Human-Robot Interaction

Module 4: Interaction

Lecture 1: Spatial Interaction

David Vernon
Carnegie Mellon University Africa

www.vernon.eu

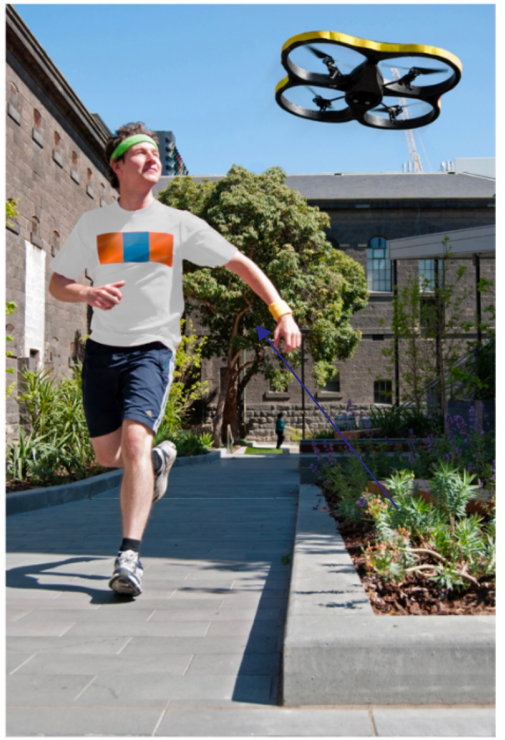
Topics

- Proxemics
- Localization and navigation
- Socially appropriate positioning
- Spatial dynamics of initiating HRI
- Informing users of the robot's intent

Proxemics

- Spatial placement is important in social interaction
- Avoid robot behaviour that is
  - Rude
  - Inappropriate
  - Makes a user feel uncomfortable
- Take into account people's preferences
- Take into account social norms

These vary



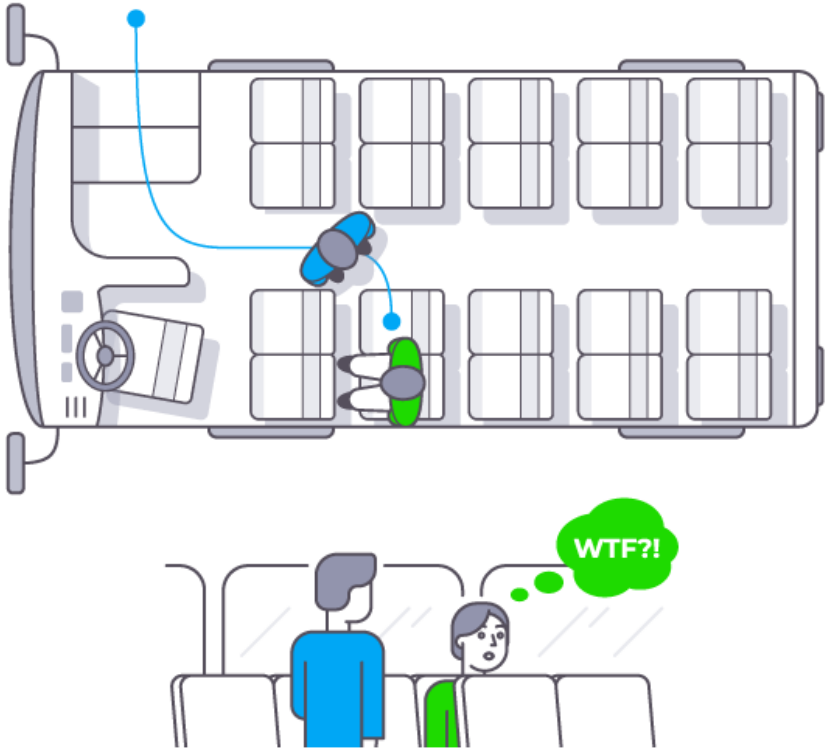
Ideal placement of the Joggobot depends on the user
Joggers don't like being chased
(Bartneck et al., 2020)

Proxemics

The study of

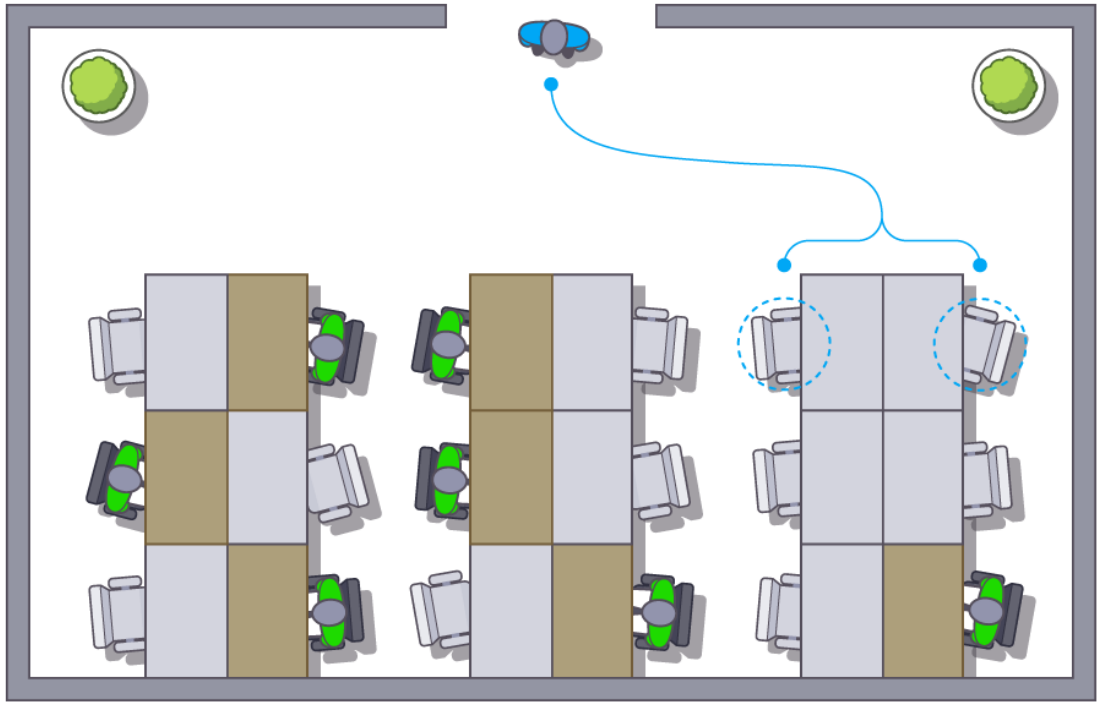
- How people take up space in relation to others
- How spatial positioning influences
  - attitudes
  - behaviors
  - interpersonal interaction

Proxemics



https://www.socialworkplacedesign.com/post/the-empty-bus-effect

Proxemics



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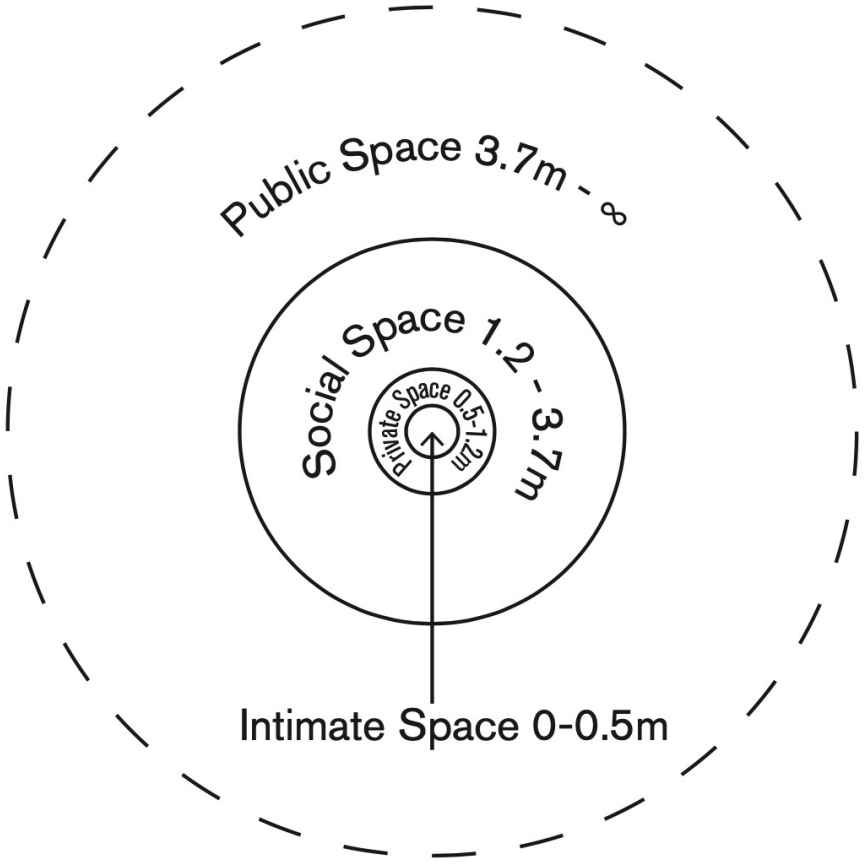
Proxemics

Four distance zones:

Intimate distance
Personal distance
} Personal space
Social distance
Public distance

Depends on age and culture

"high-contact culture"
vs.
"low-contact culture"



(Bartneck et al., 2020)

Slight breaches of proxemic norms are made on purpose

- To create psychological closeness
- To intimidate
- To bully

Need to be very cautious when doing this:

Spatial interaction cues are highly contextual

Proxemics

Distance matters but so does placement (i.e. relative positioning and orientation)

- People who sit next to each other are more cooperative
- People who sit opposite to each other are more competitive
- During conversations, people usually position themselves at an angle

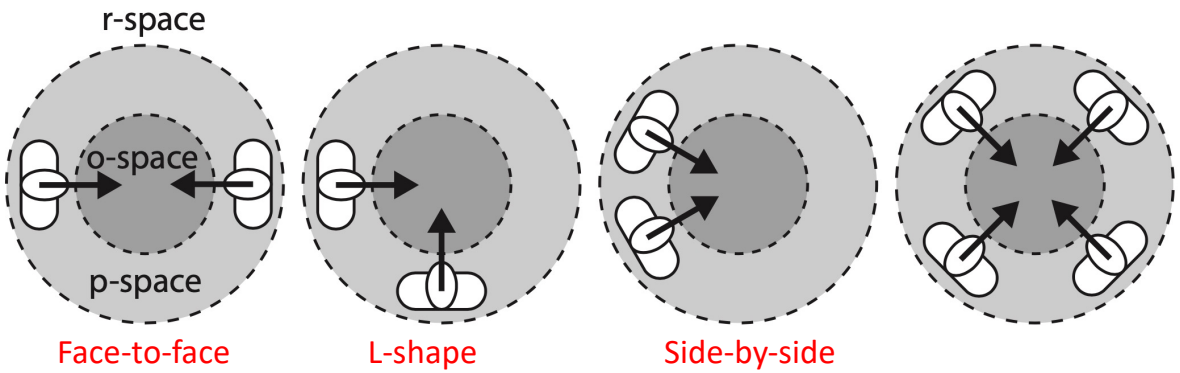
Group Spatial Interaction Dynamics

People often stand in a tight—knit circle talking

- If they notice someone wanting to join, they may open up the circle to create space
- This is effectively an invitation to join
- A robot wishing to approach a group in a public space needs to be able to perceive and interpret these signals

Group Spatial Interaction Dynamics

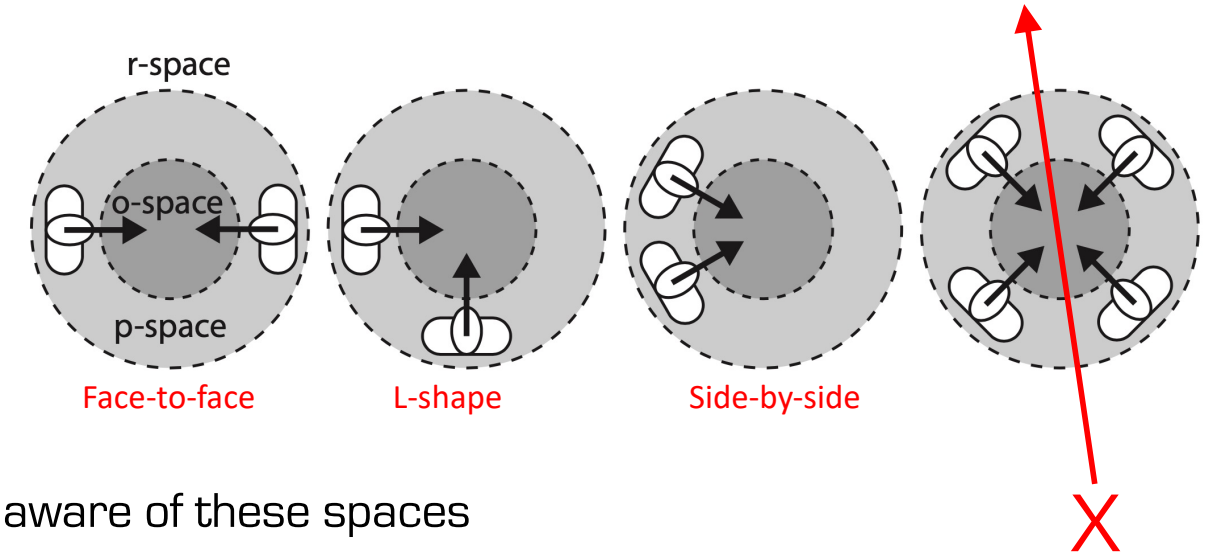
The F-formation or facing-formation



- o-space: the space between people to which they have equal, direct, and exclusive access
- p-space: the space occupied by the people themselves
- r-space: the space surrounding the people

Group Spatial Interaction Dynamics

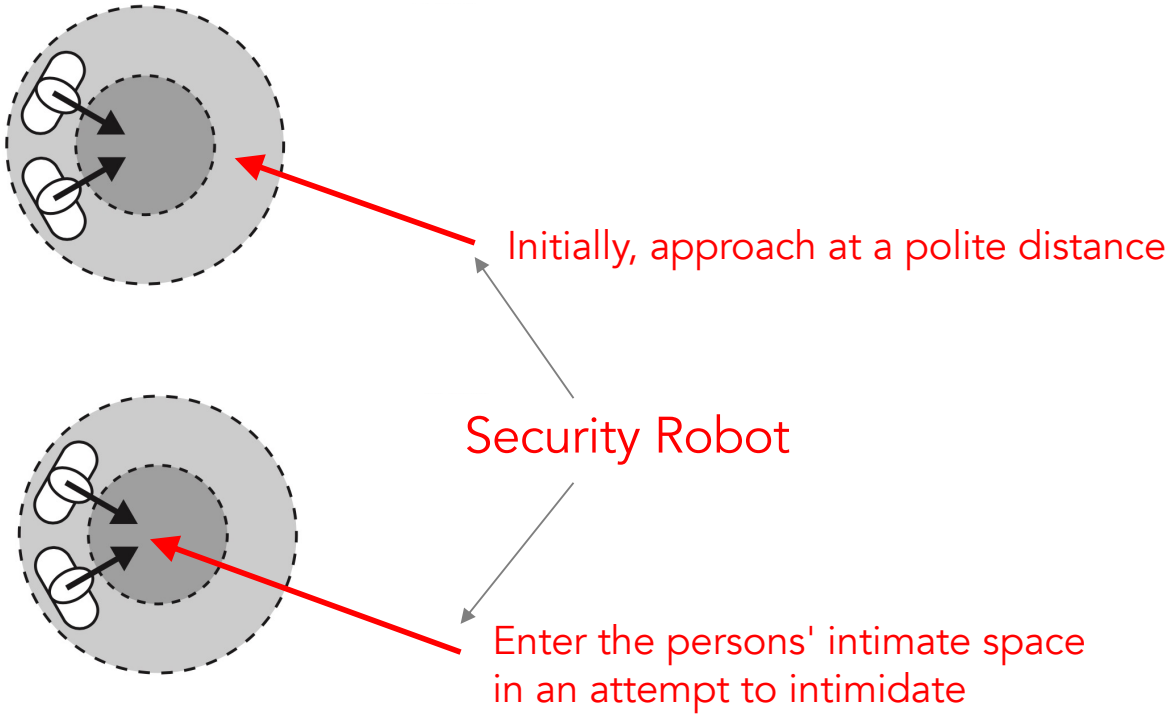
The F-formation or facing-formation



- Robots need to be aware of these spaces
- So that they don't invade them when navigating
- Even if there is enough space to pass between people

Spatial Interaction for Robots

Adjust position to create an appropriate interaction experience



Localization and Navigation

Localization: determining a mobile robot's position (and, possibly, orientation)

Odometry

- Determine position by sensing rotation of wheels
- Compute distance travelled and change in orientation
- Errors increase without bound
- Need to cross-reference occasionally with alternative position sensor, e.g., laser range finder or camera using triangulation
- Locate the robot's position on a map

Localization and Navigation

Localization: determining a mobile robot's position (and, possibly, orientation)

SLAM: Simultaneous Localization and Mapping

Construct the map as the robot moves and localizes

Localization and Navigation

Localization: determining a mobile robot's position (and, possibly, orientation)

Also, identify type of space the robot is in, e.g.,

- Foyer
- Classroom
- Living room
- Bathroom

Localization and Navigation

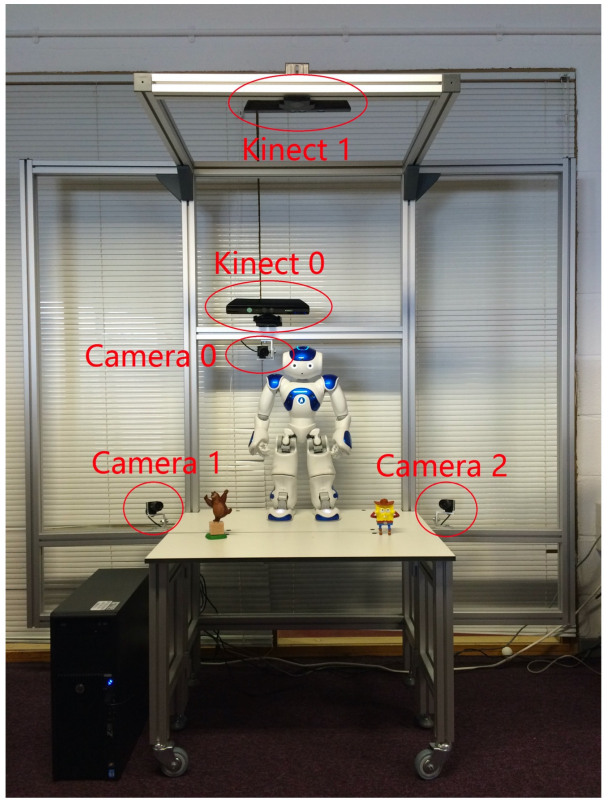
Identify location and orientation of people interacting with the robot

- Short range sensors
  - 2D RGB cameras
  - Depth / RGBD cameras
- Long range sensors
  - Laser range finders (LIDAR: light detection and ranging)
- Detect and track
  - People
  - Body parts: arms, legs, hands, head

Localization and Navigation

Identify location and orientation of people interacting with the robot

Can also mount sensors
around the interaction environment



(Esteban et al., 2018)

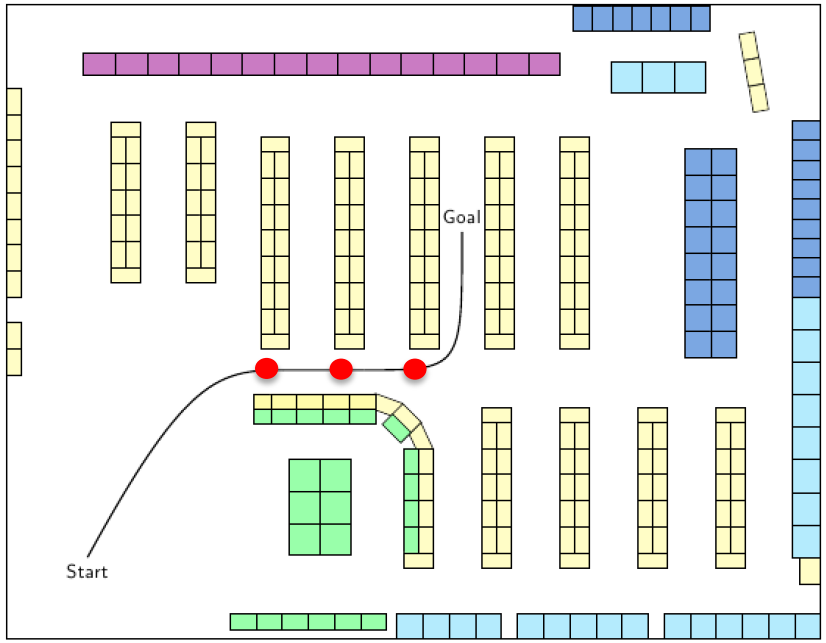
Localization and Navigation

Navigation: moving to a goal location through a possibly crowded environment

Obstacle (collision) avoidance

Path planning

- Move from waypoint to waypoint
- Avoid obstacles



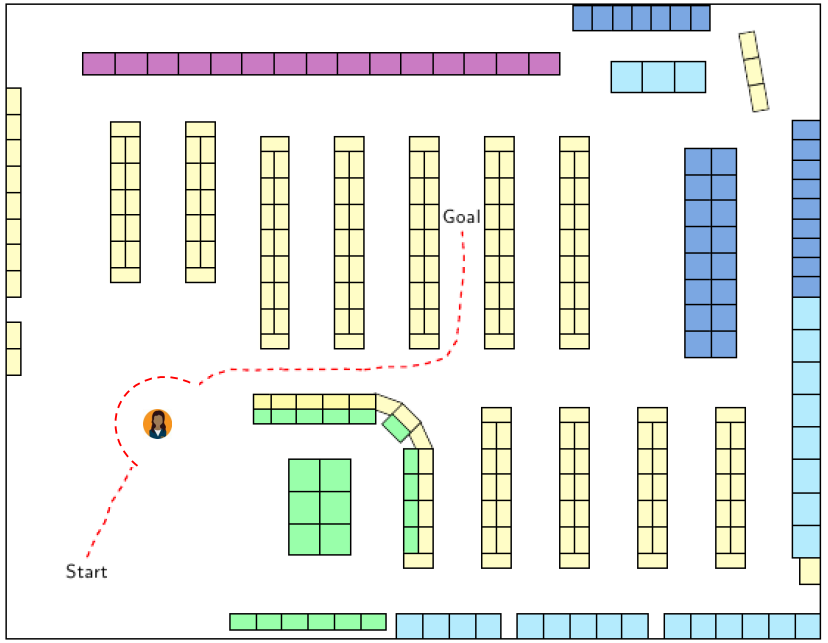
Localization and Navigation

Navigation: moving to a goal location through a possibly crowded environment

Obstacle (collision) avoidance

Path planning

- Move from waypoint to waypoint
- Avoid obstacles
- And maintain social distance



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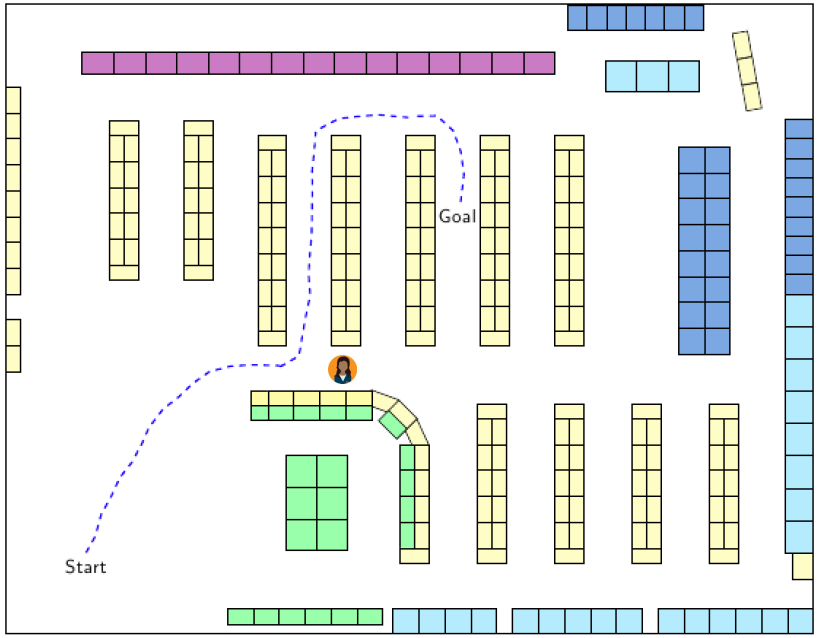
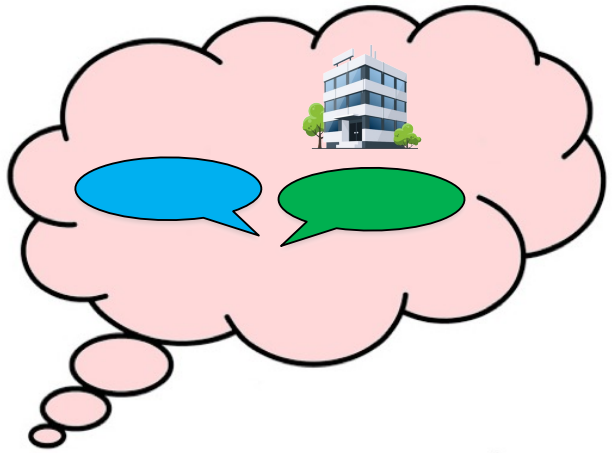


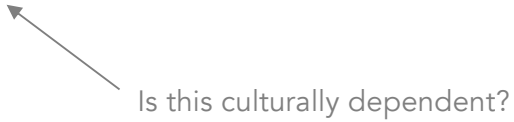
Localization and Navigation

The robot can also collect visual landmarks so that it can generate route instructions that are easily understood by people



Socially Appropriate Positioning

Normally, humans yield to each other when approaching



- To avoid entering each other's personal space
- Using nonverbal signals

A robot that doesn't do this may appear aggressive

Socially Appropriate Positioning

Most mapping techniques consider people as obstacles

They don't provide information about

- The direction people are facing
- What they are doing: conversing or just standing close together
- HRI maps need a more human-aware representation

Socially Appropriate Positioning

How close to a robot do people prefer to stand?

- Social distancing
- Personal distancing
- Intimate distancing

- One study found that people prefer personal or social distance, but some prefer closer (Walters et al. 2005)

How close is rude or inappropriate?

Robots can alter the conversational F-formations of a group by changing its body orientation

Moving its entire body is more effective than just moving its head

Socially Appropriate Positioning

What about positioning when moving?

- Walk behind
- Walk beside

Being careful not to cut ahead

Need to anticipate the humans future motion

When a robot points to something or makes a gesture, it must not invade the the human's personal space

What matters is the social impact of movement not its functional efficiency

Spatial Dynamics of Initiating HRI

Approaching behaviour

- Attract and share attention
- Factor in context
  - Delivering a package: approach from the side
  - Initiating conversation: approach from the front

Spatial Dynamics of Initiating HRI

Timing is important

The robot should respond at just the right moment

Informing Users of the Robot's Intent

Intent is also important

People should be able to read the robot's intentions
(i.e., be able to predict what the robot will do next)

The robot should be able to read the human's intentions
(i.e., be able to predict what the human will do next)

Reading

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

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