Robot Teleoperation Interfaces for Customized Therapy for Autistic Children

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***Abstract*—Socially Assistive Robots are effective at supporting autistic children in a variety of different therapies. Therapists can control the robots' motions and verbalizations to engage children and deliver therapeutic interventions based on their needs. We present teleoperation capabilities to support therapists in customizing therapy to their clients' needs. Specifically, we introduce a documentation sidebar that aims to prime therapists using their clients' documented needs, and a session summary report that helps therapists reflect on the session with the child. We present preliminary designs for these capabilities and describe future work to build upon them.**

***Index Terms*—socially assistive robots, teleoperation, teleoperation interface, autism**

I. Introduction

Autistic individuals[1] may have a variety of different needs for which they receive therapy or support services. Therapy must be tailored to the individual's needs and interests. Moreover, the success of a therapeutic intervention is dependent on how engaging therapy is to the client [2]. This has resulted in therapists sometimes adopting unconventional approaches to therapy such as art therapy [3], [4], music and dance therapy [5], and robot assisted therapy [6]. Children show increased interest and engagement when interacting with a robot [7], [8]. Autistic children, especially, are open to interacting with robots [9]. This has made socially assistive robots (SARs) a great fit for therapy with autistic children.

When these robots are used in practice, they are often teleoperated by a therapist [10]. This is likely the same therapist who would have provided therapy directly to the client were a robot not used; and the robot is often teleoperated to deliver the same therapeutic interventions they would normally have delivered without the robot. While the introduction of robots has documented benefits as described above, it also comes at a cost. Therapists report that while therapy is already difficult, doing so with a robot is even more time consuming.

There is therefore an opportunity to improve teleoperation interfaces to support therapists in ways that will limit these costs. Specifically, since therapists need to customize content for their clients, teleoperation interfaces can present information about clients to therapists as a reminder about the goals of a session. At the end of a session, the interface can present a session report that summarizes the content covered during a session including any metadata the therapist had entered previously. In this paper, we present two preliminary designs for these capabilities, and describe our plans to evaluate them through human subject experiments.

[1]Following guidelines provided by autistic self advocates, we will use identity-first language when referring to autistic individuals [1]

II. Motivation

A. Therapy for Autistic Individuals

Autism is a developmental disability that spans a wide range of experiences and behaviors [11]. Autistic individuals make up about 2% of the population [12] and may differ from neurotypical people in the way they communicate, socialize, and go about their daily life [11]. Autistic traits include, and are not limited to, exhibiting repetitive (and sometimes self-injurous) behaviors, preferring to avoid eye contact, and showing interest in few topics [11]. As such, autistic individuals will often receive therapeutic services at a young age as arranged by their parents.

Since autistic individuals do not all have the same therapeutic needs, therapy for autistic individuals can vary greatly. Depending on their specific disabilities, different therapies may be appropriate. If an autistic individual has a physical disability, physical or occupational therapy may be appropriate. In contrast, if they have a speech or language impairment, speech and language pathology may be appropriate. If the autistic individual has difficulty communicating and socializing, then applied behavior analysis may be suggested. Autism does not have a direct therapy that maps to fit all autistic individuals since each individual can have varying needs [11]. Additionally, each of these therapies must be carefully customized to the needs of individual clients [13], [14].

To customize content, therapists can spend a large amount of time preparing for sessions. They do so by examining their client's goals and interests. Using that information they can prepare content that engages the client and meets their therapeutic needs [13], [14]. Additionally, therapists must document sessions for a variety of reasons. Throughout therapy, a client's needs constantly change as they improve their skills or overcome challenges they are facing. This requires therapists to keep track of how the client is doing over time and update their goals. Doing so results in more preparation since therapy must now change to accommodate the new needs of the client. Additionally, therapy must stay customized to the client's interests to remain engaging.

Research has shown that for therapy to be effective, it must be engaging [2]. As such, therapists follow guidelines on how to ensure that engagement is a key part of therapy [15]; and the use of non-conventional methods such as art therapy [3], [4] or music and dance therapy [5] to appeal to children has shown much success, in part due to their ability to encourage engagement. Robot-assisted therapy has also shown much success, especially with autistic children, for similar reasons [6].

B. Socially Assistive Robots

Socially assistive robots (SARs) are robots that provide assistive services through social interaction [16]. An example of this is when robots are used to interact with autistic children in therapy [7], [8], [9], [17]. When used in therapy, these robots have resulted in increased eye contact by autistic children [18], [19] likely due to an increase in interest and engagement. This increased engagement can also lead to more collaboration between autistic children [20]. When interacting with robots, autistic children have also increased their verbalizations [21], [22], [19]. These examples show how SARs can support autistic children in a variety of therapies and increase children's engagement with therapeutic content. When these therapies are delivered without a robot, they are facilitated by a human therapist.

When SARs are used in practice, they are often teleoperated by a therapist [10]. Therapists control the robot's motion and verbalization to use the robot as the session facilitator. Children may be more receptive to the robot in that way since the robot does not present the same power dynamic that an adult would [23]. Therapists are often in the same location as their client and the robot while controlling the robot through the teleoperation interface. However, therapists are tasked with conducting similar therapies to what they would conduct without a robot. This requires fairly complex teleoperation capabilities and preparation. While therapists already may spend a large amount of time preparing for therapy and customizing therapeutic content, doing so with a robot takes significantly more time. This is due to the fact that therapists need to predict their clients' responses in therapy, and prepare and customize content responding to those predictions in advance of each session.

Research on SARs often focuses on the assistive capabilities of the robot and evaluates the resulting impact on the assisted individual. However, when SARs are teleoperated, the individual experiencing the burden of the system is the teleoperator. The therapist teleoperating the robot is the user of the teleoperation interface and should therefore be the focus of attention for teleoperation interface developers. Teleoperation interfaces should be designed with the operating therapist's needs in mind.

There is an opportunity to support therapists in teleoperating robots by improving their documentation capabilities so that

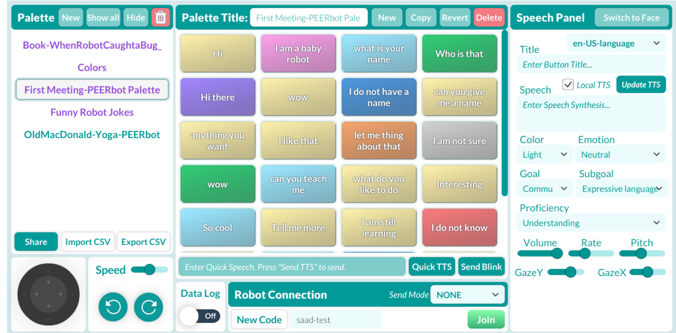

Fig. 1. An example of the Peerbots teleoperation interface. The center portion of the screen includes the buttons that, when selected, result in the connected robot verbalizing the contents of the button. The left sidebar presents a list of collections of buttons. This section allows a teleoperator to organize their content and easily navigate between grouped content. The right sidebar presents additional details about the last selected button and allows the user to edit its attributes. The bottom section of the screen presents robot connection and motion control capabilities. ©Peerbots

therapists can more easily customize therapy to their clients. In this paper, we present preliminary designs for two such capabilities: (1) incorporating client documentation in the teleoperation interface and (2) presenting documentation reports at the end of sessions to summarize a session. We also outline the research questions we hope to answer through human subjects experiments to evaluate these designs.

III. Technical Approach

A. Robot Teleoperation Interface

For this work we have chosen to build off of existing teleoperation interfaces. Specifically, we use the Peerbots [24] application as the teleoperation interface to improve upon since it is an open source application. The Peerbots application provides a comparatively low cost solution to SAR teleoperation and has also been used in practice in social skills programs for autistic children [10]. An example of the Peerbots teleoperation interface is shown in Figure 1.

Peerbots allows a teleoperator to control a robot's motion and verbalization in real-time. Ahead of time, a therapist can author and organize content they plan to have the robot verbalize during a session. Therapists can include useful metadata for each item verbalized. Importantly, therapists can specify a goal for the content verbalized as well as the proficiency level needed. This creates an opportunity for therapists to use this information after a session to evaluate a client's performance.

B. Client Documentation Sidebar

As a therapist controls the robot, they are actively selecting content that is specific to their client's needs. To support therapists with the recollection of their clients' needs, we propose a documentation sidebar that presents information about the child that the therapist or their supervisor have previously entered. By introducing the documentation sidebar, we aim to answer the following questions:

- Does having built-in documentation capabilities lead to more documentation by the therapist?

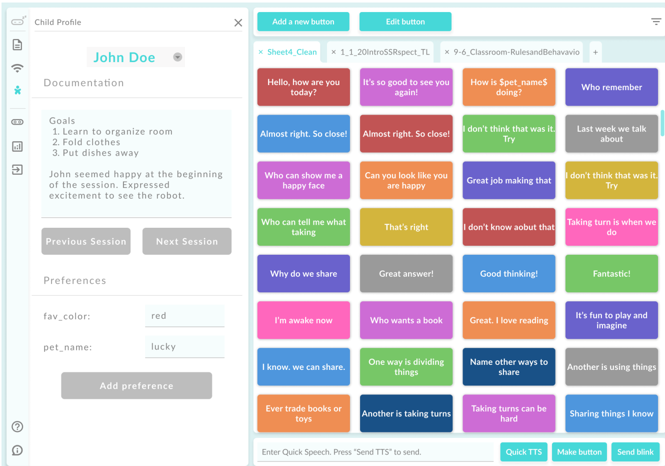

Fig. 2. A preliminary design of the documentation sidebar to include in teleoperation interfaces.

- Would a therapist check documentation about their client during a session if it was built in?
- Would a therapist update documentation about their client during a session if it was built in?
- How does a built-in system compare to current (potentially non-technological) systems?

Our preliminary design of the client documentation sidebar is shown in Figure 2. This sidebar allows therapists to select a particular child that they are interacting with during teleoperation. This can be done using the dropdown at the top that has selected John Doe in Figure 2. Upon selecting a specific client, the documentation sidebar shows the documentation about that client's sessions. It allows the teleoperator to enter content documenting the current session and also includes the ability to navigate between past sessions to preview earlier documentation that might be relevant.

C. Documentation Report

As a therapist controls a robot throughout a session, the therapist is able to save session logs locally through the Peerbots application. These session logs contain information about the content verbalized by the robot and its metadata; including timestamp, goal of content, and proficiency of content. The button information is primarily entered by the therapist using the robot or a supervising therapist. The goal behind the documentation report is to present the information provided by the therapist in a useful way at the end of sessions to guide them in reflecting about the session and evaluating their client. We aim to answer the following questions:

- Do reports help teleoperators develop an accurate mental model of what happened in the session?
- Do therapists think these reports help them at evaluating their clients?
- Does report accuracy affect teleoperator perception?
- Are visualized reports better at helping therapists notice inaccuracies in the metadata of the content?
- Does teleoperator perception of the reports and their efficacy differ based on teleoperator's therapeutic expertise?

Our preliminary design is implemented as a web application that allows a user to upload their saved logs and view a summary report of their session. The user can upload their log file and receive a report with the relevant information as shown in Figure 3. This web application can also integrate with the core Peerbots application to display the report directly after a session is complete. This approach gives users flexibility in reviewing reports of past sessions as well as the ability to view session reports upon session completion.

Fig. 3. An example session report.

Importantly, the session report contains information that is provided by the content author, and the teleoperator of the robot, both usually therapists when this tool is used with autistic children. The report aims to share a summary of that content so that therapists can reflect on the session. The report begins with some session identification information so the therapist is clear on which session the report is referencing. The report includes charts about the proficiency, goals, and emotions of the content selected. Each button containing content is labeled by a particular proficiency level and goal. These graphs present the frequency of each proficiency level and goal based on what was used in the session. Additionally, each button results in an emotional expression by the robot. The emotion chart presents the emotions that the robot expressed throughout the session and their frequencies.

Below the charts, the report includes several tables. The first table presents the content collections (palettes) used in the session and for how long each was used. The second and third table show the verbalizations that were followed by the longest robot pauses. These are split into buttons the teleoperator pressed and speech they typed ("Quick Speech"). This section may signal to therapists that there are particular verbalizations that result in a long pause until the next interaction. A box plot is also shown to visualize this information, depicting the distribution of intra-verbalization pauses. The outliers in this plot (i.e., the items shown in the preceding tables) can be clicked for more information. Finally, at the bottom of the report, the therapist can see every verbalization in chronological order with all the verbalizations' attributes such as proficiency, goal, and emotion.

IV. Conclusion

In this paper, we proposed preliminary designs of two teleoperation interface capabilities to support therapists in customizing therapy for their clients when using a robot during therapy. We also presented specific research questions to answer regarding each of these designs.

In future work, we plan on running several experiments with human subjects to answer our research questions. We plan on running different versions of these experiments with therapists and non-therapists to account for and understand the effect of therapeutic expertise on the usage of the new features. These experiments will be used to determine whether the newly designed product is in fact helpful at supporting therapists, and may allow us to make generalizable recommendations to the wider audience of SAR teleoperation interface developers.

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