CS 188 Robotics Week 7

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Human Robot Interaction

- Proposed definitions:
  - A field of study dedicated to understanding, designing, and evaluating robotic systems for use by or with humans. Interaction requires communication between robots and humans
  - Define models of humans' expectations regarding robot interaction to guide robot design and algorithmic development that would allow more natural and effective interaction between humans and robots
- The HRI problem is to *understand and shape the interactions between one or more humans and one or more robots*

A Little Bit of History

- HRI as a field started to emerge in the mid-1990s
- Interdisciplinary in nature, requiring contributions from cognitive science, linguistics, and psychology; from engineering, mathematics, and computer science; and from human factors engineering and design.

(Some) Topics in HRI

- Expression and Gase
- Proxemics
- Speech
- Perception
- Interaction Design
- Manipulation
- Decision-Making
- Mental Models
- Perspective-Taking
- Systems Engineering
- Robot Futures and Singularity
- Shared Autonomy
- Exoskeletons
- Assistive Robotics
- Educational Robotics
- Philosophy
- Ethics
- Law
- ...

Types of Interactions with Robots

- Intentional
  - E.g., human-robot search and rescue team
- Incidental
  - E.g., valuum cleaning robot bumping into your foot
- Explicit
  - E.g., assistive robot lifting a patient out of bed

- Implicit
  - E.g., UAV flying over your home

Example: Autonomous Cars

- Intentional physical contact
  - Car is physically transporting a person
- Unintentional physical contact
  - In case of an accident
- Explicit social interactions
  - Alerting people in the car about changing the route home
- Implicit social interactions
  - Opinions human drivers in other cars may have about the autonomous car's driving behavior
- Plus ethical considerations!
  - Who has access to the recorded data from the cameras in the car?
  - Should the car protect the driver or pedestrians in the case of an inevitable accident?

Human Robot Interaction Design

- A designer can control five attributes that affect the interactions between humans and robots:
  - Level and behavior of autonomy
  - Nature of information exchange
  - Structure of the team
  - Adaptation, learning, and training of people and the robot
  - Shape of the task

Attribute 1: Autonomy

- Designing autonomy consists of mapping inputs from the environment into actuator movements, representational schemas, or speech acts
- Autonomy is only useful insofar as it supports beneficial interaction between a human and a robot

Levels of Autonomy in HRI

- Teleoperation
  - A human remotely controls a mobile robot or robotic arm
  - Cons: Higher cognitive load of the operator
- Mediated Teleoperation
  - Human remotely controls the robot; the robot autonomously intervenes as necessary
- Supervisory Control
  - Human supervises the behavior of an autonomous system and intervenes as necessary

- Peer-to-peer Collaboration
  - High-level supervision and direction of the robot; human provides goals and robot maintains knowledge about the world, task, and constraints
  - Cons:
    * Difficult to create robots with the appropriate cognitive skills to interact naturally or efficient with a human
    * Must be able to flexibly exhibit "full autonomy" at appropriate times

Teleoperation Example

- Da Vinci Surgical Robot (Intuitive Surgical)

Mediated Teleoperation Example

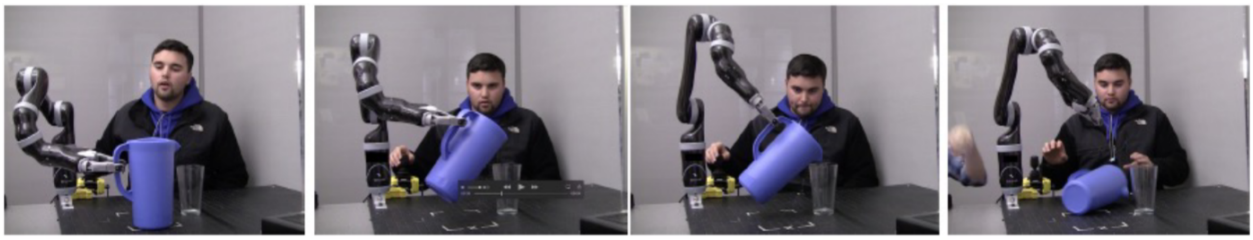


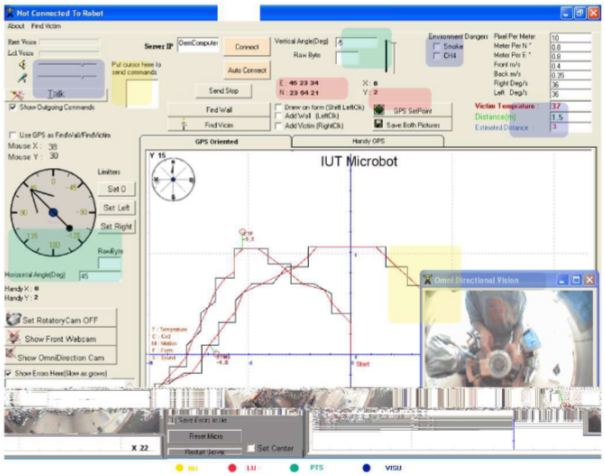
Figure 2: The user guides the robot towards an unstable grasp, resulting in task failure.

Attribute 2: Information Exchange

- Efficient interactions characterized by productive exchanges between the human and robot
- Measures of the efficiency of an interaction:
  - Interaction time required for intent and/or instructions to be communicated to the robot
  - Cognitive or mental workload of an interaction
  - Amount of situation awareness produced by the interaction (or reduced because of interruptions from the robot),
  - Amount of shared understanding or common ground between humans and robots

Visual Displays

- Typically presented as graphical user interfaces or augmented reality interfaces



Kadous et al., 2006

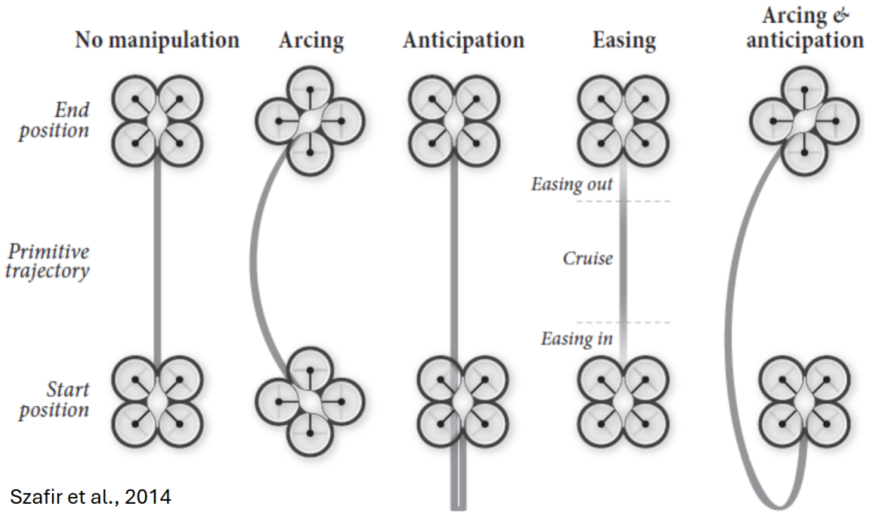
Gestures

- Gestures, including hand and facial movements and by movement-based signaling of intent

Salem et al., 2012

Baxter robot

Bandit robot



Szafir et al., 2014

Speech and natural language

- Auditory speech
- Text-based responses
- Robot must understand responses from human and must be able to perform appropriate task

TASK TO COMPLETE

Dave Daniel wants the item in slot 5.

ROBOT	How can I help?
YOU	please bring the item in slot 5 to dave daniel
ROBOT	To whom should I bring something?
YOU	dave daniel
ROBOT	What action did you want me to take involving dave daniel?
YOU	5
ROBOT	What should I bring to dave daniel?
YOU	a calander
ROBOT	I'm sorry, but I couldn't pinpoint what you meant by that.
ROBOT	What should I bring to dave daniel?
YOU	a day planner
ROBOT	I'm sorry, but I couldn't pinpoint what you meant by that.
ROBOT	What should I bring to dave daniel?
YOU	calendar
ROBOT	You want me to bring calendar to dave daniel?
YOU	yes
ROBOT	I thought so
ROBOT	Happy to help
YOU	

Final Task

DIRECTORY

People:

Alice Ashcraft; Secretary
Francis ("Frannie") Foster
Robert ("Bob") Brown
Carol Clark, PhD
Dave Daniel, PhD
George Green; Intern
Evelyn ("Eve") Eckhart
Mallory Morgan; Director
Peggy Parker, PhD
Walter Ward; Supervisor

Items available to robot:

Thomason et al., 2015

Non-speech audio

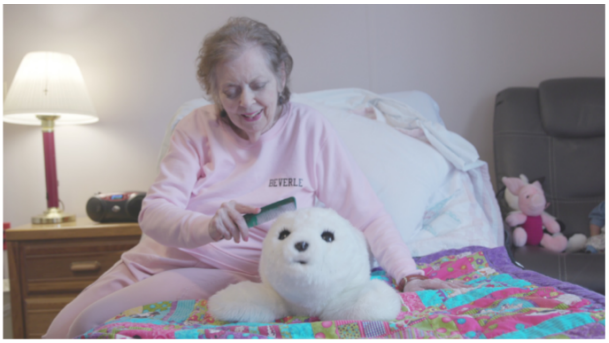
- Frequently used in alerting

Cha and Mataric, 2014

Physical Interaction and Haptics

- Used remotely in augmented reality or in teleoperation to invoke a sense of presence especially in telemanipulation tasks
- Used proximately to promote emotional, social, and assistive exchanges

Zamani et al., 2020



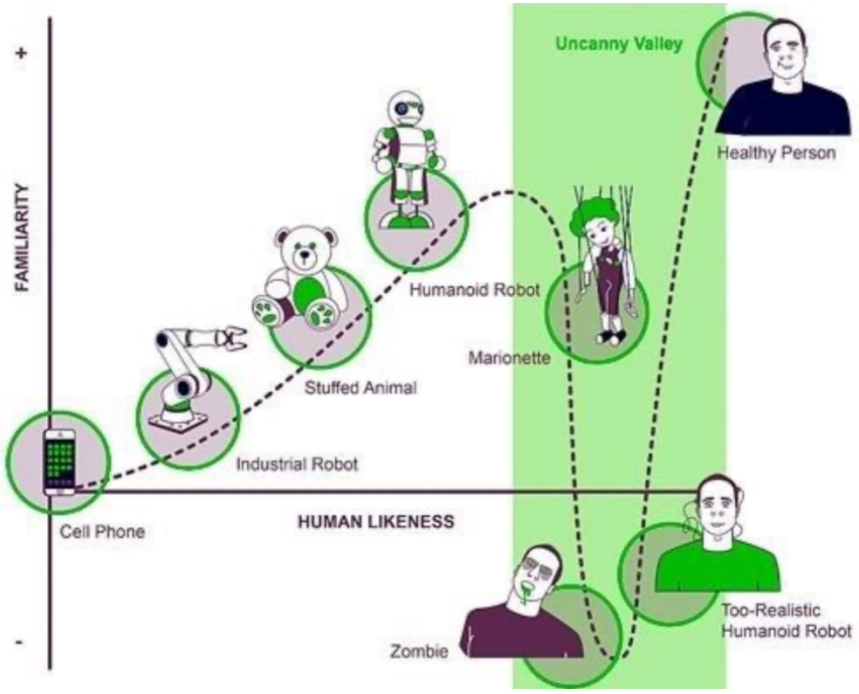
Paro seal robot

Safety in HRI

- Industrial Robots

- Human-robot interaction

The Uncanny Valley



Attribute 3: Team Structure

- HRI is not restricted to a single human and a single robot
- For example:
  - Robots used in search and rescue are typically managed by two or more people, each with special roles in the team
  - Unmanned/Uninhabited Air Vehicles (UAVs) are typically managed by at least two people: a "pilot", who is responsible for navigation and control and a sensor/payload operator, who is responsible for managing cameras, sensors, and other payloads
  - One human may also interact with multiple robots

Attribute 4: Adaptation, learning, and training

- Training human operators
  - Minimize needed training
    - i.e., the Roomba should work even without taking a class in robotics
    - Robots for children are becoming more popular
  - Specialized robots or tasks may require additional training
- Training robots
  - Improving perceptual capabilities through efficient communication
  - Improving reasoning and planning through interaction
  - Improving autonomous capabilities

Attribute 5: Task-shaping

- Robotic technology is introduced to allow a human to do a task that they could not do before, or to make the task easier or more pleasant for the human
- Consider how the task should be done and will be done when new technology is introduced

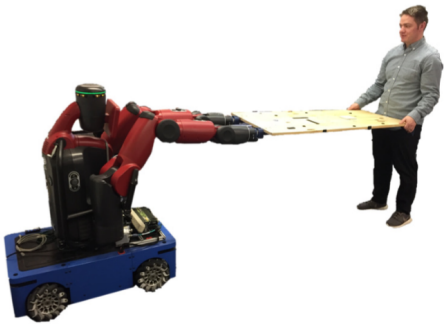
Assistive Robots

- Seek to provide physical, mental, or social support to persons who could benefit from it such as the elderly or disabled
- Challenges:
  - Providing safe physical contact
  - Moving within very close proximity
  - Cognitive and emotive computing
  - Gesture and speech

Physically Assistive Robots

- Robot physically interacts with the user to provide assistance in some task





Socially Assistive Robots

- Seeks to supplement and augment the support of clinicians and caregivers through individualized, socially mediated interventions with robots
- No physical interaction with robots

Human Subject Studies in HRI

- Must evaluate the effectiveness of the system in context of the interaction with real (naive) users
- Can measure:
  - Qualitative
    - How does the user perceive the (look, feel, sound) of the robot?
    - How much does the user trust the robot?
  - Quantitive
    - How long does it take the user to complete the task?
    - How accurately does the robot follow the user's commands?
    - How much of the user's attention is required by the task?

Designing Human Subject Studies

- Who are your subjects and how would you recruit them?
- Where would you perform the study?
- What do you want to discover? (what is the hypothesis or research question)?
- What would the protocol be?
- What would the performance metrics be?
- How would you acquire and analyze the data?