Proxemics & Social Navigation

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Proxemics

• “Interrelated observations and theories of [hu]man’s use of space as a specialized elaboration of culture” [Hall, 1966]
Personal Spaces for Social Interaction

DISTANCE (IN FEET)

1½'  4'  12'

INTIMATE  SOCIAL  PUBLIC

acquaintances, strangers

lectures, theater

lovers, family, children, close friends

friends, small groups

HRI: Proxemics

Simmons, Nourbakhsh : Spring 2015
Personal Space

- Feel uncomfortable if others within personal space
  - “egg-shaped,” with more space in front
  - Exact size is culturally determined
Measurement of Personal Space

- Break into your teams
- Create an NxN matrix of names
- One person approaches second person face on, until first person *begins* to feel uncomfortable
- Third person measures from *nose to nose*
- Fourth person records distance (in inches)
- Switch off until every person has approached every other person
- Analyze for
  (a) consistency of each person
  (b) consistency across group
- What factors can explain any differences?
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)
Proxemics and Robots

• 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 Evaluation of HR Proxemics

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

<table>
<thead>
<tr>
<th>Approach Context</th>
<th>Mean (cm)</th>
<th>Lower Bound (95% CI)</th>
<th>Upper Bound (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interaction: Pass</td>
<td>60</td>
<td>57.6</td>
<td>62.7</td>
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<tr>
<td>Verbal</td>
<td>60</td>
<td>58.0</td>
<td>63.1</td>
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<tr>
<td>Physical</td>
<td>49</td>
<td>46.3</td>
<td>51.4</td>
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<tr>
<td>Appearance: Mechanoid</td>
<td>51</td>
<td>48.7</td>
<td>53.0</td>
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<tr>
<td>Humanoid</td>
<td>62</td>
<td>60.1</td>
<td>64.2</td>
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<tr>
<td>Initiative: Robot</td>
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<td>53.4</td>
<td>61.1</td>
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<tr>
<td>Human</td>
<td>56</td>
<td>52.0</td>
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<tr>
<td>Direction: Front</td>
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<td>54.1</td>
<td>62.5</td>
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<tr>
<td>Side</td>
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<tr>
<td>Preferences: Mechanoid</td>
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<tr>
<td>Humanoid</td>
<td>56</td>
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<tr>
<td>Short</td>
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<td>Tall</td>
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<tr>
<td>Overall</td>
<td>57</td>
<td>53.0</td>
<td>60.5</td>
</tr>
</tbody>
</table>

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?*
Riding Elevators

“Wait until everyone gets off before getting on”

- Need to model people’s intentions
  - Only partially observable (ambiguous)
Passing in Corridors

Goal
• **Treat Problem as Constrained Optimization**
  – Include task constraints (e.g. minimize distance, time) and social constraints (e.g. avoid personal space, pass on right)
  – Replan continually to deal with uncertainty
Passing in Corridors

- “Social” robot seen as significantly more respectful of human’s personal space and robot did better in getting out of person’s way
- Despite that, “social” robot *not* seen as significantly more human-like or social
  - *due to both lack of social cues and confusing cues!*
Waiting in Line

• Standing in Line
  – How to detect end of the line?
  – How much space to leave in front?
  – When to move forward?
An Impatient Robot...
Approaching People
User Study of Social Approaching

• 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