Towards Co-designing Minimal Robot Behaviors with Children: What Children Can Teach Robots

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Figure 1: In the picture a user is puppeteering the robot's motion with the tangible prototype

Abstract

Carefully designed nonverbal behavior can supply minimally actuated non-anthropomorphic robots with the communicative power necessary to engage in playful tasks with children. However, this user group brings unique challenges for interaction designers as (i) it is often hard to understand how nonverbal robot behavior is perceived and interpreted by children, (ii) children's attribution of agency and perception of interaction affordances might differ from adults. In our research, we tackle the above challenges by exploring techniques to incorporate children's perspectives into the design of a robot's minimal social behaviors. Drawing from child-computer interaction research, we posit that by involving the children in the design process of a robot's minimal social behaviors, roboticists might gain deeper knowledge on how to design a robot's behavior that meaningfully communicates to children, adhering to their models of agency and animacy. In this extended abstract, we present first steps towards the development of a generative technique that contains elements of puppet theater, kinesthetic interaction, storyboarding and ex-post reflection, to externalize and embody children's view on robot's behavior.

Author Keywords

child-robot interaction; co-designing robot behaviors; puppeteering; minimal robot behavior; nonverbal robot behavior.

Figure 2: The low-fidelity representations of the robot and users used in the focus group

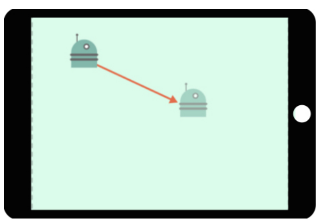

Figure 3: A Picture of the GUI: robot locomotion is controlled by drag and drop of the robot icon.

Introduction and motivation

The development of robots (e.g., toys[1], robotic objects [3]) for children's entertainment, education, social assistance and therapy is increasing. Researchers and product designers are focusing on developing cost-effective, simpler robots that are sufficiently robust to move out of the laboratory into children's real world. While human-robot interaction research (HRI) is exploring design solutions for nonverbal communication of simple robotic objects [8, 9], or low-degree of freedom robots [6, 7], less research has been dedicated to simple robots for child-robot interaction (cHRI) [3]. Findings from our research in cHRI [11, 12] show that carefully designed nonverbal behavior can supply minimally actuated non-anthropomorphic robots with the communicative power necessary for robots to engage in playful tasks with children. The communication is achieved relying only on minimal movements of the robot's whole body (i.e., rotation of the base of the robot, or the robot "nudging" objects with or without semantic free sounds), which are simple, technologically not costly and easily implementable. However, it is often hard to gain a deeper understanding on how nonverbal robot behavior is perceived and interpreted by children [5].

Without understanding how children perceive and interpret the robot behavior, it is difficult to evaluate and develop robot expressive behavior that meaningfully communicate robot's state, intentions and emotions. At the same time, children's idiosyncratic attribution of agency and perception of interaction affordances [1, 10] might require *developmentally appropriate* design methodologies. In our research, we tackle the above challenges by exploring techniques to incorporate children's perspectives into the design of minimal robot social behaviors. Drawing from child-computer interaction research on co-design with children [2, 4], we posit that by involving the children in the design process of a minimal social robot, roboticists might gain deeper knowledge on how to design a robot's behavior that meaningfully communicates to children, adhering to their models of agency and animacy.

[1] http://www.sphero.com/

Exploring and evaluating generative techniques

We explored ways to surface children's tacit and deeper levels of knowledge about robot's behavior by facilitating the enacting of robot motion, bridging the gap between the different knowledge domains (researcher versus children). In a first iteration, we carried out focus groups to understand children's perception of a robot with a low-degree of freedom and constrained appearance (Figure 1), and to explore the use of a puppet (representations of the robot) and storyboarding to facilitate enacting of robot's behaviors (mainly robot's motion and locomotion). We concluded that combining elements of storyboarding with puppeteering (e.g., sketching an interaction scenario enacted using a representation of the robot and the user), facilitates children's expression of tacit and deeper levels of knowledge about robot's behaviors (Figure 2). In a second iteration, we developed two different prototypes, based on different interaction paradigms, to combine storyboarding and robot's behavior enactment: one graphical user interface on a tablet (Figure 3) and one tangible (Figure 5), focusing on kinesthetic interaction as a way to encourage children to construct meaning through bodily action. Both prototypes represent a way to puppeteer (i.e., choreograph) the motion of the robot. In an informal evaluation (20 children between 9 and 11 years old $M = 9.55, SD = 0.55$), we found that the tangible prototype provided a more coherent mapping to externalize and embody children's enactment of robot's behavior.

Figure 4: A picture of the tangible prototype: a physical device, bearing similarity in appearance with the robot equipped with sensors (speed, rotation, tilt angle), allows the child to control the robot. Direct mapping between the small controller and the big robot results in navigation on the z-plane with rotation and forward/backward movement.

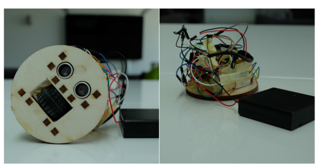

Figure 5: A picture of the micro-controller and a Wi-Fi chip.A rotary encoder is connected to a small wheel which is in contact with the floor, this senses back and forward movement speed. Rotation of the controller is measured by a compass sensor, which is part of the same inertial measurement unit (IMU) as the accelerometer. Teensy 3.1 microcontroller11 interfaces all sensors. A battery pack of 4 AA batteries supplies for all 5V components.

Future Directions

We will further develop and evaluate our generative technique. In particular, we will implement a system to automatically record children's enactments, further develop elements of puppet theater, and evaluate how this technique informs our research on minimal nonverbal robot behavior.

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