

A Study on Virtual Reality Design Considerations and Training Skill Applications for Children with Autism Spectrum Disorder

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Abstract:- Virtual Reality is an immersive application and a popular training, rehabilitation tool especially for individuals with Autism Spectrum Disorder (ASD). VR increases the effectiveness of learning and allow to practice in a safe environment for children with ASD. There are possibilities to control the tasks complexity based on their interests and engagement. This paper presents the guidelines for designing VR environments and made a brief study on the papers of various applications that train skills in VR for children with ASD.

Keywords:- Virtual Reality (VR), Autism Spectrum Disorder (ASD), Design Guidelines, Skill Training Applications.

I. INTRODUCTION

A. Virtual Reality

Virtual reality is a realistic immersive simulation of three dimensional environment. Engaging with the virtual world with the help of VR gears and controllers makes the person to experience the 'model of reality' [1], where the person can sense sight, sound and even touch /control the environment.

The initial idea was presented by Ivan Sutherland in 1965 explained that make (virtual) world real to feel, look and hear to the viewer's actions [Suth65]. The main differences between VR system and traditional media [2]:

- The features like immersion, presence and interactivity makes the VR field unique from other technologies.
- Sharing the VR environment is allowed by using networked applications.
- Motion tracking and movement utilization of the users and converting into possible interaction in the environment [3].

B. VR: Modeling, Interaction and Rendering

The integration of input and output parts of the system will contribute for an effective VR performance and interaction.

- The construction of VR environments will involve many complex methodologies compared to standard computer graphic techniques. Modeling of high quality and detailed scenes involve complex data structures, better precomputation analysis, adequate memory management and the simulation process which manages

the whole environment.

- Complete VR world means 'no user interface'. Since it includes technical risks human – computer interface is still applied and metaphors are used to enhance the interactions. The transparency and refinement of both hardware and software is needed to bring the naturalness.
- The visualization in VR is considered to be a crucial part of the work where it involves the aspects of coordinating the systems transformations and the stereo vision perceptions [4].

C. Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a complex neurobehavioral and not a single condition it is a spectrum of disorders. It is difficult to characterize individuals with a single stereotype that includes triad of impairments in social interactions, developmental language and communication skills combined with rigid and repetitive behaviors [5].

As per Diagnostic and Statistical manual of Mental Disorders (DSM5), compared to previous DSM 4 the disorders such as Asperger Syndrome, Childhood disintegrative disorder, Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) are included under the Autism Spectrum Disorder (ASD). Only the Rett Syndrome is considered as a separate disorder [6].

Autism for many people is a whole-body disorder. The combination of problems with autism includes epilepsy (seizure disorder), gastrointestinal disorders, disrupted sleep, and feeding/eating issues. It can also affect the mental health severely which induces anxiety, depression, bipolar disorders and also causes premature death [7].

ASD can be typically identified in the first 3 years among children by noticing the deficits in behaviors such as hyperactivity, aggression, reduced eye contact, cognitive impairments, lacking of sensory perception skills and experiences, emotional indifferences, repetitive behaviors and unusual body gestures [8].

D. Virtual Reality Applications with Autism

Virtual Reality (VR) allows ASD people to experience the realist environment to learn and manipulate the things in a safe manner [9]. VR technology has been used in the treatment of autism for more than two decades researches have been experimenting by setting scenarios to study

autistic traits successfully. Some of the popular VR experiments are first- person shooter game, the virtual job-interview training program built by Rizzo’s team, an application of a virtual classroom with an audience of eight avatars to practice public speaking for autistic children to encourage them, designed by University of California. In

2016, an agency developed an immersive experience for the non-profit National Autistic Society to portray how an autistic child might feel at a shopping mall called ‘Don’t Panic’ to showcase their isolated and overwhelmed experiences [10].



Fig 1:- Autism Individual Practicing Job Interview Skill in VR



Fig 2:- ‘Don’t Panic’ Application

II. GUIDELINES FOR DESIGNING VR APPLICATIONS FOR

❖ ASD PARTICIPANTS

This section explains the guidelines that are established by reviewing many previous literature papers so far which are based on the context, characteristics and preferences of small group of participants in the study. Though the design considerations are based on each individual aspect but these are the common ideas and methods to follow based on the study

A. Strategies for Presenting Information

➤ *Visual:* The concurred studies shows the graphics used for facial expressions should be emphasized. The detailed appearance of virtual avatars perceived many

of the ASD participants.

- *Environment:* Scenes with little clutter made participants to navigate through the environment very easily than making them overwhelm by more colorful objects.
- *Sound:* Several studies have suggested that verbal instructions for tasks gave preferable results when compared to no instruction. Unexpected sounds are found annoying and it should be avoided. Providing volume control will help more.
- *Animation:* Based on the researcher’s observation animated objects drawn the attention and increased the interest towards the environment. Whereas, high dynamic objects have caused the distraction from tasks [11].

B. Constraints for Designing Tasks

- *Repetition and session representation*: Repeating the tasks that are already learnt gave better results when compared with earlier sessions due to the memory skills of the individuals with ASD. Having short attention spans the contents should not be overloaded. Short sessions are preferable for better results [12].
- *Task Complexity*: Giving tasks that are unachievable and more complex demotivates the participants from the task. The dynamism, annoying noise are also advised to be removed [13].
- *Reinforcements/ Feedbacks*: For presenting the task performance the attractive tools such as score bars or task counters helped to retain the concentration towards the task [14]. For highlighting the negative actions by the participant's animations are not suitable because they don't understand the feedback given is not sufficient instead they will enjoy watching the animations. So to fix this problem the researchers have found out an alternative as displaying 'black screen' for one or two seconds will make them realize and helps them to stop the wrong action. Positive reinforcements or rewards should be given as to map the visual effects to sensory interest by showing attractive color, shape for creating the motivation among them.
- *Interaction level*: The interaction that involves full body into the environment provided better results than compared to the parts or minimal amount of body engagement [15].

III. VR BASED TRAINING SKILL APPLICATIONS AND OUTCOMES

A. For Training Emotional and Social Skills for Children with ASD

In 2018, a VR training program was developed train the emotional and social skills with six VR – based environments for primary school children diagnosed under ASD in Hong Kong. The sample set for analysis taken was 72. The environment was presented in a four side Cave Automatic Virtual Environment (CAVE) technology to allow great interaction with objects and avatars. The environment consisted of already learnt skills was exposed there. Six learning environments were designed with scenarios like training, relaxation and consolidation. The results were promising as their parents expressed that their children acted more proactively with social engagements such as greeting and communicating with neighbors. Their teachers also reported that they started to make new friends by having two-way conversations [16].

B. Multi-Modal Based Social Interaction for ASD Children

In 2016, the work presented the design and development of an adaptive multi-modal based social interaction platform for ASD children. This system is based on a school cafeteria environment where children interact with virtual avatars. The monitoring of task performances are done by using an eye tracker, an EEG monitor and biosensors data. The system successfully analyzed and was able to collect all the data from devices and helped in developing the impairments in social behavior for individuals with ASD [17].

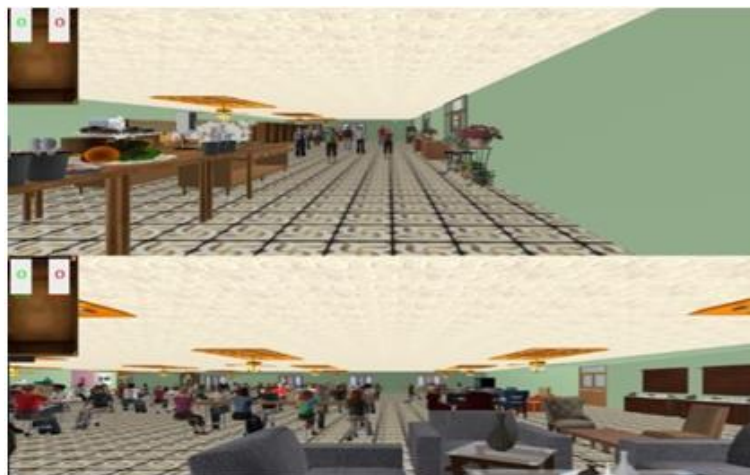


Fig 3:- The VR Cafeteria Environment for the Social Task

C. Cognition Training for Children with ASD

This study in 2016 investigated to enhance the social skills among children with ASD. The children considered for this study ranged between the age group of 7-16 diagnosed with ASD. Two sessions were held twice a week for 5 weeks. The environment consisted of locations like: a school classroom, playground, a central park, a campground and some other designed were developed to resemble each scenario and to match with the avatar characters in the environment audio voice manipulation

software called MorphVox was used.

Avatars are controlled by keyboards and mouse for body gestures like run, walk. All the sessions took place with two trained clinicians. This is a comparative study between normal children and children with high functioning autism. The results shown improvements at each sessions. This model allowed participants to encounter social skills [18].



Fig 4:- One of the Session – Classroom Project

D. Intelligence VR Driving System for Autism Intervention

This paper in 2015, designed a VR based driving model system to train and improve the driving skills with different difficulty levels. It measures the users cognitive load experience while driving. This experiment includes 12 teenagers with ASD. This model was compared with many machine learning methods for accurate measurements. The eye-gaze analysis were made to detect the baseline data while driving for ensuring their attention towards screen and task. A method called One way Analysis of Variance (ANOVA) was applied to check the eye gazing features under different aspects. The accuracy shown was above 72% for the methods selected in the paper [19].

E. Teaching Pedestrian Crossing Skill for Children with PDD-NOS

In 2015, for children with PDD-NOS developed a model for teaching road crossing skill to improve their safety. This study consisted 6 children for four sessions. The children were exposed to an immersive learning method of VR CAVE setting. The setup included wall screen with resolutions for projections, pair of stereo glasses with trackers, infrared cameras and an Xbox controller.



Fig 5:- Child Waits For Signal and Child Crossing Road with Mentor

The special education teachers guided them lively and verbal help is given when necessary. Each given four trails and at the last day of session four were able to give the predicted result and complete the task successfully [20].

F. Virtual Reality Exercise Game for Children with Autism

In 2014, a study was presented for 10 children with autism to monitor the physical activity and motivational level by immersing them into a virtual reality exercise game which involves fast-paced full body movements. Two sessions held in a lab about a week apart. The participant has to play the game Astrojumper as per given guidelines. Based on the given questionnaire the participants fill out their ratings for the game. The evaluations were based upon the Demographic and Physiological measures. Finally, the results were able to achieve exertion levels and even some children wanted to play the game again [21].



Fig 6:- In a Three Wall Rear-Projected Display Child Plays Astrojumper

G. Adaptive Responsive Technology for Children with ASD

In 2013, an interactive VR based system was developed to identify and quantify ones engagement level in tasks to improve the social based skills. The system was tested for eight children with ASD. The social communication task module involved two methods: Design of a VR-based task presentation module and design of Bi-Directional conversation module. The individualized Adaptive Response Module was based on two aspects and they were (i) Performance-Sensitive System (PS) (ii) Engagement-Sensitive System (ES). Results from this usability study enhances learning via communicating avatars and monitoring of eye-gazes to improve better social communication skills for users [22].



Fig 7:- Sample of Bi- Directional Conversation Module

H. Virtual Learning and Social Stories for Autism Children

In 2014, an implementation was designed for solving the social problems by presenting in through the formats of social stories. The VLSS environment was designed using the OpenSimulator open source platform. The environment represented the Greece school premises with a classroom and an interactive whiteboard with displayed both text and images. The scenarios described the social situations happening at home and school. The empirical evaluation was based on a online questionnaire for the participated special education teachers. The final evaluations reported that this system is easy-to-use and a beneficial educational tool for solving the social problems of autism children and also stated avatars play crucial role for motivating students [23].



Fig 8:- In a Three Wall Rear-Projected Display Child Plays Astrojumper

IV. CONCLUSIONS

In summary, the VR technology proves the ability to train and make learn about the basic skills for the individuals with ASD. The systems model in VR are safe and can contribute to any of the problem domain. The VR technology for autism children plays an important role and can result in positive feedback after required sessions for each type of training. This tool embraces therapists, counselors, parents and children as the best medium for dealing children with autism. In future VR's virtual experiments and simulations will be found in all range of applications for treating the therapy based disorders.

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