
Exceptionally Social: Design of an Avatar-Mediated Interactive System for Promoting Social Skills in Children with Autism

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Abstract

Avatar-mediated and virtual environments hold a unique potential for promoting social skills in children with autism. This paper describes the design of “Exceptionally Social,” which is an interactive system that uses avatars to mediate human-to-human interactions for social skills training of children with autism. This system aims to offer the following functionalities: (1) gives children the opportunity to practice social skills in a safe environment, under various contexts. (2) changes the dynamics of the interactions based on the child’s affective states. (3) provides visual support for children to teach them different social skills and facilitate their learning. (4) reduces the cognitive load on the interactor (a trained human orchestrating the avatars’ behaviors) by providing real-time feedback about a child’s affective states and suggesting appropriate visual supports using a recommendation system.

Author Keywords

Autism; multimodal interaction; virtual reality, virtual peers, intervention

ACM Classification Keywords

H.5.1. Information interfaces and presentation (e.g., HCI): Artificial, augmented, and virtual realities;

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Figure 1: Child interacting with the system.

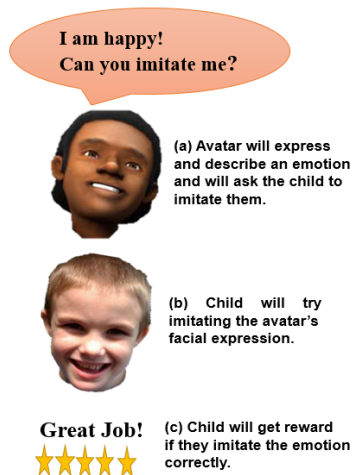


Figure 2: An example of our system in training children to understand emotions and the way they are expressed.

Introduction

Autism refers to brain development disorders that include difficulties in communicating and forming relationships with others. Although Autism Spectrum Disorders impact each individual differently, there are key characteristics that affect how people with autism interact with the world. Children with autism typically show difficulty in understanding social cues and other people's nonverbal gestures; they display problems in turn taking, maintaining eye contact, initiating social interactions, and responding to people [27].

Social skills are one of the important factors of one's success in the classroom, workplace and society. They are also critical to the success of interpersonal relationships such as friendships and romance which have significant effects on one's mental health [6]. As individuals with autism struggle with social skills, they have a hard time maintaining social relationships. Individuals with autism express loneliness as early as elementary school and their sense of isolation often increases during adolescence [3,23].

Boucenna et al. have shown that virtual environments are autism-friendly and can simulate social situations [4]. These environments can promote social skills of children with autism by providing an opportunity for the child to practice social skills. Some of the success of these environments is because they are stable, predictable and have structure, which can help decrease a child's anxiety [20]; moreover, children with autism prefer interaction with systems that include animations and sounds [15]. They can learn how to navigate through a social interaction under different contexts by interacting with avatars and virtual characters. Emotionally expressive avatars have been recognized as one of the most effective options in

improving the interaction of autistic children with virtual environments and improving their social skills [14,11,9].

Our system design focuses on helping elementary school age children with autism to (I) maintain eye contact while interacting with someone; (II) initiate social interaction with peers; (III) understand emotions and how they are expressed; and (IV) learn basic social rules such as turn-taking and greeting someone. This system will not only help children with autism to practice and learn social skills, it will also offer opportunities in eliciting various affective states in children with autism for the purpose of affect analysis and recognition, assessing the child's response to avatars' behaviors in various contexts and it takes initial steps towards reducing the cognitive load of the remote interactors, professional actors who are trained in improvisation, standardized virtual character behaviors, and interactive performance techniques.

Related Work

Impairments in social communication skills is one of the major challenges of children with autism. There has been an extensive body of work on developing technology to help children with Autism [10,18,26]. Most of these efforts show the effectiveness of computer assisted technology in helping children with autism. However, because of the limited space, we only focus on virtual reality and avatar-mediated systems.

Given the success of VR-based social interaction and the usefulness of monitoring eye-gaze in real-time, there have been several studies that design gaze-sensitive systems to help individuals with autism to maintain eye contact [16,17]. Some of these works also investigate the use of virtual characters in teaching



Figure 3: Social signals. A collection of nonverbal behavioral cues such as posture, gestures, laughter, etc. is perceived as a social signal (excitement, anxiety, etc.) [31].



Figure 4: Examples of the visual support that children receive in the interaction.

individuals to recognize the emotional state of other people [28]. Although these studies have shown success in achieving particular goals, there are common issues among the existing frameworks. We will discuss some of the four important ones that we address in our design: (1) Most of the previous frameworks focus on a limited set of fixed tasks such as maintaining eye contact. This over simplifies social interactions and ignores their complex nature. Individuals will find themselves in a much more complicated situation in real world interactions and will be unable to handle the interaction appropriately as the skill set learned in these systems is limited and have been taught under fixed contexts that do not generalize [2,15]. (2) Previous systems do not provide appropriate visual support, such as diagrams and graphics which has been shown to be an effective in teaching to children with autism [24], to individuals on social skills. It has been shown that people with autism, prefer feedback from a computer rather than a human [4,5]; however, this fact has not been integrated into existing systems to boost their performance and increase their motivation to learn. (3) The majority of previous systems are not affect-sensitive, and they do not consider the affective state of the person interacting with the system. We believe that affect is an important factor in designing assistive technologies [35], as some situations can make individuals nervous and should be handled with more care. (4) Avatar-mediated systems that must consider affective states of participants put a high cognitive load on interactors, which can lead to lower performance. With current advances in affective computing, computer vision, dialogue systems and machine learning [8,25,32] it is feasible to assist the interactors by automating or providing recommendations for some aspects of the interaction,

thereby reducing cognitive demand and helping the interactors to achieve more personalized interaction.

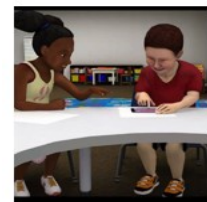
To the best of our knowledge our system is the first that will integrate the use of emotionally expressive avatars with an affect sensitive interaction and provides visual support for children with autism to facilitate their learning of various social skills under different contexts. This system also helps reduce the cognitive load on the interactor by providing context-aware feedback. In the following sections we will describe the design of our system and the options it provides in supporting social skill training for children with autism.

System Overview

Figure 5 shows an overview of our interactive system. Exceptionally Social will be built on a previously developed avatar-mediated interactive system [19] with enhancements that suit the purposes of social skill training for children with autism.

System Description

The proposed system consists of two major stations: (1) **Child's Station:** This is the station where the child interacts with avatars. The child's posture and facial expressions are monitored using the Microsoft Kinect and their speech is tracked using a microphone. These signals provide appropriate data for the visual and acoustic modules in the *Social Signal* (See Figure 3) *Recognition* module, described next, to provide feedback to the child about their performance and to the interactor about the child's success in learning social skills and their affective state. These signals also help the recommendation system to keep track of the state of the interaction and retrieve visual support accordingly.



(a): playing a social interaction between avatars, where there was a problem in the interaction.



(b): Sending Visual feedback and describing what went wrong and how should one act in similar situations.



(c): Giving the child a chance to practice the social skill in the same situation

Figure 6: Example of the simulation of a social situation in our system.

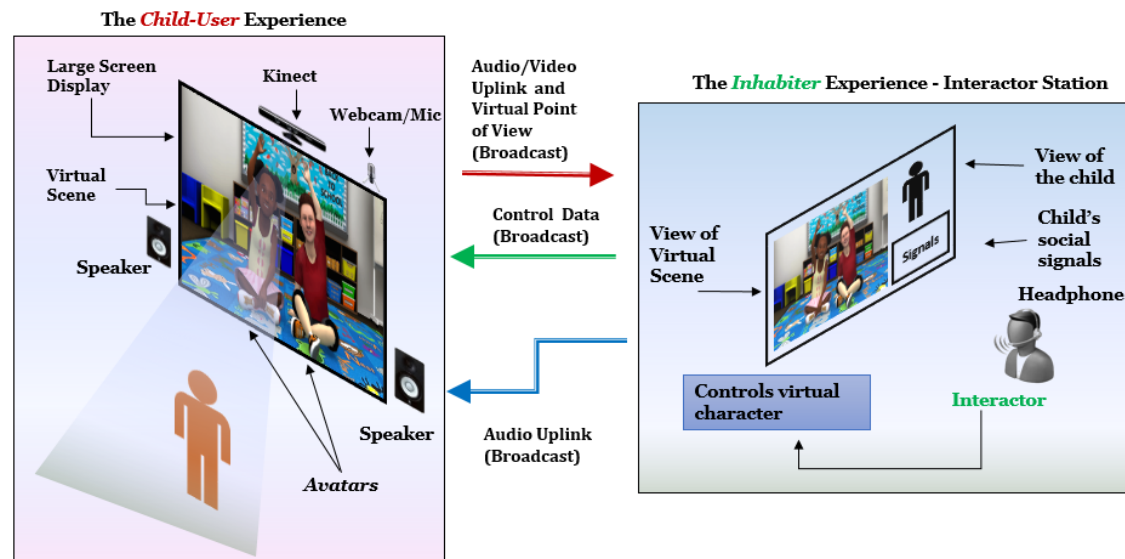


Figure 5: Overview of our system. The system has two main stations (1) child station where the child will interact with the system (2) Interactor station where the interactor will control the avatars and talk to the child.

(2) **Interactor's Station:** The interactor controls the avatars from this station. The interactor receives input that considers the dynamics of the interaction and the affective state of the child. The interactor will be provided with options from which they can select appropriate visual support to the child and they will be given warnings if the child is experiencing a negative state such as anxiety or anger.

Social Signal Recognition

Figure 7 shows an overview of our social signal processing unit. Automatic recognition of social signals in real time is of importance towards effective interaction design for children with autism. Interactors can also benefit from this feature by keeping track of

the child's affective states and their behaviors for designing the interaction accordingly. As the purpose of our system is to promote social skills by practicing in an interactive environment, it is not feasible to use an offline annotation process that employs human workers for tagging social signals such as eye contact, turn taking, etc. We are proposing to integrate a social signal recognition module in the system to provide real time information about some of the most important social signals. To achieve this goal, we extract information from both visual and acoustic channels.

Visual Signals : (1) Gaze tracking: This module is necessary for tracking the gaze behavior and

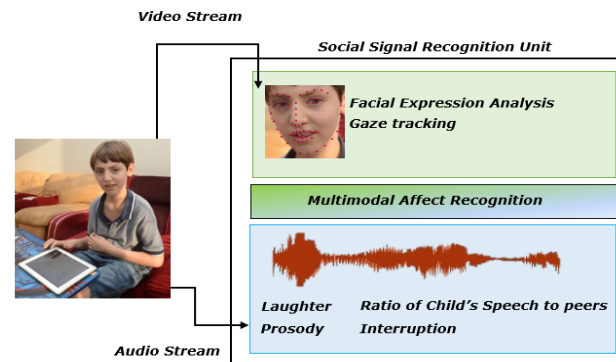


Figure 7: Overview of social signal recognition unit.

recognizing the ability of the child to maintain eye contact with the avatars in an interaction. (2) Facial expression analysis: This unit outputs information such as smiling or frowning. By using this module, in a matching process, the system will recognize if the child is successfully imitating the facial expression of the avatar and will give them rewards if the child's facial expression matches that of the avatar. Figure 2 shows an example of this module in social skills training through our system.

Acoustic signals: The information we extract from the audio channel includes laughter [30], prosody, ratio of the child's speech to their virtual peers and interruptions [7]. These signals will help the system to detect some social behaviors such as turn-taking, being responsive and dominating the interaction.

Finally, our multimodal affect recognition unit uses extracted information from visual and acoustic channels to provide information about affective state of the child. These affective states include basic emotions such as happiness and sadness as well as complex emotions like confusion and frustration. These modules have

already been developed in our previous work [1,20,21] and will be integrated as a part of our existing interactive system [19].

Visual Support Recommendation and Feedback

One logical approach for teaching social skills to children with autism is to break down social skills into their components and then teach these basic skills in a stepwise fashion. Although it is effective to simplify the language and provide some structure and predictability [13,18,20], these skills and interactions should not be oversimplified and learned only under a certain context. Individuals with autism find it difficult to perceive the relevance of a certain social skill under a different context, if it is learned in a certain setting [12].

Rao et al. [24] have explored different ways of teaching autistic children and have found that providing visual supports such as drawings, graphic organizers, flow charts, and Venn diagrams in addition to verbal instructions is effective in teaching children with autism. Visual supports can attract a child's attention and make abstract concepts more concrete. They can help give structure and routine to the message and enable children to focus better, which can result in reducing their anxiety [36].

There is also some evidence that children with autism might prefer to receive feedback about their performance from a computer rather than an examiner [5]. This evidence shows that receiving feedback from a computer can increase the motivation of children to learn the tasks.

Additionally, our system makes the social interactions with avatars more realistic by replacing the child's face with an avatar's face and letting the children observe their behaviors in a peer-to-peer interaction in the

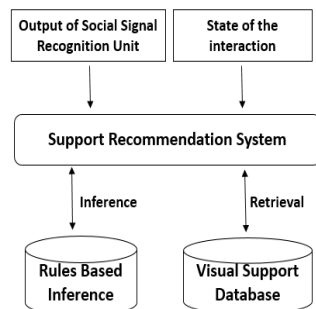


Figure 8: Architecture of our rule based visual support recommendation system.

virtual environment [33, 34]. Figure 6 shows an example of a social interaction with the goal of teaching children the importance of sharing while playing. (a) First the child observes the interaction between two other children, (b) then the child received an explanation of what went wrong in the interaction and how one should act in these situations and gets visual and verbal instructions/explanations. Appropriate visual supports are displayed to the child by keeping track of the state of the interaction, processing audio-visual signals of the child and using a rule based inference system that is designed based on social rules. Figure 8 shows the architecture of our visual support recommendation system. (c) Finally the child can see themselves in the environment interacting with the avatar and practicing the target social skill and is rewarded if they do well.

In addition to helping the child, Exceptionally Social takes steps towards reducing the cognitive load that is being imposed on interactors. The less they shift their attention to analyze detailed facial expressions trying to figure out the user's affective state, the more they will be able to focus on the interaction and use mental resources to assure avatars stay in character. This system will assist interactors by displaying real-time information on the child's affective states and automating the visual support recommendation.

Conclusions and Future Work

In this paper, we presented the design of an avatar mediated interactive system for social skill training of children with autism. Our system will offer a valuable opportunity for children with autism to practice social skills via role-playing under various social contexts in a safe and supportive environment. To our knowledge, this is the first affect sensitive avatar-mediated system

that will offer visual support provided by a computer for teaching social skills to children with autism. Our system provides a step towards reducing the cognitive load on the interactors by offering real-time feedback on the affective state of children and automatically providing visual support recommendations.

After finishing the integration of the social signal recognition and the visual recommendation modules to our existing avatar-mediated system, future work will focus on user studies. It is only by studying actual users in their real-world spaces., e.g., homes, schools and therapist offices, that we will get to know the actual capacities of our system. We will evaluate our system using a number of criteria including: social rules that the child learned to follow; number of times the child recognized an emotion correctly and can express it the same way; number of times the child initiated a social contact; and number of times the child maintained proper eye contact. At the end of the training, children who received the training should do significantly better than the ones who did not. The results of these evaluations will enable us to tackle different challenges of social skills training and gain further insights into possible improvements to the system.

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