

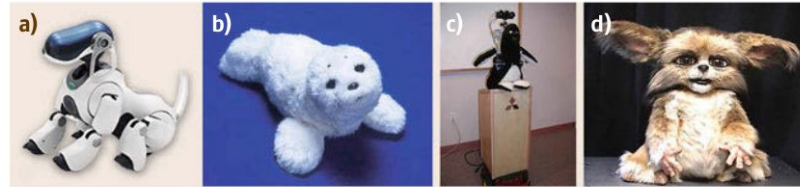
# Humanoid robots - Social human-robot interaction

**Doc. Mgr. Matěj Hoffmann, Ph.D.**

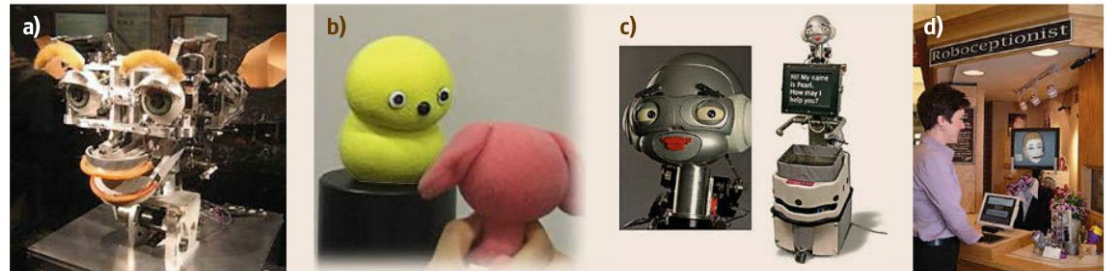
# Safe design for social HRI

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])

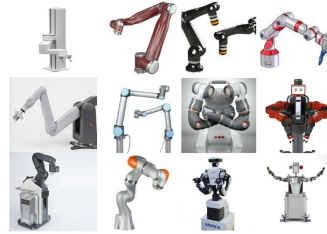


**Fig.72.4a-d** Examples of social robots that are neither humanoid nor zoomorphic but capture key social attributes: (a) Kismet (after [72.3]); (b) Keepon (after [72.34]); (c) Pearl (after [72.35]); (d) Valerie (after [72.36])

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  $\frac{1}{3}$  of the picture...



A selection of collaborative robots. Image credit: Robotiq.

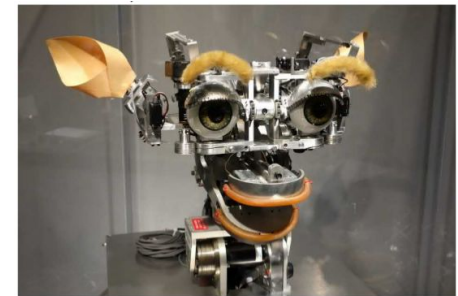
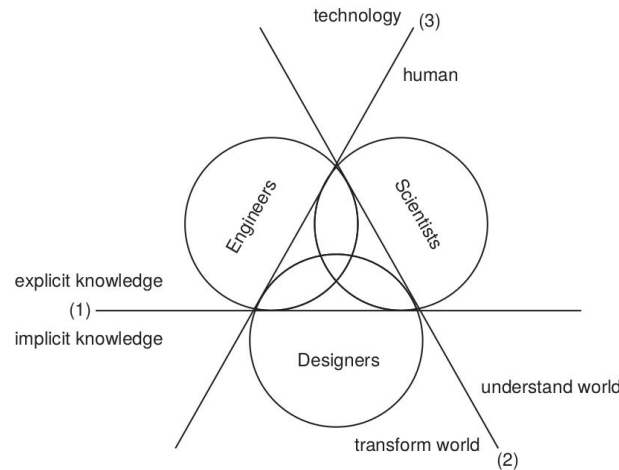


Figure 2.3  
Kismet  
(1997–2004), an  
early example of  
social  
human-robot  
interaction  
research from the  
Massachusetts  
Institute of  
Technology.  
(Source: Dauterot)

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

# Springer Handbook of Robotics

Siciliano  
Khatib  
Editors

2nd Edition

Kröger  
Multimedia Editor

 Springer

Multimedia Contents



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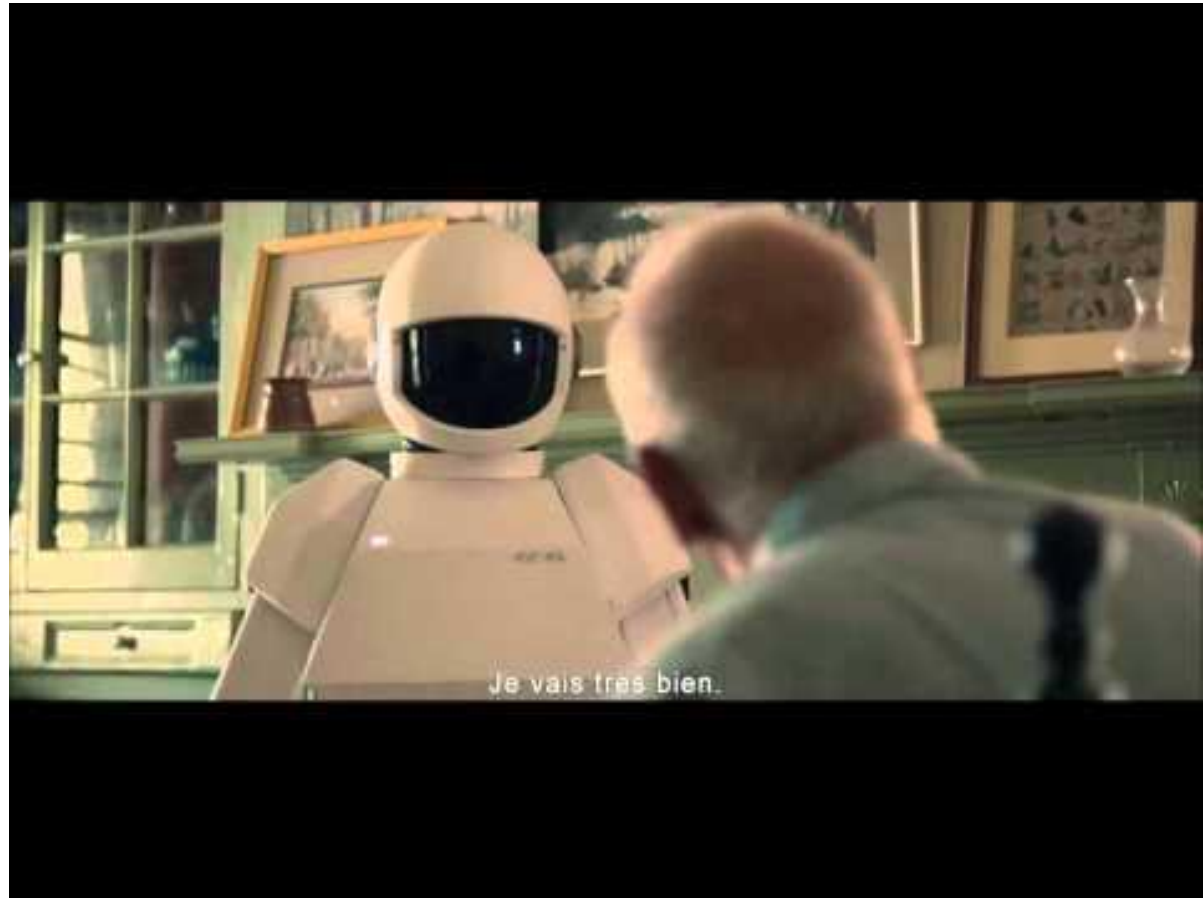
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# Robots at home

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



# Robocup@home



2012 overview

<https://youtu.be/YpjeNa8BAYg>



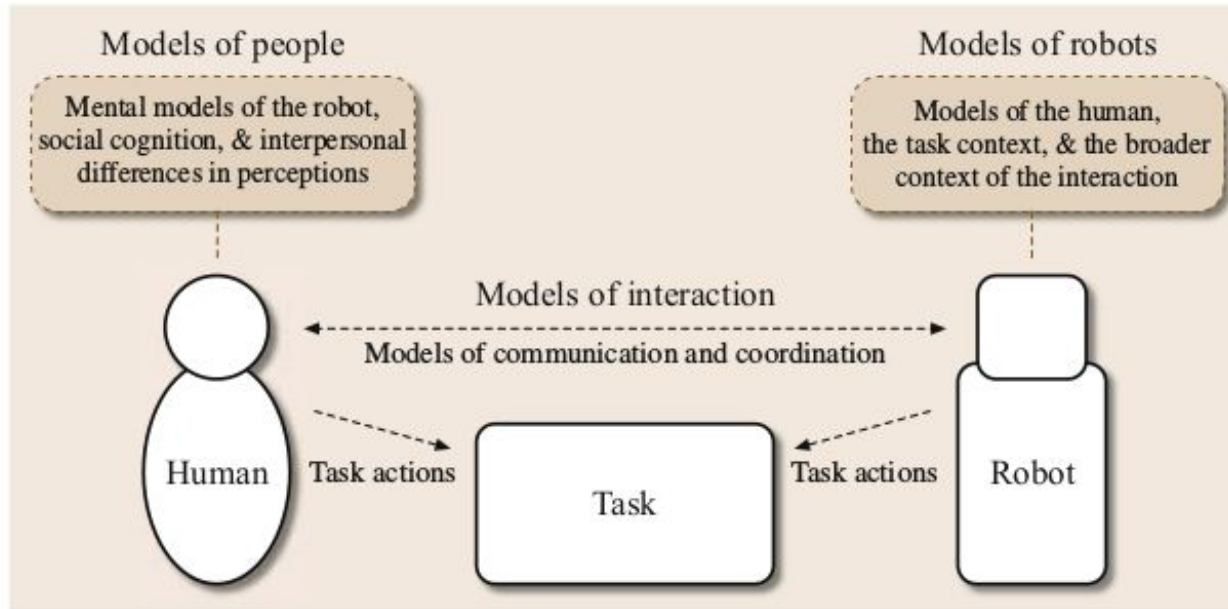
2021 Poster – Team Tidyboy,

<https://youtu.be/4GZAo41-pws>

<https://athome.robocup.org/>

RoboCup@Home [Youtube official channel](#)

# Cognitive HRI

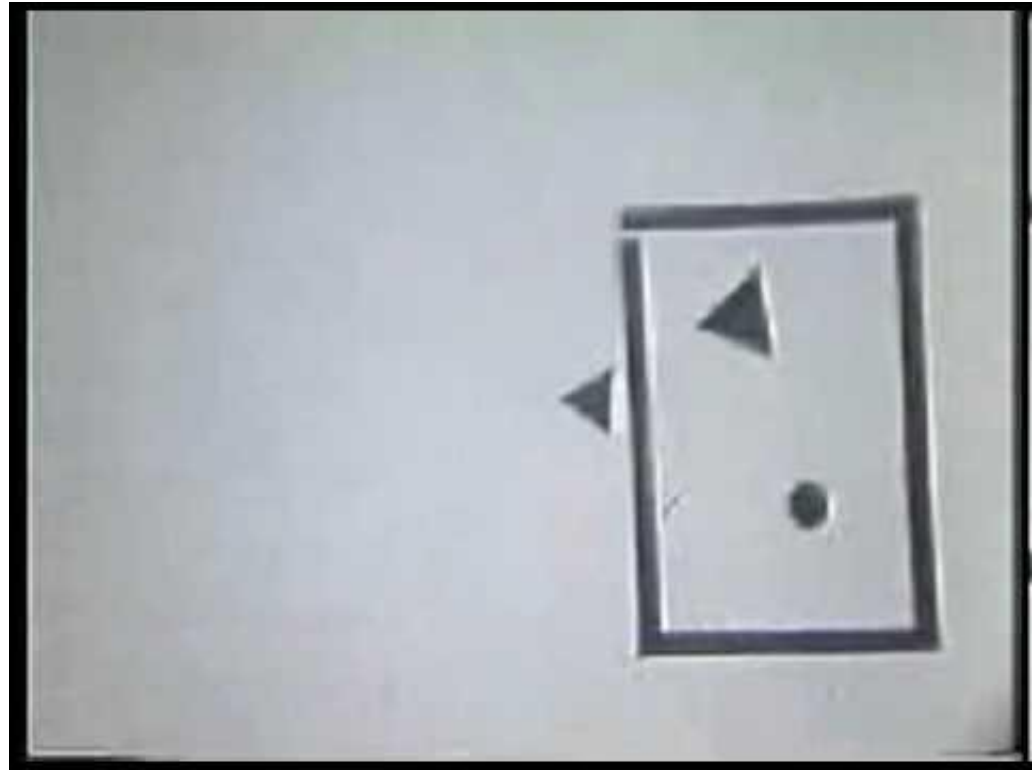


Mutlu, B., Roy, N., & Šabanović, S. (2016). Cognitive human–robot interaction. *Springer Handbook of Robotics*, 1907-1934.

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

- 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

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



<https://youtu.be/VTNmLt7QX8E>



# Design for HRI

zoomorphic

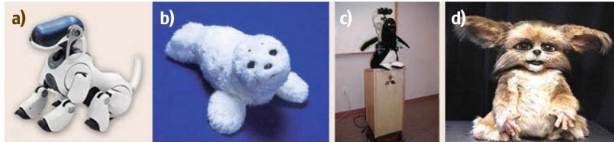


Fig.72.3a-d Examples of social robots inspired by animals with anthropomorphic qualities: (a) AIBO, the robotic dog developed by Sony (after [72.30]), (b) Paro, the therapeutic seal robot developed at AIST (after [72.31]), (c) Mel, the conversational robotic penguin developed at MERL (after [72.32]),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

“minimalist”

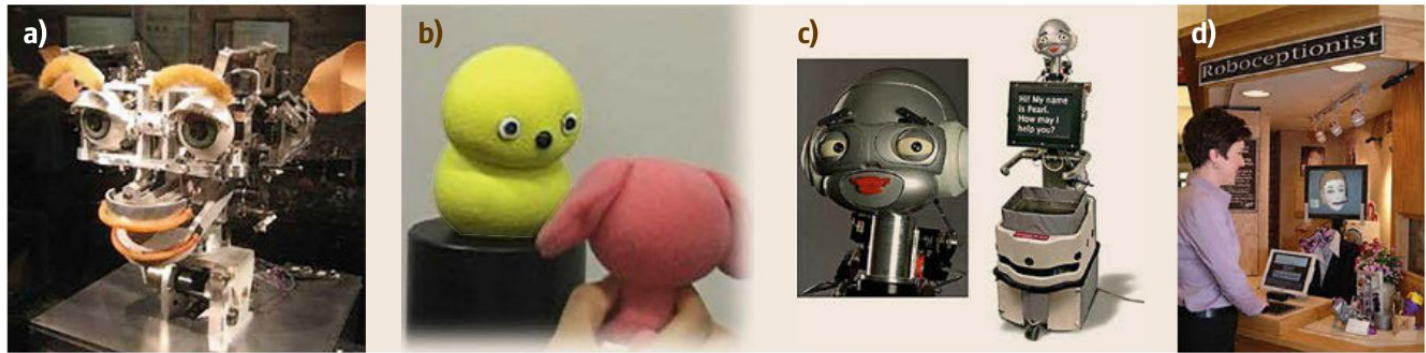


Fig.72.4a-d Examples of social robots that are neither humanoid nor zoomorphic but capture key social attributes: (a): Kismet (after [72.3]); (b) Keepon (after [72.34]); (c) Pearl (after [72.35]); (d) Valerie (after [72.36])

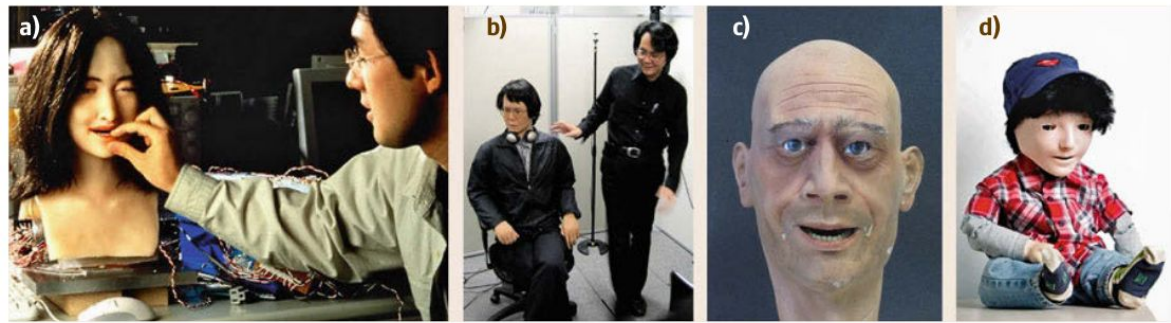
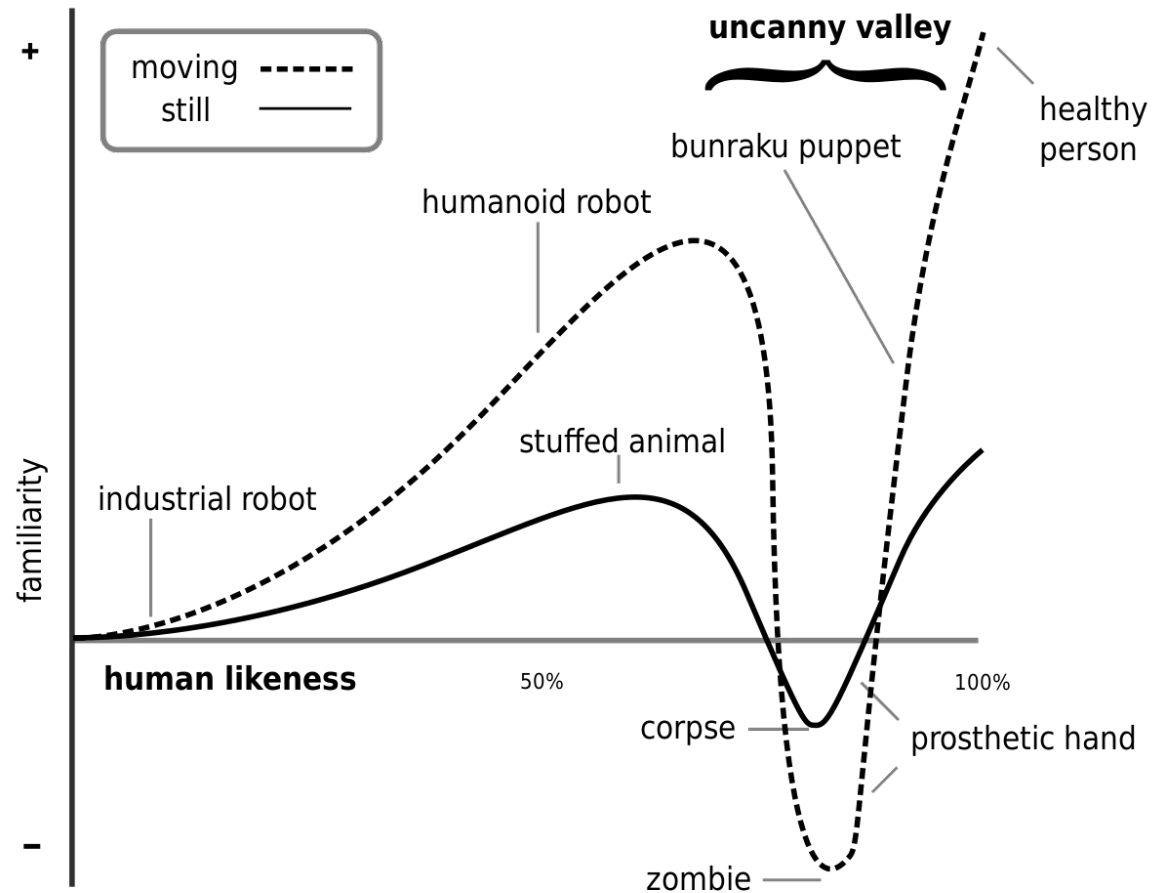


Fig.72.2a-d Some examples of androids: (a) One of the earliest face robots developed at the Science University of Tokyo (after [72.18]); (b) Geminoid developed at ATR (after [72.19]); (c) ROMAN developed at the University of Kaiserslautern (after [72.20]); (d) KASPAR developed at the University of Hertfordshire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

android and humanoid

# Uncanny valley

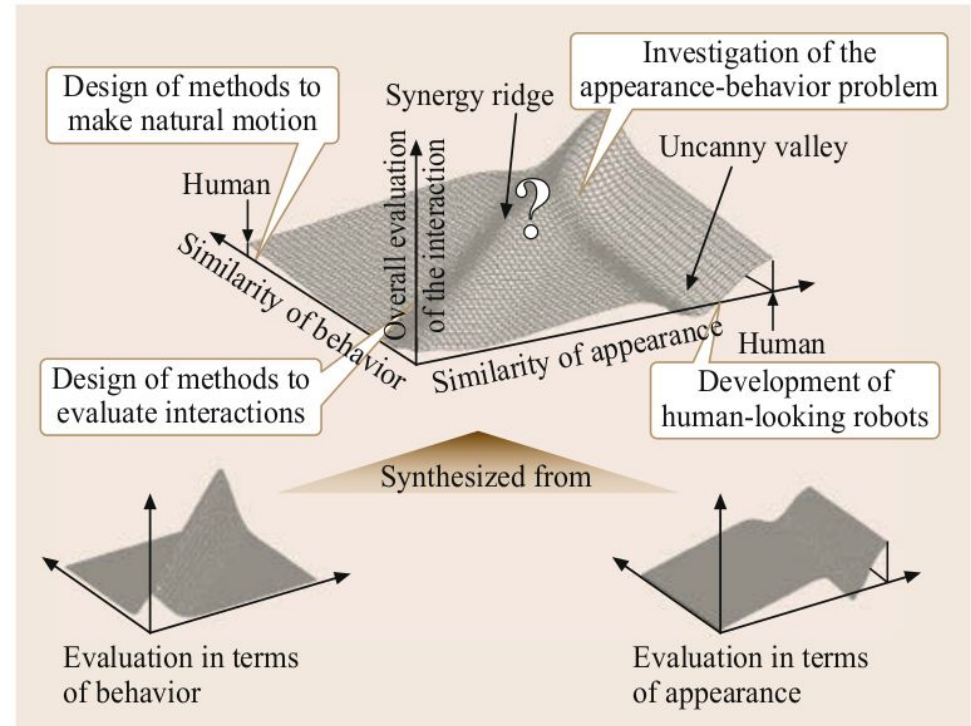
- Masahiro Mori, 1970
- The problem of human-likeness
- Relevant also for animation



[wikipedia](https://en.wikipedia.org/wiki/Uncanny_valley)

# 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.

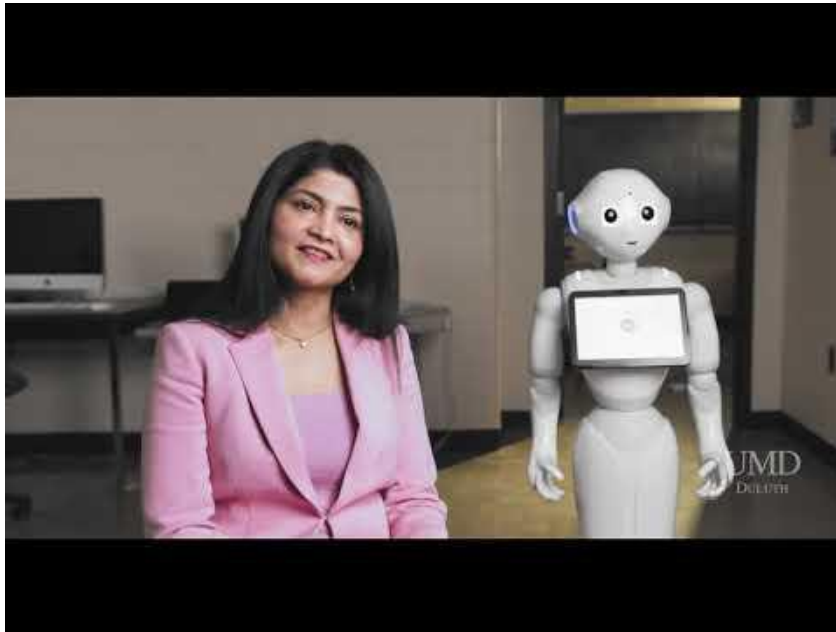
<https://youtu.be/J71XWkh80nc>

You can check

<https://www.soulmachines.com/resources/research/baby-x/> too.



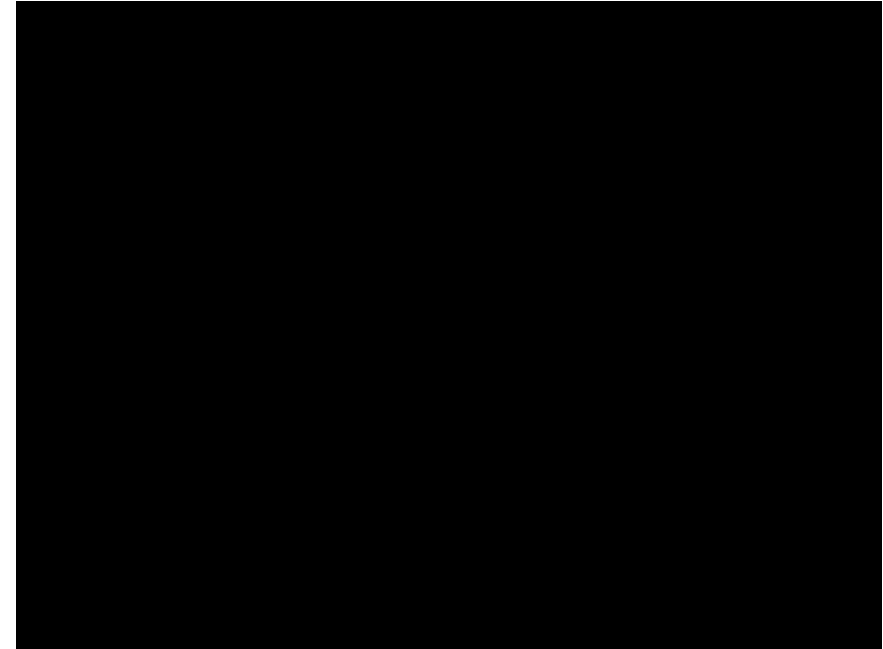
# Naturalistic movements



<https://youtu.be/ZFrwk5auOvU>

(in iCub, it's the “breather”)

<https://github.com/robotology/funny-things/tree/master/modules/iCubBreather>



- 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])

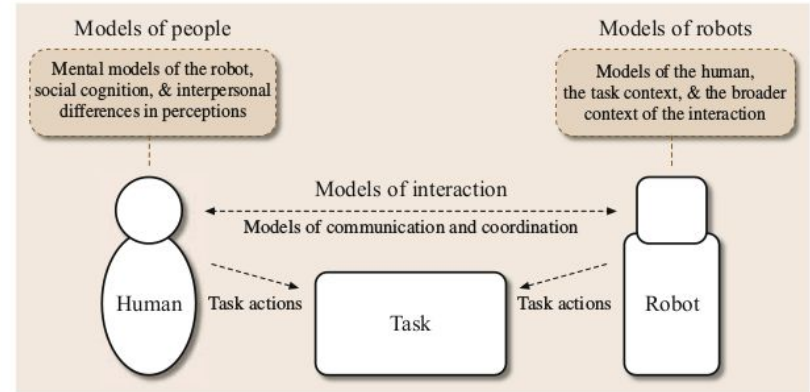
Lehmann, H., Roncone, A., Pattacini, U., Metta, G.: Physiologically inspired blinking behavior for a humanoid robot. In: International Conference on Social Robotics, pp. 83–93. Springer, Cham

(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.



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

Bartneck, C., Belpaeme, T., Eyssele, 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



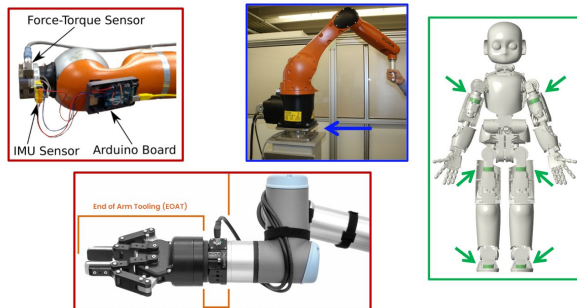
pHRI

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](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

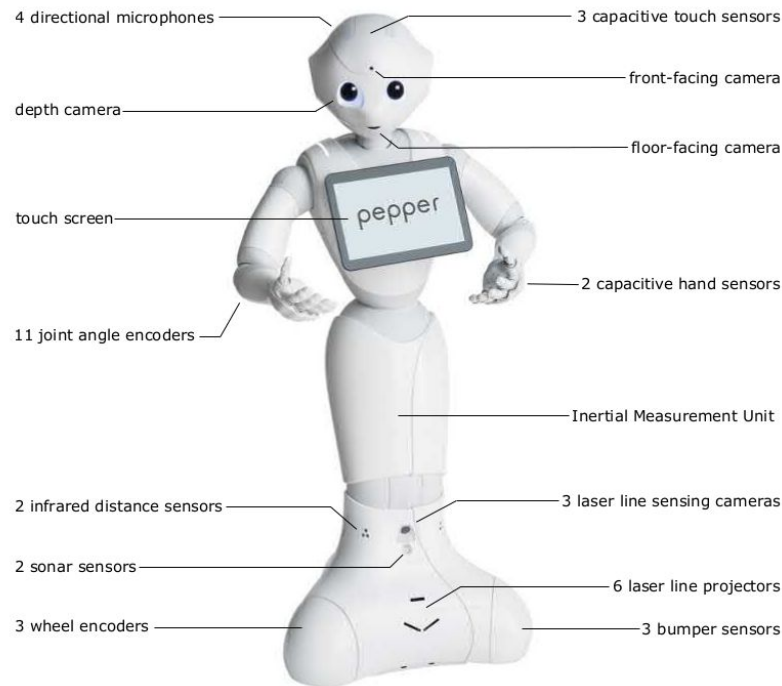


Fig. 3.3 in Bartneck, C., Belpaeme, T., Eyssele, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). *Human-Robot Interaction: An Introduction*. Cambridge University Press.

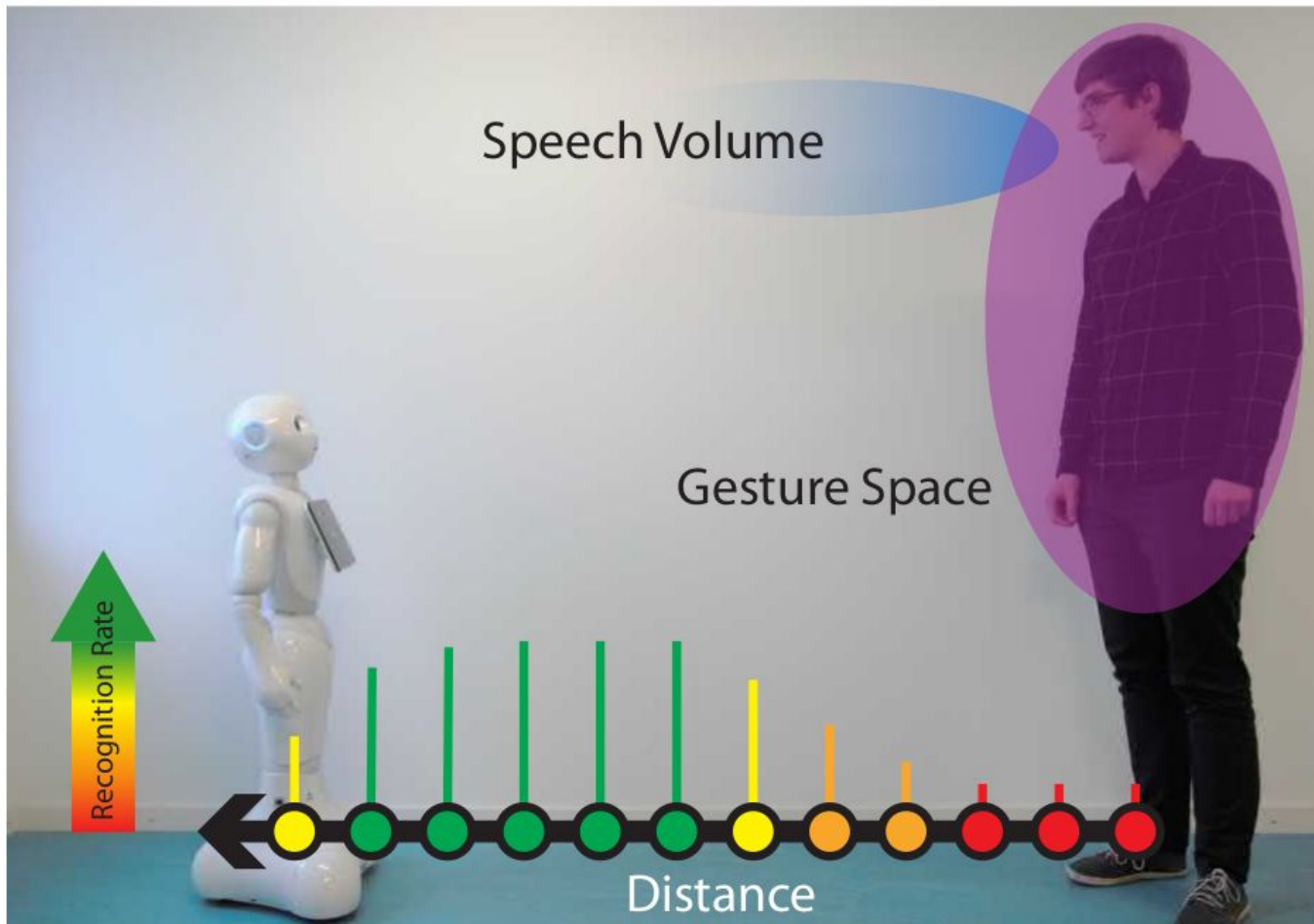


Fig. 5.6 in Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). *Human-Robot Interaction: An Introduction*. Cambridge University Press.

# Action and perception for social HRI

## Not just perceive but also display!

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

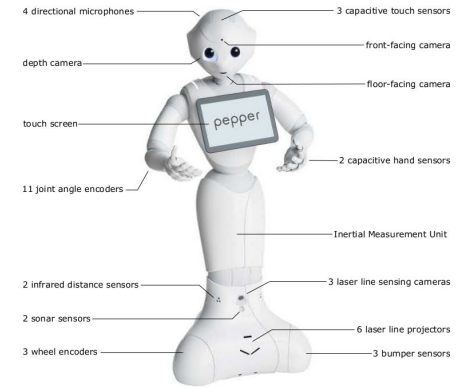
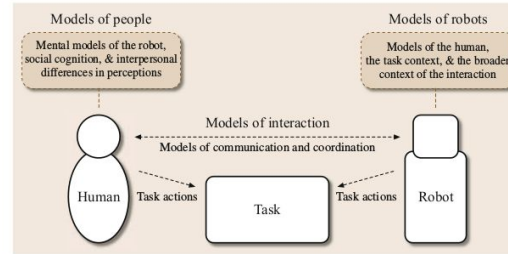


Fig 3.3 in Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). *Human-Robot Interaction: An Introduction*. Cambridge University Press.

# Verbal interaction - building blocks

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

# Gaze



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

# Gaze and facial expression



<https://youtu.be/SGKvft8rifl>

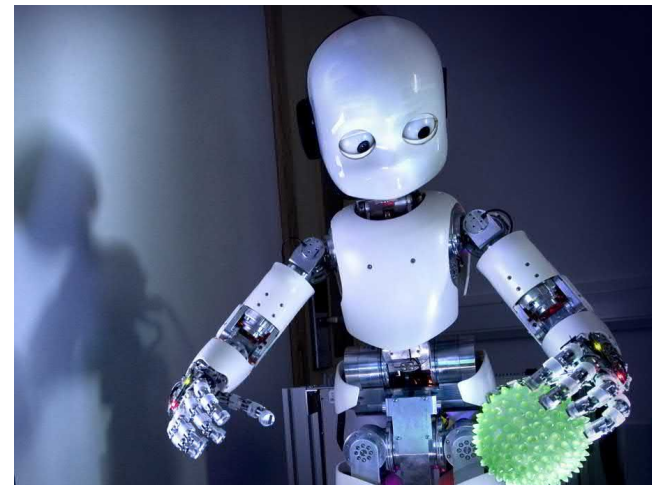
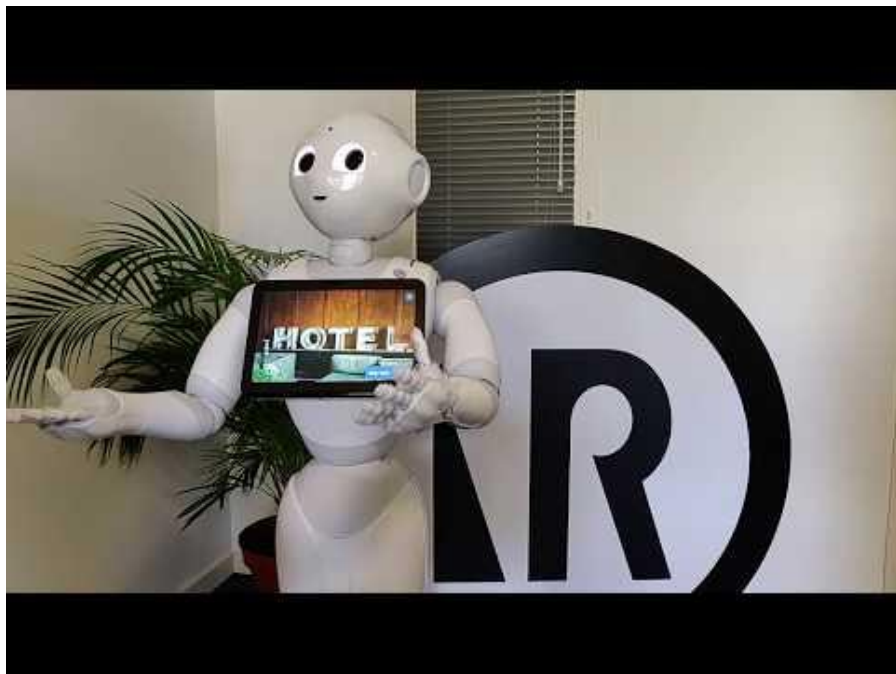


Fig. 6.3 in Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). *Human-Robot Interaction: An Introduction*. Cambridge University Press.

# Gestures



<https://youtu.be/8HXhsKpETXE>



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

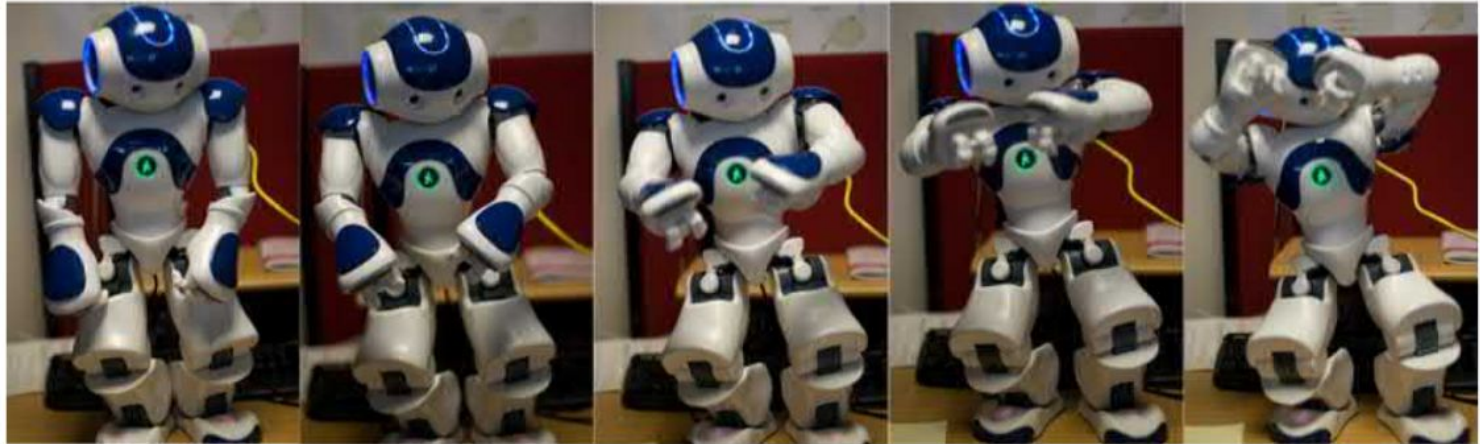
The Thrifty Faucet (2009) is a simple interactive prototype that uses its posture to communicate 15 lifelike motion patterns, including seeking, curiosity, and rejection, to users. The aim is to enable communication with users about more sustainable water use (Togler et al., 2009).



(Source: Jonas Togler)

# Posture

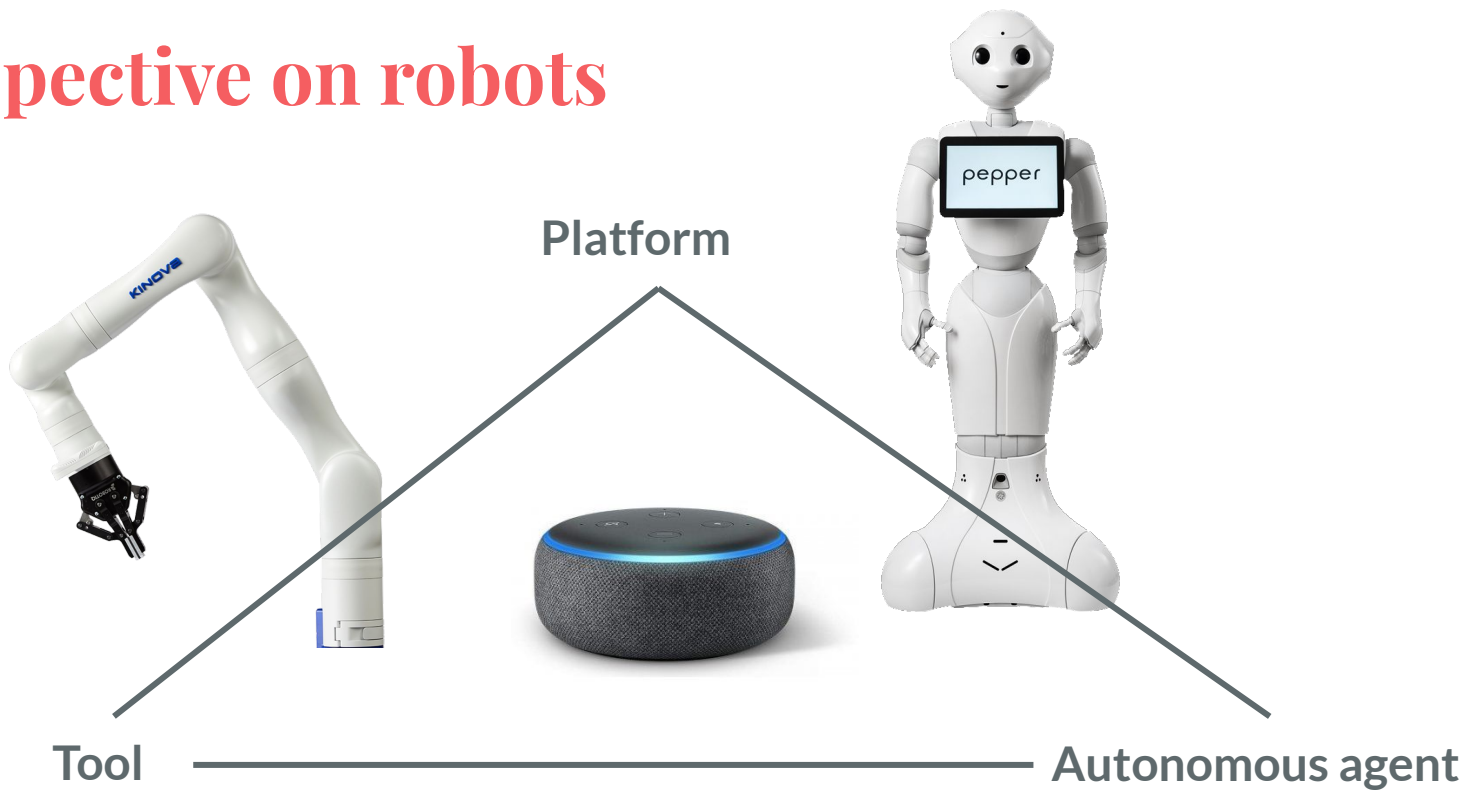
**Figure 6.7** A Nao robot (2008–present) using body postures to express emotions, morphing between sad (left) and fearful (right). (Source: Beck et al. (2010))



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

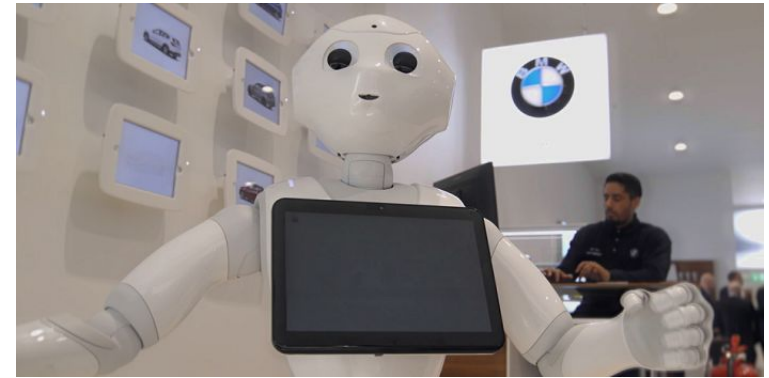


# Perspective on robots



# “New” HRI roles areas

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



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



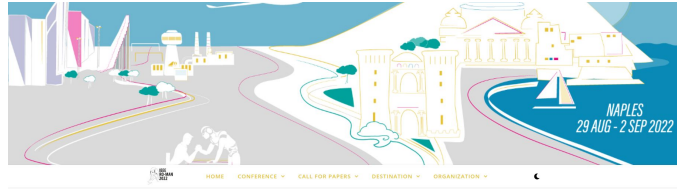
Moley kitchen  
<https://www.forbes.com/sites/eustaciahuen/2016/10/31/the-worlds-first-home-robotic-chef-can-cook-over-100-meals/?sh=60ab72147228>

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

# Thriving research community

ICSR 2022 – 14th International Conference on Social Robotics

December 13th-16th 2022, Florence, Italy



WELCOME TO  
IEEE RO-MAN 2022

31st IEEE International Conference on Robot & Human Interactive Communication



<https://www.icsr2022.it/>



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.

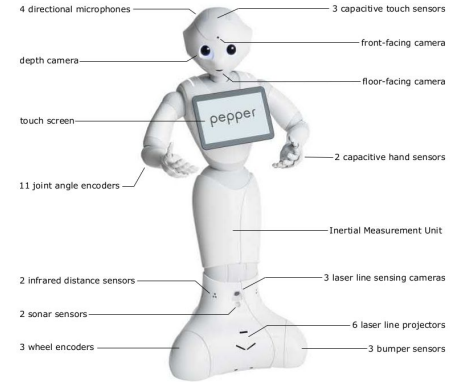
[https://humanrobotinter  
action.org/2023/](https://humanrobotinteraction.org/2023/)

# 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...
- Jibo (900 \$)
- Kuri (700 \$)
- Anki - Cozmo & Vector



[https://youtu.be/Gvle\\_O4vD18](https://youtu.be/Gvle_O4vD18)



<https://youtu.be/H0h20jRA5M0>



<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

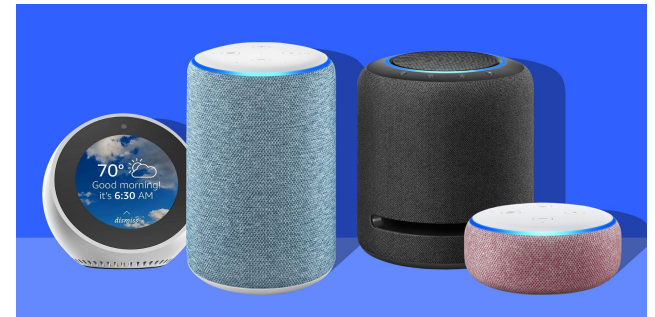
### Anki, Jibo, and Kuri: What We Can Learn from Social Robots That Didn't Make It

> 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 | □

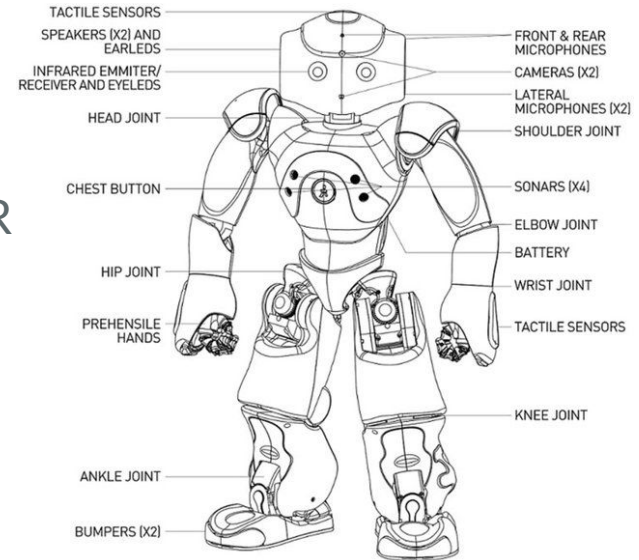
<https://spectrum.ieee.org/anki-jibo-and-kuri-what-we-can-learn-from-social-robotics-failures>

VS.



# 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., Eyssele, 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.robotcup.org/>