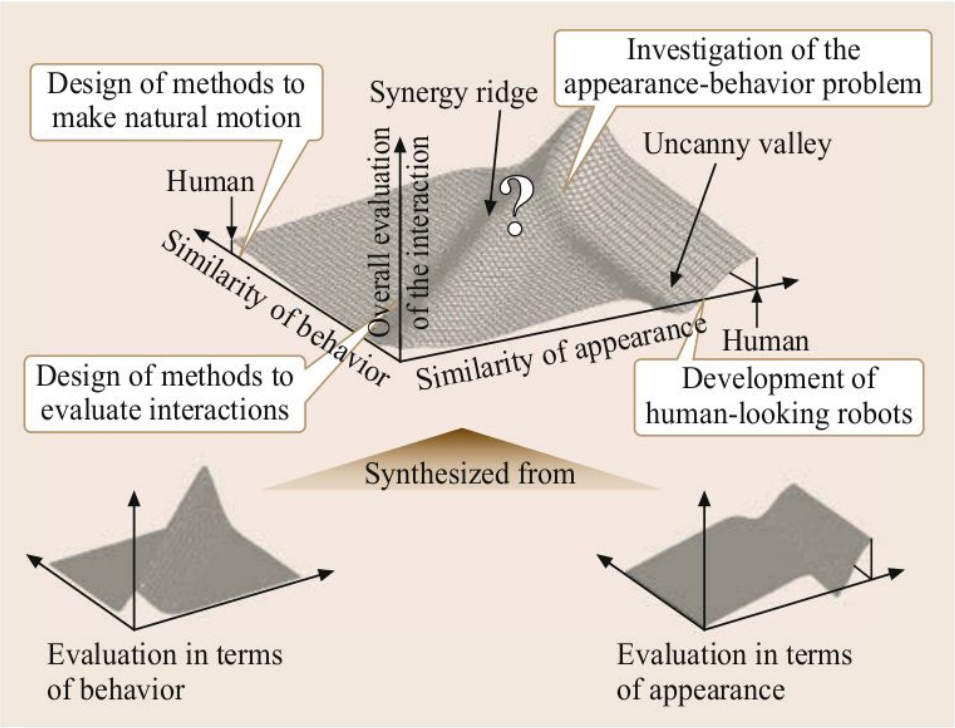


Fig. 71.2 An extended notion of the uncanny valley which includes appearance and behavior as significant variables (after [71.24])

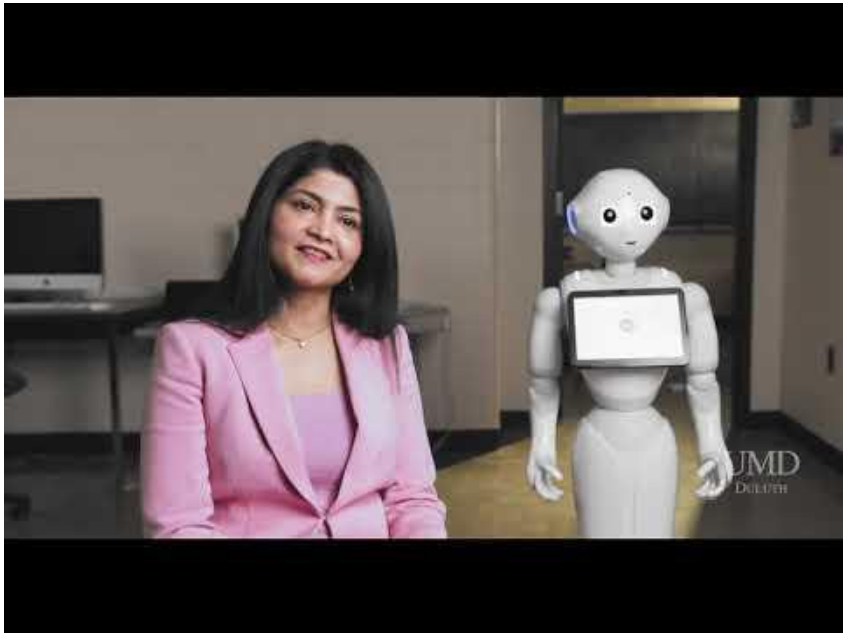
Mutlu, B., Roy, N., & Šabanović, S. (2016). Cognitive human–robot interaction. *Springer Handbook of Robotics*, 1907-1934.

Geminoids

Geminoid summit, ATR, Japan, March 2011.
https://youtu.be/J71XWkh80nc

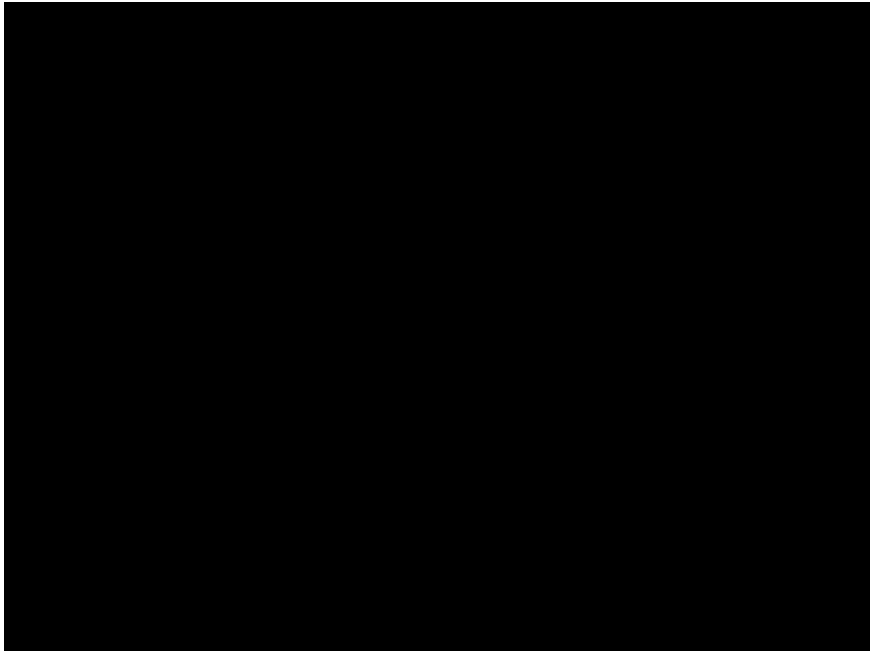
You can check https://www.soulmachines.com/resources/research/baby-x/ too.

Naturalistic movements



https://youtu.be/ZFrwk5auOvU

Did you notice the “micro-movements” of Pepper?
(Pepper: “autonomous life”; iCub: the “breather”)
https://github.com/robotology/funny-things/tree/master/modules/iCubBreather



What do you think was the focus of this video?

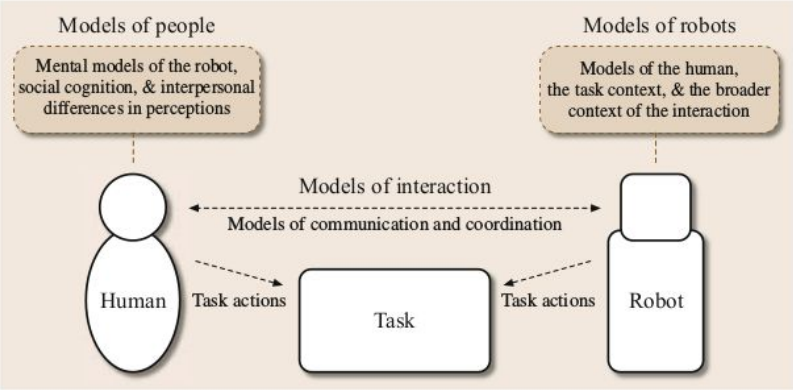
- **Blinking** based on physiological data from Doughty (2001), but adapted for iCub embodiment
- Average blinking rate (Conversation): 23.3 b/min
- IEBI: 2.3 +/- 2 s
- 15 % of blinks are double blinks
- Blinks at Onset/offset of speech
- Each blink divided into three phases with different speeds (attack 111ms [31ms], sustain 20ms [5ms], decay 300ms [123ms])

Lehmann, H., Roncone, A., Pattacini, U., Metta, G.: Physiologically inspired blinking behavior for a humanoid robot. In: International Conference on Social Robotics, pp. 83–93. Springer, Cham (2016)

iCub “blinker”
https://github.com/robotology/funny-things/tree/master/modules/iCubBlinker

Humans making mental models of robots

People apply a variety of mental models relating to animacy, sociality, affect, and consciousness to explain their experiences and emerging relationships with robots.



Mutlu, B., Roy, N., & Šabanović, S. (2016). Cognitive human–robot interaction. *Springer Handbook of Robotics*, 1907-1934.

Design principles in HRI

1. Matching the form and function.
    - If your robot is humanoid, people will expect it to do humanlike things—talk, think, and act like a human.
    - If this is not necessary for its purpose, such as cleaning, it might be better to stick to less anthropomorphic designs.
    - Similarly, if it has eyes, people will expect it to see; if it talks, they will expect it to be able to listen.
2. Underpromise and overdeliver.
3. Interaction expands function.
    - E.g. Paro.
4. Do not mix metaphors.
    - " Design should be approached holistically—the robot's capabilities, behaviors, affordances for interaction, and so forth should all be coordinated. If you design a humanlike robot, people may find it disturbing if it has skin covering only some parts of its body. Similarly, if the robot is an animal, it may be strange for it to talk like an adult human or try to teach you mathematics. This is related to the Uncanny Valley because inappropriately matched abilities, behaviors, and appearance often lead to people having a negative impression of the robot."

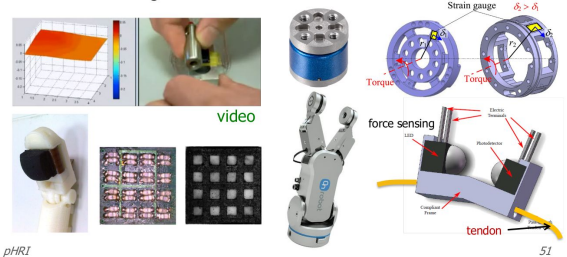
Paro, therapeutic seal robot, https://youtu.be/2ZUn9qtG8ow

Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). *Human-Robot Interaction: An Introduction*. Cambridge University Press.

Perception for pHRI

Perception for interaction

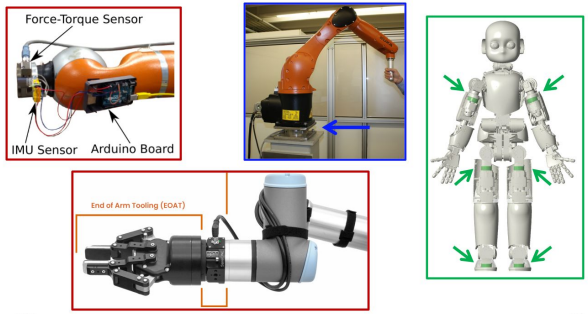
- proprioceptive and contact sensing
  - joint torque and tendon force sensing, stiffness sensing (indirect or by estimation), Force/Torque (F/T) sensors (in fingers and at the tip)
  - tactile sensing for distributed contact measurement



pHRI 51

Perception for interaction

- F/T sensors at the end-effector, link, and/or base levels



pHRI 52

Perception for interaction

- exteroceptive sensing
  - laser scanners, proximity sensors (magnetic, ultrasound, …)
  - cameras (single, stereo, catadioptric, event-based, …), Vicon system

pHRI 54

Physical HRI - Lecture slides by Alessandro de Luca http://www.diag.uniroma1.it/deluca/pHRI_elective/pHRI_Introduction.pdf

Perception for social HRI

What do we want to perceive?

- verbal interaction - speech
- nonverbal interaction
  - gaze
  - facial expressions
  - gesture
  - touch
  - posture
  - ...
- location - proxemics...
- emotion

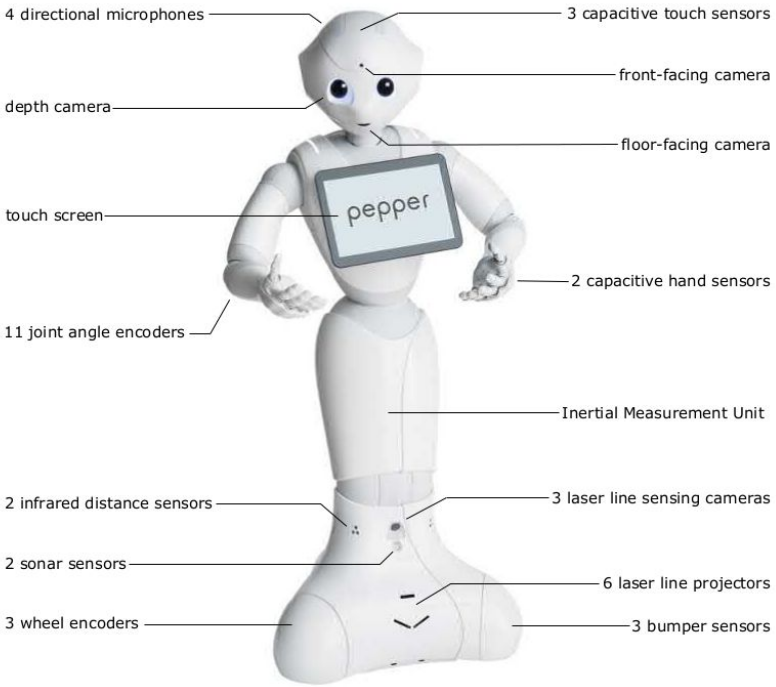


Fig. 3.3 in Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). *Human-Robot Interaction: An Introduction*. Cambridge University Press.

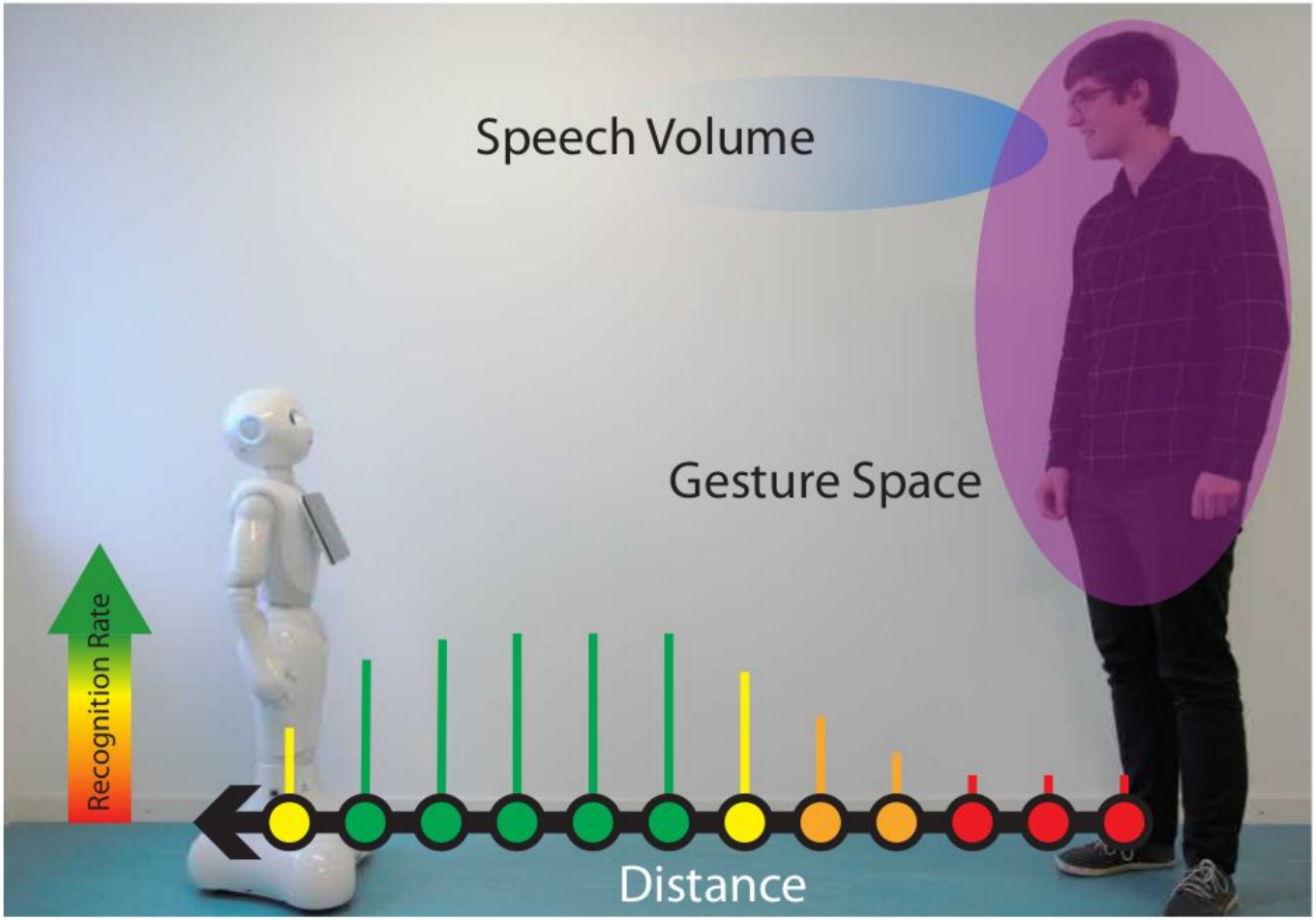
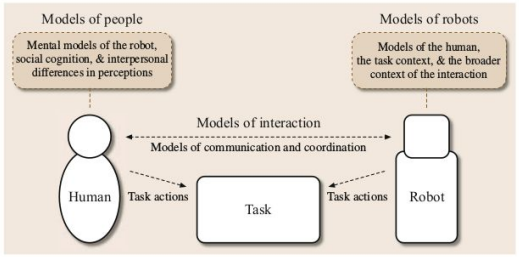


Fig. 5.6 in Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). *Human-Robot Interaction: An Introduction*. Cambridge University Press.

Action and perception for social HRI

- verbal interaction - speech
- nonverbal interaction
  - gaze
  - facial expressions
  - gesture
  - touch
  - posture
  - …
- location - proxemics…
- emotion



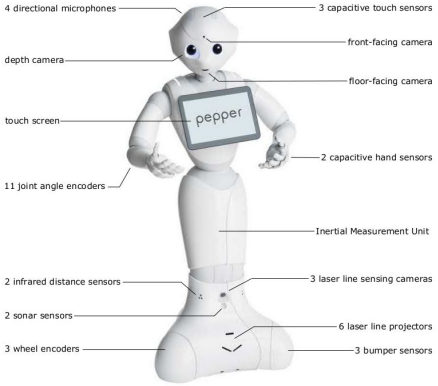


Fig 3.3 in Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). *Human-Robot Interaction: An Introduction*. Cambridge University Press.

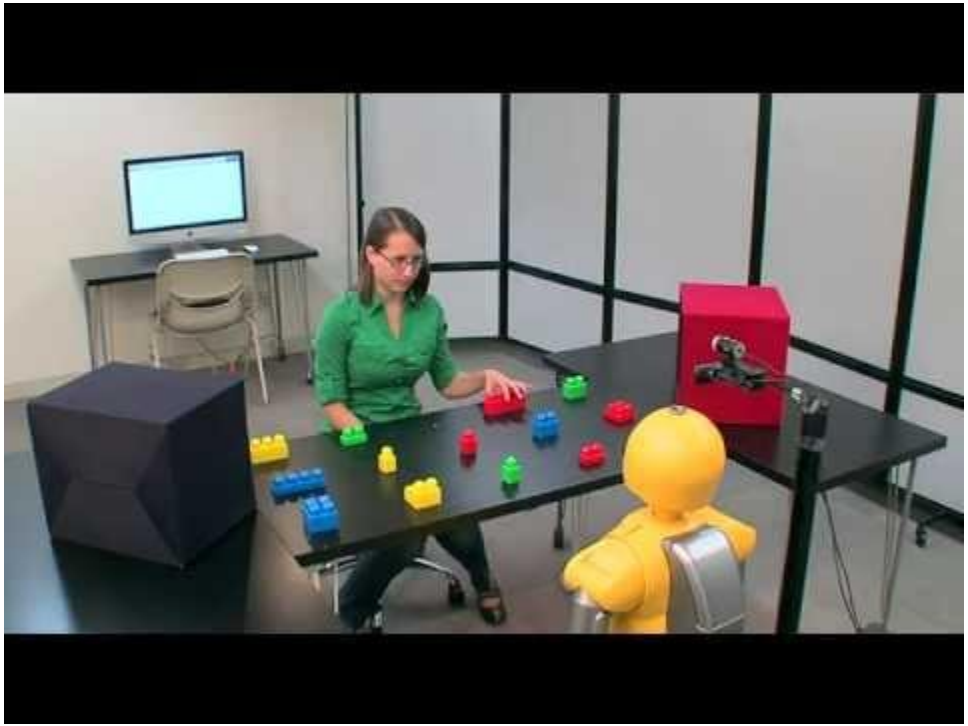
Not just perceive but also display!

Verbal interaction - building blocks

- Automated speech recognition (ASR) / speech-to-text (STT)
- Language understanding
- Turn-taking
- Speech production - speech synthesis / text-to-speech (TTS)

Which of the above are easier and which harder?

Gaze



Bilge Mutlu. Gaze and gesture cues for robots. https://youtu.be/p8ZuRQ7p2vM

Gaze and facial expression

https://youtu.be/SGKvft8rifI

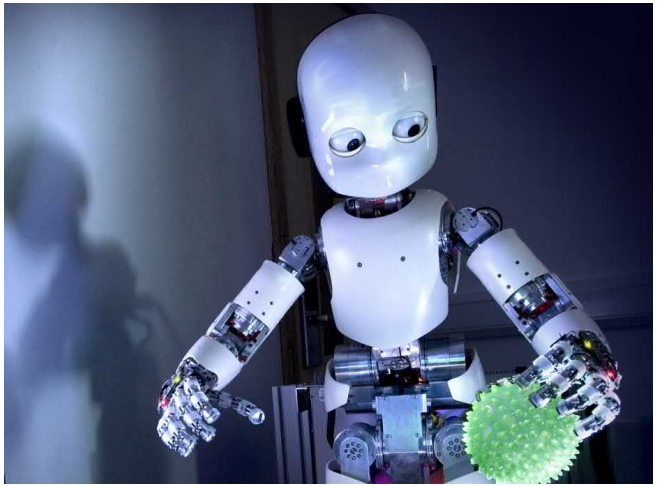
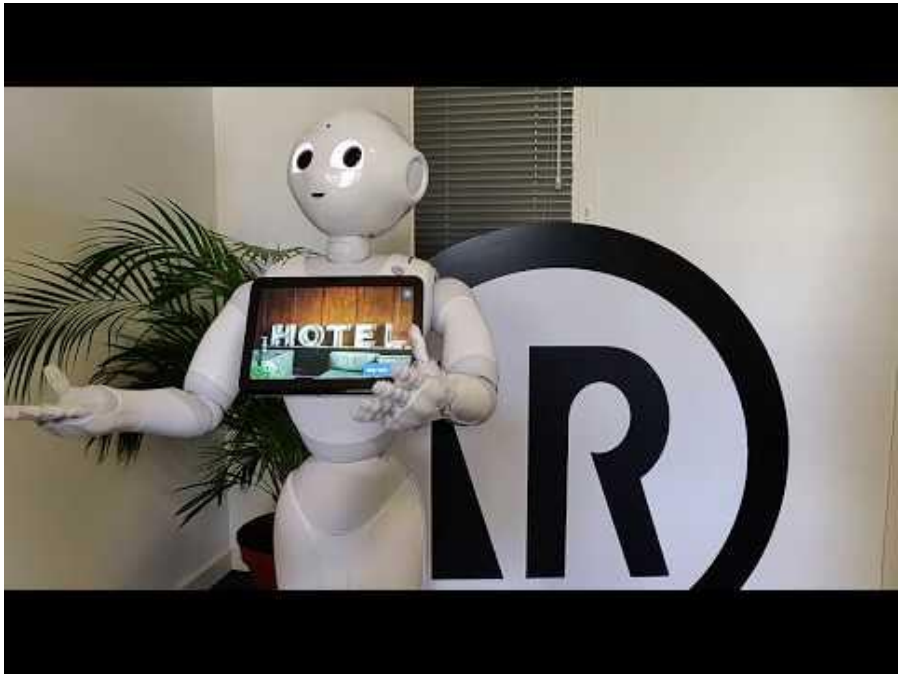
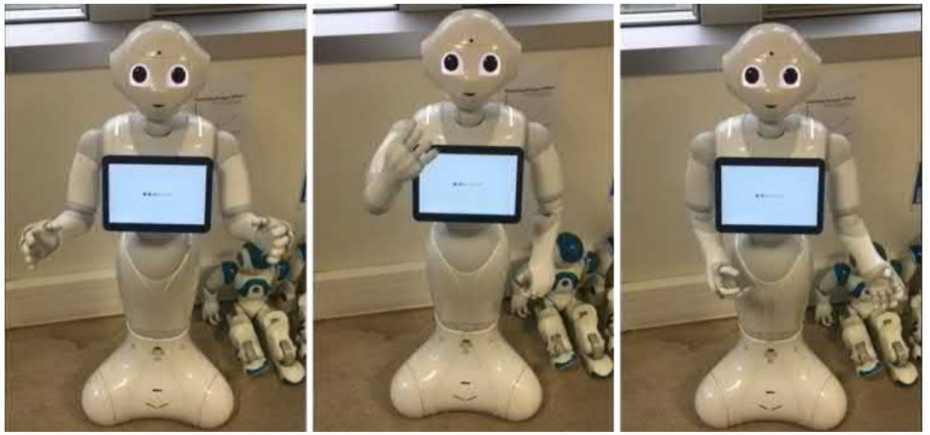


Fig. 6.3 in Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). *Human-Robot Interaction: An Introduction*. Cambridge University Press.

Gestures



https://youtu.be/8HXhsKpETXE



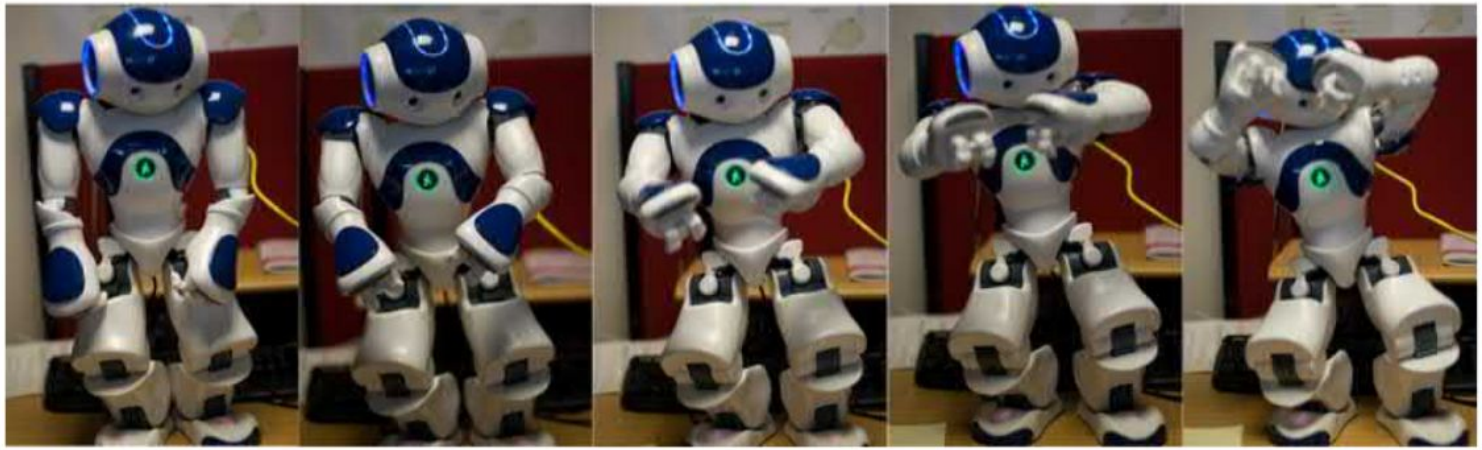
Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). *Human-Robot Interaction: An Introduction*. Cambridge University Press.

The Thrifty Faucet (2009) is a simple interactive prototype that uses its posture to communicate 15 lifelike motion patterns, including seeking, curiosity, and rejection, to users. The aim is to enable communication with users about more sustainable water use (Togler et al., 2009).

(Source: Jonas Togler)

Posture

Figure 6.7 A Nao robot (2008–present) using body postures to express emotions, morphing between sad (left) and fearful (right). (Source: Beck et al. (2010))



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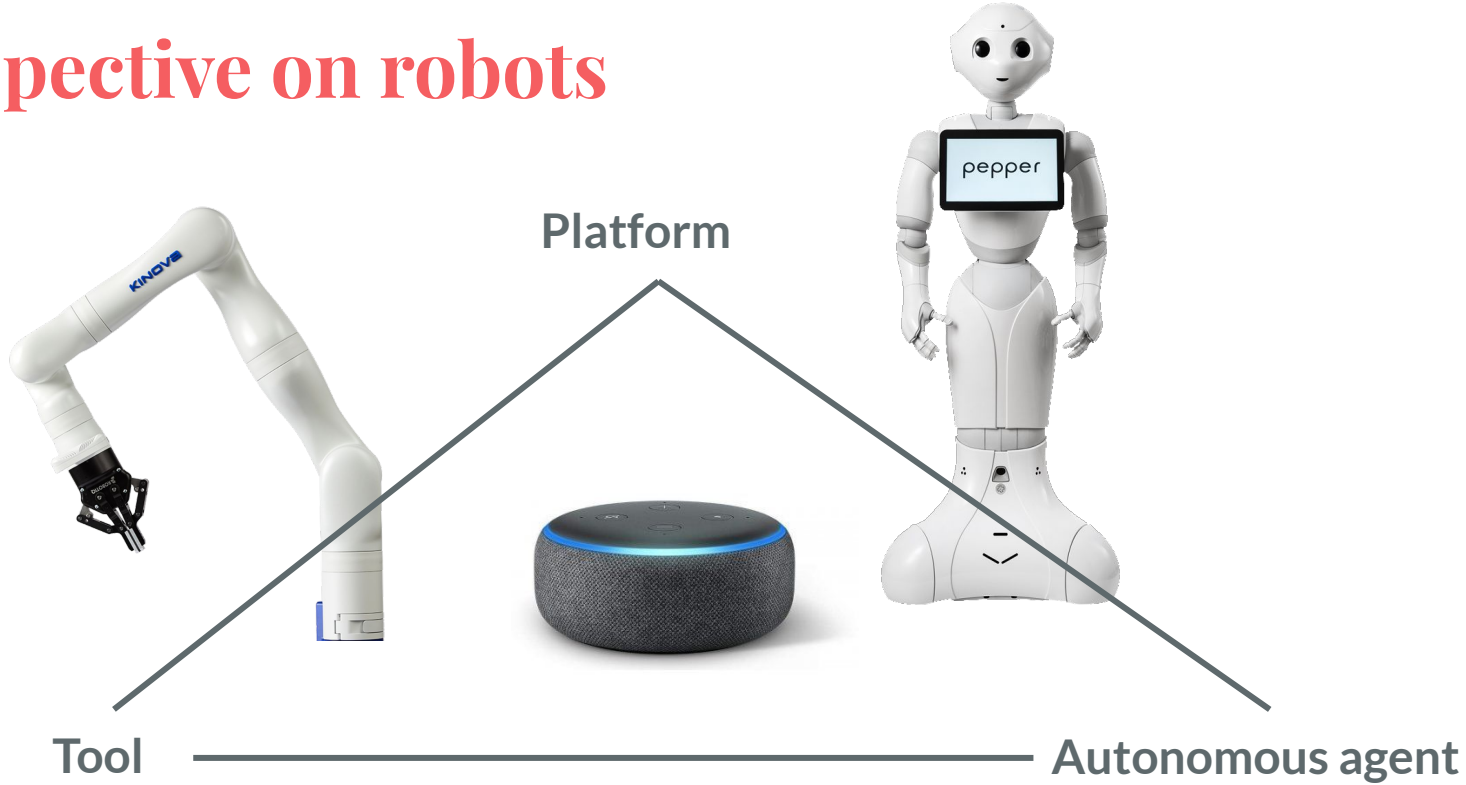
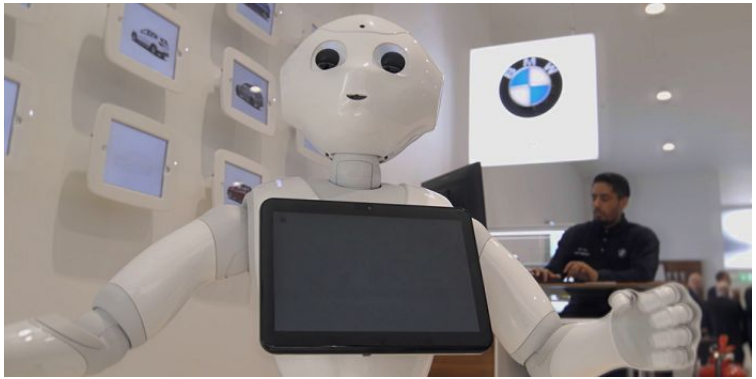
Perspective on robots



“New” HRI roles areas

- Sales/presentation
- Healthcare industry
- Food service (not industrial mass production)



https://www.softbankrobotics.com/emea/en/pepper-retail-ga

Panasonic Resyone carebot -
https://news.panasonic.com/jp/topics/154051.html

Moley kitchen
https://www.forbes.com/sites/eustaciahuen/2016/10/31/the-worlds-first-home-robotic-chef-can-cook-over-100-meals/?sh=60ab72147228

Thriving research community

WELCOME TO
IEEE RO-MAN 2022

31st IEEE International Conference on Robot & Human Interactive Communication

ICSR 2022 – 14th International Conference on Social Robotics

December 13th-16th 2022, Florence, Italy

https://www.icsr2022.it/

HRI 2023 STOCKHOLM, SE

Authors Submission Attending Program About Press

ACM/IEEE International Conference on Human-Robot Interaction

March 13-16, 2023 Stockholm, SE

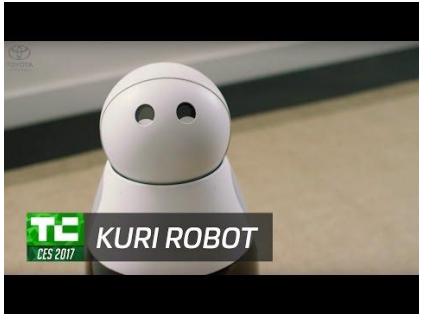
We are excited to announce the 18th Annual ACM/IEEE International Conference on Human Robot Interaction (HRI). HRI 2023 is the 18th annual conference for basic and applied HRI research. Researchers from across the world present their best work to HRI to exchange ideas about the theory, technology, data, and science furthering the state-of-the-art in the field.

https://humanrobotinteraction.org/2023/

Problems with commercial social robots

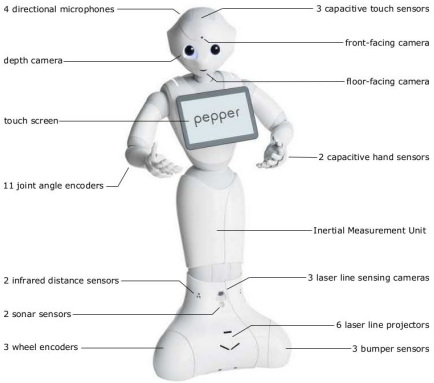
- Sony AIBO
  - 1999-2006 - then discontinued - not commercially successful
  - 2018 new generation relaunched
- Softbank Pepper (20 000 $)
  - Alive, but expectations were probably greater…
- Kuri (700 $)
- Jibo (900 $)
- Anki - Cozmo & Vector

Kuri



https://youtu.be/Gvle_O4vD18

Pepper



Jibo

https://youtu.be/H0h20jRA5M0

Cozmo & Vector

https://youtu.be/gW2fCFSzuIQ

Problems with commercial social robots

Lessons learned (Guy Hoffman)

1. Long-term engagement is the holy grail.
2. We need artists.
3. Embodiment does create emotional bonds.
4. Design matters.

GUEST ARTICLE | ROBOTICS

Anki, Jibo, and Kuri: What We Can Learn from Social Robots That Didn't Make It ›It's been a tough few years for social home robots: Where do we go from here?

BY GUY HOFFMAN | 01 MAY 2019 | 7 MIN READ |

https://spectrum.ieee.org/anki-jibo-and-kuri-what-we-can-learn-from-social-robotics-failures

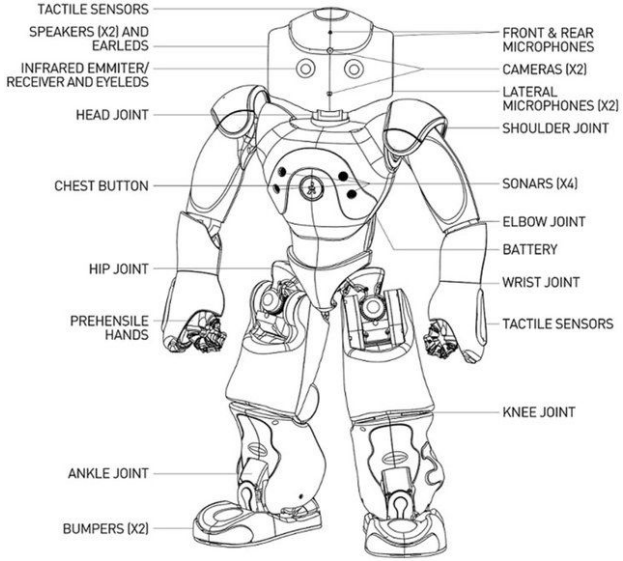
Note: Robots for education are a different market segment.
https://www.robot-advance.com/EN/cat-educational-robots-1.htm

vs.

But see
https://arstechnica.com/gadgets/2022/11/amazon-alexa-is-a-colossal-failure-on-pace-to-lose-10-billion-this-year/

Some success stories - Nao (2008-now)

- 2008, Aldebaran/Softbank
- Price: ~ 10 000 $
- More than 10 000 exemplars sold.
- Currently in V6
- Used as a unified platform for **research**, social HR in particular.
- Used also for robot football - Robocup.
- Allows easy control via Choregraphe.



Some success stories - Kaspar

- Not a commercial success story.
- Social robot for children with autism.

https://youtu.be/D6gTHPoO9VI

Further reading and resources

- Books / book sections
  - Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). *Human-Robot Interaction: An Introduction*. Cambridge University Press.
  - Mutlu, B., Roy, N., & Šabanović, S. (2016). Cognitive human–robot interaction. *Springer handbook of robotics*, 1907-1934.
  - Breazeal, C., Dautenhahn, K., & Kanda, T. (2016). Social robotics. *Springer Handbook of Robotics*, 1935-1972.
  - Matarić, M. J., & Scassellati, B. (2016). Socially assistive robotics. *Springer Handbook of Robotics*, 1973-1994.
- Online resources
  - https://www.human-robot-interaction.org/podcast-overview/
  - https://athome.robocup.org/