Robot-assisted therapy for children with Autism Spectrum Disorders

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Abstract
Our research is the exploration of the social effects of human-robot interaction (HRI) on children with ASD, a population that has deficiencies in many types of social behavior. Computers and robots have been shown to be a catalyst for increased social interaction in children with ASD, yet that effect requires further study to be effectively employed as a therapeutic intervention.

Introduction
This abstract presents an approach for developing socially assistive robot (SAR) systems for use as part of an intervention for children with autism spectrum disorders (ASD), a population that has deficiencies in many types of social behavior. A central feature of ASD involves difficulties with self-initiation of social behaviors, possibly due to motivational issues (Koegel 2003). Robots have been shown to have promise as potential assessment and therapeutic tools, because children with ASD express an interest in interacting socially with such machines (Werry 2001; Scassellati 2005). Our work is thus motivated by the fact that SAR may hold significant promise for ASD intervention. Related work has studied SAR as a tool for diagnosis (Scassellati 2005) and socialization (Dautenhahn 2000; Kozima 2005; Michaud 2005; Lathan 2007) of children with ASD. However, most explored systems have been

in the form of toys, not humanoid-form social partners, and, importantly, current human-robot interaction (HRI) control architectures do not readily facilitate the complex interactions necessary for therapeutic interventions with such robotic social partners. Our research includes the development of an HRI intervention design that uses a robot to augment a human for a social intervention.

Robotics and Children with ASD

While robots have been used for social interaction, there is untapped potential for their use as therapeutic social partners. Our research provides a process by which a socially assistive robot is developed and used as part of a therapeutic intervention for children with autism spectrum disorders (ASD), children who have severe deficits in turn-taking, joint-attention, play, imitation, and self-initiated behavior. This work is focused on robots whose behavior encourages, facilitates, and trains social behavior in children with ASD through embodied social interaction.

Robins, et al., (2005) observed that robots can provoke social behavior that is not naturally occurring in children with ASD. The authors are working to develop a robot-assisted intervention based on the DIR (Developmental, Individual-Difference, Relationship-Based)/Floortime, a flexible intervention that uses a participant's existing social behavior to build new social behavior (Greenspan 1997). Any increase in social interaction should be observable through standard ASD assessments. Our methodology combines best practices and research methods from psychology and education with current robot sensing, planning, and control methods. A major challenge addressed in this work is the difficultly in constructing a robot system that can recognize, understand, and correctly act upon behavior observed in its user, especially one with special needs

Human-Robot Interaction Scenarios

The robot is intended as a catalyst for social interaction (both human-robot and human-human, thus aiding human-human socialization of ASD users), rather than as a teacher for a specific social skill. This allows for scenarios where the robot is not specifically generating social behavior or participating in social interaction, but instead where the robot behaves in ways known to provoke human-human interaction. For example, a bubble-blowing robot, while not behaving socially, actually provokes social interaction between a child and parent. We designed several specific robot-assisted intervention scenarios that test the architecture. Two have already been used in validation, as follows.

Figure 1: Left: The mobile robot used in the experiment. Right: The humanoid robot used in the experiment.

In the first scenario, the robot uses a bubble gun mounted on the front of the robot to blow bubbles.

(Bubble blowing games are a standard part of ASD diagnosis since bubbles are an effective method of provoking social behavior such as joint attention and pointing.) Social skills observed in this scenario include vocalizations, initiation of behavior, and pointing. This bubble play scenario is designed to stimulate contingent behavior. In the second scenario, the robot engages the user in a game of Simon-Says, where the robot makes an exaggerated gesture or pose using an anthropomorphic torso, and verbally encourages the child to imitate the robot. Success was defined as the robot's ability to successfully engage the child in the task. Engagement, in turn, was defined as appropriate reaction in response to the robot's behavior. In the ASD context, more than in any other, such a response is not the default, and so it is a valuable measure of system effectiveness.

Pilot Experiment

We conducted experiments with children with and without ASD in order to verify that the architecture meets the three requirements outlined above and that it is effective as part of the described intervention design. We wanted to examine whether or not the behavior of the robot affected social behavior for children with ASD.

To test that the behavior of the robot affected the behavior of the child, we compared two conditions, contingent and random. In the contingent condition, large buttons mounted on the robot triggers the bubble blower. When the child pushes a button, then the bubbles blow. In the random condition, the robot blows bubbles after a random amount of time, whether or not a button has been pushed. If there was a measurable difference between the contingent and random conditions, then we would know, for two extremes, the behavior of the robot can affect resulting social behavior for children with ASD. If the contingent condition elicited more social interaction than the random condition, we can infer that the robot behaving contingently with the child would be more effective as part of an intervention than a random robot. For the pilot experiments, we recruited five participants (4 ASD, 1 typically developing) ranging in age from 20 months up to 12 years old. This pilot resulted in a series of qualitative and quantitative observations.

Results

For each presentation we annotated the video recordings for social behavior (including speech, gestures, movement, and physical contact), noting the target of the social behavior as well as whether or not the behavior is proactive or in response to the parent or robot. We found that the behavior of the robot affects the social behavior of a child (both human-human interaction and human-robot interaction): social behavior with a contingent robot was greater than with a random robot. Total speech went from 39.4 to 48.4 utterances, robot speech from 6.2 to 6.6 utterances, and parent speech from 17.8 to 33 utterances. Total robot interactions went from 43.42 to 55.31, with button pushes increasing from 14.69 to 21.87 and other robot interactions going from 24.11 to 28. Total directed interactions (interactions that were clearly directed at either the robot or the parent) went up from 62.75 to 89.47. Generally, when the robot was acting contingently, the child was more sociable. This increase is reflected in the observed number of social actions. These results demonstrate that the robot's behavior is, in part, responsible for the resulting social behavior on the part of the child. If this result holds true for a larger population, which will be validated by our experiments in progress, it will demonstrate the importance of robot development, since the behavior of the robot is part of the social effects observed.

Ongoing Work

Our ongoing work involves a larger study with an age and deficit-controlled participant cohort, which will evaluate the complete implementation of the robot with several scenarios, including the use of a humanoid torso compared to a mobile base. The torso will be used to engage the participant in imitation behaviors, part of the intervention design we are validating. The details of the scenarios and the associated HRI algorithm implementations as part of the robot control architecture will be described, along with the experimental results of the large-scale (35-65 participants) study taking place this spring.

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