NRI: FND: Spatial Patterns of Behavior in HRI Under Environmental Spatial Constraints

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This project aims to advance autonomous reasoning about spatial patterns of behavior during human-robot conversations. It provides empirical knowledge and methods to incorporate spatial constraints into the way robots reason about spatial formations.

The Challenge

Prior work has shown that methods that reason about human spatial behavior are promising for automatic conversational group detection. However, these methods tend to be brittle because they build on simple mathematical models of spatial formations (e.g., side-by-side or circular arrangements). These models do not consider that the configuration of the space where the interactions happen and the presence of other nearby people can affect human spatial patterns of behavior.

Scientific Impact

As robots enter consumer marketplaces, it is essential for them to be able to cope with the complexity of group interactions. Spatial reasoning is a foundational ability to facilitate group HRI in domains like service robotics, education and healthcare.

This project focuses on studying:

1) How do spatial constraints influence conversational group formations in HRI?
2) How can robots detect these formations under spatial constraints?
3) How can they autonomously generate appropriate spatial behavior to sustain conversations in constrained environments?

Broader Impacts

The methods and insights gained from this project are relevant to robotics applications in a wide range of critical, socially relevant domains. For all publications, we have open-sourced our code, lowering barriers of entry to this line of research.

Thus far, this project has provided training for 3 PhD students and 12 undergrads (including 5 female students and 2 Hispanic students). Research findings have been incorporated in class lectures (e.g., AI, HCI) and used to engage more than a 100 middle school and high school students with our research.

Contributions

1. We proposed **data-driven approaches to detect conversational groups** [1,2]. These approaches combine graph abstractions, neural networks, and graph clustering to identify interactions.

2. We proposed methods to **predict appropriate poses for a robot to take part in group formations** subject to the physical layout of the surrounding environment [3], as illustrated in Fig. 1. One method was model-based and explicitly encoded key geometric aspects of conversational formations. The other method was data-driven. It implicitly modeled key properties of spatial arrangements using Graph Neural Networks and adversarial training. The model-based, geometric approach was more successful at avoiding poses generated in nonfree areas of the environment, but the data-driven method was better at capturing the variability of conversational spatial formations.

3. We contributed an approach to gather qualitative human feedback about conversational group formations in HRI via online surveys. We used this approach to evaluate pose generation methods but also to advance our **understanding of the effects of robot embodiment on human perception of conversational groups** [4]. Our results suggest that human perception of groups can be significantly affected by whether robot embodiment leads to discernible robot orientation.

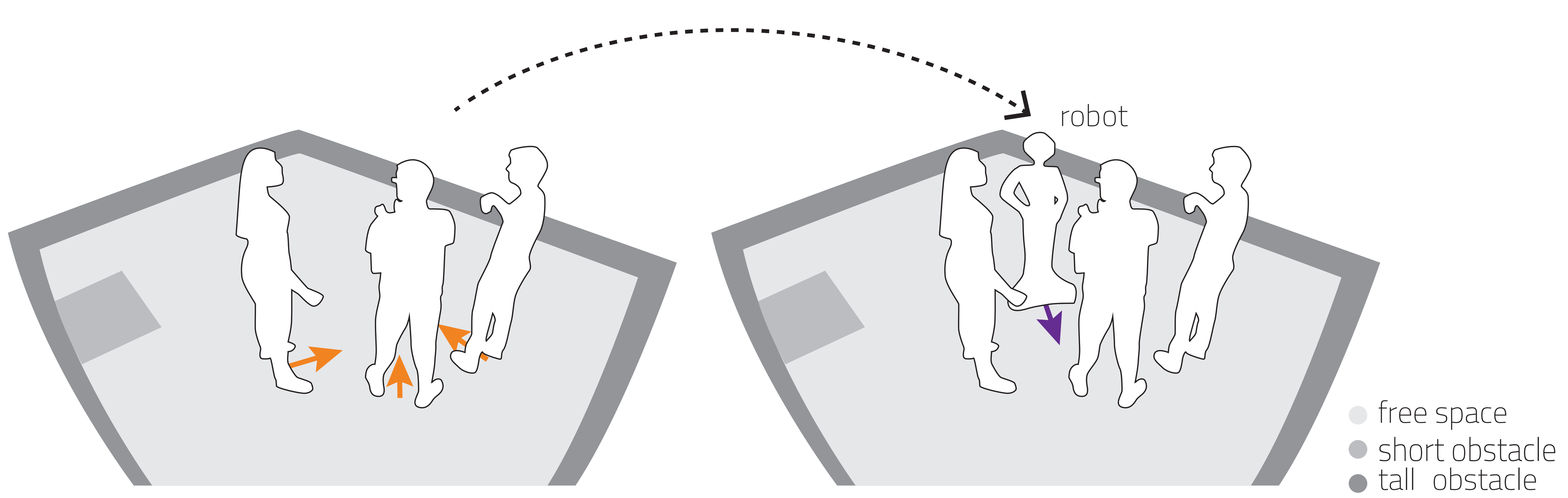

Fig. 1. Pose generation problem: Given the **poses** of interactants and a **map** of the environment, predict a **pose** for a robot in the group.

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References

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Award ID#: 1924802