Towards Effective Robot-Teleoperation in Therapy for Children with Autism

Saad Elbeleidy
selbeleidy@mymail.mines.edu
MIRRORLab,
Colorado School of Mines
Golden, Colorado, USA

ABSTRACT

Socially assistive robots (SARs) receive a lot of research attention due to their positive impact in a variety of contexts. Importantly, studies have shown that children with autism are much more receptive to SARs in therapy while resulting in similar learning outcomes. Given the sensitive nature of therapy and the current state of autonomous robots, in practice robots are teleoperated by a therapist controlling their motion and dialogue. There is an opportunity to produce more effective teleoperation interfaces of SARs in the context of therapy for children with autism. In this paper, I outline research for improving teleoperation interfaces of SARs through (1) analyzing current teleoperation usage, (2) interviewing therapists about their needs, and (3) implementing and evaluating varied designs for teleoperation interfaces.

KEYWORDS

Socially Assistive Robots, Robot-assisted Therapy, Children with Autism, Interface Design, Robot Teleoperation

ACM Reference Format:
Saad Elbeleidy. 2021. Towards Effective Robot-Teleoperation in Therapy for Children with Autism. In *Interaction Design and Children (IDC '21), June 24–30, 2021, Athens, Greece.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3459990.3463401

1 INTRODUCTION

Socially Assistive Robots (SARs) have been receiving increasing research attention over the last few years. Specifically, research of SARs for use with children with autism (CWA)[1] is on the rise. Research has shown intervention delivery to CWA through robots to produce measurable improvements in children's engagement[7, 16], spontaneous verbalization [3, 4, 10, 13, 18], and prosocial behaviors [2, 6, 21, 22] across both short and long-term studies [17]. For context, SARs exist in a vast space of therapeutic modalities aimed at engaging with children to deliver therapeutic interventions. Importantly, SARs result in similar learning outcomes when compared to therapy delivered by a human [20] while being unique in that children are highly receptive to them [7, 16]. Children's receptiveness is especially valuable given the importance of child engagement in therapy.

Most studies examining the effectiveness of SARs in therapy with CWA take place in a research context since robots have yet to be widely deployed in clinics. There is an opportunity to deploy robots widely to start benefiting from their positive effects on CWA. Cost is generally a barrier to high scale deployments, however, low-cost robots have been developed that use a touchscreen device such as a smartphone for the robot's face while the robot's body is similar to a fuzzy doll. An example of these is the Romibo robot [19]. The more pressing barrier to deploying these robots is their therapy delivery approach with two general options; autonomous robots and teleoperated robots.

While SAR autonomy is a heavily researched topic [5, 9, 18] with various approaches taken to create effective autonomous robots, in practice, therapists are teleoperating robots in therapy [1, 14]. Robot teleoperation is a more immediate solution that allows the current therapy industry to embrace robots as tools for therapeutic intervention delivery. If viewed as an intermediate stage, teleoperation could also provide valuable data to inform the development of autonomous robots. However, robot teleoperation is also an effective long-term solution. Given the sensitive nature of therapy, it would be valuable to continue having a human in-the-loop. Additionally, as CWA develop and improve their skills, the presence of a therapist can be valuable in verifying their skills transfer to human-human interactions.

2 RESEARCH QUESTIONS

Given the opportunity to widely deploy teleoperated SARs in therapy for CWA, I present the following research question as the high-level scope I aim to explore:

RQ How can we design effective teleoperation interfaces for robot-assisted therapy for children with autism?

To answer this high level research question, I plan to specifically focus on the following relevant components:

Q1 How are current teleoperation systems being used in robot-assisted therapy for CWA?
Q2 What are therapists' needs in conducting therapy for CWA, specifically in teleoperating robots?
Q3 What interface capabilities can meet therapists' teleoperation needs in therapy for CWA?

These questions aim to help us understand the current state of robot usage and deployment, the needs of therapists in conducting

[1]Throughout this paper I will refer to autism and children with autism upon considering the disagreement outlined in [12].

IDC '21, June 24–30, 2021, Athens, Greece

ACM ISBN 978-1-4503-8452-0/21/06.
https://doi.org/10.1145/3459990.3463401

Figure 1: The PEERbots interface used for teleoperating robots during sessions. The interface allows therapists to author content, organize content in collections called "palettes", connect to a robot, and control the robot's verbalization and motion. ©PEERbots

therapy in general, and the way in which different interface designs meet these needs. Answering these questions will move us towards designing effective teleoperation interfaces for robot-assisted therapy for CWA.

3 RESEARCH METHODOLOGY

In the remainder of this paper, I present my progress so far in answering each of these questions and my plan for ongoing work. This research covers archival data analysis, qualitative analysis of semi-structured interviews, and experimental evaluation of interface design improvements.

3.1 Therapist Usage

In order to find a population that works with robots in therapy in practice (i.e. outside of a research context) we've partnered with Fine Art Miracles (FAM) [11]. FAM is a service nonprofit that uses experiential therapeutic modalities to assist children and the elderly who are experiencing challenges. FAM runs 8-week programs for children with special needs at their schools to assist them with a variety of different skills. Therapists at FAM use the PEERbots[15] open source software to teleoperate robots in these weekly sessions. An example of the interface is shown in Figure 1. We acquired usage logs from two 8-week sessions run by a therapist including the content authored by therapists and verbalized by the robots. From there, we identified key content themes and usage patterns that led to design recommendations for improving robot teleoperation in the context of therapy [8].

Dialogue verbalized by the robot had one of the following intents: (1) rapport-building, (2) lesson content, (3) feedback, (4) attention management, or (5) ignorance. From these themes we identified key patterns about the therapist's usage that informed our design recommendations. While authoring, therapists author content in a sequential pattern where content is expected to be verbalized in the authoring order. Therapists also place dialogue options (buttons) with the same intent throughout a given collection, presumably for when that intent is reasonable in relation to surrounding options. For example, a feedback option verbalizing "good job" and another verbalizing "great" may appear several times within a collection, usually after questions. Another example is when the robot is greeting a child; multiple dialogue options are authored in order for the robot to say each child's name. Therapists also author collections specifically for a given session. During a session, therapists follow a sequential structure in relation to these themes; they may start with lesson content, then provide feedback when applicable and end a session with rapport-building. The bulk of any given session is lesson content.

From these usage patterns we provided some preliminary design recommendations to improve teleoperation interfaces for therapy with CWA. Given the identified themes and their sequencing, we recommend that authoring and teleoperation interfaces provide custom capabilities focused on the needs of each content theme. Due to duplicate intents of dialogue options with only slight variations as well as the inclusion of ignorance responses, we recommend the ability for interfaces to handle dynamic content that is unique to a given session or is discovered within a session. Finally, by looking at the sheer number of options within each collection for a therapist, as can be seen in Figure 1, we recommend the inclusion of suggested options that can lower the time for a therapist to make their desired dialogue selection.

Through our analysis of this archival data and our recommendations, we've begun to uncover some usage patterns of teleoperation in practice. Upon implementing design improvements, we plan to monitor therapists' usage to determine the effectiveness of these interfaces and ways to improve them as discussed in Section 3.3

3.2 Therapists' Needs

In terms of therapists' needs in robot teleoperation for therapy, we must understand their needs in conducting therapy in general, as well as how therapy is different when teleoperating a robot. We've begun semi-structured interviews with therapists asking about (1) how they prepare for and conduct therapy in general, and if applicable, (2) why they've used robots in therapy, (3) how they prepare and conduct therapy when using a robot, and (4) how they would use a specific interface (PEERbots) in teleoperating a robot in therapy. From their answers we aim to uncover therapists' needs that are consistent regardless of robot usage, determine how robots change therapy, and identify the gap in robot teleoperation.

From our preliminary analysis of the initial interviewee's answers, we've understood that therapy is an adaptive process that is customized for a particular child based on their abilities, goals, and how they're present in a particular session. Therapists try a variety of approaches, tools, and activities with children to get them engaged in the intervention that can help them. Robots are one of these tools that can be effective with engaging with CWA [7, 16] and since engagement is so crucial in therapy, robots have been uniquely successful at helping children achieve their goals.

When asking therapists why they use robots in practice, several respond that it is their employer's decision. They also say that they enjoy using robots because they see their impact on children. Therapists who no longer use robots in therapy say that is also due to an employer decision in that they wish they could use robots. Other relevant stakeholders to consider in this context are insurance providers and schools. While therapists' employers are the ones deciding what tools they get to use, this decision is heavily influenced by insurance providers who are providing the financial coverage for therapy. Therapists may also conduct therapy at schools who have their own priorities in therapeutic outcomes and practices for children. Therapists who have used robots in therapy want to continue using them despite the technology often malfunctioning. There is room for improvement in terms of stability, and capabilities that allow therapy to be successful. While therapy is highly customized in general, when using robots therapists have to predict the child's actions and produce a reasonable response ahead of time. Teleoperation interfaces allow for on-the-fly responses but therapists can't solely rely on that since it would still take a long time to respond. Response times of the robot are crucial, especially given that therapy with CWA is often focused on developing social skills including timely responses.

It is important to approach the improvement of these systems by understanding what end users (therapists) need. With this preliminary interview analysis, we've only begun to scratch the surface of what is most important to therapists in practice and what they need in order to make therapy with robots more widely accessible.

3.3 Interface Capabilities

Once we've established an understanding of robot teleoperation usage and what therapists need in this context, we aim to further develop design recommendations that inform interface development. We plan to develop several approaches implementing the design recommendations following best practices in interface design. For each implementation, we will design experiments to evaluate their effectiveness. Initial experiments will take place in a lab environment where individuals are asked to follow a script in producing a desired teleoperation outcome. We will analyze their interface usage to evaluate the various design implementations. Upon determining the best interface designs, we will deploy the design improvements to therapists teleoperating robots as part of their clinical practice and monitor their usage. Finally, we will interview therapists about their usage of the interface to determine their satisfaction level.

4 CONCLUSION

Socially assistive robots have shown much success in the context of therapy for children with autism. When used in practice, therapists currently teleoperate these robots, however robots are still not widely adopted. There is an opportunity to improve the effectiveness of robot teleoperation interfaces used in therapy to aid in their large scale deployment. To make progress towards improving these teleoperation interfaces, we believe it is important to (1) understand how therapists currently teleoperate robots in therapy with CWA, (2) understand what therapists' needs are in therapy in general, and (3) evaluate different interface designs in terms of their effectiveness at delivering therapy. We've described some progress in each of these areas and a path forward that we hope will provide the sufficient research to help in deploying SARs at a larger scale.

ACKNOWLEDGMENTS

I would like to thank Dr. Tom Williams, Aubrey Shick, and Dr. Elizabeth Reddy for their guidance on this research.

REFERENCES

[1] Laura Boccanfuso, Sarah Scarborough, Ruth K Abramson, Alicia V Hall, Harry H Wright, and Jason M O'Kane. 2017. A low-cost socially assistive robot and robot-assisted intervention for children with autism spectrum disorder: field trials and lessons learned. *Autonomous Robots* 41, 3 (2017), 637–655.

[2] Thierry Chaminade, David Da Fonseca, Delphine Rosset, Ewald Lutcher, Gordon Cheng, and Christine Deruelle. 2012. FMRI study of young adults with autism interacting with a humanoid robot. In *2012 IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication*. IEEE, 380–385.

[3] Eva Yin-han Chung. 2019. Robotic intervention program for enhancement of social engagement among children with autism spectrum disorder. *Journal of Developmental and Physical Disabilities* 31, 4 (2019), 419–434.

[4] Eva Yin-han Chung. 2020. Robot-Mediated Social Skill Intervention Programme for Children with Autism Spectrum Disorder: An ABA Time-Series Study. *International Journal of Social Robotics* (2020), 1–13.

[5] Caitlyn Elise Clabaugh, Kartik Mahajan, Shomik Jain, Roxanna Pakkar, David Becerra, Zhonghao Shi, Eric Deng, Rhianna Lee, Gisele Ragusa, and Maja Mataric. 2019. Long-term personalization of an in-home socially assistive robot for children with autism spectrum disorders. *Frontiers in Robotics and AI* 6 (2019), 110.

[6] Oliver Damm, Karoline Malchus, Petra Jaecks, Soeren Krach, Frieder Paulus, Marnix Naber, Andreas Jansen, Inge Kamp-Becker, Wolfgang Einhaeuser-Treyer, Prisca Stenneken, et al. 2013. Different gaze behavior in human-robot interaction in Asperger's syndrome: An eye-tracking study. In *2013 IEEE RO-MAN*. IEEE, 368–369.
[7] Julia Dawe, Craig Sutherland, Alex Barco, and Elizabeth Broadbent. 2019. Can social robots help children in healthcare contexts? A scoping review. *BMJ paediatrics open* 3, 1 (2019).
[8] Saad Elbeleidy, Daniel Rosen, Dan Liu, Aubrey Shick, and Tom Williams. 2021. Analyzing Teleoperation Interface Usage of Robots in Therapy for Children with Autism. *ACM Interaction Design and Children Conference*.
[9] David Feil-Seifer and Maja J Matarić. 2009. Towards the integration of socially assistive robots into the lives of children with ASD. In *International Conference on Human-Robot Interaction Workshop on Societal Impact: How Socially Accepted Robots Can be Integrated in our Society*, Vol. 21.
[10] Irini Giannopulu. 2013. Multimodal cognitive nonverbal and verbal interactions: the neurorehabilitation of autistic children via mobile toy robots. *IARIA International Journal of Advances in Life Sciences* 5 (2013).
[11] Fine Art Miracles Inc. 2021. *Fine Art Miracles*. https://fineartmiracles.com/
[12] Lorcan Kenny, Caroline Hattersley, Bonnie Molins, Carole Buckley, Carol Povey, and Elizabeth Pellicano. 2016. Which terms should be used to describe autism? Perspectives from the UK autism community. *Autism* 20, 4 (2016), 442–462.
[13] Elizabeth S Kim, Lauren D Berkovits, Emily P Bernier, Dan Leyzberg, Frederick Shic, Rhea Paul, and Brian Scassellati. 2013. Social robots as embedded reinforcers of social behavior in children with autism. *Journal of autism and developmental disorders* 43, 5 (2013), 1038–1049.
[14] Maja J Matarić and Brian Scassellati. 2016. Socially assistive robotics. In *Springer handbook of robotics*. Springer, 1973–1994.
[15] PEERbots. 2021. *PEERbots*. https://peerbots.org
[16] Ben Robins, Kerstin Dautenhahn, Rene Te Boekhorst, and Aude Billard. 2004. Effects of repeated exposure to a humanoid robot on children with autism. In *Designing a more inclusive world*. Springer, 225–236.
[17] Brian Scassellati, Henny Admoni, and Maja Matarić. 2012. Robots for use in autism research. *Annual review of biomedical engineering* 14 (2012).
[18] Brian Scassellati, Laura Boccanfuso, Chien-Ming Huang, Marilena Mademtzi, Meiying Qin, Nicole Salomons, Pamela Ventola, and Frederick Shic. 2018. Improving social skills in children with ASD using a long-term, in-home social robot. *Science Robotics* 3, 21 (2018).
[19] Aubrey Shick. 2013. Romibo Robot Project: An Open-Source Effort to Develop a Low-Cost Sensory Adaptable Robot for Special Needs Therapy and Education. In *ACM SIGGRAPH 2013 Studio Talks* (Anaheim, California) *(SIGGRAPH '13)*. Association for Computing Machinery, New York, NY, USA, Article 16, 1 pages. https://doi.org/10.1145/2503673.2503689
[20] Wing-Chee So, Miranda Kit-Yi Wong, Wan-Yi Lam, Chun-Ho Cheng, Sin-Ying Ku, Ka-Yee Lam, Ying Huang, and Wai-Leung Wong. 2019. Who is a better teacher for children with autism? Comparison of learning outcomes between robot-based and human-based interventions in gestural production and recognition. *Research in developmental disabilities* 86 (2019), 62–75.
[21] Joshua Wainer, Ester Ferrari, Kerstin Dautenhahn, and Ben Robins. 2010. The effectiveness of using a robotics class to foster collaboration among groups of children with autism in an exploratory study. *Personal and Ubiquitous Computing* 14, 5 (2010), 445–455.
[22] Joshua Wainer, Ben Robins, Farshid Amirabdollahian, and Kerstin Dautenhahn. 2014. Using the humanoid robot KASPAR to autonomously play triadic games and facilitate collaborative play among children with autism. *IEEE Transactions on Autonomous Mental Development* 6, 3 (2014), 183–199.