Projectable Robot Intent

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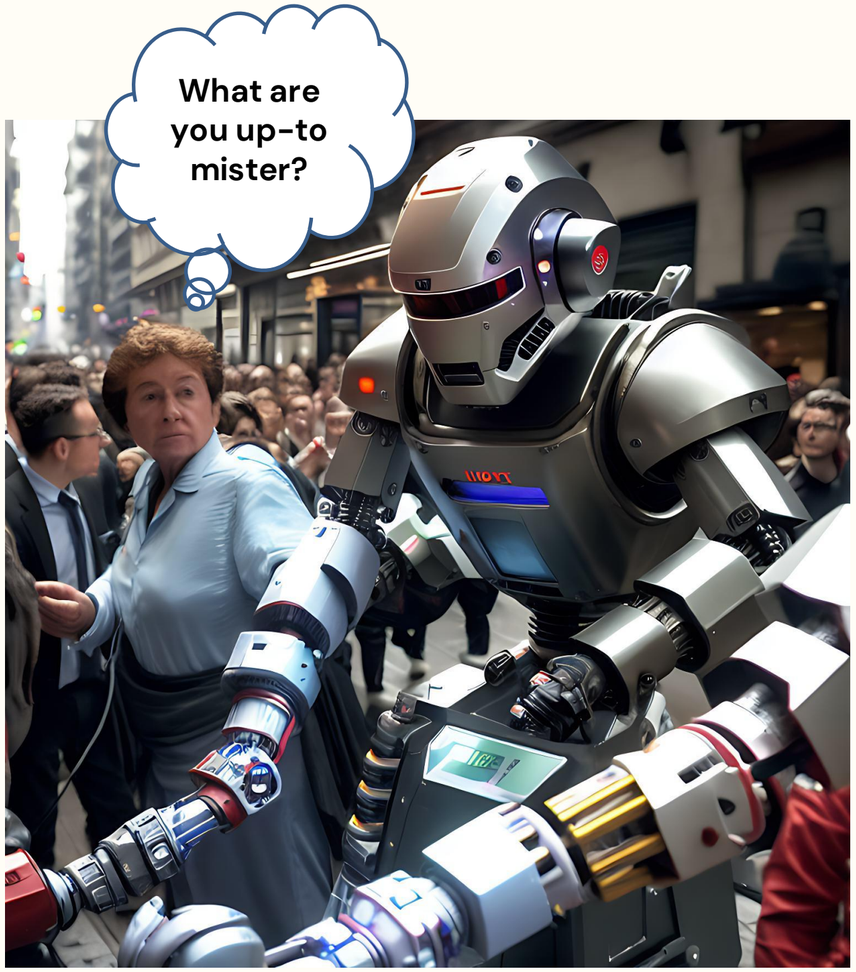
Motivation:

With the rise of robots in social environments, effective communication between humans and robots is more important than ever.

- Difficulty in predicting a robot's future actions during social interactions.
- Need for effective communication of robot's intentions and goals to people.
- Sense of uncertainty and fear of collision when walking near robots in crowded scenarios.

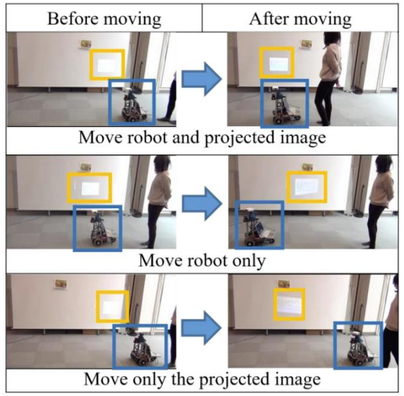


Related Works

[1] Agarwal, R., et al. “Touchless Human-Mobile Robot Interaction Using a Projectable Interactive Surface.” 2016 IEEE/SICE International Symposium on System Integration (SII), 2016,

The paper describes a mobile robot integrated with a Projectable Interactive Surface that can interact with humans of any physical attribute without recalibration. The system uses a projector and a Microsoft Kinect for gesture tracking and responding with an audio-visual signal without physical contact.

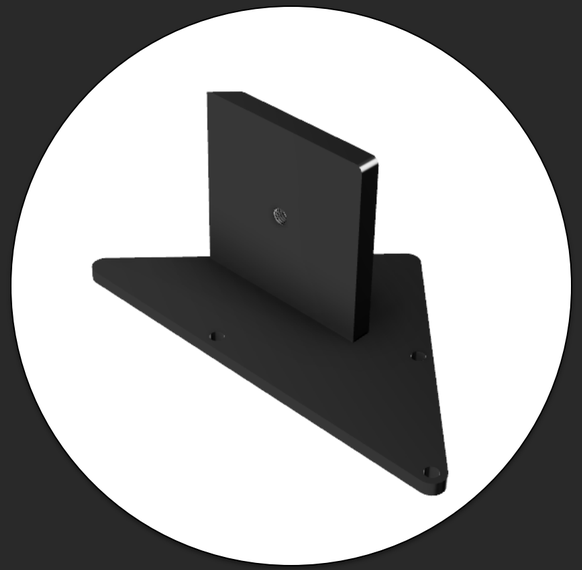
[2] Tamai, Aki, et al. “A Method for Guiding a Person Combining Robot Movement and Projection.” *2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2019,

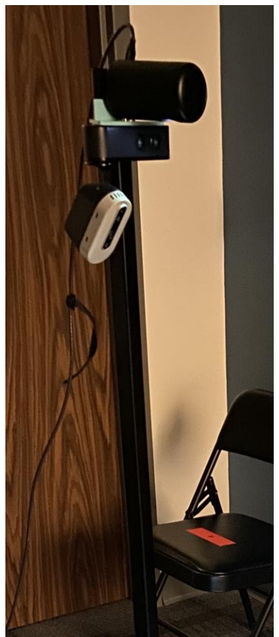


The paper proposes a new method for guiding people along a route when a mobile robot explains an exhibition. The method uses a mobile robot with a projection function to control human positions without explicit instructions by combining movement and projection of a robot. The paper introduces three basic guiding behaviors combining projection and movement that can guide a person effectively while controlling the position of the person.

Hardware

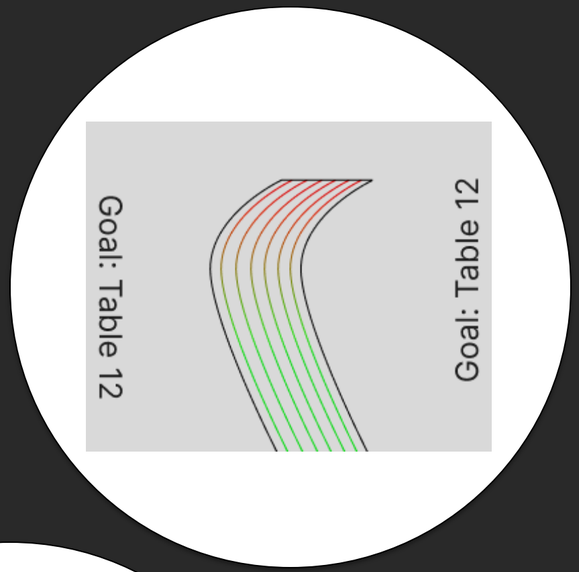
- Designed and prototyped custom, 3D printed projector mount with Fusion 360
- Securely fastens projector to Hello Robot during operation
- Allows for optimal projection for human viewing

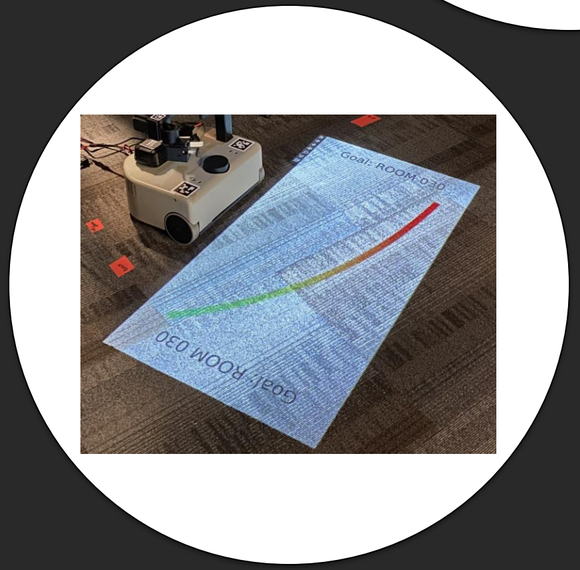




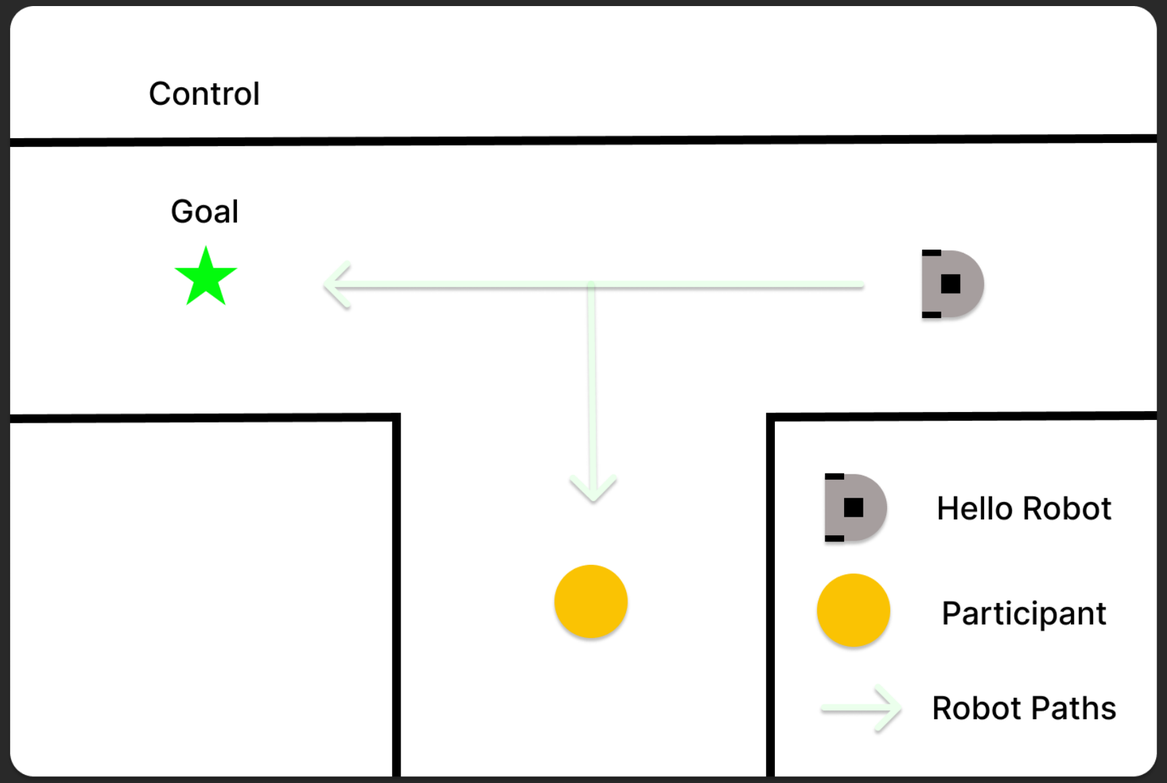
Software

- Developed dynamic graphic of robot path trajectory and goal position
- Safety warnings for nearby detected obstacles and people
- Utilized ROS NavStack and Python GUI





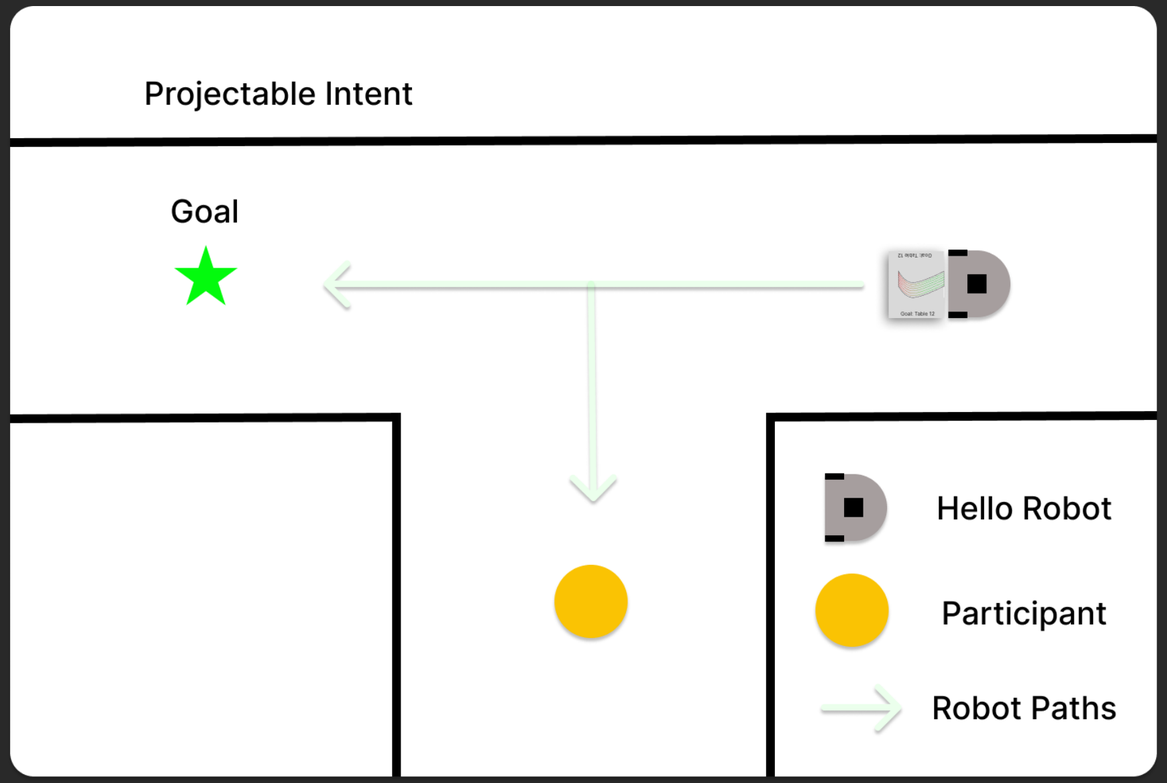
User Study



Control:

- Participant is told to take a left and reach the goal position marker
- Robot randomly either goes toward the goal position marker or participant's starting position
- Time taken to reach goal and subjective measures on participant behavior are recorded

User Study



Projectable Intent:

- Participant is told to take a left and reach the goal position marker
- Robot randomly either goes toward the goal position marker or participant's starting position and shows path trajectory on ground
- Time taken to reach goal and subjective measures on participant behavior are recorded

Hypotheses

- H1 - Participants who interact with the robot with projectable intent are more likely to reach the destination in less time compared to those interacting with the robot without projectable intent.
- H2 - Participants who interact with the robot with projectable intent feel significantly safer than those who interacted without with projectable intent .

Results

- Running a Two-Sample t-Test between subjects for time taken to reach the goal and for subjective safety measures
- Time-to-Goal (s):
  - $M_{control}$ = 15.84, $M_{projector}$ = 11.01
  - $SD_{control}$ = 26.05, $SD_{projector}$ = 4.85
  - t (14) = 2.46, p = 0.027 < 0.05

- Subjective Safety:
  - $M_{control}$ = 5.62 $M_{projector}$ = 8.12
  - $SD_{control}$ = 2.27 , $SD_{projector}$ = 1.84
  - t (14) = -3.21 , p = 0.015 < 0.05

H1 ✓

H2 ✓

Participant Comments:

- My Attention was drawn to the screen on the floor.
- Adding a control study could be a good idea.
- Cool looking robot!
- more instructions??? i was confused
- Twas fun.
- Great Job!

Future Works

- GUI can be updated to show additional information relevant to the application such as advertisements, etc.
- The study can be conducted by formulating more hypotheses and involving more participants to get accurate results.
- Implement multiple interactions of the user with the robot to get more inferences.
- Use the projectors that can have more visual capabilities in different light conditions.
- Implement a better navigation stack that gives accurate trajectory

Thank You!