Social Robot Toolkit: Tangible Programming for Young Children

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ABSTRACT

Teaching children how to program has gained broad interest in the last decade. Approaches range from visual programming languages, tangible programming, as well as programmable robots. We present a novel social robot toolkit that extends common approaches along three dimensions. (i) We propose a tangible programming approach that is suitable for young children with reusable vinyl stickers to represent rules for the robot to perform. (ii) We make use of social robots that are designed to interact directly with children. (iii) We focus the programming tasks and activities around social interaction. In other words, children teach an expressive relational robot how to socially interact by showing it a tangible sticker rulebook that they create. To explore various activities and interactions, we teleoperated the robot's sensors. We present qualitative analysis of children's engagement in and uses of the social robot toolkit and show that they learn to create new rules, explore complex computational concepts, and internalize the mechanism with which robots can be programmed.

Categories and Subject Descriptors

K.3.1 [**COMPUTERS AND EDUCATION**]: Computer Uses in Education; I.2.9 [**ARTIFICIAL INTELLIGENCE**]: Robotics

Keywords

Robot Programming, Ambient Computing, Relational Bots, Child Programming

1. INTRODUCTION

Recent years have seen a growing interest in approaches to introduce children to the concepts and applications of programming. In order to meet 21^{st} century digital literacy requirements, many curricula have been suggested to promote childrens' understanding of the underlying principles of computer science, as well as pragmatic applications of programming, e.g., game design and robotics. While initially targeting young adolescents and high school children, recent advances in education, system design and affordable and usable media have enabled researchers to promote programming education to younger children. Furthermore, simplifying the interface, via either visual languages, e.g., Scratch [1] or tangible programming [2, 5] has allowed kids as young as pre-schoolers to learn basic concepts of programming. A more engaging and real-world application of these concepts manifests in robots designed to be programmable, in situ, by children of a wide age range, e.g. Lego Mindstorms [3]. Most contexts involving robot programming have been focused on behavioral tasks, e.g., navigation and manipulation.

In this contribution, we present a novel approach to programming, namely, the Social Robot Toolkit. It explores several fronts of computer science education: (i) tangible interface of custom-made vinyl stickers that is understandable and appealing to children; (ii) a social robot, DragonBot, designed to be engaging for children and; (iii) a context of social interaction, i.e., the children program rules that "teach" the robot how to socially interact. We present early observations of pre-school children using this toolkit in an exploratory study that demonstrate promise that children can use the Social Robot Tookit to explore new computational concepts, such as event-based logic, action sequences and non-determinism, while interacting with a socially engaging robot.

2. TOOLKIT DESIGN & EVALUATION

We use the DragonBot platform as the social robot to be programmed by the child. This is a squash-and-stretch expressive robot in the form of a cute furry dragon [4] controlled by a smart-phone. Dragonbot can express a wide range of body and facial expressions, as well as speak. In this exploratory pilot study, the robot was teleoperated by the experimenter via a tablet, to enable sensing. Later versions of the toolkit will support autonomous sensors.

The programming interface is comprised of a set of reusable custom-made vinyl stickers that represent triggers and events in a physical rulebook. Template stickers represent triggers (blue diamonds) and actions (green squares) with a black arrows that specifies order, Figure 1. The child can place a circular icon sticker for actions she can perform (e.g., clap hands, say "hi"), or a circular icon for actions the robot can take, e.g., facial expressions or saying something.

A rule is created by placing a blue trigger sticker with icon on the page, followed by a black arrow, pointing to a green

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Figure 1: Children exploring computational concepts with the social robot toolkit.

event sticker with icon on a page. For instance, Figure 1 shows the rule: when I say "hi" you laugh, and other more complex rules. The vinyl stickers can be written upon with dry-erase markers, which also enables children to experiment with their own writing, drawing, and creative ideas.

The programming interaction with the robot is socially situated, in the sense that the child "shows" the robot the rule she creates to "teach" it to the robot. The robot says "I got it!" upon seeing the rule and then can perform it, e.g., laugh whenever it hears "hi". The robot can be programmed with several rules, enabling experimentation with sequences and non-determinism.

The exploratory pilot protocol consisted of teaching the children to use the toolkit and observing their abilities and questioning them on their comprehension before, during and after the interaction.

3. RESULTS

Qualitative analysis of this exploratory study, with 3 boys and 5 girls, ranging in age from 4 to 8 years lead to important preliminary findings. The children explored different computational concepts. All children created simple rules with a single trigger and event. When asked what the rule means, one girl's rather typical answer, was: "when I clap my hands, the robot will do like this" and made a funny face, consistent with the robot action in the rule.

Children also learned about event-based logic and rules, i.e., the dissociation between commanding and programming. Commands which they showed the robot and the robot immediately performed; and programming, where they "taught" the robot a new rule that the robot would perform *whenever* perceiving the triggering event. Several children also experimented on their own with different types of action sequences, i.e., an action chain where a trigger leads to a response action which leads to another action. One child also explored non-determinism with the toolkit by having a single trigger point to several actions, see Figure 1. When asked "How does the robot know the order?" the child answered "It can be any order."

Children were highly engaged; they frequently expressed enthusiasm and excitement in "teaching" the robot new things to do. Furthermore, all were enthusiastic to continue the interaction by showing the robot more event stickers. A unique feature of the toolkit is its playful relational quality (social interaction context). Indeed, children communicated with the robot, e.g., "Hi", made silly faces to the robot and even petted the robot and taught it to say "I love you".

The children could also articulate ideas about programming, i.e., we asked one 8 year old boy: "How do robots decide what to do?" Before the session began, he answered "They are probably ... wires and everything that make them do things and everything, electric gadgets and everything.". After the session with the toolkit, his answer changed to "That electric gadgets and everything make something inside of it get programed to what you say and what you do, so that the robot does what you want."

4. CONCLUSIONS AND FUTURE WORK

We have presented a novel educational tool, the Social Robot Toolkit, aimed at pre-school aged children. It is based on a tangible interface which is appealing for this age group. Our early observations hold promise that young children are highly engaged with and can derive educational benefit from using the social robot toolkit. The children explored computational concepts while engaging in a social interaction with the teleoperated robot.

We aim to extend the toolkit to include additional events and actions, e.g., enabling the robot to react to faces the children make. Further, we intend to make the toolkit autonomous with more sophisticated sensing through machine vision and speech recognition. We shall also conduct a more comprehensive study with pre-school children to evaluate and quantify their understanding and engagement with the Social Robot Toolkit.

5. ACKNOWLEDGMENTS

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