Excluded by the JellyFish: Robot-Group Expressive Motion

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***Abstract*— This piece will explore motion strategies that multi-robot groups can use to make humans feel like they are in the robot in-group or out-group. Staged as a art exhibit, this aquatic-inspired installation is also meant to raise questions about whether robots would establish their own communities and have relationships with each other. We have constructed three robot *jellyfish*, each with an umbrella, linear actuator, mobile base, and jellyfish-inspired decorations. During the future exhibit, museum attendees will walk into a room, see fish projected on the floor alongside the robot jellyfish. Attendees will move among the robot jellyfish, carrying a sensor pack themselves. Structured as exploratory design research, each week the first author will vary the robots' programming to explore new strategies for inclusion, exclusion, and indifference based on psychology research but also in watching people's live reactions to the experience. For example, the robots could form a circle that includes the person, or gather on the far side of the room. The attendees will also have the chance to be considered jellyfish themselves if they flap their arms like tentacles. We describe the physical design of these robots, and share concepts for the including/excluding social formations that will be the expected output of this future exhibit.**

I. Introduction

Social robots are in their adolescence, moving beyond the big eyes and baby-caretaker metaphors of Kismet, into cooperative roles where humans and robots work side-by-side. Just as human middle schoolers move beyond learning skills for themselves (rolling over, walking, learning to write), and begin to look at what their friends wear, and how they move, and struggle with when to conform and when to challenge [1], [2]. People find happiness in community, thus future robots must eventually understand community as a well. Group membership is our first attempt to explore this concept of what makes a coherent social group.

Both authors have conducted previous works on expressive motion, and would like to apply this experience to robot groups [3], [4], [5], [6]. While Fraune et. al. found that people act more favorably towards groups of heterogeneous robots than homogeneous robots [7], [8], no work has yet explored making people a member of the robot group. In this exhibit, we will explore movement-based inclusion and exclusion between a multi-robot group and individual human participants.

II. Why Multi-Robot Art?

The study will take place as a special exhibit, ideally in a museum setting. Within the exhibit area, there will be two main areas: the observation area and the interaction area, as seen in Fig. 2-3. In the first iteration of the jellyfish behavior, in the observation area the jellyfish will sometime turn to look at the participant, and in the interaction area the robotic jellyfish will either move towards the participant, away from them, or randomly. The room will have two ushers: one each by the entrance and exit.

Fig. 1. Robot jellyfish performing in robot comedy show *Singu-Hilarity*

Using art installations to test ideas in social robotics avoids the arduous process of recruitment for the study, as museum goers are coming to the museum for both the installation and the other exhibits. It is also useful because participants are in a setting that is encouraging to play, and can explore concepts outside of traditional research. This work aims to fill the gaps in two areas: multi-robot human interaction and multi-robot art installations. This paper is novel in multi-robot human interaction because it examines feelings of inclusion and exclusion created by a multi-robot group in a social interaction, specifically how those feelings can be created with movement. In terms of art exhibition, we will allow people to become part of the multi-robot art installation, blurring the line between robot and person, and raising questions of identity as each agent (robots and human) simulate being an aquatic something else.

This approach is novel in both art and research. While artistic works using multiple robots have existed [9], [10], people have not directly interacted and integrated into the robot groups. The works that have been interactive, in contrast, generally involved single robots [9], [11]. We build on previous examples of robot expressive motion, such as mobile office robots, or multi-robot social navigation [12],

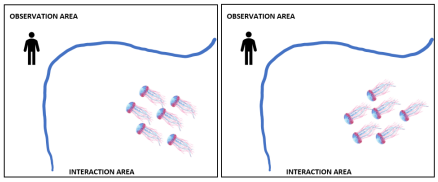

Fig. 2. Options for Behaviors when Participant is in the Observation Area

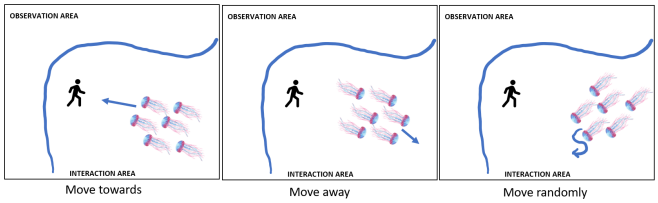

Fig. 3. Options for Behaviors when Participant is in the Interaction Area

however, we do not seek out how to avoid the person, but rather how to integrate or exclude them. This social component is complementary to action plans developed for collaborative robotics [13], [14], [15], exploring not only how to get something done, but the social atmosphere of the group itself.

III. The Robots

The robotic jellyfish can be seen in a live performance in Figure 1. The jellyfish move through space using a Neato vacuum as a base. The jellyfish umbrellas are attached to the Neato with a linear actuator. This allows the jellyfish to move up and down in addition to the base motion translation and rotation.

In order to create a multi-robot group that can create feelings of inclusion and exclusion, it is necessary to understand the human-human models of inclusion and exclusion. In a general sense, inclusion encompasses feeling the same and like and insider while exclusion encompasses feeling different and like an outsider, often referred to as "outgroup" [16]. When a group wants to include an outsider, they typically try to either make the group easier to join or make the individual feel wanted [16]. However, when the group does not want to include an outsider, they will ignore them or possibly test or punish them [16], [17]. These ideas will be explored in the robot group motions, potentially addressing attraction/repulsion, integration in formation, including concepts of robot relative-orientation, path-shape, accelerations, and energy levels.

For example, the first base motion exploration will consist of the jellyfish following randomly generated, smooth, curving paths while maintaining their group formation. In a study on pedestrian movement relating to social structure, it was seen that within groups, pedestrians turned themselves towards the other groups members to facilitate communication [18]. Thus, we might trigger particular behaviors when the participant is in the observation area or the interaction area, looking at the participant instead of just continuing on a random path. In the interaction area, the robots might seek to include the people in both the direction of their behavior and in their spatial formation, as opposed to continuing on a random path. Some concepts for these behaviors can be seen in Figure 3.

IV. An Exploration of Inclusion and Exclusion

The exhibit is intended to be open for six weeks with the robot behaviors being varying each week to explore a variety of inclusion and exclusion strategies, sourced from both prior work (e.g., psychology literature and our previous works on expressive motion), as well as user-centric design processes (based on the attendee experiences and researcher observations).

As participants enter, they will be given a hat with a OptiTrack marker and accelerometer bracelets so they can interact with the system. The interaction structure is open-ended, but the system itself will transition through modes in which they are seeking to socialize or chasing the fish projected using light through the floor. The responses and interactions of the visitors with the jellyfish will be recorded with a motion capture system and analyzed to inspire new explorations though out the exhibit. Attendees will also have the option to fill out a short survey after they exit, and a researcher will be present one day of the week for live observation and casual conversation with guests to gain additional insights and ideas about their experiences.

To measure inclusion, we plan to use grounded coding of the exhibition video data, and an optional exit survey based on [19], measuring: activity in the group, satisfaction with those activities, goals for participation, and if they would like to increase or decrease their level of participation. These questions will be cross-referenced to the video data to parse participant feelings of inclusion/exclusion with the jellyfish.

V. Conclusion

In summary, this study explores how the movement of multi-robot groups can affect feelings of inclusion and exclusion. Participants will be allowed into an experiment room to move around and interact with a group of robot jellyfish. This work will explore strategies for group expressive motion, themed around inclusion and exclusion. Another aspect to exhibit could be how people can encourage the fish to include them, which is currently scheduled as future work, but may be a feature that emerges from the data. For example, if a person mimics the movement of the jellyfish, the jellyfish could be programmed to recognize that and be more inclined to accept them.

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