Implicit Behavioral Cues for Enhancing Trust and Comfort in Robot Social Navigation

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Introduction & Motivation

- Robots are entering shared public spaces with humans.
- Pedestrian **comfort** and **safety** are key for trust and social acceptance.
- *Explicit signals* (e.g., speech, signals) can help convey intent, but may not always be practical or noticed.
- *Subtle, implicit cues* (e.g., speed or trajectory changes) can signal intent naturally, but their interpretation can vary depending on context.
- Our goal is to improve social navigation between robots and bystanders in shared environments.

Research Question & Objectives

Main Research Question:

"How can robots use implicit behavioral cues to improve pedestrian comfort, trust, and safety during navigation encounters?"

Objectives:

- Identify key implicit behavioral cues (trajectory adjustments, speed modulation, proxemics).
- Determine which cues best enhance pedestrian comfort.
- Quantify pedestrian trust and perceived safety in response to these cues.

References

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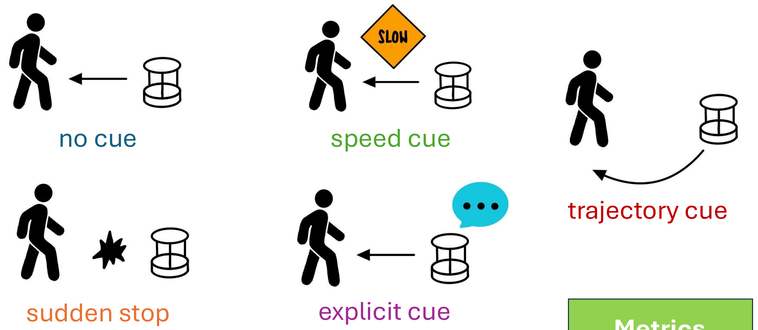
This study was approved by the University's Institutional Review Board (IRB), and all processes were conducted after obtaining the participants' consent.

Methods & Approach

We explore how different robot behaviors impact pedestrian comfort and trust during navigation in a shared space. A participant walks down a narrow hallway while a TurtleBot approaches from the front.

Experiment Design:

The robot's behavior is varied across five conditions:



Data Collection:

- Behavioral analysis (e.g., pedestrian hesitation, passing distance, crossing duration, and trajectory patterns).
- Subjective ratings through post-survey.

Metrics
Comfort
Trust
Predictability
Clarity
Proxemics

1 2 3 4 5

Discussion & Future Work

Our preliminary results suggest that even simple motion cues like slowing down or curving can improve how pedestrians perceive robot behavior in shared spaces. These implicit cues offer a lightweight, intuitive way to signal intent and enhance trust and comfort. This highlights the importance of designing robot motion not only for safety, but also for how it is interpreted by people nearby.

Future Work:

- Extend social navigation strategies to robot-human teams, such as robot guide dogs and other assistive or service robots working with people.
- Testing identified cues across more diverse participant groups.
- Integrate motion cues into navigation algorithms and safety frameworks.

Preliminary Findings

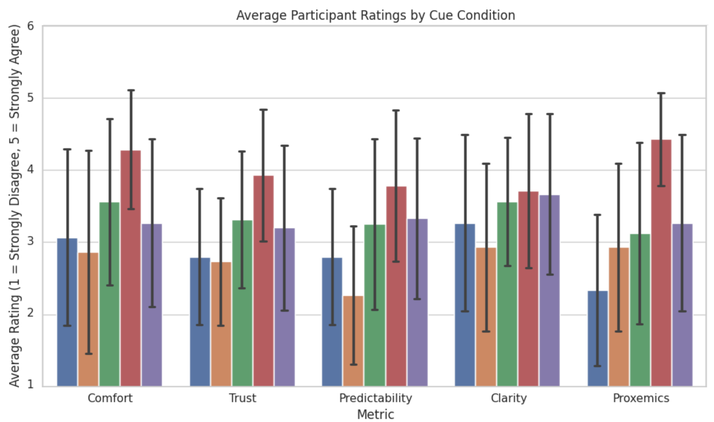
We conducted a pilot study with **15** participants to explore how different robot navigation cues affect pedestrian comfort, trust, and behavior during shared hallway navigation. Each participant experienced five robot behaviors in a counter-balanced order: No Cue, Sudden Stop, Speed Cue, Trajectory Cue, and Explicit Cue (voice message).

Subjective Ratings:

- **Trajectory Cue** received the **highest average rating** across all five metrics: **comfort**, **trust**, **predictability**, **clarity**, and **proxemics**.
- Speed Cue and Explicit Cue performed similarly overall:
  - **Speed Cue** provided greater **comfort** and **trust**.
  - **Explicit Cue** offered higher **clarity** and **predictability** and **proxemics**.
- **Sudden Stop** and **No Cue** consistently received **lower ratings**, with Sudden Stop rated lowest in **predictability** and No Cue in **proxemics**.

Behavioral Analysis:

- **Trajectory Cue** led to **smooth**, **confident paths** with **minimal hesitation**.
- **Speed Cue** allowed for **early decisions** and **smooth paths**.
- **Explicit Cue** caused **occasional confusion** and **route adjustments**.
- **Sudden Stop** led to **pauses** and **uncertainty**.
- **No Cue** resulted in **inconsistent behavior**, including **abrupt stops** and **rerouting**.



"Even when it told me the direction, I couldn't figure out if it was going to give me space or not."