CAREER: Modeling Group Human-Robot Interactions: Towards A Unified Data-Driven Perspective

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This project proposes a data-driven perspective for modeling key aspects of human-robot interactions. This perspective will allow social robotic systems to reason about individuals and groups. Additionally, this project includes activities in pursuit of making Computer Science a more diverse and inclusive field, and increasing engagement in STEM via Artificial Intelligence technologies.

The Challenge

Despite progress over the last decade on experimentally studying multi-party interactions, computational understanding of group HRI remains difficult. The field is characterized by siloed efforts that make it challenging to create integrated robotic systems capable of reasoning about individual interactants, pairwise relationships, and higher-order group constructs relevant to HRI.

Scientific Impact

To unify many modeling problems in group HRI, this project comprises a three-pronged approach that addresses:
1) **data representation via graph abstractions**,
2) **learning via Graph Neural Networks**, and
3) **data collection via self-supervision in HRI**.
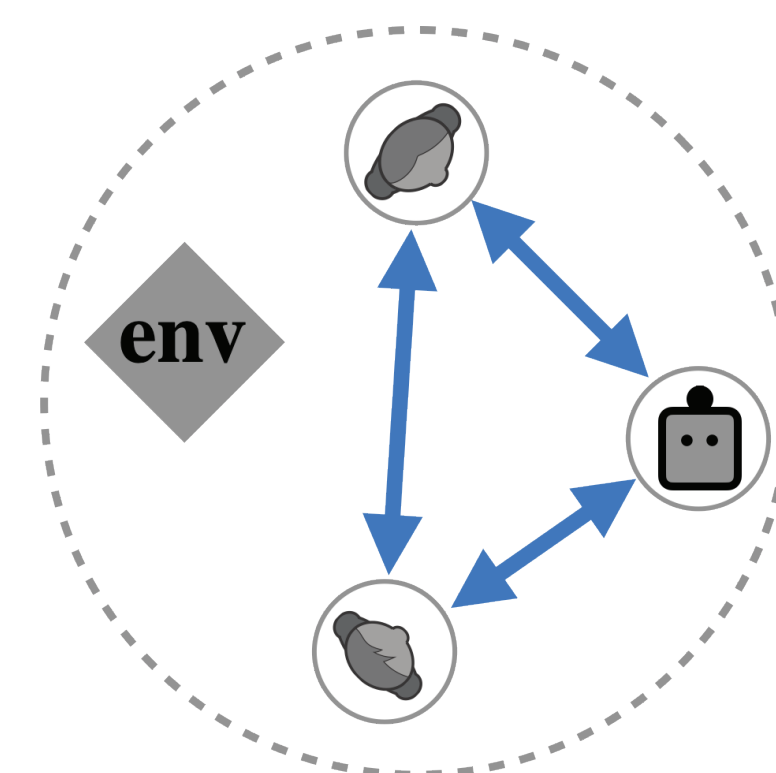
The project will demonstrate the approach by improving how robots initiate and sustain interactions.

Broader Impacts

Because multi-party interactions abound, we foresee the proposed data-driven perspective for group HRI having an impact on socially-relevant domains, e.g., service applications or education settings.

As part of this project, we have conducted demos to students from underrepresented backgrounds in CS (Figure 1), and open sourced our software and hardware for HRI experiments in public environments. Check out
https://shutter.interactive-machines.com

Figure 1. Shutter demo, Oct. 2022.

Contributions

1. We have started to study the problem of predicting human intent to begin interactions with robots in public environments. Our initial results on the ATC trajectory dataset suggest that representing the state of the world with graph abstractions and using GNNs to make inferences over multiple pedestrians jointly is beneficial in HRI [1]. We are now evaluating our approach using richer observations from the Shutter platform (Figure 2).
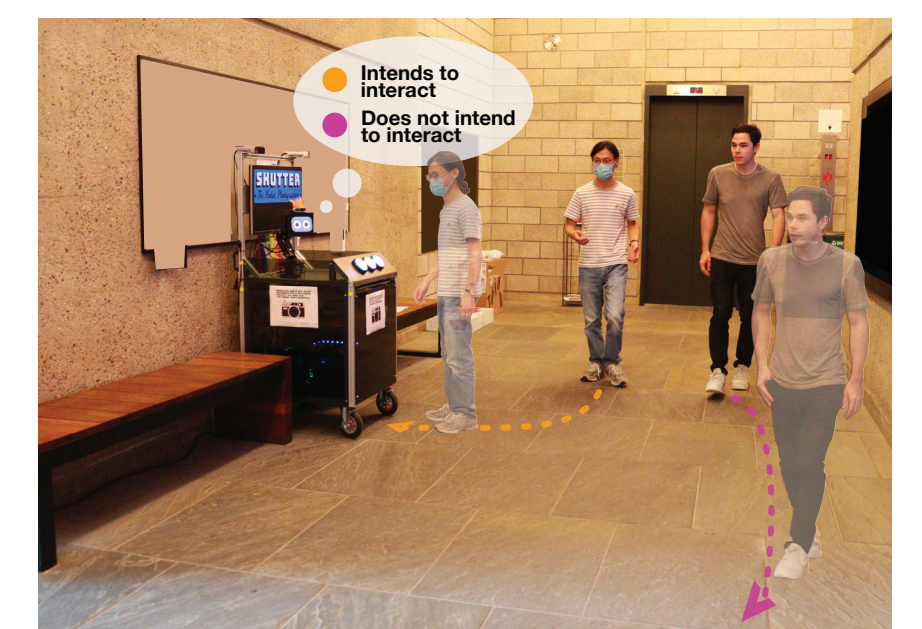

Figure 2. Intent prediction with Shutter at Yale.

2. We have started to work on a novel approach to visualize robot logs and facilitate the anlysis of human-robot interaction breakdowns. Instead of replaying the logs of interactions from the robot system's perspective only, we are visualizing an interaction from the viewpoint of a user as well [2]. We expect this type of visualization to help human annotators better infer from robot logs how users perceived the robot system in public environments, while they were interacting with it. See Figure 3.
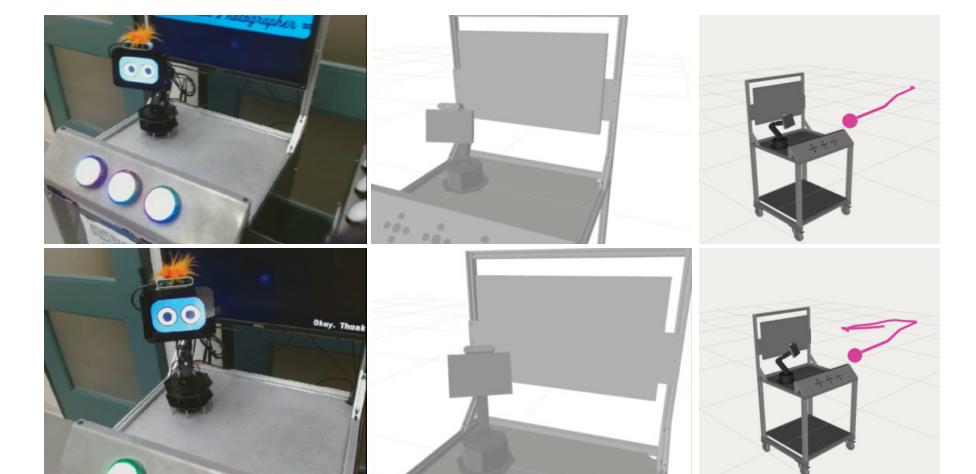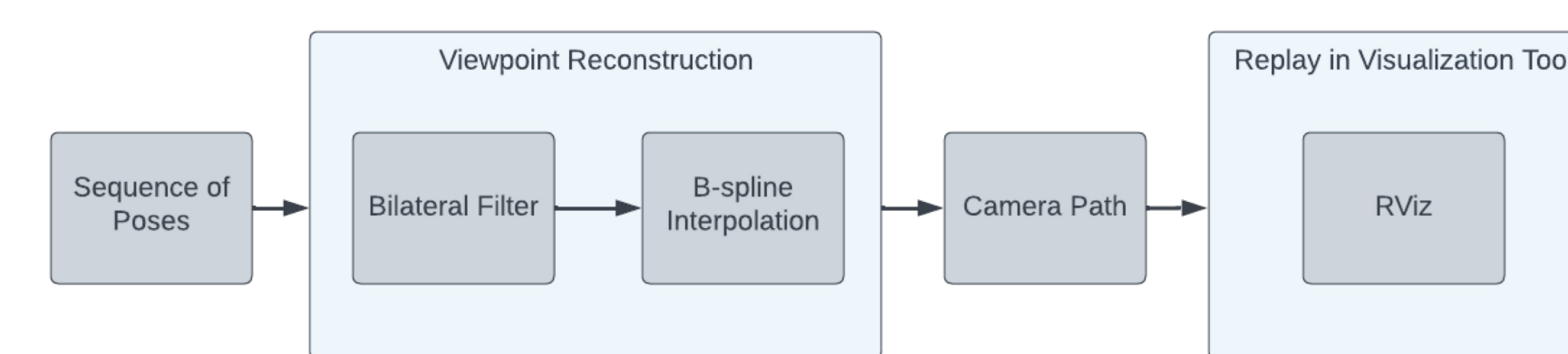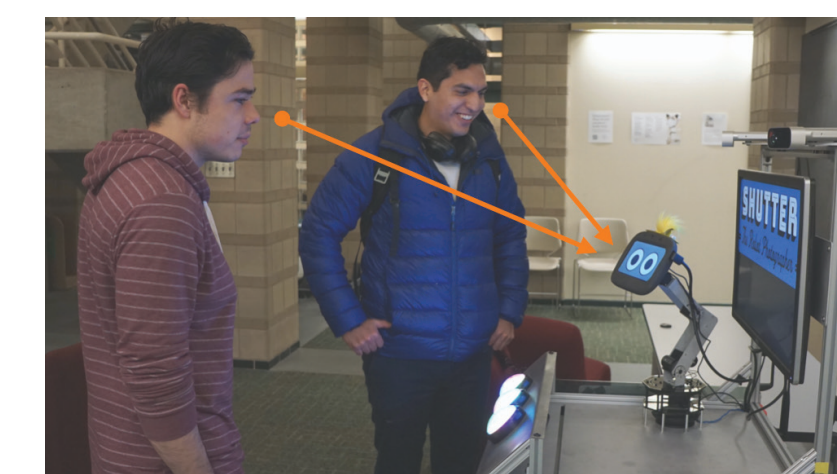

Figure 3. *Left:* What did people see during an interaction? *Middle:* Proposed system to visualize logs from a user's viewpoint *Right:* Example result.

3. We have applied our data-driven perspective to the problem of predicting "Who should a robot address in a group conversation?" under an imitation learning setting [3]. Our approach, based on a Graph Neural Network, has resulted in more compact models than less structured approaches, like a more common LSTM model. See Figure 4 for the results.
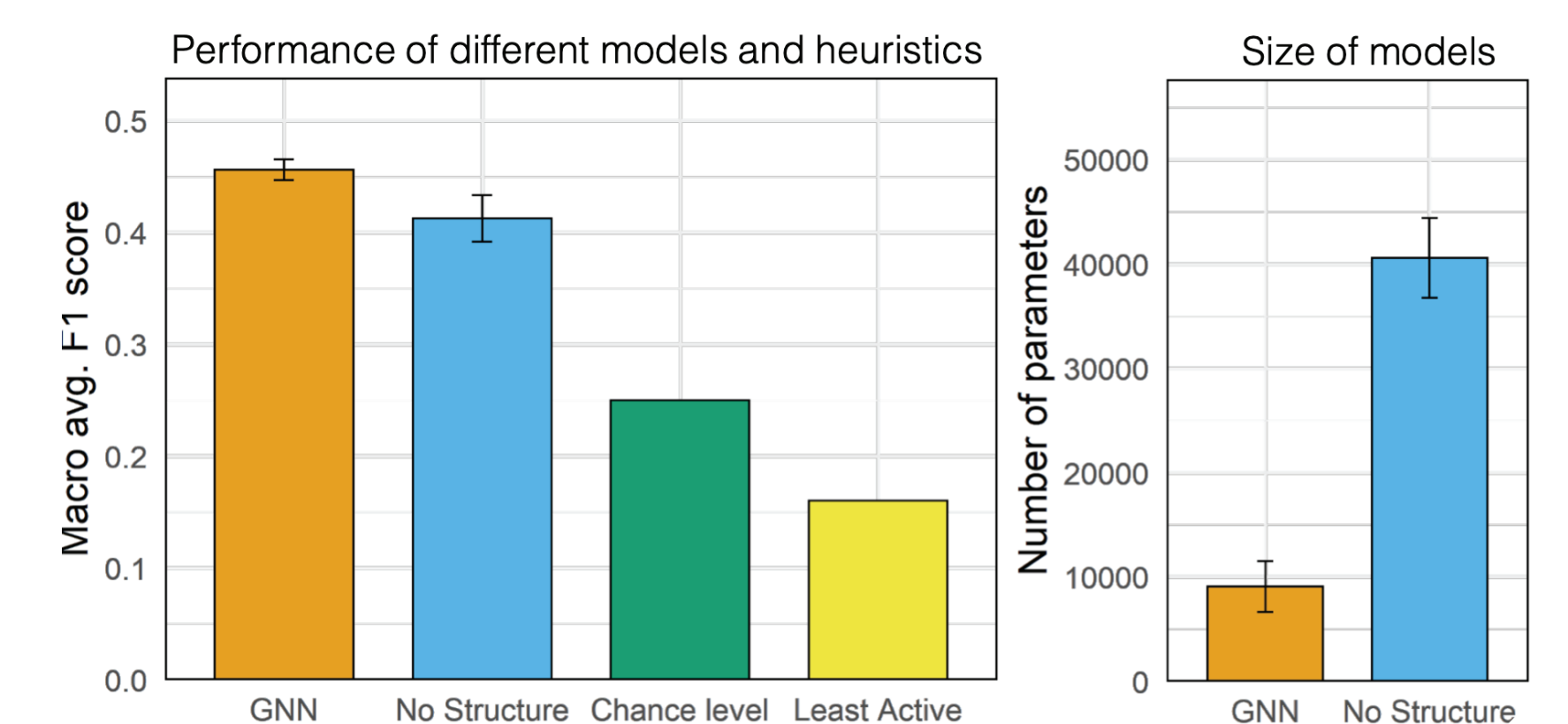

Figure 4. Who Should a Robot Address in a Group Interaction?

References

[1] S. Thompson, Y. Li, M. Vázquez. Do People Intend to Interact With a Public Robot? A Comparison of Intent Prediction Methods on the ATC Trajectory Dataset. AAMAS 2023 workshop on "Autonomous Robots and Multirobot Systems".

[2] A. Lew, D. Rakita, M. Vázquez. Replaying User Viewpoints to Analyze In-the-Wild Robot Failures. HRI'23 workshop on "The Imperfectly Relatable Robot: An Interdisciplinary Workshop on the Role of Failure in HRI."

[3] S. Gillet, I. Leite, M. Vázquez. A Graph Neural Network Approach for Choosing Robot Addressees in Group Human-Robot Interactions. CORL'22 workshop on "Aligning Robot Representations with Humans".