Human-Robot Interaction

Module 3: Design

Lecture 1: Physical Design and Anthropomorphism

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Topics

- Physical design of a robot
  - How a well-designed robot impacts on positive interaction
- Anthropomorphism
  - How people treat robots as humanlike entities,
    not as an assembly of plastic, electronics, and code
  - The role of psychological theories of anthropomorphism in
    - Design of robots
    - Study of people's interactions with robots

Approaches to Design

- Inside-Out design
  - Most robots are developed by engineers
  - Their ability to interact with humans is then tested later on by social scientists
  - "Frankenstein approach":
    - assemble technical components and worry about appearance and interaction later

(Bartneck et al., 2020)

- Outside-In design
  - Start with required interaction designers
    - This determines outside shape and behaviours
  - Select the technical components to fit

(Bartneck et al., 2020)

Robot Morphology and Form

- Form follows function
  - Shape is determined by intended function
- In HRI: form and function are interconnected
  - Cannot be considered separately
  - Holistic approach
- Different forms
  - Androids and humanoids (human-like)
  - Zoomorphic (animal-like)
  - "Robjects"
    - Social trashcans
    - Robotic piggy banks

(Bartneck et al., 2020)

Robot Morphology and Form

- Key principle: Robot appearance should be commensurate with their limited capabilities
  - Avoid creating expectations of behaviour that are not fulfilled.
  - Design minimalist robots, e.g. Keepon
- Given users and context: design focusses on making appropriate decisions about
  - Form
  - Function
  - Level of autonomy
  - Interaction modalities

(Bartneck et al., 2020)

Affordances

- Introduced by J.J. Gibson, a psychologist
- Perceivable relationship between an organism and its environment that enable certain action
  - Objects are perceived to afford certain actions that depend on the form of the perceiver

https://spatulascorkscrews.typepad.com/my_weblog/2008/07/how-to-roll-a-pie-crust-without-a-rolling-pin.html

Affordances

- Need to make affordances explicit when designing a robot: "design affordances"
- A robot's appearance is an important affordance
  - Humans make assumptions about what a robot can do based on its appearance
  - Appearance and capabilities need to be consistent
    - Eyes: able to see
    - Arms: able to pick things up
    - Speaks: able to understand replies
    - Expresses emotion: able to interpret emotion of others
- Affordances signal ways of engaging with the robot

Design Patterns

"A problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice"

(Alexander, 1977, p. x).

Design patterns should be

- Abstract: possible to have multiple different instantiations
- Combinable: complex patterns comprise simpler patterns
- Descriptive of interaction with the social and physical world

Design Patterns

HRI Design patterns can be based on observation of

- Human interaction
- Prior empirical knowledge about robots and humans
- Designer's experience

Design Principles in HRI

Consider Design Patterns and Design Affordances together

Design process then assesses how different forms
(e.g. android, humanoid, zoomorphic, robjects)

- Express design patterns
- Provide the affordances that signal the required robot interaction and purpose

Design Principles in HRI

1. Match the form and function of the design
2. Underpromise and overdeliver
3. Interaction expands function
   - People "fill in the blanks" left open by the design
   - Design the robots in an open-ended way
   - Leverage people's expectations
4. Don't mix metaphors
   - Keep the design consistent across all design considerations

Anthropomorphization and Robots

"Anthropomorphization is the attribution of human traits, emotions, or intentions to nonhuman entities"

(Bartneck et al., 2020)

Humans have an innate predisposition to anthropomorphize

e.g. pareidolia: seeing humanlike features in random patterns or everyday objects (a type of apophenia)

This is an important design affordance in HRI: exploited so that humans see robots as social agents

(Bartneck et al., 2020)

Anthropomorphization and Robots

Anthropomophic design

- leverages appearance and behaviour
- to exploit human's predisposition to imbue robots with traits and abilities they don't necessarily have

Theoretical Aspects of Anthropomorphism

Three core factors that determine anthropomorphic inferences about non-human entities:

1. Effectance motivation

   Predisposition to explain behaviour as social: compensates for unfamiliarity & reduces stress

2. Sociality motivation

   Predisposition to be social: compensates for social isolation or lonliness

3. Elicited agent knowledge

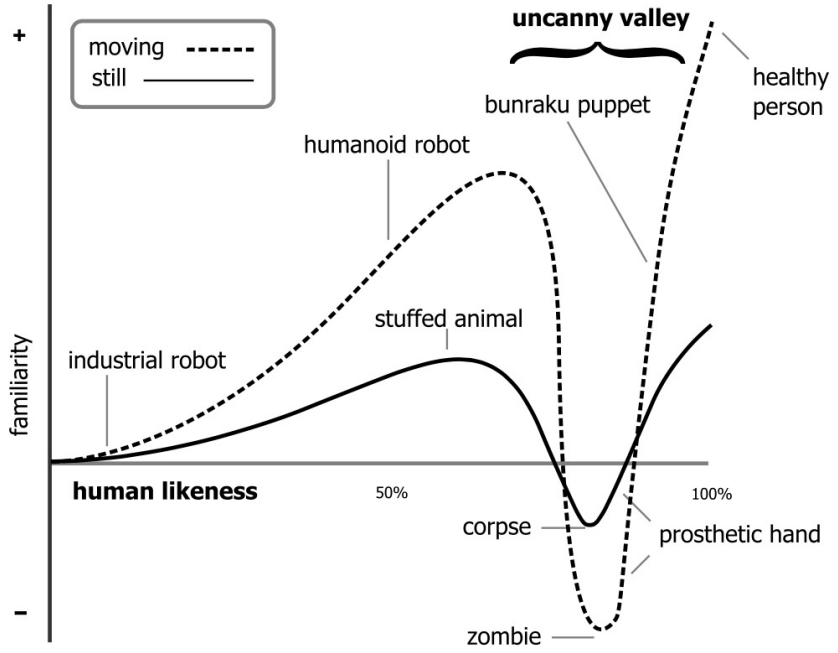
   Predisposition to use commonsense in social interactions: prior knowledge, preconceptions, bias to make sense of situations involving non-human entities

Theoretical Aspects of Anthropomorphism

Uncanny valley

The more humanlike a robot is, the more likable it is, until it becomes almost exactly humanlike, in which case it become unlikable

- Proposed by Mori without empirical testing
- Amplified by movements



Designing Anthropomorphism

Robot designers: anthropomorphism is a characteristic of the robot

Social scientists: anthropomorphism is attributed by humans to robots

Conclusion:

anthropomorphism depends on the relationship between robot design and people's perceptions of robots

Designing Anthropomorphism

Robot appearance

Face: two dots and a simple nose or mouth are sufficient

Minimal cues are sufficient

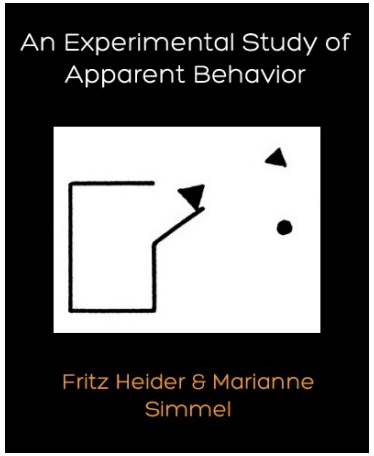
(Bartneck et al., 2020)

Designing Anthropomorphism

Robot Behaviour

Humans perceived humanlike characteristics in inanimate objects

Attribution of agency (animacy) to inanimate objects



Fritz Heider and Marianne Simmel, 1944

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

Designing Anthropomorphism

Robot Behaviour

- Fast reactions
  - Switch gaze in response to a loud noise
- Contingency
  - Context-appropriate behaviour
  - Switch gaze to look at a movement
  - Look away again if it's not relevant or important
    - Swaying branch of a tree vs. someone waving

Measuring Anthropomorphization

Assess degree to which people attribute key characteristics

- Agency
- Human nature and uniqueness
- Emotions
- Intentions
- Free will

Measuring Anthropomorphization

Godspeed Questionnaire Series (Bartneck et al., 2009)

Godspeed I: Anthropomorphism

Fake	1 2 3 4 5	Natural
Machinelike	1 2 3 4 5	Humanlike
Unconscious	1 2 3 4 5	Conscious
Artificial	1 2 3 4 5	Lifelike
Moving rigidly	1 2 3 4 5	Moving elegantly

http://www.bartneck.de/2008/03/11/the-godspeed-questionnaire-series/

Measuring Anthropomorphization

Godspeed Questionnaire Series (Bartneck et al., 2009)

Godspeed II: Animacy

Godspeed III: Likeability

Godspeed IV: Perceived Intelligence

Godspeed V: Perceived Safety

Reading

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

Chapter 4 – Design, pp. 41-56

References

Bartneck, C., Croft, E., Kulic, D. & Zoghbi, S. (2009). Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots. International Journal of Social Robotics, 1(1) 71-81.