Roles of Robots in Socially Assistive Applications

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***Abstract*—Socially assistive robots help people through *social*, rather than *physical*, interactions. While physically assistive robots act by physically manipulating a user's body, socially assistive robots provide help through tutoring, therapy, home assistance and other tasks. For example, tutoring robots can offer struggling students additional one-on-one assistance outside of the classroom. For such robots, the prevailing interaction paradigm sets the robot as an authority figure—a teacher or instructor—who conveys information to students. While robot-as-teacher can be an effective formula, robots are uniquely suited to other roles in the teacher-student relationship as well. This article describes our lab's work with socially assistive robots that embody alternative roles for teaching, including acting as peers and as students, as well as acting in multi-robot groups. We outline ongoing research with robots that help children and discuss some open questions in socially assistive robotics.**

I. Introduction

Socially assistive robotics (SAR) aims to help people through social, rather than physical, interaction. Application areas include robot tutoring [1], autism therapy [2], and elder care [3]. Tutoring applications are particularly well-researched because robot tutors offer a chance for students—especially children—to engage with and reinforce material outside a classroom environment, strengthening a teacher's impact and improving educational outcomes. Because robots can be programmed, teachers can determine how and when material is shown to students. And because robot behaviors are infinitely repeatable, robots make good practice partners. Robot tutors need not be limited to traditional classroom lessons. For example, robots can offer "real-world" training on topics such as healthy eating or handling emotions.

The prevailing paradigm for robot tutors involves robots as authority figures or experts. A robot is programmed with some information or a set of skills, and it tries to convey that knowledge to its human students. This approach has been successful in teaching sign language [4] and puzzle solving [5].

However, teaching can happen without a formal teacher-student interaction, and robots are uniquely suited to fill roles that would be difficult or impossible for an adult to adopt. For instance, learning can be augmented by *peer* interactions, in which student and teacher roles are fluid between a child and a robot. Children can also practice newly-learned skills by taking the teacher role themselves, with the robot as *student*. By using multiple robots at a time, *robot groups* can help students visualize their knowledge through storytelling and imagination. Our lab's work explores these alternate robot roles in a variety of child-robot interactions.

Fig. 1. Dragonbot collaboratively designing a meal in a peer interaction with a six-year-old.

II. Robots as Peers

Peer tutoring is a valuable addition to traditional classroom instruction [6]. In peer tutoring, the role of authority is intermittently exchanged between two peers. These interactions are helpful for sharing facts or concrete knowledge, which can be conveyed explicitly between peers. Previous research on robots as peers [7] looked at unstructured interactions without explicit lesson plans. Our lab's work focuses on designing child-robot interactions that present the robot as a collaborative agent while accomplishing specific educational goals.

One study from our lab investigates robot peers within the context of a lesson on nutrition [8]. Held over six sessions, the aim of the interaction is to increase children's knowledge about healthy eating. Children are tasked with designing a meal for a Dragonbot robot named Chili (Figure 1). Chili has some information about the nutritive value of certain foods (like that whole wheat bread has more fiber than white bread), but it relies on the child to synthesize this knowledge to create a meal. By alternately providing nutrition information and looking to the child for help, the robot swaps teacher and student roles with the child in a natural way. Metrics showed high levels of engagement and increasingly sophisticated communication from children over the six sessions.

Another study from our lab applies the robot-as-peer framework in an English language learning setting with four- and five-year-old children [9]. The goal of the interaction is to practice English verb conjugations with children whose native language is Spanish (Figure 2). The robot tells children a story in Spanish, but at key points it requests assistance in translating sentences into English. Key sentences use the Spanish verb *hacer*, which can be translated into English verbs *make* or *do*, depending on sentence context. By requesting assistance in translation, the robot allows children to take on the role of language authority in a playful, engaging way. Preliminary data analysis reveals improvements in children's language use over repeated sessions.

Fig. 2. A student translates sentences with a peer-like storytelling robot.

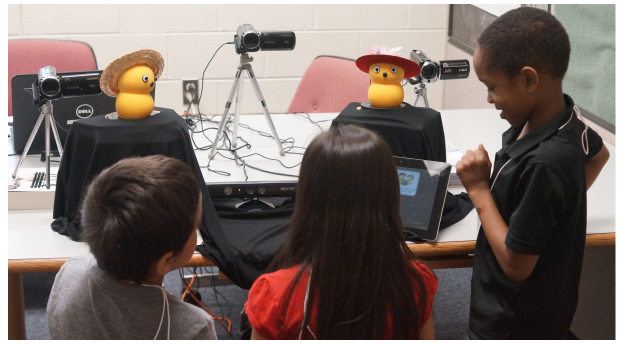

Fig. 3. Children explore social scenarios in a multi-robot interaction.

III. Robots as Students

Robots can also embody a strictly student role, inviting children to teach information they recently learned as a way of solidifying their knowledge. This is especially useful for learning that requires practice, such as behavior modification.

At the Yale Parenting Center, children with behavioral disorders are taught a series of steps to handle charged situations. In collaboration with researchers there, our group is conducting a study to investigate a robot intervention that reinforces learned behavioral modification by having children teach the information to a social robot. The robot, which is teleoperated in a semi-autonomous mode, engages with children purely as a student. The child leads the interaction and conveys information to the robot, strengthening their own knowledge in an engaging, confidence-boosting manner. This study, which is currently being performed, will compare the efficacy of the robot-as-student interaction to a written homework assignment, the current mechanism for lesson reinforcement.

IV. Robot Groups

Multi-robot settings open new possibilities for interaction. Controlling multiple agents allows researchers to modify interaction dynamics in desirable ways that would be impossible in single-robot single-user environments. For example, multi-robot settings enable social interaction between the robots themselves. For children learning about social behavior, having robots model social interactions and the consequences of certain decisions is a powerful teaching tool.

Under the RULER framework [10], children learn a series of strategies to handle bullying and other challenging social situations. Although they learn explicit strategies, the skills are fairly abstract and benefit from extended examples. A study from our lab, in collaboration with the Yale Center for Emotional Intelligence, uses two robots to help children understand and apply the skills learned through RULER. Children observe a short, pre-scripted interaction between the robots, which reaches an emotionally challenging decision point. At that point, children can select one of three responses, and watch as the robots play out the scenario with that response. For example, in one skit, a robot that is new to the class is sitting alone, and children must select the appropriate action for a second robot to make the first robot feel included: invite it to play a game, make fun of other students, or tell the teacher. For children, stories and skits are natural ways of conveying information. Preliminary analyses reveal high levels of engagement and interest, even over multiple interactions.

V. Future Work

Robot tutoring through non-traditional roles is a promising area of research. However, few studies (including those described here) directly compare the effectiveness of robots in alternative roles against robots in traditional teacher-student roles. Such studies are difficult to control, because researchers must ensure that similar information is conveyed through traditional and alternative behaviors. However, a direct comparison of alternative and traditional roles for robot tutors would help evaluate the benefit of alternative robot roles in teaching.

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References

[1] Kanda, Sato, Saiwaki, and Ishiguro, "Friendly social robot that understand human's friendly relationships," in *Proceedings of the 2004 IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2004, pp. 2215–2222.

[2] Scassellati, Admoni, and Matarić, "Robots for use in autism research," *Annual Review of Biomedical Engineering*, vol. 14, pp. 275–294, 2012.

[3] Wada and Shibata, "Living with seal robots—its sociophsychological and physiological influences on the elderly at a care house," *IEEE Transactions on Robotics*, vol. 23, no. 5, pp. 972–980, October 2007.

[4] Kose, Yorganci, Algan, and Syrdal, "Evaluation of the robot assisted sign language tutoring using video-based studies," *International Journal of Social Robotics*, vol. 4, no. 3, pp. 273–283, 2012.

[5] Leyzberg, Spaulding, and Scassellati, "Personalizing robot tutors to individuals' learning differences," in *Proceedings of the 2014 ACM/IEEE International Conference on Human-robot Interaction*. New York, NY, USA: ACM, 2014, pp. 423–430.

[6] Slavin, "Cooperative learning," in *Learning and Cognition*, Aukrust, Ed. Elsevier, 2011.

[7] Kanda, Hirano, Eaton, and Ishiguro, "Interactive robots as social partners and peer tutors for children: A field trial," *Human-Computer Interaction*, vol. 19, pp. 61–84, 2004.

[8] Short, Swift-Spong, Greczek, Ramachandran, Litoiu, Grigore *et al.*, "How to train your dragonbot: Socially assistive robots for teaching children about nutrition through play," in *International Symposium on Robot and Human Interactive Communication (RO-MAN)*, August 2014.

[9] Leyzberg, "Creating personalized robot tutors that adapt to the needs of individual students," Ph.D. dissertation, Yale University, August 2014.

[10] Rivers, Brackett, Reyes, Elbertson, and Salovey, "Improving the social and emotional climate of classrooms: A clustered randomized controlled trial testing the RULER approach," *Prevention Science*, vol. 14, no. 1, pp. 77–87, 2013.