Multi-modal Proactive Approaching of Humans for Human-Robot Cooperative Tasks

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Introduction

Approaching humans for interaction

Estimate 3D human pose estimate

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Select suitable pose to approach person

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Generate global motion plan using layered cost-map

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Follow planned path using local motion planner while adapting robots behavior

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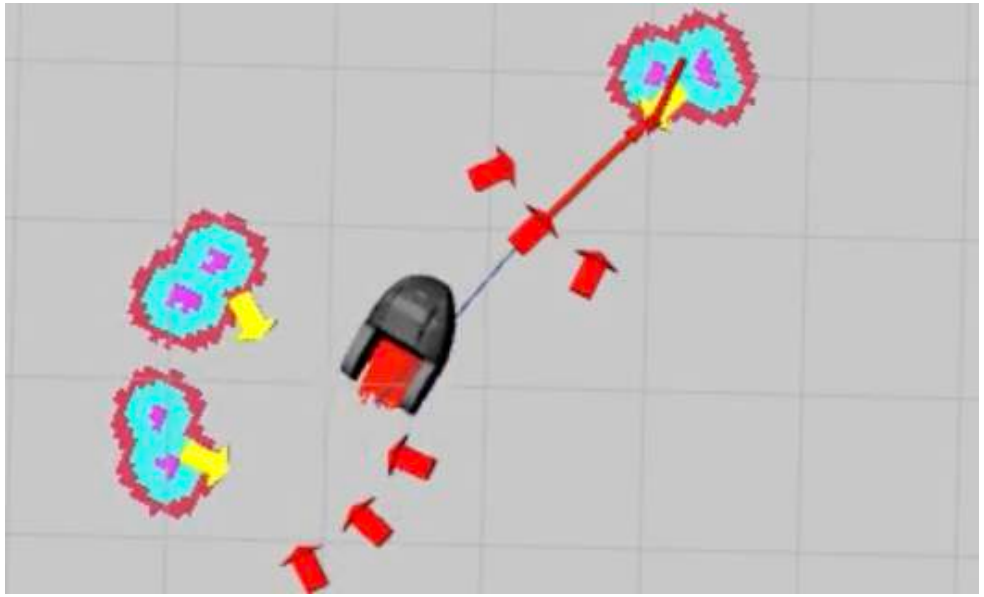
Start interaction



Motivation

Practical challenges

- **Uncertainty in perception**
  - 3D human pose estimation under occlusions
  - Quality of approach poses depends on human pose estimates
- **Social acceptance**
  - Psychological comfort while approaching from behind

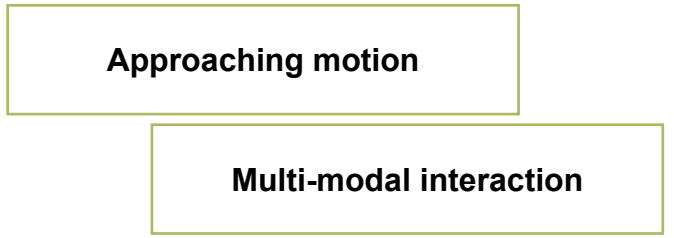
Proactively approaching humans under uncertainty in perception while ensuring social acceptance

Problem formulation

Using approaching motion as one of the modality in multi-modal human-robot interaction

Sequential approaching motion and interaction

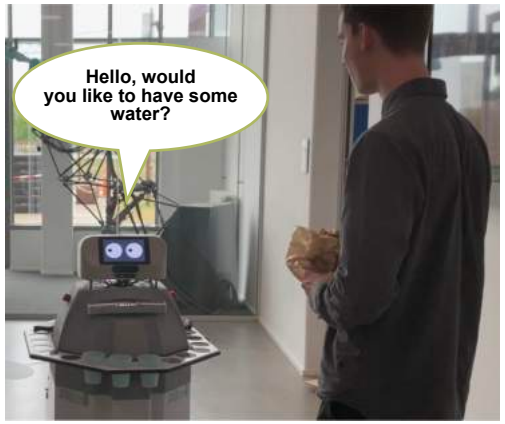
Combined approaching motion and interaction

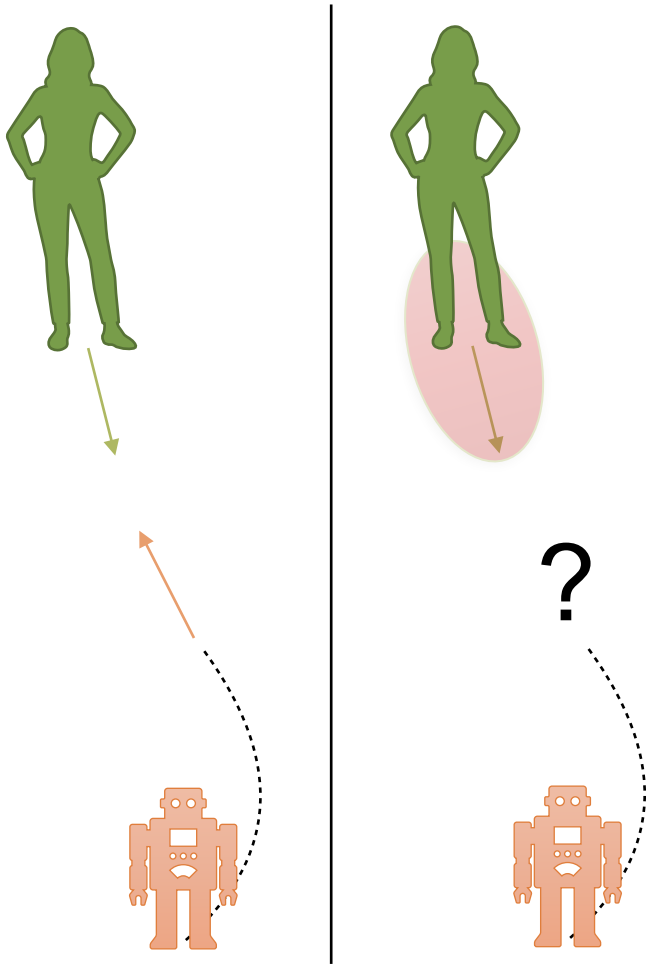


Proposed approach

Challenges

- All different modalities must convey the same intention or message
- Motion planning without assuming that the exact pose estimate of the approached human is available





Planning approaching motion

Proposed approach

Ensuring social acceptance by triggering different modalities during approaching motion

Eyes

- Eyes are used to convey robots intention for interaction during initial stages of approaching human

Speech

- Speech is used to get persons attention when robot has reached his personal space
- It is specially useful when robot is approaching the person from behind

Body orientation

- Body orientation acts as a second stage signal for communicating robots intention for interaction

Gaze estimation

- Gaze estimation is used to understand persons interest in interacting with the robot
- Robot starts interaction only when mutual gaze has been established

Proposed approach

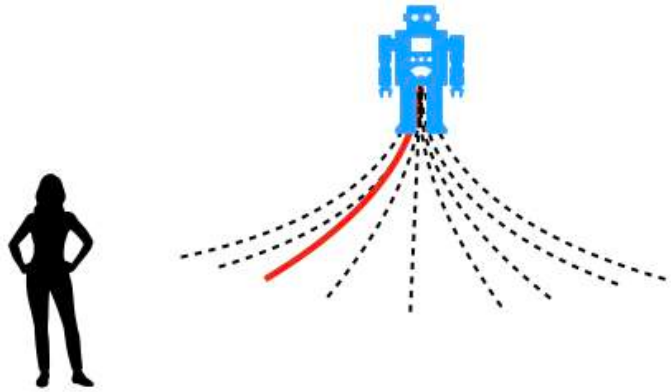
Planning approaching motion under uncertainty in perception

Global motion planning

- Global motion planning using layered social cost-maps is used for ensuring social acceptance
- It requires approach pose to plan motion trajectory
- We replace global motion planning with different modalities for ensuring social acceptance

Local motion planning

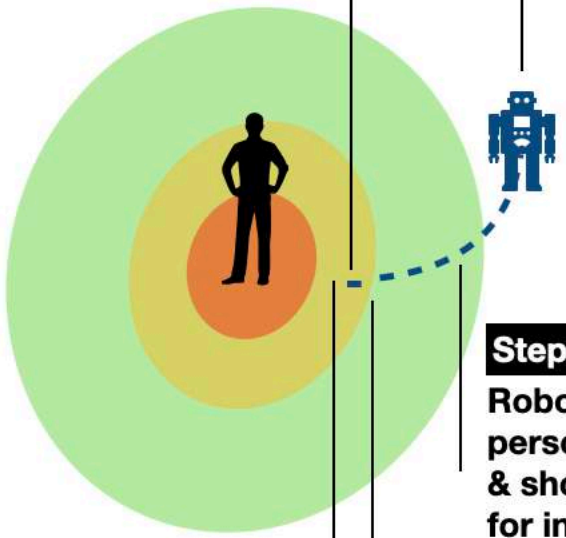
- Local motion planning is used for following the trajectory planned by the global planner
- We propose the DWA base local planner that allows robot to move in the direction of approached human while aligning its body orientation towards the person



Proposed approach

Step 4
If person shows interest robot starts entering personal space to initiate interaction

Step 1
Robot detects person in its own social space

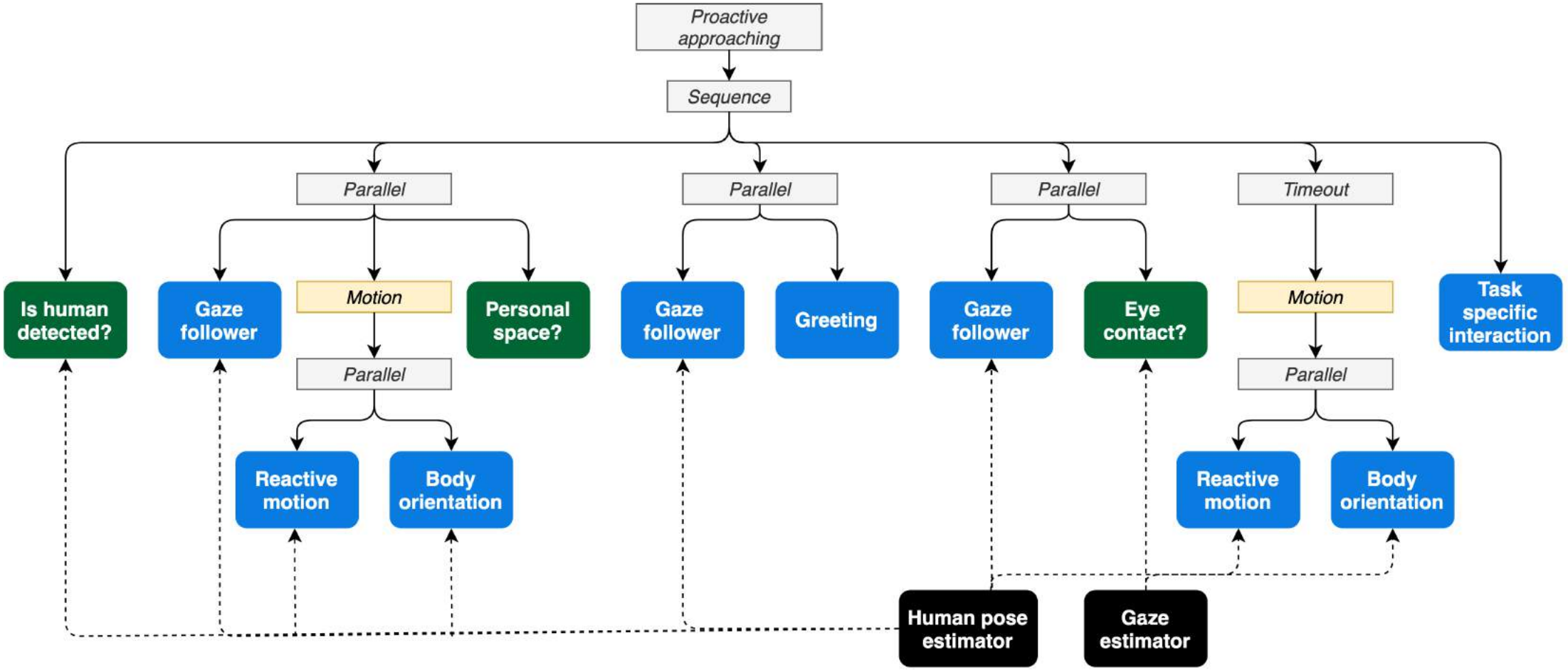


Step 2
Robot starts approaching the person using reactive motion & shows non-verbal intention for interaction using eyes & body orientation

Step 5
Robot starts interaction

Step 3
Robot greets the person to get his attention and waits to see if person is interested in interacting with it.

Integration using behavior tree



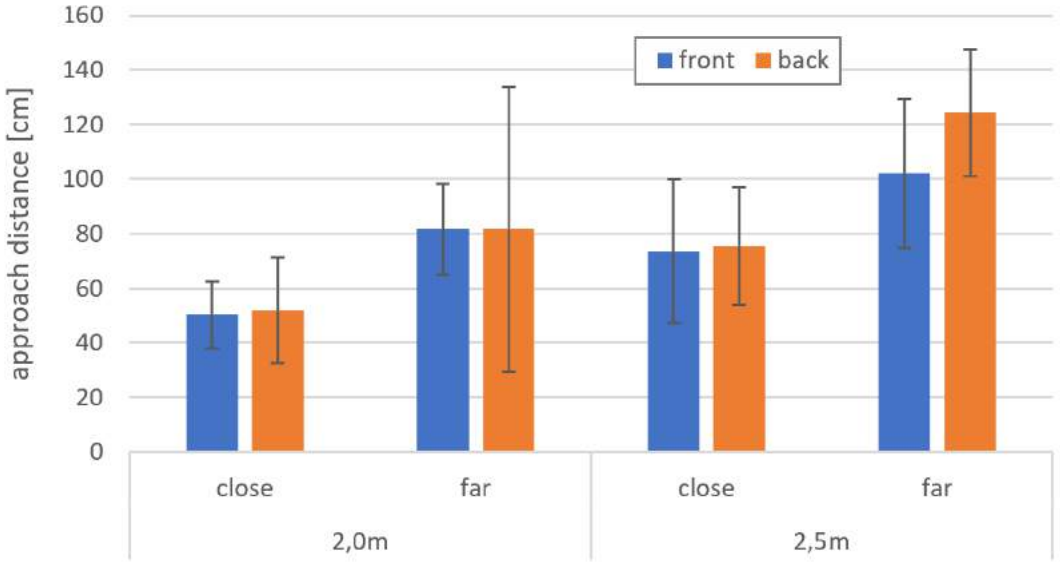
Demonstration

Evaluation

Experiments were conducted in the context of drink serving task

- ~~In the wild study to test social acceptance~~
- Success rate of offering water to people
- Distance of approaching people to ensure convenient access to beverages on the robots tray

	2.0 m		2.5 m	
	close	far	close	far
front	100	77	100	100
back	90	43	100	81



Conclusions and future work

- Robot can robustly approach people even under high uncertainty in perception when no significant obstacles are present between the robot and approached human
- The environments in which robot is deployed plays an important role. It is suitable for deploying robot in more open spaces without significant obstacles between robot and humans (e.g. airports)

- We plan to introduce global motion planning during the initial phase of approaching to robustly deal with significant obstacles
- We intend to conduct in the wild experiments on naive subjects to test the social acceptance of the proposed method

Thank you!