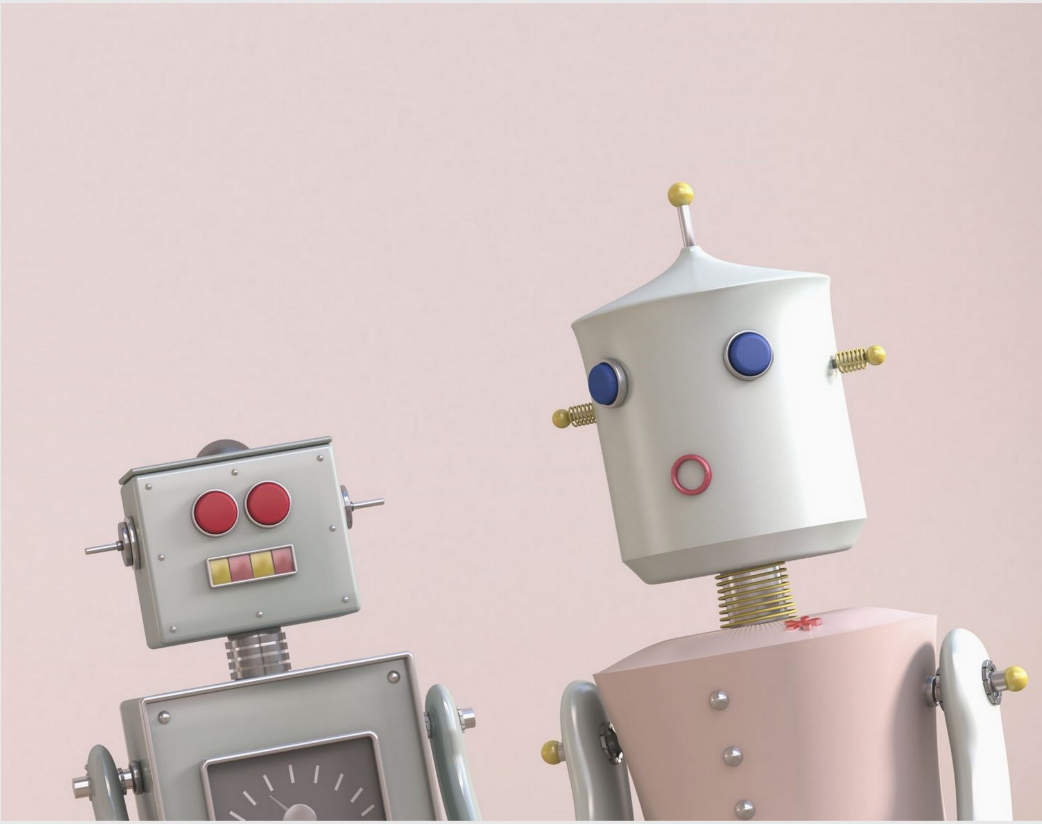
UiO : Department of Informatics
University of Oslo

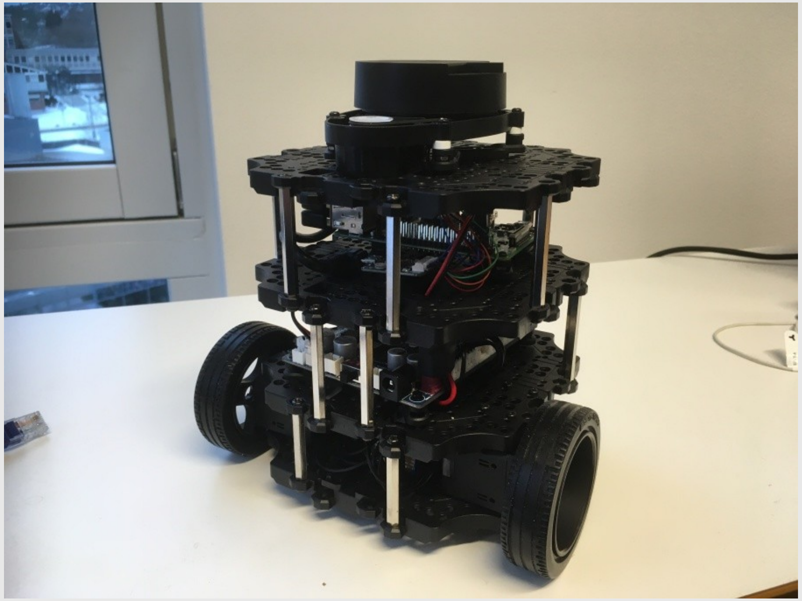
Robots and Movement

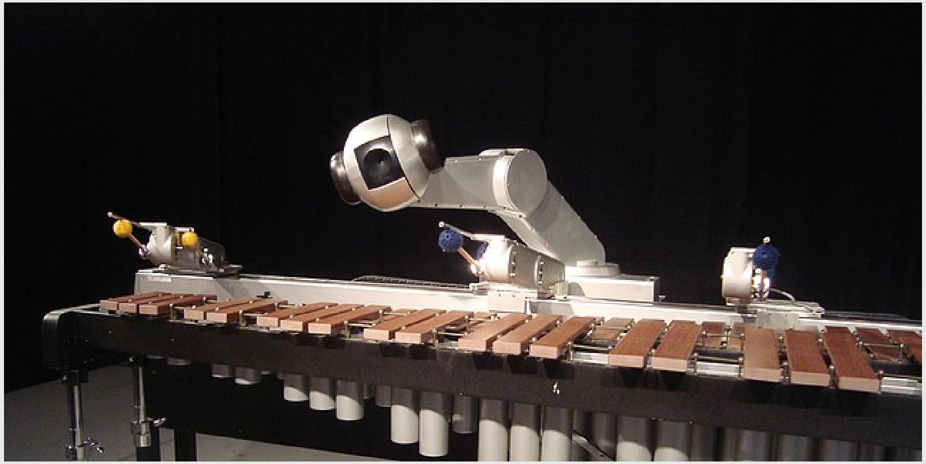
IN5480

8 September 2021



This lecture discusses robots, animation, & an experiment with both





Definition:

ROBOT

A robot is:

"Actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks"

—ISO 8373:2012

https://www.iso.org/obp/ui/#iso:std:iso:8373:ed-2:v1:en

Or … a robot is:

"A robot … refers to a physical object that interacts with the physical environment, either on its own or via a person, to accomplish a task."

—Me

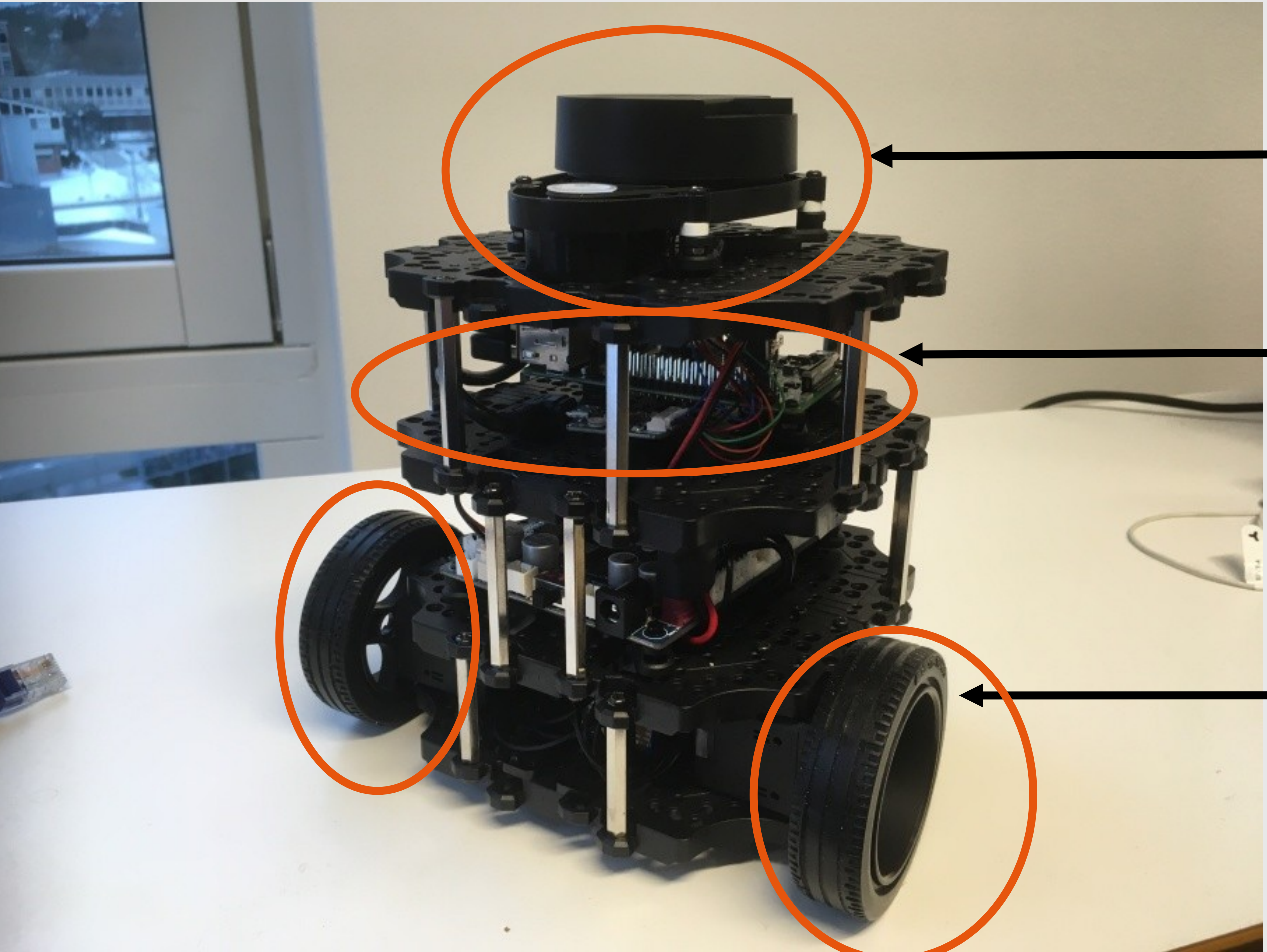
Exploration of Moving Things in the Home
http://urn.nb.no/URN:NBN:no-77171

The term *robot* is difficult to agree on

"We recommend that future investigations should consider the evolving nature of the concept of a robot in our global culture and perception of the term which is clearly varying across time."

Kessler, T. T., Larios, C., Walker, T., Yerdon, V., & Hancock, P. A. (2017). A Comparison of Trust Measures in Human–Robot Interaction Scenarios. In P. Savage-Knepshield & J. Chen (Eds.), *Advances in Human Factors in Robots and Unmanned Systems* (Vol. 499, pp. 353–364). Springer International Publishing. https://doi.org/10.1007/978-3-319-41959-6_29

Robots typically have three actions



Sense: Read data from sensors

Compute: Process data

Act: Do something based on the data

Human-Robot Interaction follows from an origin in teleoperation in factories, but has spread to other areas

1. Search and Rescue
2. Assistive and educational robotics
3. Entertainment
4. Military and police
5. Space exploration
6. Unmanned air vehicles

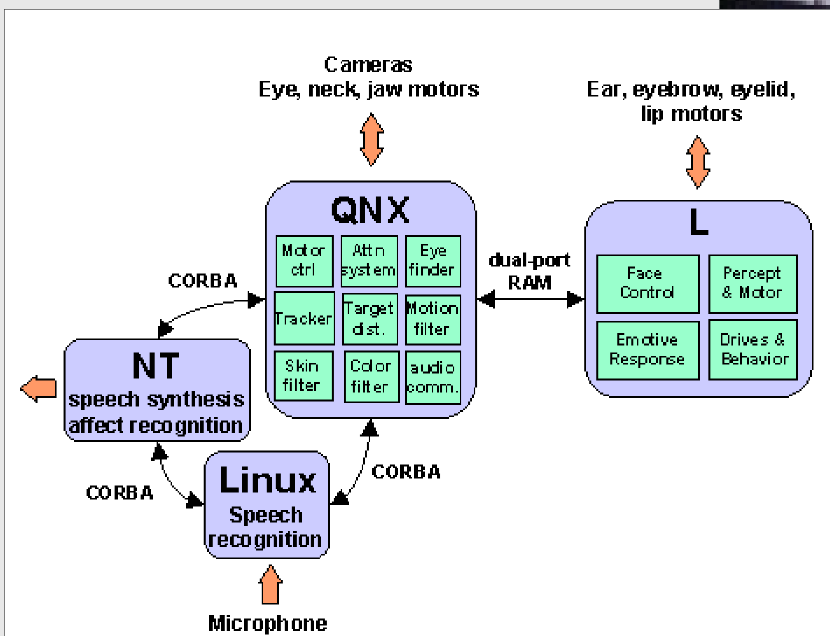
Robots can play different roles in an interaction

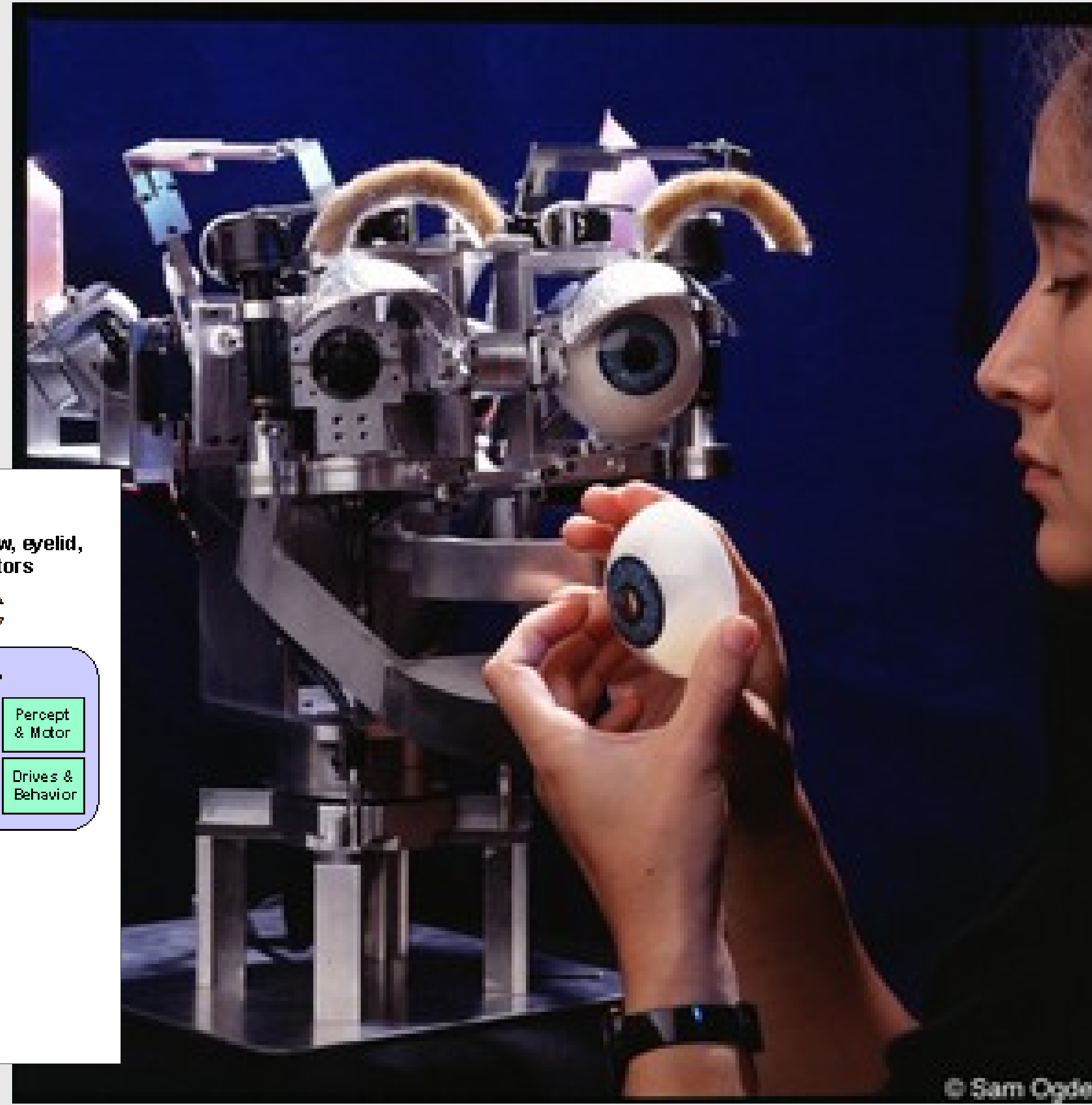
- Supervisor
- Operator
- Mechanic
- Peer
- Bystander
- Mentor

There are several best practices for doing HRI Research…

Including experts from multiple disciplines

Creating real systems





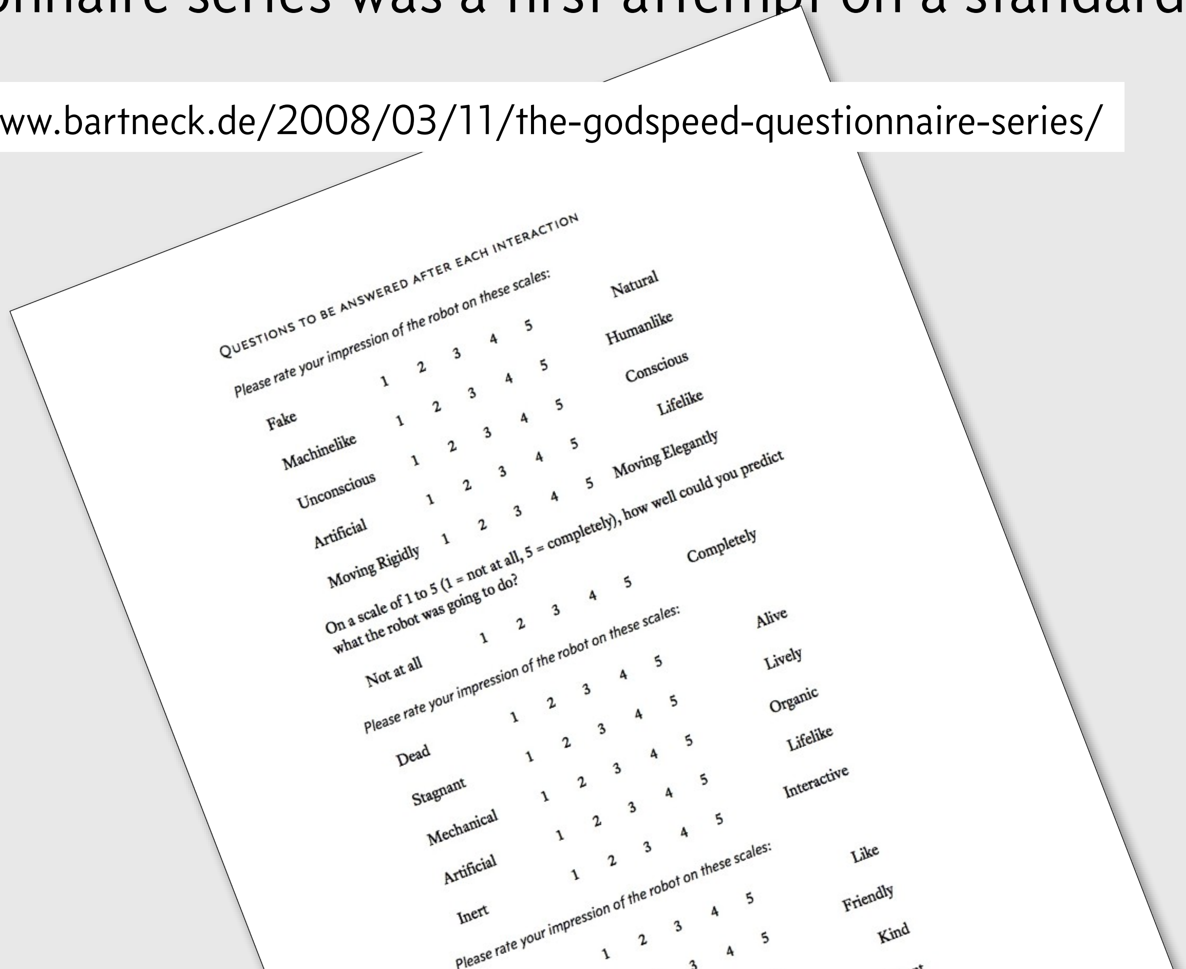
Breazeal, C. (2002). *Designing Sociable Robots*. MIT Press. https://mitpress.mit.edu/books/designing-sociable-robots

Conducting experiments blending simulation and physical robots

Running Longitudinal Studies

Establishing standards and common metrics: the Godspeed Questionnaire series was a first attempt on a standard metric

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



QUESTIONS TO BE ANSWERED AFTER EACH INTERACTION

Please rate your impression of the robot on these scales:

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

On a scale of 1 to 5 (1 = not at all, 5 = completely), how well could you predict what the robot was going to do?

Not at all	1	2	3	4	5	Completely

Please rate your impression of the robot on these scales:

Dead	1	2	3	4	5	Alive
Stagnant	1	2	3	4	5	Lively
Mechanical	1	2	3	4	5	Organic
Artificial	1	2	3	4	5	Lifelike
Inert	1	2	3	4	5	Interactive

Please rate your impression of the robot on these scales:

	1	2	3	4	5	Like
			3	4	5	Friendly
						Kind

The Robotic Social Attribute Scale (RoSAS) is inspired from Godspeed and captures the user feelings better

Competence	**Warmth**	**Discomfort**
Reliable	Organic	Awkward
Competent	Sociable	Scary
Knowledgeable	Emotional	Strange
Interactive	Compassionate	Awful
Responsive	Happy	Dangerous
Capable	Feeling	Aggressive

Carpinella, C. M., Wyman, A. B., Perez, M. A., & Stroessner, S. J. (2017). The Robotic Social Attributes Scale (RoSAS): Development and Validation. *Proceedings of the 2017 ACM/IEEE International Conference on Human-Robot Interaction*, 254–262. https://doi.org/10.1145/2909824.3020208

Discussion

- How would you define the word “robot”?
- Use your definition to decide if the following things are a robot or not:
    - drone
    - machine gun
    - Smart speaker
    - Self-driving car
    - Chatbot

I wrote a paper to map the landscape of using animation techniques with HRI

Animation Techniques in Human-Robot Interaction User Studies: A Systematic Literature Review

TRENTON SCHULZ, JIM TORRESEN, and JO HERSTAD, University of Oslo, Norway

There are many different ways a robot can move in Human-Robot Interaction. One way is to use techniques from film animation to instruct the robot to move. This article is a systematic literature review of human-robot trials, pilots, and evaluations that have applied techniques from animation to move a robot. Through 27 articles, we find that animation techniques improves an individual's interaction with robots, improving the individual's perception of qualities of a robot, understanding what a robot intends to do, and showing the robot's state or possible emotion. Animation techniques also help people relate to robots that do not resemble a human or robot. The studies in the articles show further areas for research, such as applying animation principles in other types of robots and situations, combining animation techniques with other modalities, and testing robots moving with animation techniques over the long term.

CCS Concepts: • **Computer systems organization** → **Robotic autonomy**; *Robotics*; • **Human-centered computing** → *HCI design and evaluation methods*; *Interaction paradigms*;

Additional Key Words and Phrases: Robot, human-robot interaction, literature review, animation, motion

ACM Reference format:
Trenton Schulz, Jim Torresen, and Jo Herstad. 2019. Animation Techniques in Human-Robot Interaction User Studies: A Systematic Literature Review. *ACM Trans. Hum.-Robot Interact.* 8, 2, Article 12 (May 2019), 22 pages.
https://doi.org/10.1145/3317325

12

1 INTRODUCTION

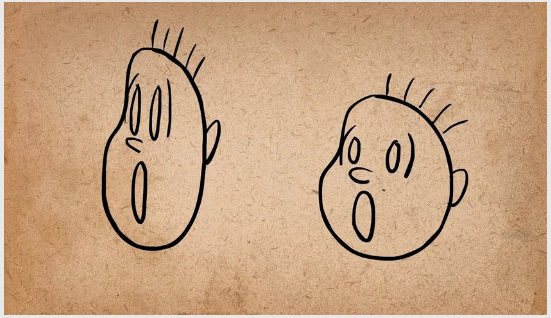
When the Kismet robot was introduced, individuals could interact with it via conversation or gestures as opposed to typing on a keyboard [18]. Human-robot interaction (HRI) requires the robot to also respond. A robot that gestures and moves can aid an individual in understanding what the robot is doing and aid in the interaction.

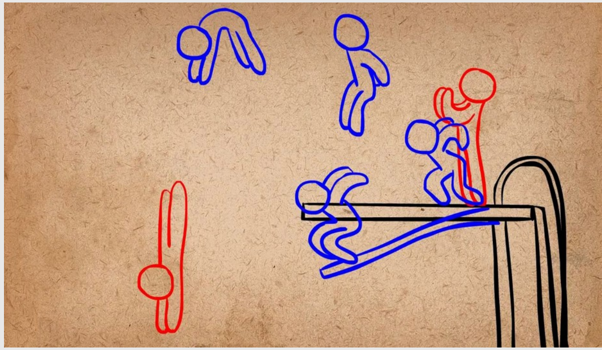
...movie production, we observed the phenomenon of *animation*—layering slightly different ...object to create the illusion of movement. Animators follow principles such that ...believable and tell stories [85]. The principles are successfully used in computer ...dies suggested that the principles should be considered for robots [68, 89]. ...tent to which animation techniques are used with robots and how do ...

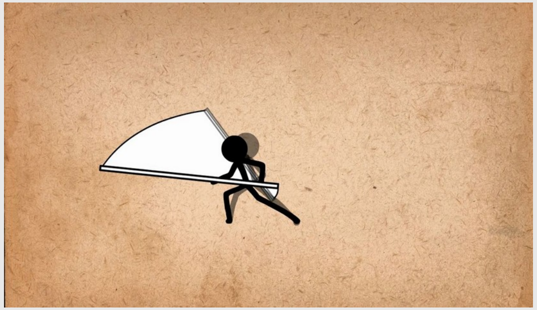
...orwegian Research Council under Grant No. 247697 of the IKT- ...luss/Home_page/1254002053513). ...ity of Oslo, Department of Informatics, Postbox 1072 ...ahe}@ifi.uio.no. ...nal or classroom use is granted without fee ...e and that copies bear this notice and ...thers than the author(s) must be ...ers or to redistribute to lists,

Thomas & Johnston documented the 12 Principles of Animation

1. Squash and Stretch
2. Anticipation
3. Staging
4. Straight Ahead Action and Pose to Pose
5. Follow Through and Overlapping Action
6. Slow In and Slow Out
7. Arcs
8. Secondary Action
9. Timing
10. Exaggeration
11. Solid Drawing
12. Appeal

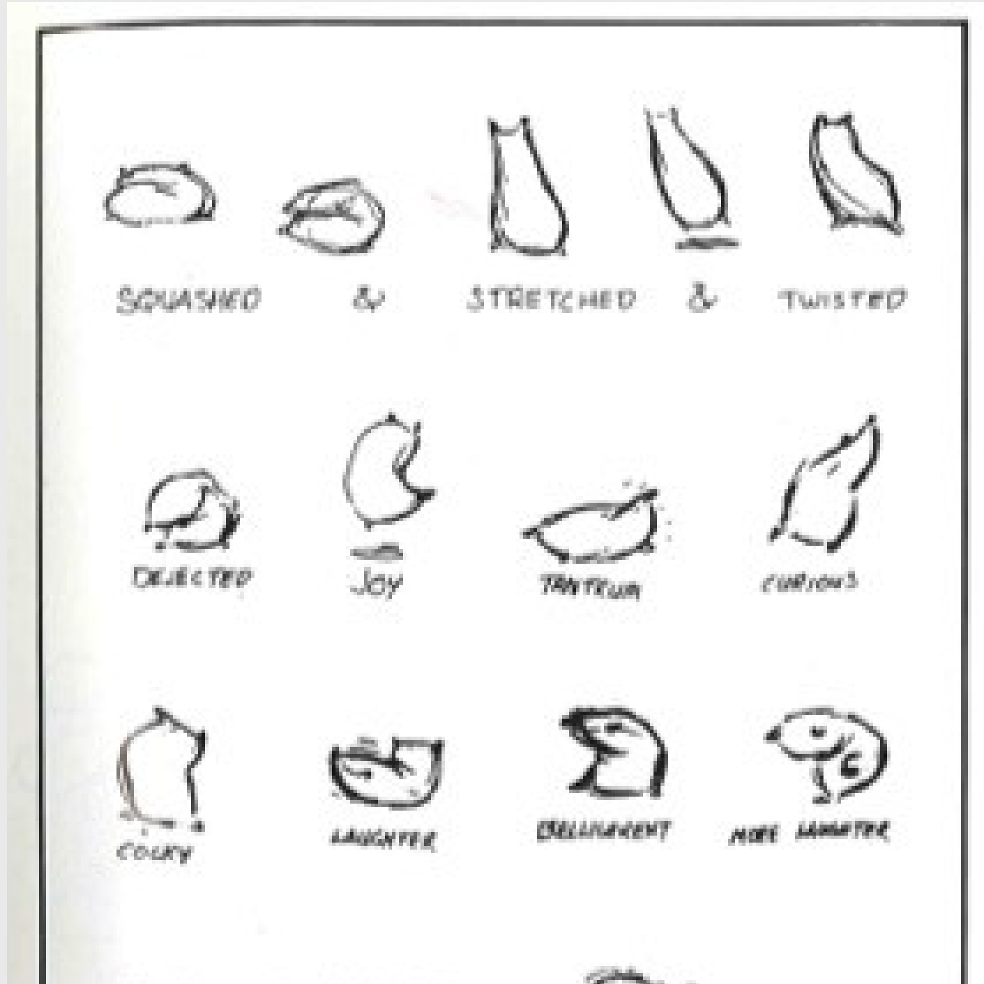






Images courtesy Alan Becker

Squash and stretch—objects should squash and stretch, but they should not lose their shape



Squash and stretch—objects should squash and stretch, but they should not lose their shape

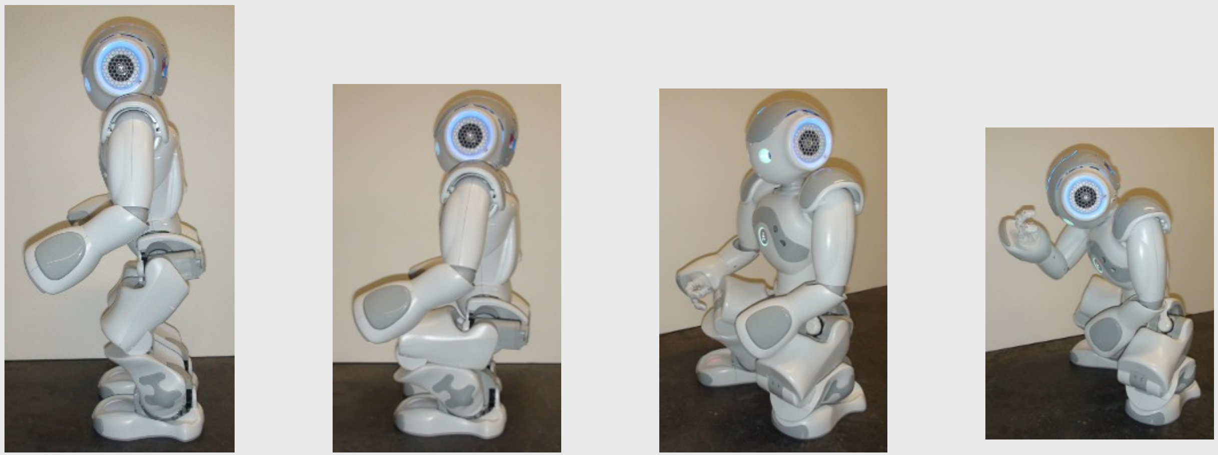
Anticipation—Major action should be telegraphed

Donald draws back with raised leg in anticipation of the dash he will make out of the scene.

Anticipation: Shimon grew a head for making it easier to collaborate with multiple musicians

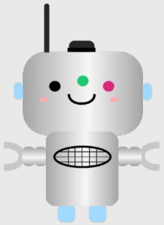
https://youtu.be/jtC_CNPiGe8

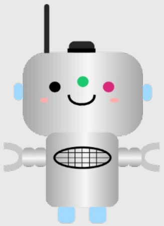
Straight Ahead Action and Pose to Pose—Just have action happen or set up certain poses and interpolate between.



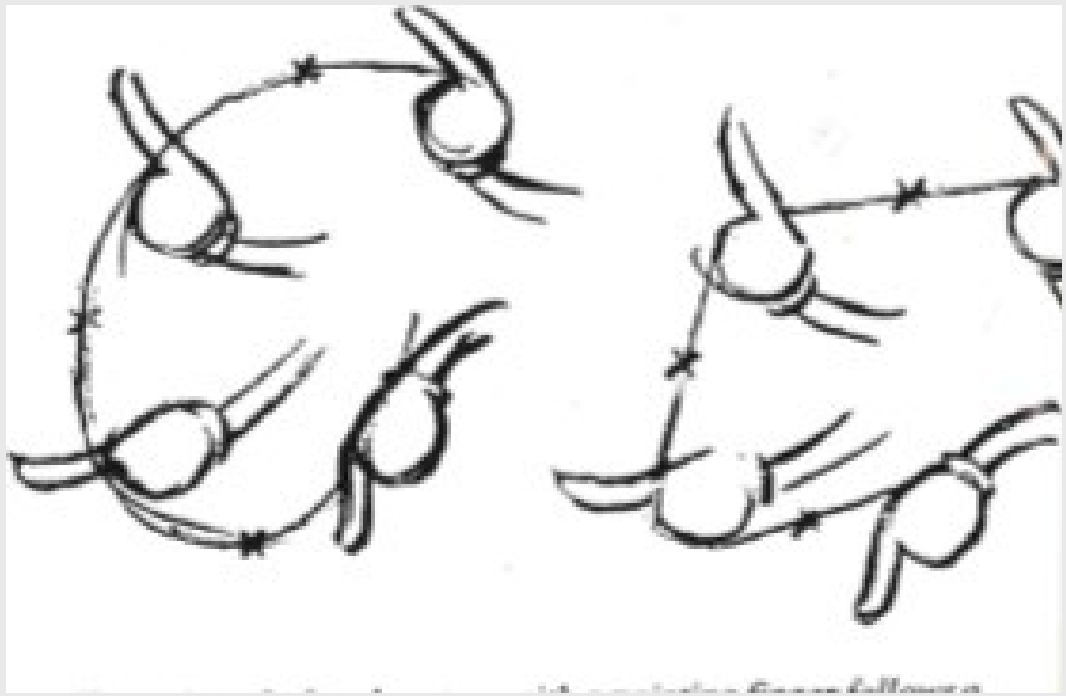
Follow Through and Overlapping Action —Actions are not performed in isolation; they lead into each other

Slow In and Slow Out—Action is slower at the beginning and the end of an action





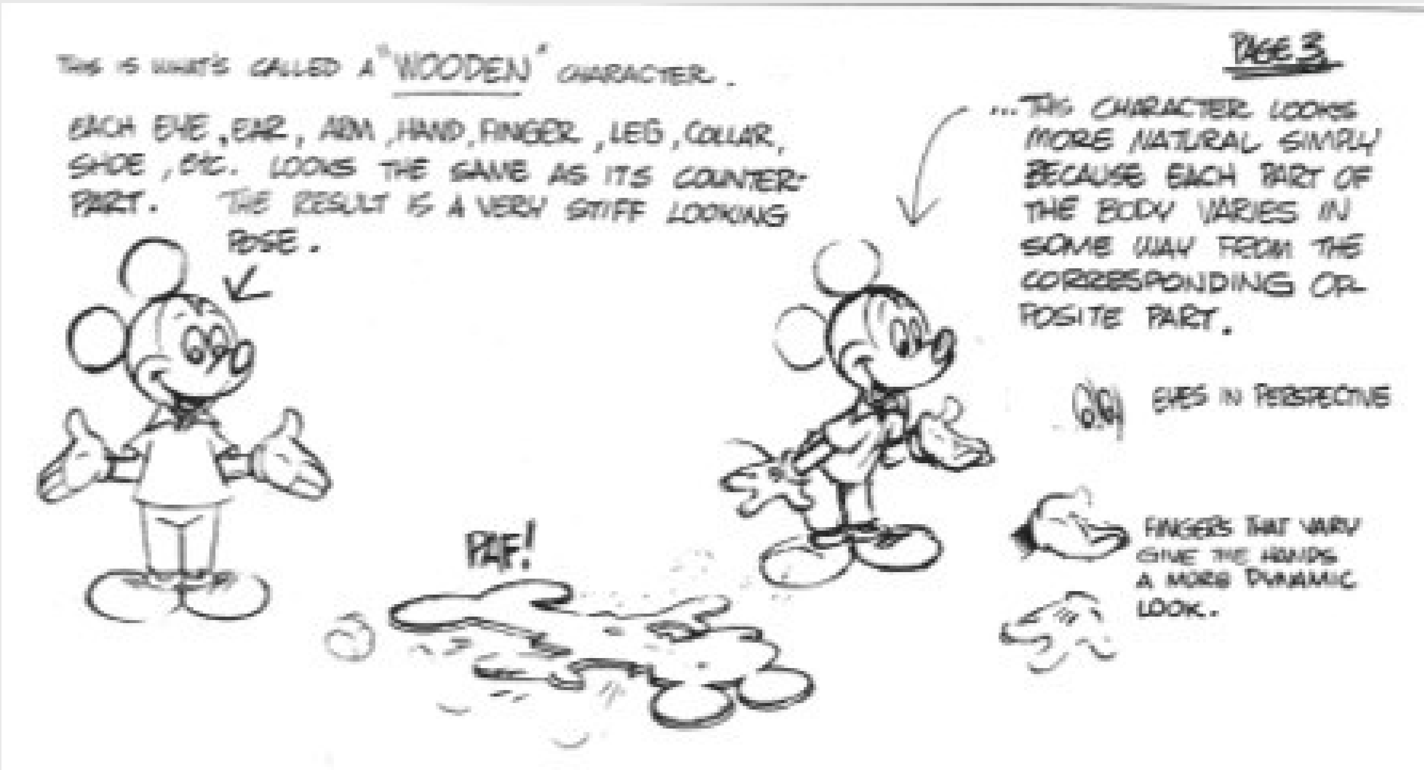
Arcs—Move limbs in arcs as opposed to of straight up-down and left-right motions



Exaggeration—Exaggerated motion makes it easier to read a character’s emotion

https://youtu.be/CL0qxUWekMU

Solid Drawing—Avoid twins: symmetrical limbs on a character



I’ll present a some work that I’ve done on animation techniques with robots

Classifying Human and Robot Movement at Home and Implementing Robot Movement Using the Slow In, Slow Out Animation Principle

Trenton Schulz, Jo Herstad, Jim Torresen
University of Oslo
P.O. Box 1080 Blindern
0316 Oslo, Norway
Email: [trentonw|johe|jimtoer]@ifi.uio.no

Abstract—We examine how robot movement can help human-robot interaction in the context of a robot helping retired people at home. Many people are not familiar with a robot moving in their home. We present four movement conditions to classify movement between a human and robot at home. Using phenomenology and familiarity, we recognize some of these conditions from other interactions people have with other moving things. Using techniques from animation in movies, we give the robot a distinctive style that can make the robot's movement more familiar and easier to understand. We examine animation further and present how to implement the animation principle of slow in, slow out with a research robot that can control its speed. We close the paper with future work on how to use the classification system and how to build on the slow in, slow out principle implementation for animated robots.

Keywords—*human-robot interaction; animation; style; movement; slow in, slow out; familiarity; home;*

I. Introduction

In previous work [1], we saw that projections for people over 60-years old not working (hereafter "the elderly") will be larger than the number of people working [2]. As people age, they tend to accumulate different aches, pains, diseases, and disabilities. The elderly will need assistance to continue to live independently with these acquired health issues. For example, a robot with sensors can help monitor and assist the elderly person staying at home. The elderly and other people need to easily interact with the robots. Making the robot move distinctively using techniques from animation could make this interaction easier.

Previously, we used phenomenology to examine movement [1] and classified robot movement into classes. We also discussed robot movements in the frame of proxemics [3], people's familiarity with robot movement, and animation techniques that could help make the movement more familiar. In this paper, we build on the previous work [1] by further exploring the topics of familiarity and proxemics, before introducing a formalized version of robot movement and a possible way to animate it using a classic animation principle of *slow in, slow out*. Combining the phenomenological and the formalized exploration of robot movement and animation gives us a starting point for building future work on human-robot interaction (HRI).

To accomplish this, we first present the context for examining robot's movement in the home (Section II).

robot (Section IV). We use this framework to aid in looking at the concept of familiarity and how robot motion compares to motion of other objects people encounter in everyday life (Section V) and how animation can help with this familiarity. Then, we present a formalized version of robot movement and how to derive slow in, slow out movement from it (Section VI). Finally, we present ideas for future work (Section VII) before concluding the article (Section VIII).

II. Research Context: Robots at Home

Western countries are examining the issue of the "elderly wave" [2]: the number of people who will be retiring and needing care will be larger than the people entering the workforce for these jobs. To cut down on the demand for care, some countries have set goals that more elderly should live independently at home longer. One way of addressing this goal is to turn to welfare technology that can assist the elderly [4]. Some new technology includes the Internet of Things and smart home sensors for reporting and helping elderly complete tasks [5][6]. Sensors can also provide a warning when things go wrong, such as an elderly person falling [7].

Instead of mounting the sensors all over in the house, we can mount the sensors on robots. Robots are mobile and can be customized for handling different tasks. Robots are already in the home domestic robots cut the lawn and vacuum carpets, and other robots provide entertainment (the robot dog Aibo [8]) or stress relief (the Paro seal [9]).

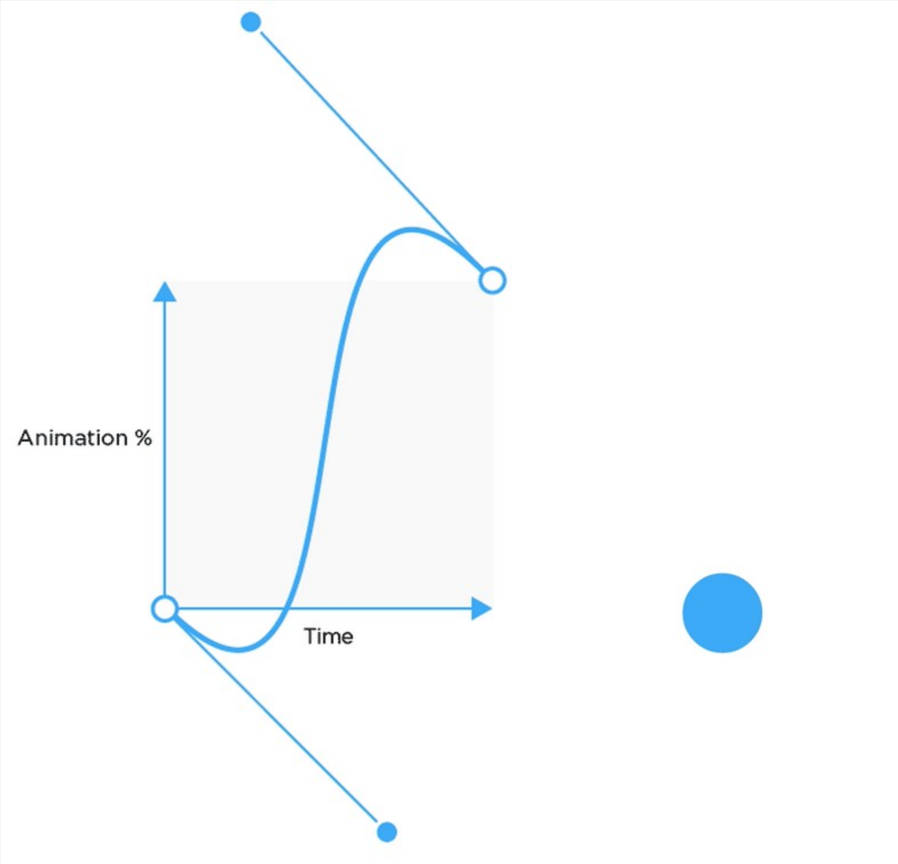
A. Projects Looking at Elderly and Robots

Several other projects have looked at having robots help the elderly. One example is Care-o-bot [10], [11] that can do multiple tasks for the elderly at home.

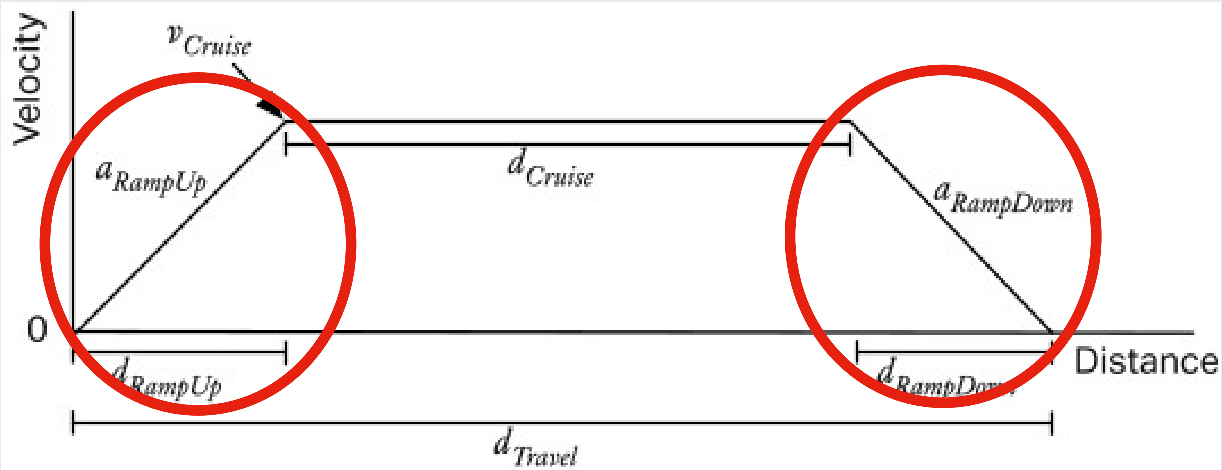
We can classify movement between robot and human in 4 conditions

Condition	Human	Robot
1	Local	Local
2	Local	Global
3	Global	Local
4	Global	Global

Slow in and slow out uses easing curves to specify *movement*, but robots control their *speed*, not their movement

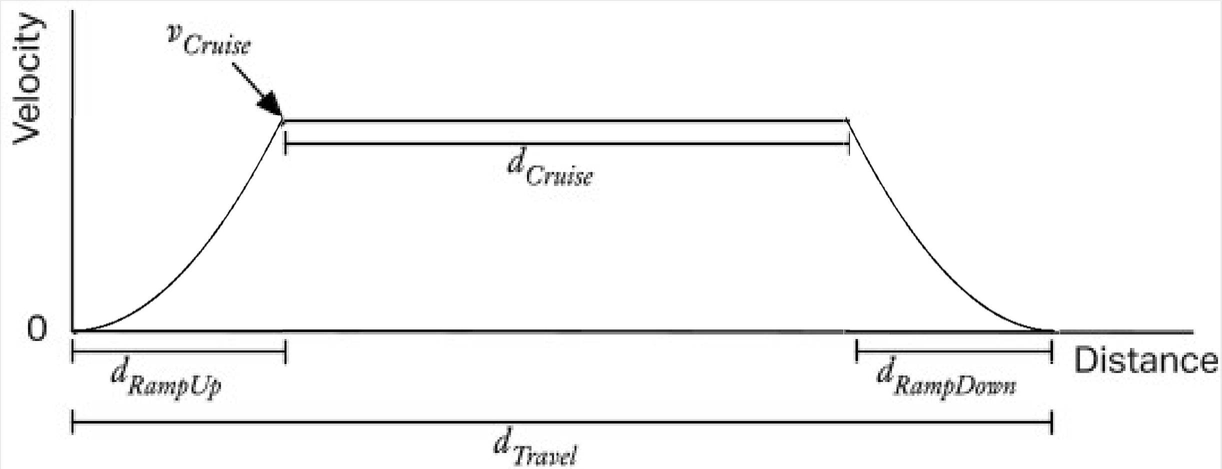


Robots movement can be graphed as a velocity profile of velocity over distance



Using Calculus, we can take the derivative of an easing curve and use it to get the velocity

Applying the derived velocity curves results in a slow in and slow out appearance



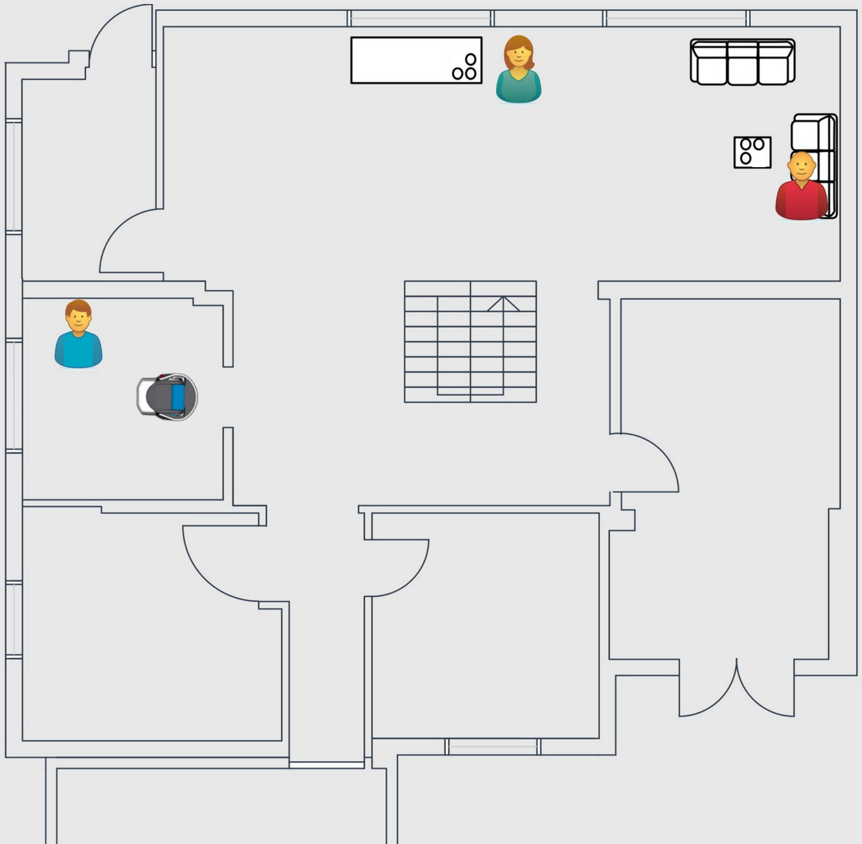
Discussion: How to test a robot using an animation principle with people? Which animation principle would you like to explore more?

https://youtu.be/4RZn15EdMbo

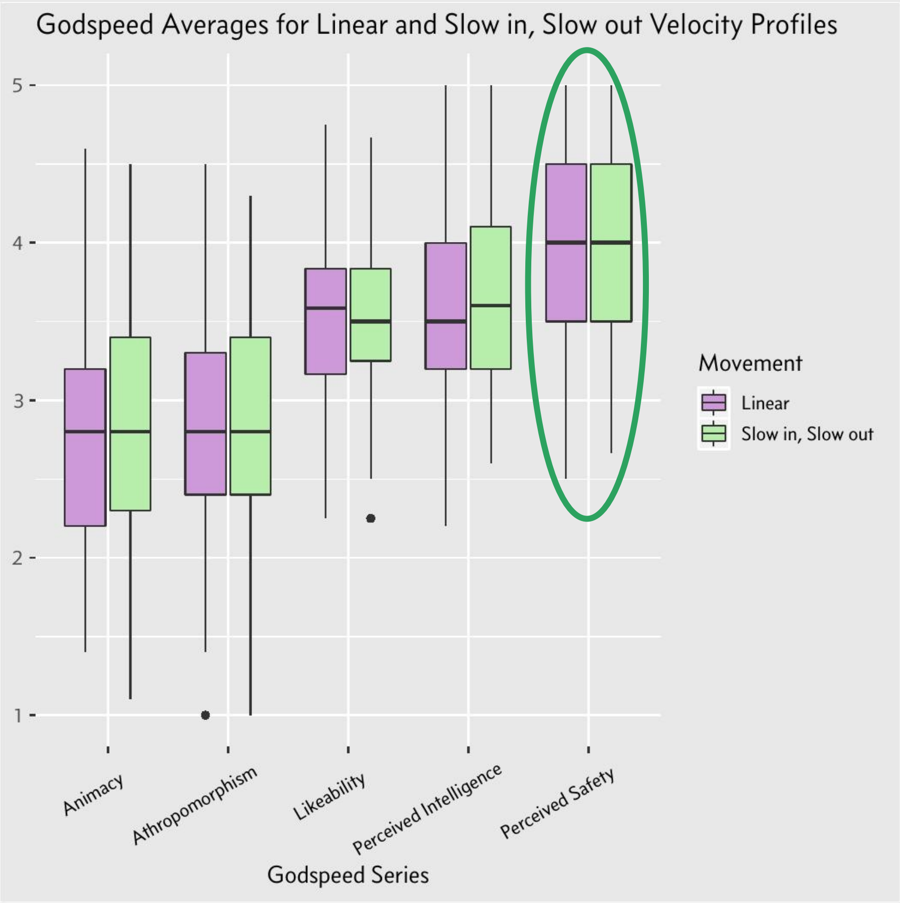
This was an experiment run at the University of Hertfordshire's Robot House

University of Hertfordshire UH

People cooperated with a robot on a cleaning task

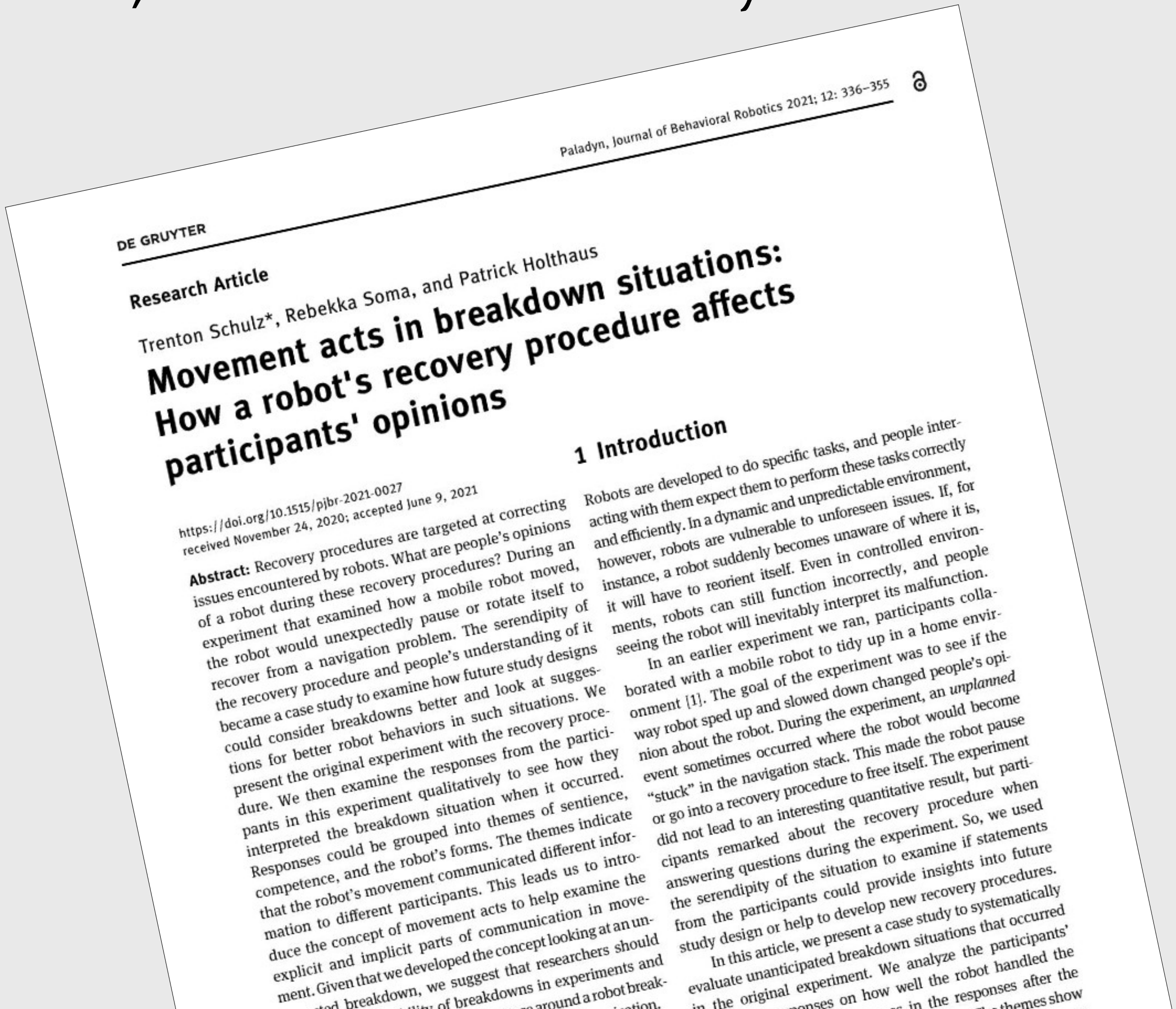


There is not a large enough effect to reject null hypotheses; Holm-Bonferroni correction confirms this



Godspeed Series	***n***	**Average**	**95% CI**
Anthropomorphism			
Linear	36	2.84	(2.56, 3.06)
Slow in, Slow out	37	2.83	(2.60, 3.08)
Animacy			
Linear	36	2.88	(2.65, 3.1)
Slow in, Slow out	38	2.87	(2.66, 3.1)
Likeability			
Linear	37	3.59	(3.37, 3.82)
Slow in, slow out	38	3.71	(3.52, 3.92)
Perceived Intelligence			
Linear	37	3.57	(3.36, 3.77)
Slow in, slow out	37	3.51	(3.32, 3.69)

This led us to explore the idea of *movement acts* and designing with breakdown in mind, but that is another story.



Paladyn, Journal of Behavioral Robotics 2021; 12: 336–355

DE GRUYTER

Research Article

Trenton Schulz*, Rebekka Soma, and Patrick Holthaus

Movement acts in breakdown situations: How a robot's recovery procedure affects participants' opinions

https://doi.org/10.1515/pjbr-2021-0027
received November 24, 2020; accepted June 9, 2021

Abstract: Recovery procedures are targeted at correcting issues encountered by robots. What are people's opinions of a robot during these recovery procedures? During an experiment that examined how a mobile robot moved, the robot would unexpectedly pause or rotate itself to recover from a navigation problem. The serendipity of it the recovery procedure and people's understanding of it became a case study to examine how future study designs could consider breakdowns better and look at suggestions for better robot behaviors in such situations. We present the original experiment with the recovery procedure. We then examine the responses from the participants in this experiment qualitatively to see how they interpreted the breakdown situation when it occurred. Responses could be grouped into themes of sentience, competence, and the robot's forms. The themes indicate that the robot's movement communicated different information to different participants. This leads us to introduce the concept of movement acts to help examine the explicit and implicit parts of communication in movement. Given that we developed the concept looking at an un-

1 Introduction

Robots are developed to do specific tasks, and people interacting with them expect them to perform these tasks correctly and efficiently. In a dynamic and unpredictable environment, however, robots are vulnerable to unforeseen issues. If, for instance, a robot suddenly becomes unaware of where it is, it will have to reorient itself. Even in controlled environments, robots can still function incorrectly, and people seeing the robot will inevitably interpret its malfunction.

In an earlier experiment we ran, participants collaborated with a mobile robot to tidy up in a home environment [1]. The goal of the experiment was to see if the way robot sped up and slowed down changed people's opinion about the robot. During the experiment, an *unplanned* event sometimes occurred where the robot would become "stuck" in the navigation stack. This made the robot pause or go into a recovery procedure to free itself. The experiment did not lead to an interesting quantitative result, but participants remarked about the recovery procedure when answering questions during the experiment. So, we used the serendipity of the situation to examine if statements from the participants could provide insights into future study design or help to develop new recovery procedures.

In this article, we present a case study to systematically evaluate unanticipated breakdown situations that occurred in the original experiment. We analyze the participants' responses on how well the robot handled the

In summary, we have examined HRI & robot movement

- There are multiple ways to define a robot; find one that works for you
- Techniques from animation might be an interesting way to look at moving robots
- Experiments can lead to results that are not what you expect

Thank you!