Human Robot Interactionmkk

CIR - Session 1

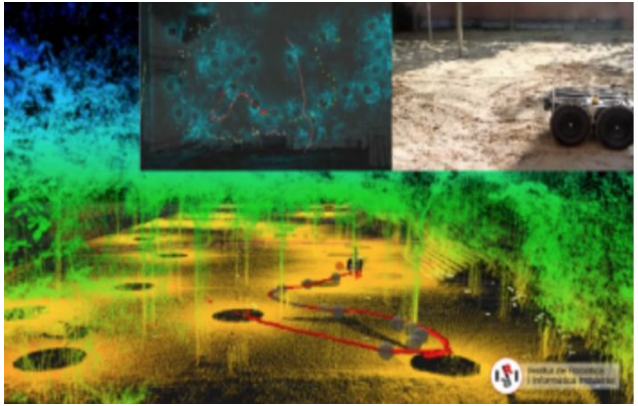
Dr. Anaís Garrell

Barcelona, September 2022

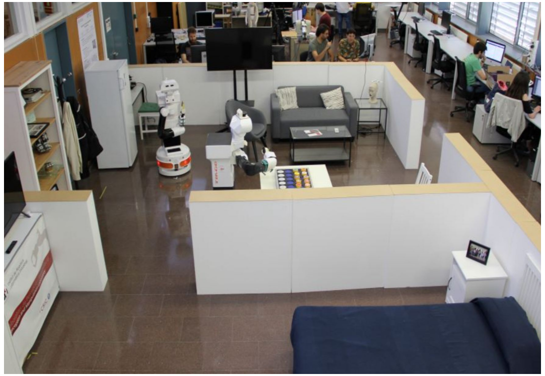
My background and interests in research

Kinematics

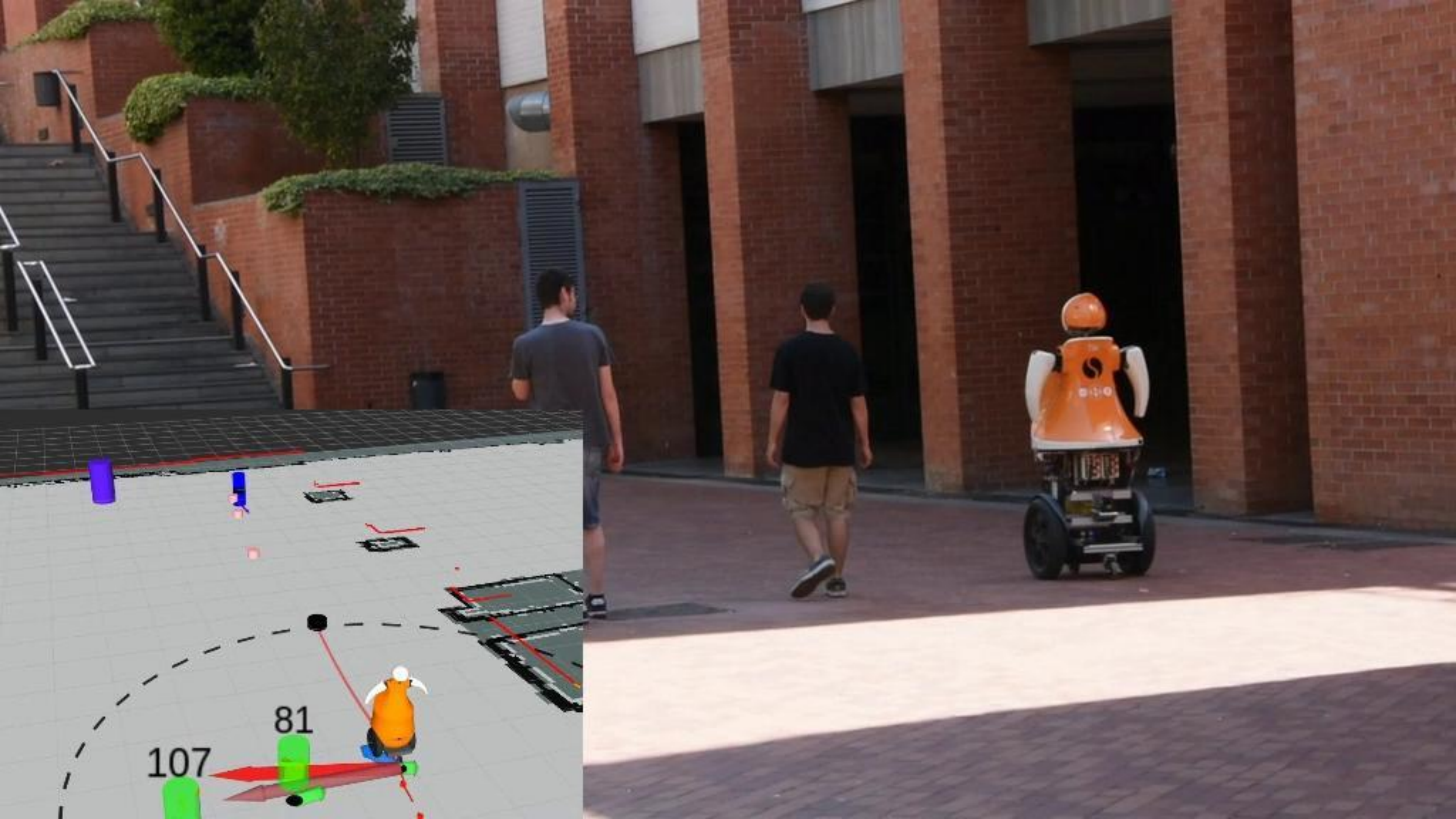
Mobile Robotics



Perception and manipulation



Automatic Control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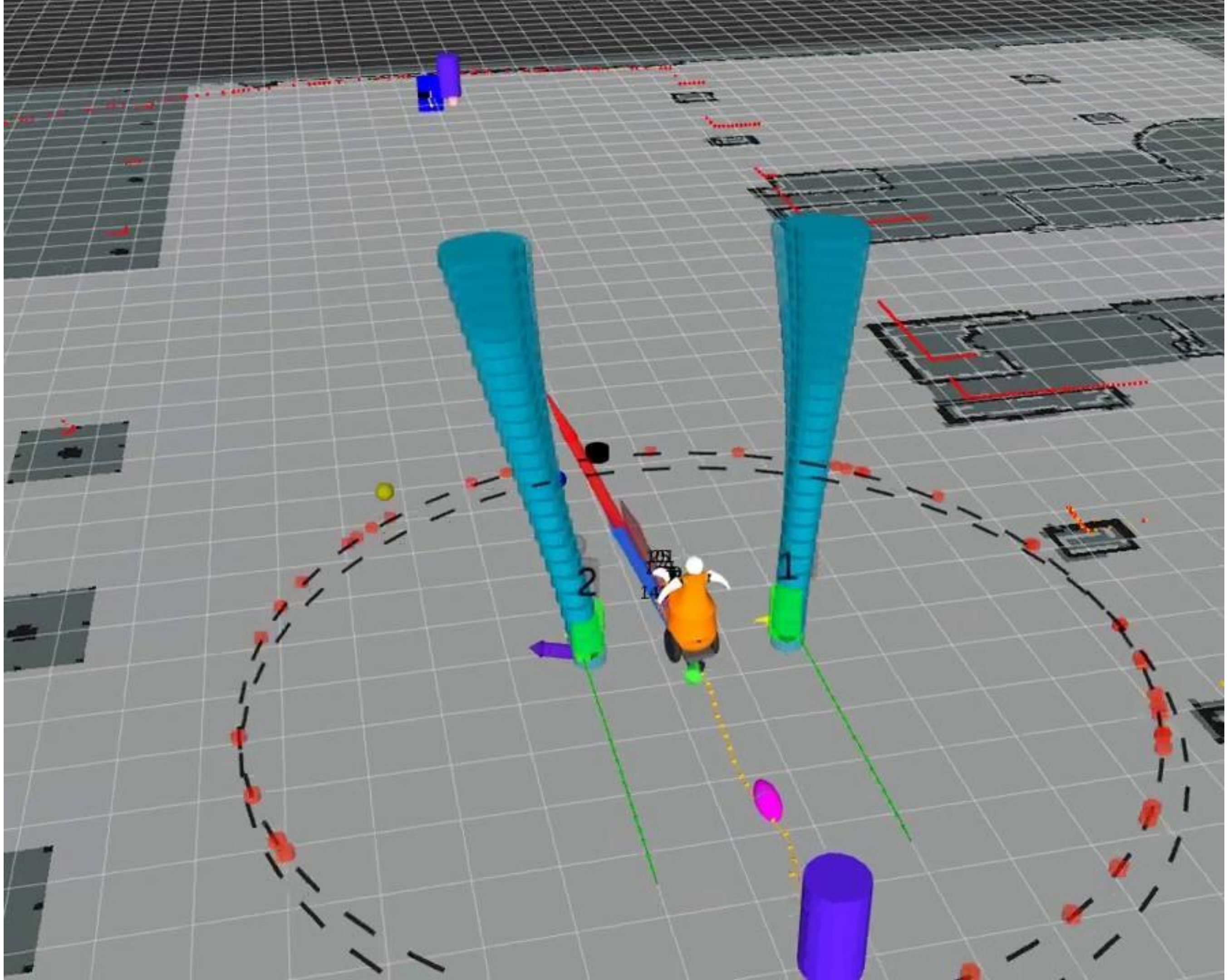
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Contents

- What is HRI
- Modalities and Resources for sHRI
    - Roles of intervention
    - Caveats to roles
    - Awareness in hri
    - HRI Taxonomy (i) and (II)
    - HRI vs HCI
    - Evaluation of HRI
- Our Focus : Robot motion and body language

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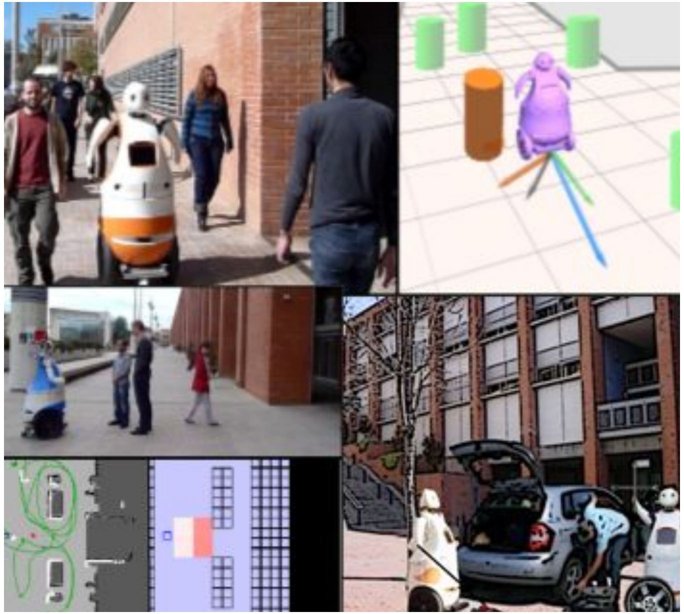
What is HRI? What is Social HRI?

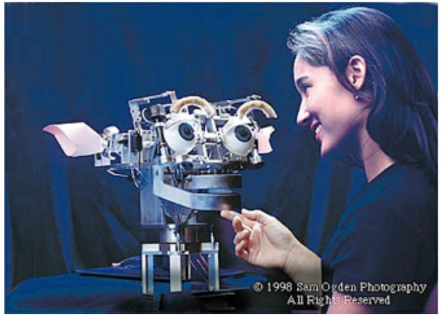
Systematic study of the interaction between humans and robots



What is HRI? What is Social HRI?

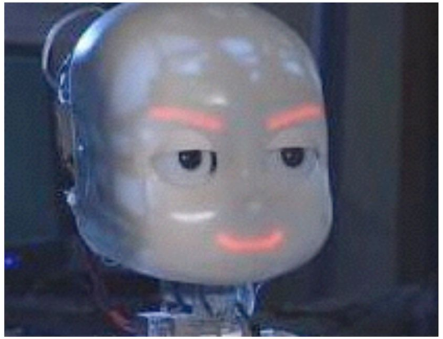
Example of Sociable Robots

Kismet
(MIT)



Asimo
(Honda)

iCub
(RobotCub)



hyper-realistic
Einstein robot

What is HRI? What is Social HRI?

Current State of the Art: Some Examples

- Health care and Assistive Technology
  - Aids for the Blind
  - Robotic walkers
  - Robotic wheelchairs
  - Companion robots
- Robot Soccer
- Humanoid Robots

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What is HRI? What is Social HRI?

Aids for the blind

GuideCane, UMich

NavBelt, UMich

What is HRI? What is Social HRI?

Robotic walkers

What is HRI? What is Social HRI?

Robotic wheelchair

Wheelesley, MIT AI Lab

Hephaestus Smart Wheelchair, AT Sciences

What is HRI? What is Social HRI?

Companion Robot

CosmoBot, AnthroTronix

What is HRI? What is Social HRI?

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Robot Soccer

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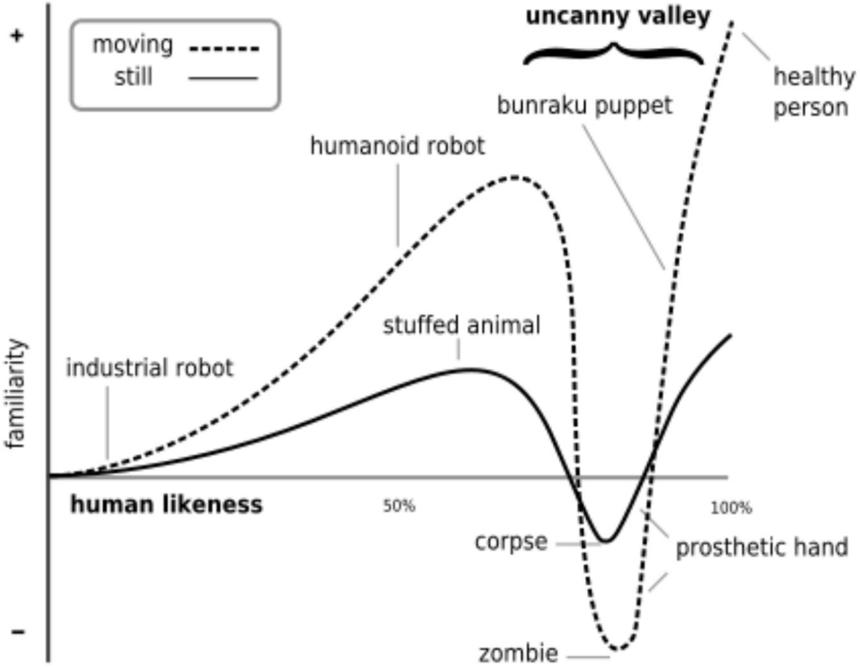
What is HRI? What is Social HRI?

Humanoid Robots

What is HRI? What is Social HRI?

Uncanny Valley



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Modalities and resources for SHRI

(a) Roles of interaction

- Supervisor
- Operator
- Teammate
- Mechanic/programmer
- Bystander

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Modalities and resources for SHRI

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Modalities and resources for SHRI

Supervisor

- Oversees a number of robots.
- Needs global picture of all robots/mission.
- Needs to understand when a robot is having a problem, the seriousness of the problem, the effect on the mission.
- **Challenge**: How many robots can a supervisor effectively monitor?

Modalities and resources for SHRI

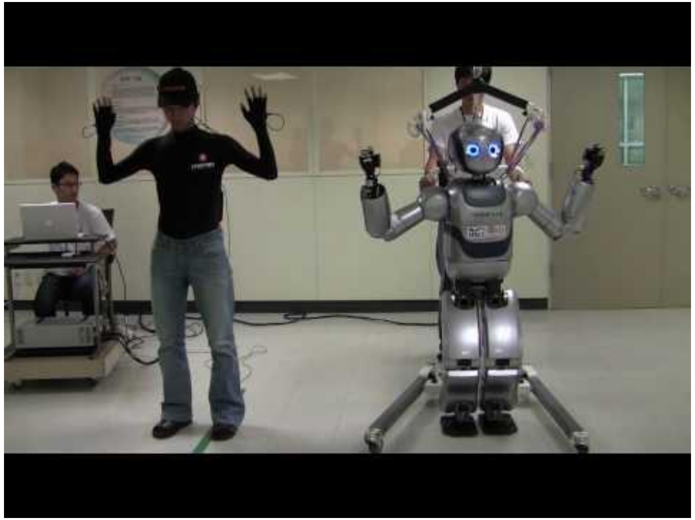
(a) Roles of interaction

- Supervisor
- Operator
- Teammate
- Mechanic/programmer
- Bystander

Modalities and resources for SHRI

Operator

- Needs to have “telepresense” to understand where robot is and what must be done.
- Can vary from complete teleoperation to giving high level task to specifying a mission.
- Needs awareness of robot health, awareness of environment and awareness of what robot is doing to support task/ mission
- **Challenges:**
    - How to maintain awareness despite communications limitations?
    - How to control multiple robots?



Modalities and resources for SHRI

(a) Roles of interaction

- Supervisor
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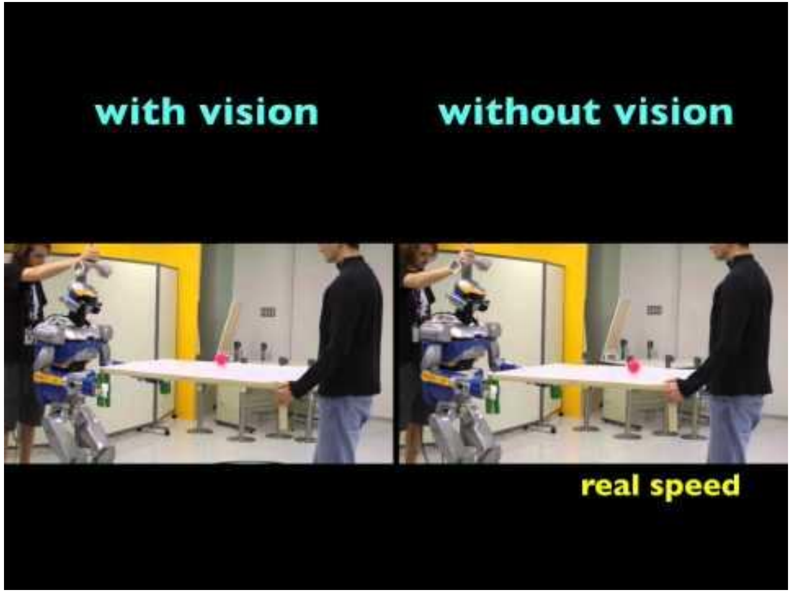
Modalities and resources for SHRI

Teammate

- Robot is a member of the team
- Teammates can give commands within the scope of the task/mission
- Interactions such as gestures and voice maybe helpful here
- Need to understand any limitations robot has in capabilities
- **Challenge:**
    - Can the robot understand the same interaction vocabulary as other team members?



Modalities and resources for SHRI

Roles of interaction

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- Operator
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- Bystander

Modalities and Resources for sHRI: Roles of intervention

Mechanic/Programmer

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Mechanic/Programmer

- Comes into play if the operator cannot resolve the issue.

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- Given that a hardware/software change is made, the mechanic/programmer must have a way of interacting with the robot to determine if the problem it is solved.

Modalities and Resources for sHRI: Roles of intervention

Mechanic/Programmer

- Comes into play if the operator cannot resolve the issue.
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- Given that a hardware/software change is made, the mechanic/programmer must have a way of interacting with the robot to determine if the problem it is solved.
- **Challenges:**
  - How much self diagnosis can the robot do?
  - Have to determine when to move from operating in degraded capability to pulling robot off task and attempting to fix problem.

Modalities and resources for SHRI

Roles of interaction

- Supervisor
- Operator
- Teammate
- Mechanic/programmer
- Bystander

Modalities and Resources for sHRI: Roles of intervention

Bystander

- No formal training using robot but must co-exist in environment with robot
- Consider health care situation; floor cleaning robots; robot pets; on-road driving,
- **Challenges**:
  - How can a bystander form a mental model of what the robot's capabilities are?
  - Should a bystander have a subset of interactions available?
  - What type of social interactions come into play?

Contents

Contents

Modalities and resources for SHRI: caveats to roles

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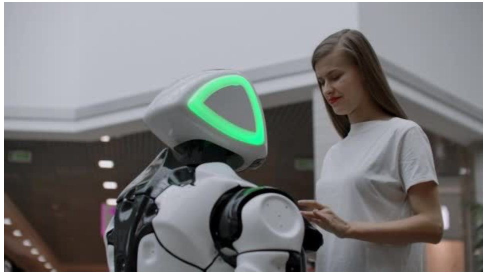
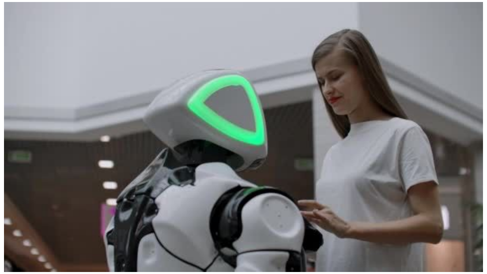
- One person might be able to assume a number of roles for a particular robot (excluding the bystander role).



Modalities and resources for SHRI: caveats to roles

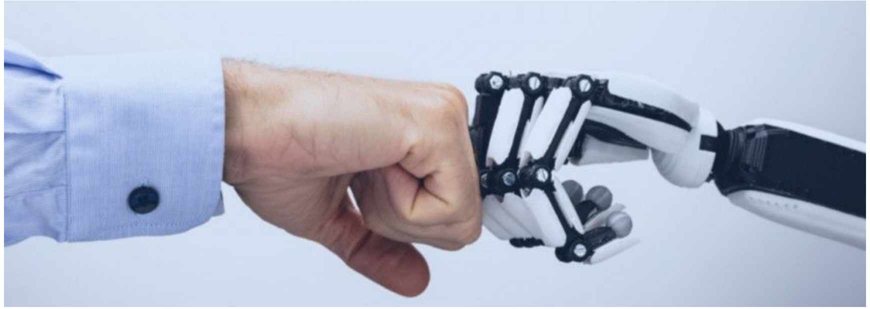
- One person might be able to assume a number of roles for a particular robot (excluding the bystander role).
- Assuming we can determine information/interaction needs for different roles, then we could use that information to
  - Design a user interface to support a given role.
  - Determine whether multiple roles could be supported in one user interface.



Contents

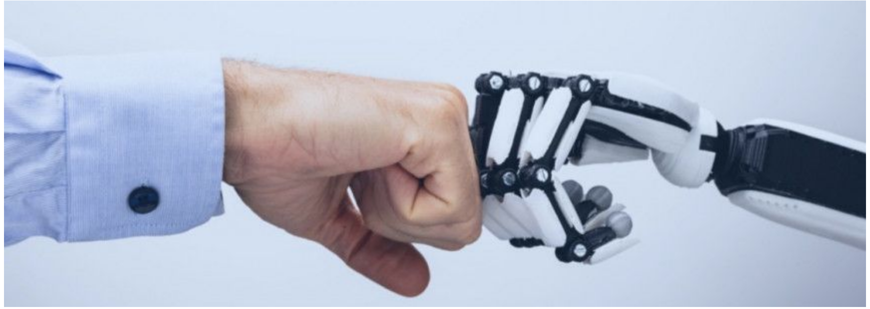
Contents

Modalities and Resources for sHRI: Awareness in HRI



Modalities and Resources for sHRI: Awareness in HRI

- Awareness is used frequently in CSCW (Computer supported cooperative work, 1980)
- **Definition [Drury 2001]:** Given two participants p1 and p2 who are collaborating via a synchronous collaborative application, awareness is the understanding that p1 has of the
  - presence,
  - identity and
  - activities of p2



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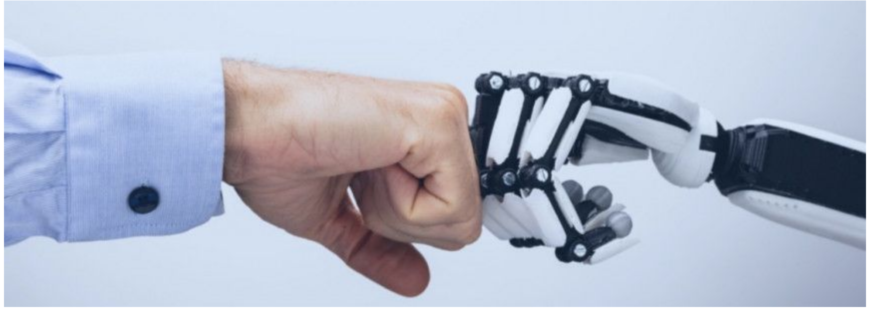

- But HRI is different due to
  - Single or multiple humans interacting with a single or multiple robots
  - Non-symmetrical relationships between humans and robots; e.g., differences in:

Cognition & Free Will

Modalities and Resources for sHRI: Awareness in HRI

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Given one human and one robot working on a task together, **HRI awareness** is the understanding that the ***human*** has of the

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Given one human and one robot working on a task together, **HRI awareness** is the understanding that the ***human*** has of the

- Location,
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and

The knowledge that the ***robot*** has of

- the human's commands necessary to direct its activities and
- the constraints under which it must operate

Modalities and Resources for sHRI: Awareness in HRI

A General Framework for HRI Awareness

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A General Framework for HRI Awareness

Given **n** humans and **m** robots working together on a synchronous task, **HRI awareness** consists of five components:

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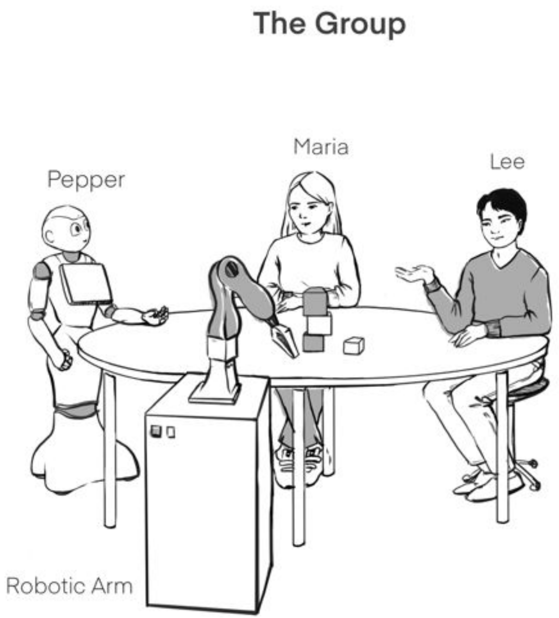
Given **n** humans and **m** robots working together on a synchronous task, **HRI awareness** consists of five components:

- Human-robot awareness
- Human-human awareness
- Robot-human awareness
- Robot-robot awareness
- Humans' overall mission awareness



Modalities and Resources for sHRI: Awareness in HRI

A General Framework for HRI Awareness

Human-robot awareness: the understanding that the humans have of **the locations, identities, activities, status and surroundings of the robots**. Further, the understanding of the certainty with which humans know this information.

Human-human awareness: the understanding that the humans have of the **locations, identities and activities** of their fellow human collaborators

Robot-human awareness: the robots' knowledge of the **humans' commands needed to direct activities** and any human- delineated constraints that may require command noncompliance or a modified course of action

Modalities and Resources for sHRI: Awareness in HRI

A General Framework for HRI Awareness

Robot-robot awareness: the knowledge that the robots have of the **commands given to them**, if any, by other robots, the tactical plans of the other robots, and the robot-to-robot coordination necessary to dynamically re-allocate tasks among robots if necessary.

Humans' overall mission awareness: the humans' understanding of the **overall goals of the joint human- robot activities** and the measurement of the moment- by-moment progress obtained against the goals.

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Modalities and Resources for sHRI: Taxonomy

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- Why classify?
  - Way to measure properties of systems
  - Easier to compare systems

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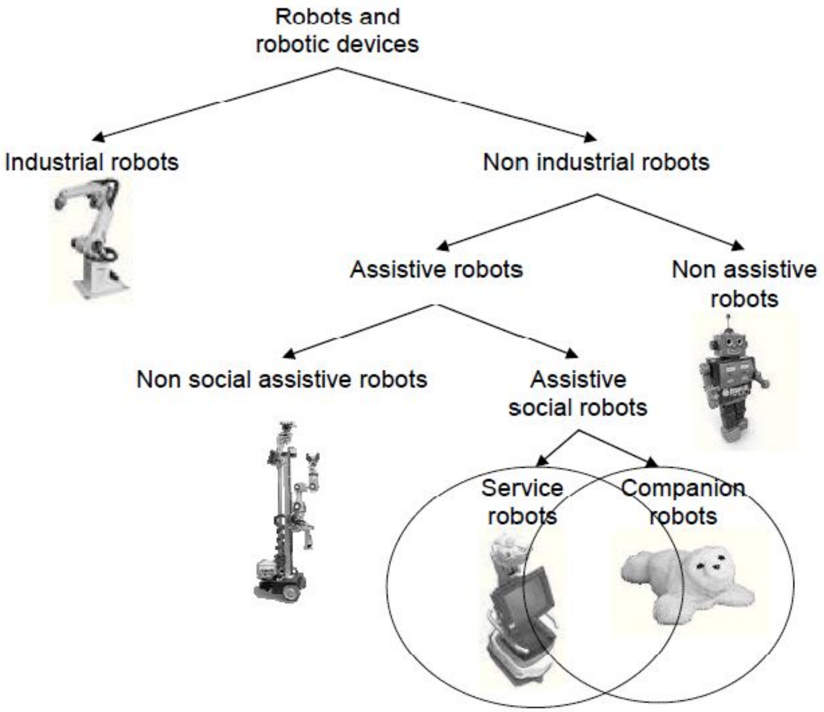

Modalities and Resources for sHRI: Taxonomy

(1) Task type

- e.g., urban search and rescue, walking aid for the blind, toy, etc.

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Modalities and Resources for sHRI: Taxonomy

(1) **Task type**

- e.g., urban search and rescue, walking aid for the blind, toy, etc.

(2) **Task criticality**

- high, e.g., as in disaster situations
- medium, e.g., hospital delivery robot
- low, e.g., robot soccer

Modalities and Resources for sHRI: Taxonomy

(3) Robot morphology

- ***anthropomorphic***: human appearance, e.g., ASIMO humanoid
- ***zoomorphic***: non-human animal appearance, e.g., AIBO robot dog
- ***functional***: related to robot function, e.g., RAPOSA

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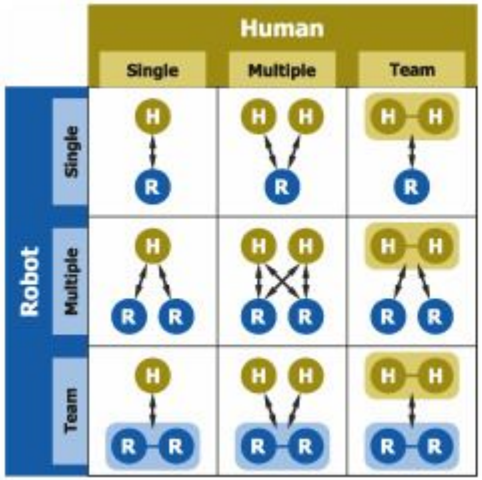
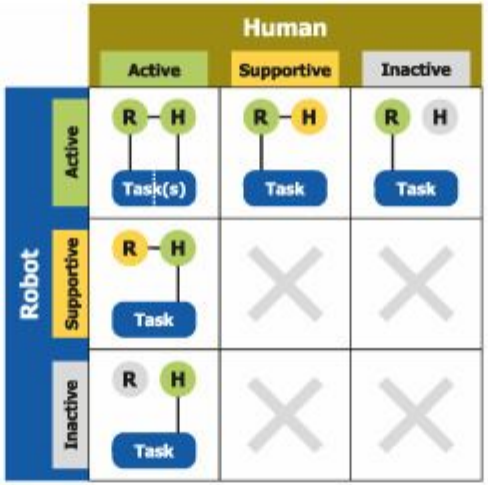
(4) Ratio of people to robots

- non-reduced fraction of number of humans over number of robots
- e.g., in urban search and rescue 2/1 is a commonly found

Modalities and Resources for sHRI: Taxonomy

(3) Robot morphology





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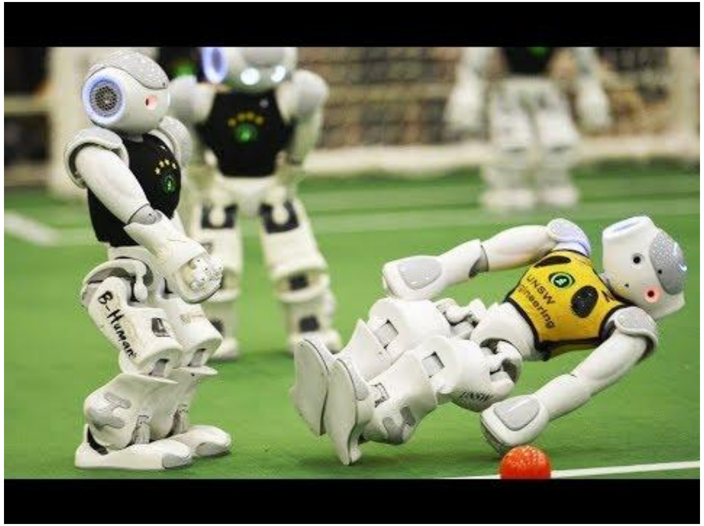
- e.g., in urban search and rescue 2/1 is a commonly found

Modalities and Resources for sHRI: Taxonomy

(5) Composition of robot teams

- ***homogeneous***, all of the same type, e.g., soccer team
- ***heterogeneous***, different types, e.g., land robot + aerial robot



Modalities and Resources for sHRI: Taxonomy

(6) Autonomy Level

- ***autonomy***: from 0% (teleoperated) to 100% (fully autonomous)
- ***intervention***: = 1 - autonomy
- ***adjustable autonomy***: the user is given the possibility of defining the robot's level of autonomy dynamically
- ***example***: the development of automated tasks for RAPOSA, namely automatic docking and automatic stair climbing, allow to increase the level of autonomy of the system

Modalities and Resources for sHRI: Taxonomy

(6) Autonomy Level

Modalities and Resources for sHRI: Taxonomy

(7) Type of human-robot physical proximity

- Avoiding
- Passing
- Following
- Approaching
- Touching
- None

Modalities and Resources for sHRI: Taxonomy

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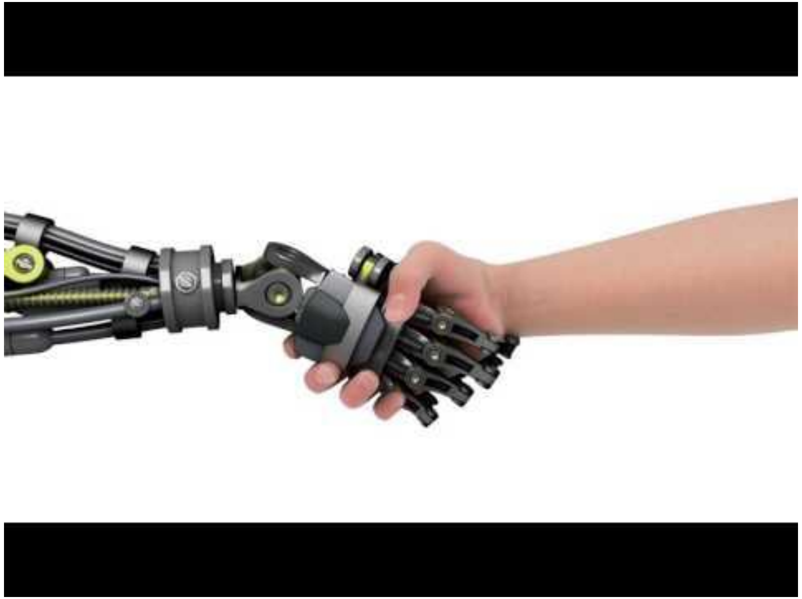

Modalities and Resources for sHRI: Taxonomy

(8) Decision support for operators

- *available sensors:* list of all available sensors, baseline for following fields
- *provided sensors:* list of sensor information provided to the operator
- *sensor fusion:* list of sensor fusion mappings, e.g., {{sonar,laser}→map}
- *pre-processing:* list of sensor data processing operations

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(9) Time/space taxonomy

- *in terms of time:* synchronous (same time) or asynchronous (diff. times)
- *in terms of space:* collocated (same place) or non-collocated (diff. places)

Modalities and Resources for sHRI: Taxonomy

(8) Decision suppor

- *available sensors:*
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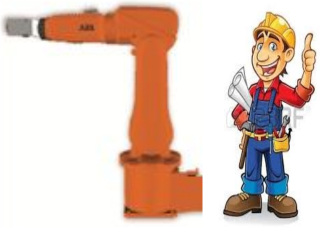
Modalities and Resources for sHRI: Taxonomy

Example

Illustration of the robot



Communication channel

H → R
Acoustically

R → H
Acoustically
Visually

Tasks of the robot

information exchange/ manipulation

Reliability of the robot

reliable/ faulty

Proximity

Approaching / touching

Form of interaction human ←→ robot

collaboration

Application area of the robot

industry

Morphology of the robots

functional/ humanoid

Temporal proximity

synchronous

Interaction role of human

collaborator

Degree of autonomy of the robot

information recording
information analysis
decision selection
action performance

low — high

Team composition ratio human – robot

$N_H = N_R$

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Modalities and resources for SHRI

Modalities and resources for SHRI: HRI vs HCI

- Much research to date has been devoted to robot technology but little on human-robot interaction (HRI)
- Human-computer interaction (HCI) has been studied for many years, but **tools and metrics do not directly transfer to HRI**

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Need to test robots in degraded conditions

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- Human-computer interaction (HCI) has been studied for many years, but **tools and metrics do not directly transfer to HRI**

Need to test robots in degraded conditions

- Environment (noise, poor visibility)
- Sensor failures
- Repeatability
- No two robots will follow the same path

Modalities and resources for SHRI

- Different roles of interaction are possible
- Multiple people can interact in different roles with same robot
- Robot acts based on “worldmodel”
- Degraded state of operation of robot
- Physical world–air, land, and sea
- Intelligent systems, learning, emerging behaviors
- Harsh environments

Contents

Contents

Modalities and resources for SHRI: Evaluation of HRI

Real world:

- Difficult to collect data
- Can see what they did – but there isn’t time to determine why
- Best used to get an idea of the difficulties in the real world
- Can identify “critical events” but don’t know for certain whether operator was aware of them

Laboratory studies

- Take what we learned in the real world and isolate factors to determine effects
- Repeatability is still difficult to achieve due to fragile nature of robots

Modalities and resources for SHRI: Evaluation of HRI

Some Metrics (ex. In rescue tasks)

- Time spent navigating
- Amount of space covered
- Number of victims found
- Critical incidents
- Positive outcomes
- Negative outcomes
- Operator interventions
- Amount of time robot needs help
- Time to acquire situation awareness
- Reason for intervention

Modalities and resources for SHRI: Evaluation of HRI

Some Metrics (ex. In rescue tasks)

- Time spent navigating, on UI overhead and avoiding obstacles
- Amount of space covered
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- Negative outcomes
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Anova test, croachbach's alpha...
To compare two methods (next sessions)

Modalities and resources for SHRI: Evaluation of HRI

Human-Computer Interaction (HCI) design principles apply naturally to HRI

Modalities and resources for SHRI: Evaluation of HRI

Human-Computer Interaction (HCI) design principles apply naturally to HRI

Nielsen’s heuristics applied to HRI

Modalities and resources for SHRI: Evaluation of HRI

Human-Computer Interaction (HCI) design principles apply naturally to HRI

Nielsen’s heuristics applied to HRI

- Is the robot’s information presented in a way that makes sense to human controllers?

Modalities and resources for SHRI: Evaluation of HRI

Human-Computer Interaction (HCI) design principles apply naturally to HRI

Nielsen’s heuristics applied to HRI

- Is the robot’s information presented in a way that makes sense to human controllers?
- Can the human(s) control the robot(s) without having to remember information presented in various parts of the interface?

Modalities and resources for SHRI: Evaluation of HRI

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- Does the interface provide shortcuts and accelerators?
- Does the interface have a clear and simple design?

Modalities and resources for SHRI: Evaluation of HRI

Norman’s HCI model, seven stages of interaction:

1. Formulation of the goal, in high-level terms
2. Formulation of the intention, what will satisfy the goal?
3. Specification of the action, what actions are necessary to accomplish goal?
4. Execution of the action
5. Perception of the system state, after/while executing action
6. Interpretation of the system state
7. Evaluation of the outcome, does it accomplish goal initially set?

These stages are iterated until goal achieved (or modified)

Contents

- What is HRI
- Modalities and Resources for sHRI
  a. Roles of intervention
  b. caveats to roles
  c. Awareness in hri
  d. HRI Taxonomy
  e. HRI vs HCI
  f. $\boxed{\text{Evaluation of HRI}}$
- Our Focus : Robot motion and body language

Contents

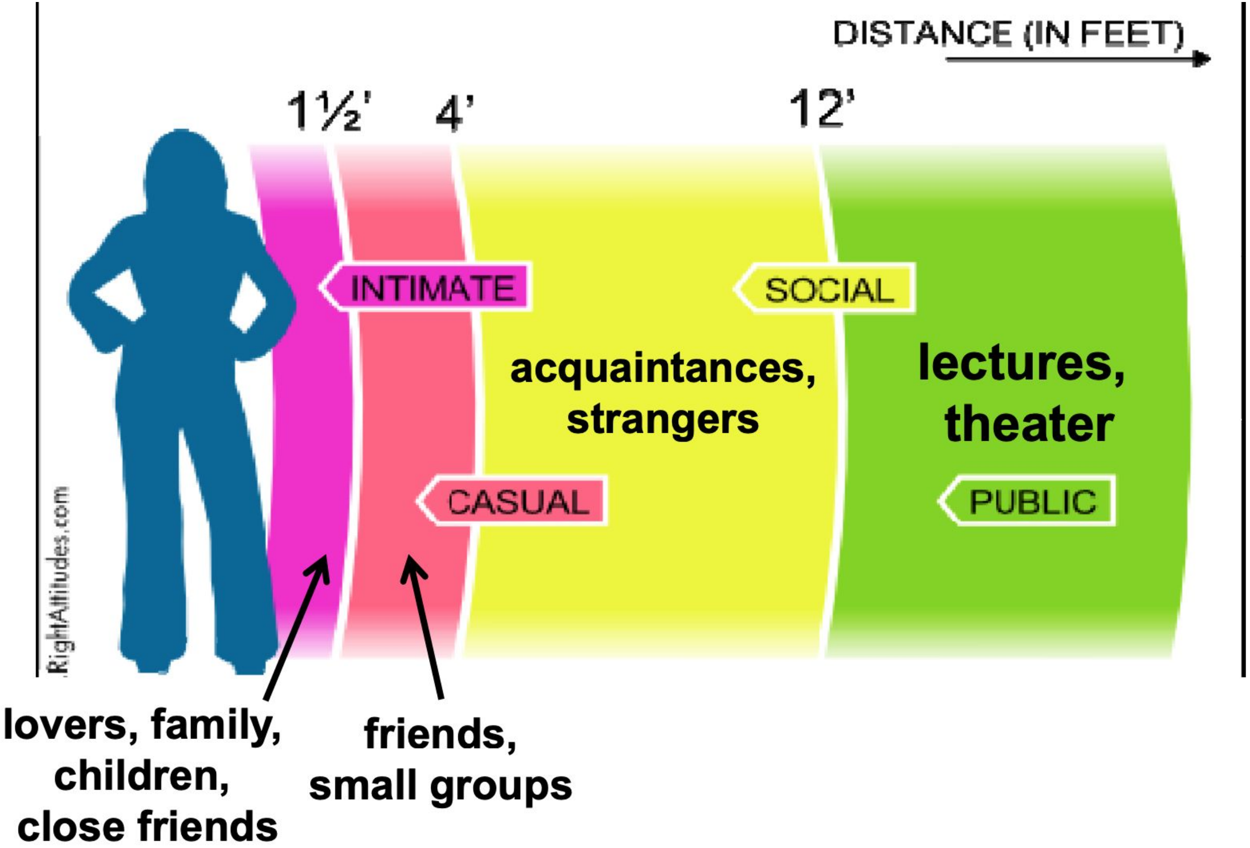
Our focus: robot’s motion and body language

- Robot Motion:
    - Proxemics
    - Spatial configurations
    - Social formations
    - Space managing for collaboration
    - …
- Body language:
    - Communicating through body stance, orientation, position, gestures, gaze, facial expression and vocalizations
    - Pets Robots

Proxemics

- “Interrelated observations and theories of human’s use of space as a specialized elaboration of culture” [Hall, 1966]

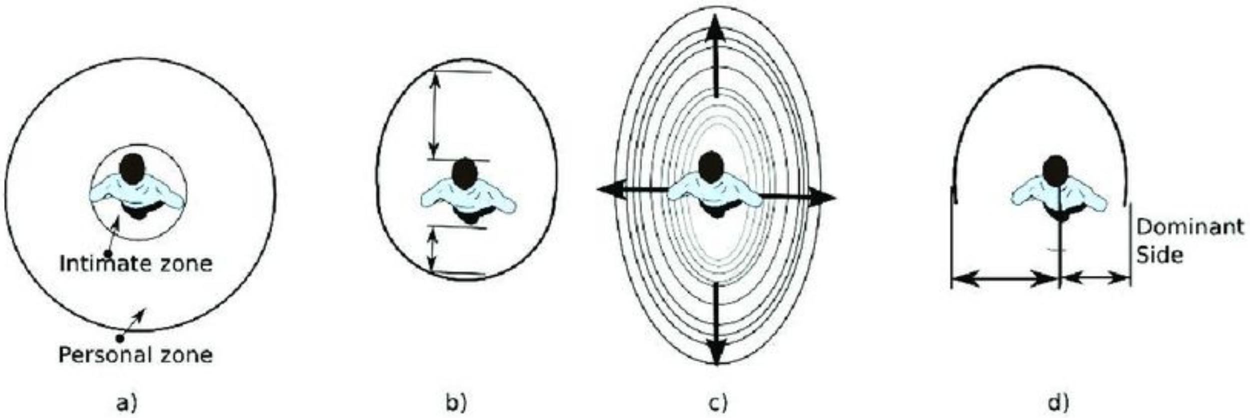
Personal Space for Social Interaction



Personal Space for Social Interaction

Feel uncomfortable if others within personal space

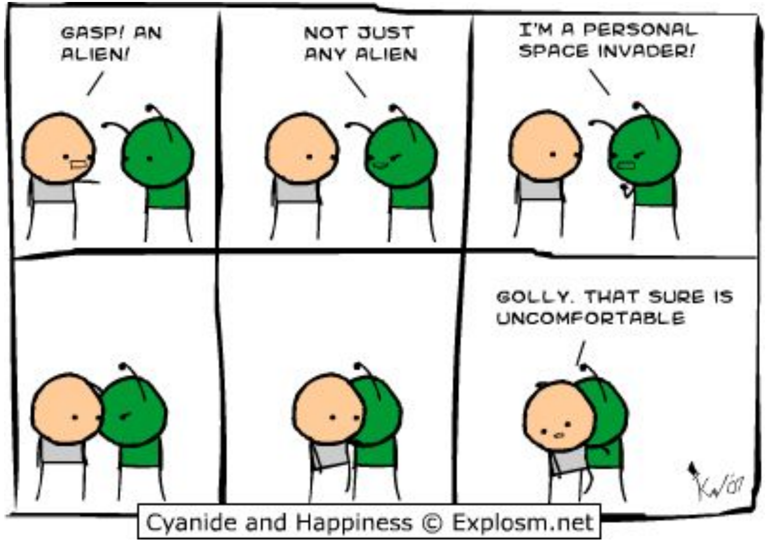
- “egg -shaped,” with more space in front with more space in front
- Exact size is culturally determined



Personal Space for Social Interaction

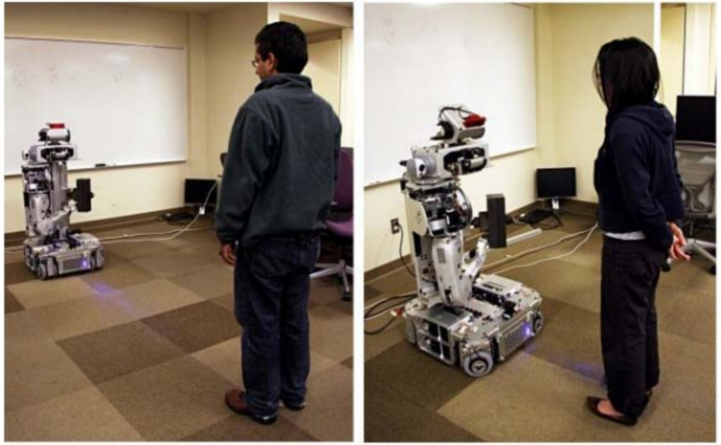
Factors Affecting Personal Space •

- Interpersonal Relationships
- Gender
- Culture **Lewis Model of Cultural Types**
    - Cool and decisive (US, Germany)
    - Accommodating and non-confrontational (China, Japan)
    - Warm and impulsive (Italy, Mexico)



Personal Space for Social Interaction

- One method people have for dealing with violated personal space is dehumanization – treating the intruder as inanimate
  - Are robots seen as deserving of personal space, or are they treated as inanimate?



Empirical Empirical Evaluation of HR Proxemics

Based on several studies with many participants and different robots (Walters, Dautenhan, et al)

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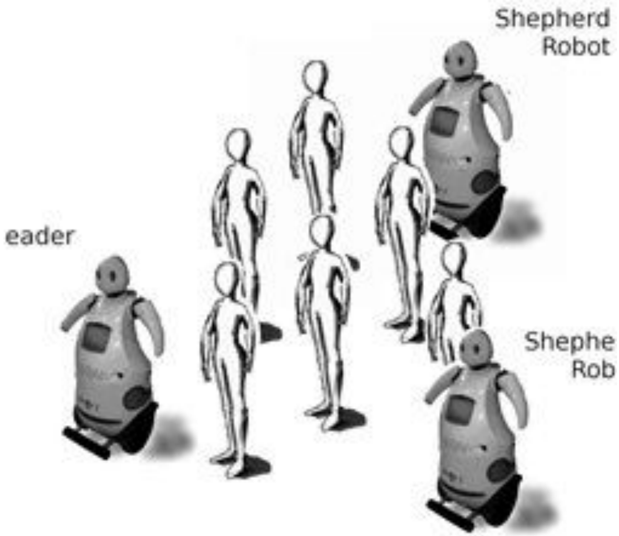
Approach Context	Mean (cm)	Lower Bound (95% CI)	Upper Bound (95% CI)
Interaction: Pass	60	57.6	62.7
Verbal	60	58.0	63.1
Physical	49	46.3	51.4
Appearance: Mechanoid	51	48.7	53.0
Humanoid	62	60.1	64.2
Initiative: Robot	57	53.4	61.1
Human	56	52.0	60.6
Direction: Front	58	54.1	62.5
Side	55	51.4	59.0
Preferences: Mechanoid	60	46.8	54.2
Humanoid	56	61.6	69.2
Short	61	53.6	61.4
Tall	55	54.8	62.1
Overall	**57**	**53.0**	**60.5**

Compares to:
51 cm for human
56 cm for "dummy"

Social Navigation

- Culturally determined conventions that guide our movement through (peopled) space
- Why do we use social conventions?



User Study of Social Approaching

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User Attitudes

- Social robot seen as more intelligent and social in both back-facing and side-facing conditions
- Social robot seen as more attentive to personal space and social conventions in back-facing condition
- Women found social robot more attentive to personal space and social conventions, under all conditions

HRI Study example

https://www.focusforwardfilms.com/films/41/robot

Please read the paper,

Create a document:

- Explain the relation between the user and the robot
- Why is important the interaction here?
- What are the authors analyzing in the paper?
- What is the advantage of this robot behavior?