Contextual Collision: The Social Consequences of Touch and Collision in Human Robot Interaction

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ABSTRACT

The use of touch in human to human relationships is an important one, as both an emotive and communicative gesture. For a simple rolling robot, touch is accomplished via collision. This work proposes a combination of soft robotics and social robotics to explore the social consequences of intentional collision. It introduces a blowfish-inspired soft robot, which can use retractable silicone spikes for both actuation and social expression.

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1 INTRODUCTION

While early social robots often had humanoid forms, minimal robots are becoming much more common in recent times. They provide a cost effective, simpler alternative, but require creative ways of communicating, as shown in Sirkin et al's work with robotic ottomon et. al. [8] and Bonarini et. al.'s work with zoomorphic robots [1].

In personal interactions, touch as collision can be social or incidental. Co-workers might elbow each other during a meeting, or tap the back of each other's chairs to get attention. Football players may collide after a game as a sign of affection, joy, or camaraderie. Turns and bumps on crowded public transport can also incite collisions.

To clarify when and how collisions are interpreted as communication, this paper describes a novel robot and study design. The robot is spherical with inflatable silicone spikes (Figure 1) that can be used for both expression and actuation. The biological inspiration for the expressive aspect of this system was the pufferfish, which extends its spines when agitated or threatened.

The experiment places this "spike-optional" robot in a sea-inspired context, where the robot is chasing projected fish around a table, and the participant sits with their elbows on the desk. To utilize the sea-creature inspired form, the robot will be given the task to "catch" a fish and either return to the participant or ignore the participant. The robot will "happen to" collide with the participant's arms in both conditions, from both direct and tangential directions (Table 1).

Our hypotheses are that H1: spike extended actuation will be more scary, spike-retracted more friendly, H2: direct motion will be seen as more threatening or more social, depending on the speed (high correlating with former, medium with latter), and H3: that people are more likely to "forgive" collisions with the socially interactive robot.

Potential applications for this work include navigating constrained spaces, naturally integrating social signals, and weighing social consequences before choosing a behavior.

2 RELATED WORK

Social touch has been well established as an important method of communication in both human-human interactions and human-robot interactions [2][10][4]. Touch can modulate behavior, and facilitate communication between groups. It is also a good method for eliciting emotions [9]. This is the first work the authors could find, however, that explores collision as a form of social communication.

Not all touch is socially appropriate. For example, the idea of personal bubbles has been formalized into proxemic zones, which specify numbers for inter-agent distance in intimate, social, and stranger/bystander interactions [5]. The introduction of both the spike and social manipulation in this experiment may also provide insight into how the social appropriateness of collision varies for different social relationships or robot forms.

3 SPIKE-OPTIONAL ROBOT

The robot used in this work is a fully modular, self-contained rolling system designed by the author that has a similar size profile to a small dog. Spikes were chosen for this design to serve a dual purpose; to illustrate defensive body language on a minimal system and to move the system. The spikes are inspired by biological non-verbal communication systems, like the extendable spikes of a blowfish.

The spikes are constructed from embedded material in silicone to maintain a soft profile when physically bumping into a human. Multiple iterations of the spikes were created to find the most dynamic shape-change profile possible. Previous versions include origami structures [7] and can be seen in Figure 1. The final design built off of inspiration from work by Pikul et. al. [6].

The modularity of the system allows the spikes to be exchanged when damaged or replaced with different shape profiles. The robot is actuated pneumatically (control adapted from the Soft Robotics toolkit [3]), and can be both pre-programmed and teleoperated.

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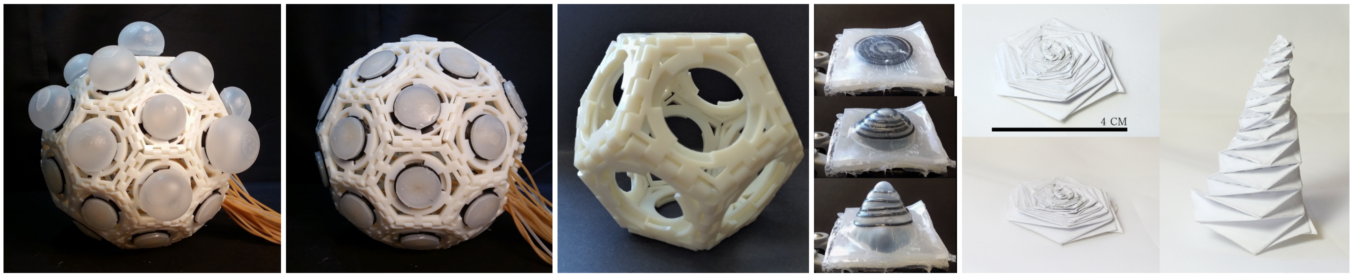


Figure 1: Current System and actuation iterations. Starting from the left, the figure shows the current system in its fully inflated state, deflated state, prior iteration of the modular system, and conical actuator iterations

Eventually, the system will autonomously interact with humans. An example of the current system can be seen in Figure 1.

4 COLLISION AND COMMUNICATION

The proposed study will investigate how spike-protrusion, robot-sociability level, and collision pathway affects the social appropriateness of collisions. It also explores how these manipulations impact participant interpretations of collisions, and their attitude toward the robot.

Moving light patterns in the form of fish will be projected on the study table to support the pufferfish-like interpretation of the robot. When the robot "catches" a fish, it will extend/extract the spikes three times, as if celebrating, then return to its original state. The robot's next behavior will either be socially interactive or socially agnostic. In the socially interactive case, the robot will travel to the research participant, as if delivering the fish, approaching from either a tangential or direct path. In the socially agnostic case, the robot will appear to ignore the participant, but may occasionally bump into the participant from the direct or tangential paths, with no relationship to the fish-catching task.

After interaction with the robot, the participant will be subsequently asked about the robot. Interview questions will assess the general attitude of the participant towards the robot and the perception of the robot as a social other. Post-interaction surveys will ask the participant to rate the robot from A: not scary to scary, B: unfriendly to friendly, C: asocial to social, D: rude to polite. Possible modalities that this experiment will assess can be seen in Table 1.

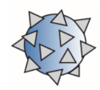
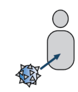
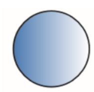
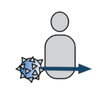
Further work on the project will focus on the inclusion of different protrusion shapes, the importance of materiality on a system, and collision in real-world scenarios.

5 CONCLUSIONS AND CONTRIBUTIONS

These experiments meld the fields of social and soft robotics to explore the acceptability of social collision between humans and robots. The proposed study will establish how spiked actuation impacts the the perception of robot collisions across a variety of contextual manipulations.

Robot applications using physical contact, such as massage therapy or rehabilitation therapy, could also make use of collision-based communications. Given the playfulness of the behavior and form, a responsive companion creature may be popular with young children in educational settings.

Table 1: Variables to Test in Human Trials

Modalities	Example	Directionality	Example
Protruded		Toward	
Flat		Tangent	

Performing similar experiments as future work, with higher degree-of-freedom forms, would continue to broaden the field's understanding of social-appropriate collision. Such systems could encourage a new mode of communication for mobile robots, and help robots know when collisions are acceptable during navigation through crowded corridors.

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