

Professor Bilge Mutlu | Spring 2023

What will we cover today?

- \rightarrow What is embodiment?
- \rightarrow History of embodied representations
- → Designing and implementing embodied representations

What is embodiment?

In cognitive science: the role the body plays in supporting the computational circuits that realize cognition¹

In computer science: the use of the human body^{*} as the central representation for computer intelligence²

¹ Kiverstein (2012). <u>The meaning of embodiment.</u> *Topics in cognitive science*.

* Or the bodies of animals, fictional characters, etc.

² Cassell (2001). <u>Embodied conversational agents: representation and intelligence in user interfaces.</u> AI Magazine.

Types of Embodiments³

Virtual Embodiment: Two- or three-dimensional presentation of a character on the screen of a computer, a mobile device, or a large screen.

Physical Embodiment: Physical representations that are situated in the user's environment.

Blended Embodiments: Representations that integrate virtual and physical components (e.g., a robot with a screen-based face).

³ Mutlu (2021). The virtual and the physical: two frames of mind. *Iscience*.





⁴ McDonnell & Mutlu (2021). <u>Appearance.</u> The handbook on socially interactive agents.



Metaphors in Embodiment

Embodied representations follow **metaphorical design** — following a well-known metaphor to elicit familiarity and jumpstart user mental models of the agent's capabilities.⁴



⁴ McDonnell & Mutlu (2021). <u>Appearance.</u> The handbook on socially interactive agents.

Why use metaphors?

Representations must:

- Reflect the system's social role in relation to the user (e.g., a peer, a subordinate, a \rightarrow tool)
- Communicate the system's task role and capabilities (e.g., a seal can't talk, but a \rightarrow parrot can)
- Follow a consistent design in its appearance and behavior \rightarrow

Metaphorical design can achieve these, **but** we still have to overcome the limitations of the *global metaphor*.⁵ We can achieve that through *abstraction*!

⁵ Cooper et al., 2014, *About Face*. Wiley.

Abstraction in Metaphorical Design⁶



Human Design Metaphor

⁶ Deng et al. (2019). <u>Embodiment in socially interactive robots.</u> Foundations and Trends[®] in Robotics.

When metaphors go wrong

Uncanny valley: that humanoid objects that *imperfectly* resemble actual human beings provoke uncanny or strangely familiar feelings of uneasiness and revulsion in observers.⁷



⁷ Uncanny valley via Wikipedia



⁸ Image sources: <u>left</u>, <u>right</u>

History of embodied representations

Physical embodiments⁹



⁹ Image sources: <u>Karakuri Ningyo (17th Century)</u>, <u>Kismet (1998)</u>, <u>Pearl Nursebot (2002)</u>





¹⁰ Source: <u>Karakuri Robot [NHK World via YouTube]</u>

Virtual embodiments¹¹



¹¹ Image sources: <u>Knowledge Navigator (1987)</u>, <u>Herman the Bug (1997)</u>, <u>Cosmo (1998)</u>, <u>Rae (2000)</u>

Designing and Implementing Embodiments

Virtual or Physical?³

Characteristics	Physical	Virtu
Applications	Physical, situated collaboration, assistance	Coun educ
Activities	Activities interspersed across time and space	Focus activi
Interactions	Interactions situated in day-to-day life	Meta intera

³ Mutlu (2021). <u>The virtual and the physical: two frames of mind.</u> *Iscience*.

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Building virtual embodiments¹²



¹² Image source

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Building physical embodiments⁶



⁶ Deng et al. (2019). <u>Embodiment in socially interactive robots.</u> Foundations and Trends[®] in Robotics.



⁴ McDonnell & Mutlu (2021). <u>Appearance.</u> The handbook on socially interactive agents.

Programming (virtual or physical) embodiments

Approaches include:

- → Manufacturer-supplied APIs
- → Robot Operating System (ROS)¹³
- → Visual programming (e.g., Rover)¹⁴
- → Demonstration-based programming (e.g., Tabula)¹⁵

¹³ What is ROS?

¹⁴ Porfirio et al. (2018). <u>Authoring and verifying human-robot interactions.</u> UIST 2018.
¹⁵ Porfirio et al. (2023). <u>Sketching Robot Programs On the Fly</u>. HRI 2023.

Visual Programming Example¹⁴



¹⁴ Porfirio et al. (2018). <u>Authoring and verifying human-robot interactions.</u> UIST 2018.

Demonstration-based programming¹⁵



¹⁵ Porfirio et al. (2023). <u>Sketching Robot Programs On the Fly</u>. *HRI 2023*.



Integrating embodiments in interactive systems¹⁶



¹⁶ Image sources: <u>left</u>, <u>right</u>



¹⁷ The Reals Platform



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