Exploring child-robot engagement in a collaborative task

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Abstract
Imagine a room with toys scattered on the floor and a robot that is motivating a small group of children to tidy up. This scenario poses real-world challenges for the robot, e.g., the robot needs to navigate autonomously in a cluttered environment, it needs to classify and grasp objects, and it needs to interact with the children and adapt its behaviors to the children's group dynamics. Within the EU FP7 project SQUIRREL, we aim to address these challenges and develop a robot for children (4-10 years old) that cannot only perform complex navigation and manipulation tasks in a cluttered environment, but is also affectively and socially intelligent, engaging and fun in a collaborative task. We currently focus on designing appropriate robot interaction styles for a small group of children and evaluating the levels of fun and engagement in child-robot and child-child interactions.

Motivation
Children respond readily and strongly to robots showing social behavior. Some aspects of child-robot engagement have been researched, but most previous work has focused mainly on impaired children (with the exception of [2]), in one-to-one child-robot interactions [1]. As a result, little is known about the patterns of engagement between a robot and a small group of normally developing children. We aim to address this gap in our research by conducting

a first user study and developing a model of engagement in child-robot interaction (CRI).

How to engage groups of children in a collaborative task with a robot: a first study

One of the main factors in our study on CRI is the definition of robot interaction styles (i.e., a combination of behaviors that evoke a perceivable robot role) [5] that result in engaging interactions. Thus, a first question is: what kind of interaction style should a robot have to interact in an engaging way with children in a collaborative task?

The term 'engagement' is often used in human-robot interaction (HRI) to describe the connection between the human and the robot during an interaction [6], but a discrimination between task engagement (i.e., the engagement occurring or not while performing a task) and social engagement (i.e., the engagement elicited or not by the robot while interacting with humans) is needed [3]. With this in mind, a second question is: how does the potentially engaging robot interaction style affect social and task engagement? Another challenge is the lack of a widely accepted method of assessment of the interaction, and of engagement, despite the need of task-dependent, user-dependent and context-dependent approaches.

In order to tackle these challenges, we envisage a Wizard of Oz (WoZ) experiment. It entails a triadic scenario where an off-the-shelf robot (i.e.,Nao Robot) and two same sex children (6-8 years old) perform a collaborative task with the help of the robot. The effect of two different potentially engaging interaction styles, is evaluated. One is a peer-like behavior, based on peer-like collaboration, another is a tutor-like behavior, based on scaffolding support; both of them will encourage collaboration in completing the task. We aim to determine which of these interaction styles is more engaging for the children. Thus, this first exploratory study will potentially contribute to gaining insights into how to evaluate interactions, into the role of collaboration between a small group of children and a robot while performing a task, and into how to design engaging robot interaction styles.

Assessment of child-robot engagement: our approach

We propose a model of engagement which uses insights from [3, 4]. It considers the level of intensity of cognitive, affective, and behavioral attributes of engagement during the interaction. These attributes are present in both social and task engagement (see Table 1). The more qualitatively positive these attributes are, the more fun, engaging, efficient (i.e., percentage of task completion) and effective (i.e., time required to complete the task) the interaction will be. Hence, the novelty of our research lies in the exploration of combined methods to assess engagement based on a task- and user-centered definition. The interactions among the robot and the two children and between the two children will be assessed in an explorative way to identify, e.g., if one of the children is more dominant or is more engaged than the other.

eng.	attributes	examples
social	cognitive	paying attention to the robot
	affective	showing emotion toward the robot
	behavioral	taking the robot's hand
task	cognitive	paying attention to the task
	affective	having fun performing the task
	behavioral	completing the task

Table 1: Attribute examples of social and task engagement

The main goal is to observe and annotate the cognitive, affective, and behavioral aspects of social and task engagement, and to frame the frequent and collaborative [7] behaviors occurring among the children. Cues such as mutual gaze, emphatic gestures and facial expressions, which are indicative of these aspects of engagement and collaboration, will be annotated manually. Microsoft Kinect will be employed to address the feasibility of automatic detection of these cues. In addition, to have a more objective account of the children's affective states, electrodermal activity (EDA) will be registered. Measures of effectiveness and efficiency will be used to account for behavioral task engagement. Next to the measures described above, the study will be supplemented by children's self-reports (mainly post-interaction questionnaires specifically adjusted to children) as a 'ground truth' mean of subjective evaluation of the children's engagement.

Expectations toward the workshop

Engagement is considered a preamble of social bonding, hence discussing child-robot social bonding with considerations on the role of engagement will be an opportunity for us to exchange views on two of the main aspects affecting the relation between children and robots.

Reasoning about the design of appropriate robot interaction styles and roles, which induce engagement and bonding, will present an interesting topic of debate. Furthermore, discussing methodologies of interaction assessment will lead to a stimulating scientific discourse, which will potentially have a beneficial influence on our research.

Overall, given its creative character, participating in the Child-Robot Interaction Workshop at IDC 2014 will be an opportunity to discuss with fellow colleagues in an unconventional, but inspiring way.

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