

Autism Spectrum Disorder Treatment Through Virtual Environment: A Survey

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Abstract— Virtual reality (VR) is a technology that simulates 3D image or environment that allows user to interact with a real or virtual environment. Virtual realities artificially create sensory experience, which can include sight, touch, hearing, and smell. The output of virtual realities may be either through computer monitor, head-mounted display, speakers or headphones. The immersive environment can be similar to the real world in order to create a lifelike experience. Autism is a spectrum of developmental disorder characterized by qualitative impairments in social interaction and communication and a restricted range of activities and interests. There are many treatments and therapies for autism. We have suggested a treatment using virtual environment which increases the Intelligent Quotient and Behavioral quotient of a particular child. By increasing the interactivity of the environment, the attentiveness of the child can be increased.

Keywords—Virtual Reality, Virtual Environment (VE), Virtual Gaming, Autism Treatment, Interactions, Artificial Intelligence, Human Computer Interaction (HCI)

I. INTRODUCTION

Virtual Reality (VR) is to immerse a user within a computer generated, virtual environment that should be visually identical to the real one. The basic concept is to block out the sensory input from the outside world and use the visual and auditory cues to give a feeling of reality to the virtual world. VR has its applications in a large spectrum of fields such as Military, Education, Healthcare, Entertainment, Fashion, Construction, Business and the arts. Virtual reality apps are Augmented Reality, Virtual Worlds and Kinect. VR depends highly on Artificial Intelligence (AI). For making more realism and increase Human Computer Interaction, AI plays a major role. It is also used to design good haptic interfaces. As Virtual Reality plays a major role in Health care, we have focused our research towards treatment for Autism Children.

Autism is one of five developmental disorders included under the umbrella of the Pervasive Developmental Disorders [23]. In addition to autism, other disorders in this family are Asperger's Syndrome, Rett's Disorder, Childhood Disintegrative Disorder. According to Kathleen Quill of the Autism Institute, —children with autism display a wide range of attention disabilities and deficits across the many domains of attention function, including selective and sustained operations.|| *Selective attention* refers to the ability of children with autism to stay on task, even when a distraction is present, and *sustained attention* refers to their ability to focus for an extended period of time during continuous or repetitive activity.

Children with autism also experience difficulties recognizing and expressing emotions, and most educators and psychologists agree that children's emotions can affect their ability to focus on a task. Therapeutic interventions for autism heavily rely on *discrete trial teaching*, a method that breaks down tasks into smaller components called *trials*, and *stimulus-response-reward techniques* that use physical objects to teach basic skills such as attention management, compliance, and imitation. However, most children with autism find task repetition boring and frustrating, and the objects used don't appeal to them. Consequently, children with autism often spend a lot of time off task and have difficulty sustaining their selective attention. Caretakers use a variety of strategies to help such children stay on task and have a more positive experience, such as annotating text on top of physical objects, using verbal and physical prompts, and offering rewards.

These therapeutic interventions cannot be made common for autism treatment, because of its spectrum nature. It means it varies with each and every individual affected by autism. Autism is characterized by deficits in social interaction and communication, and unusual and repetitive behavior. Cognitive abilities in people with autism vary between those with average to above average intelligence, and others who function within the moderate to profoundly mentally retarded range. Mostly, autism manifests at birth or within the first

two-and-a-half years of life. Many autistic children are perfectly normal in appearance, but spend their time engaged in puzzling and disturbing behaviors that are different from those of typically developing children. They may show little or no interest in people including their parents, and pursue repetitive activities with no apparent purpose. The prevalence of autism is estimated at 1–2 per 1000, and close to 6 per 1000. This paper is organized as follows. Section II gives a brief survey on autism spectrum disorder treatment. Section III describes the methodology of the proposed work and Section IV presents the outcome of the survey. Section V concludes this research.

children. Next, teachers select from the tablet the object children need to discriminate, and monitor students' responses on each trial. Children later put their smart phones on the physical object, using it as a —visor to uncover the digital content tagged on top of the object. Results shows that how the individuals with autism and their caregivers intuitively, effectively, and ubiquitously interact with smart environments

An innovative **VR-based facial** emotional expression presentation system [18] that allows monitoring of eye gaze and physiological signals related to emotion identification to explore new efficient therapeutic paradigms. This system captures the facial expressions of the user and act accordingly. A usability study of this system has been studied with 10 adults. The eye tracking and physiological data were analyzed

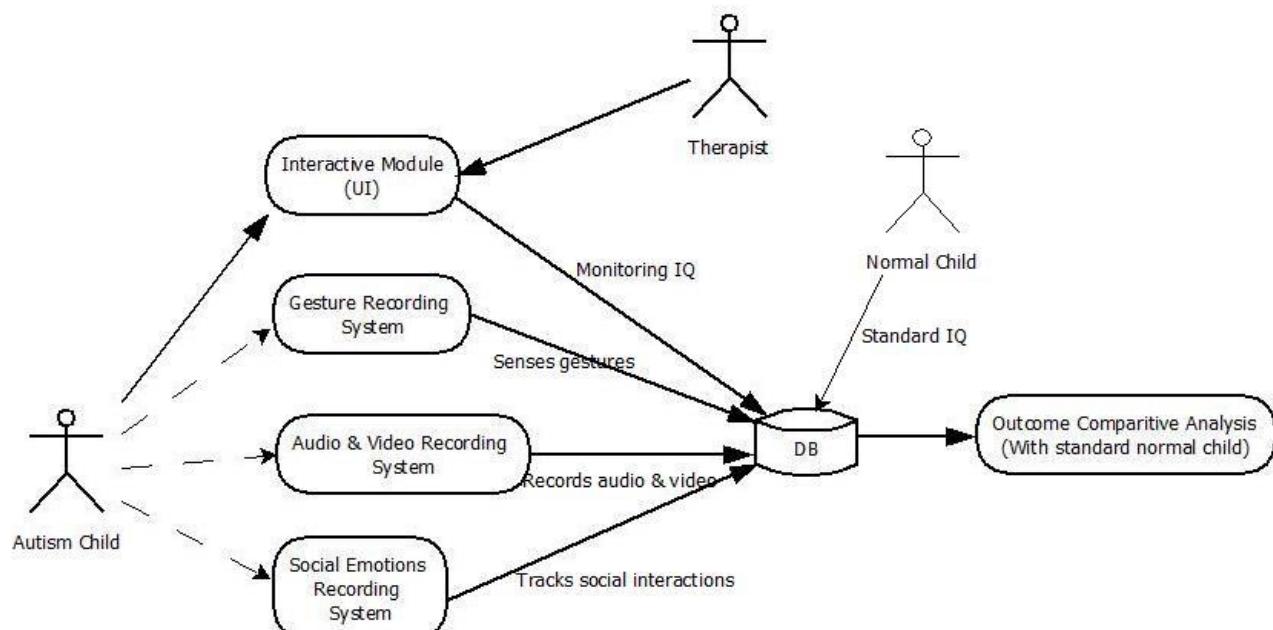


Fig.1 Proposed Autism Treatment using virtual environment

II. RELATED WORK

Mobile Object Identification System (**Mobis**) is a smart environment [14,16] for autism children using android tablets. This highly interactive physical world furnished with sensors, actuators, and novel displays that are seamlessly embedded and connected through advanced communication technologies. Cognitive training is given using Mobis in such a way that the students are given various objects and a cognitive goal, the student has to discriminate between various items to identify the goal object. Mobis is an AR system that lets teachers to superimpose digital content—including text, audio-recorded messages, and visual shapes on top of physical objects used for cognitive training. First, teachers use their tablet to create a database of images used during therapies and associate digital content that will be later discovered by

to determine intra-group and intergroup variations of gaze and physiological patterns. These results were used in future for developing an online adaptive VR-based multimodal social interaction system to improve emotion recognition abilities of individuals with ASD.

FACE [21] is an interactive life like facial display developed in android platform that helps the children with autism to learn, identify, interpret, and use emotional information and extend these skills in a socially appropriate, flexible, and adaptive context. Therapist will help the student to interact with FACE. The treatment scheme is based on a series of therapist-guided sessions in which a patient communicates with FACE through an interactive console. If the student is not interested the image will fade off. It has been developed with an underlying philosophy and design approach

of the display is founded on the simulation of biological behavior using materials, structures, and control algorithms that can replicate some of the functions and responses of living systems. The architecture of the facial automaton consists of an anthropomorphic head and a facial tracking and expression recognition device. FACE is able to express and modulate the basic emotions in a repeatable and flexible way, to quantitatively analyze the emotional reactions of individuals through optical analysis of facial expression, to track a human face over time, and to automatically store all data. FACE's control can be performed by an external supervisor or by an algorithm which implements a predefined design. The skeletal support structure is a resin based reconstruction of the head of a real adult subject, realized using CAD/CAM. Soft tissues of the head were fabricated from materials used for facial reconstruction in the world of animatronics and archeology [22].

Virtual Dolphinarium [19] has been developed for potential autism intervention. Instead of having Dolphin Assisted Autism therapy they provide IDM- Enabled Autism Therapy. Dolphin Assisted Therapy encounters between dolphin and children with autism. These children have to spend their initial times in out pool activities to encounter the real dolphins. This treatment is not affordable as many because it's an endangered species. And also putting weak children to a strong dolphin is not advisable. So they have proposed Virtual dolphin interaction program that will allow children with autism to act as dolphin trainers at the poolside and to learn nonverbal communication through hand gestures with the virtual dolphins. Immersive visualization and gesture-based interaction are implemented to engage children with autism within an immersive room equipped with a curved screen spanning a 320° and a high-end five-panel projection system. It will promote learning skills and positive behavior.

Joint attention [17] plays a major role in the development of autism. This helps to identify the social interactions of an autism child by gaze inputs. Human gaze conveys important non-verbal communication and expressive cues. Some researchers attempted to model these communicative cues in virtual or robotic agents to create credible non-verbal communication phenomena based on gaze. They developed Virtual Attention Object paradigm (VAO) that notices the candidate's focus of attention of the user. The system then evaluates the level of engagement of the user in the task by estimating shared attention with the virtual character. To have reliable eye tracking system head mounted devices can be used in which eye tracker is embedded in a magnetic resonance scanner. The platform they designed is intended for research and treatment of autism by detecting the social interactions using gaze tracker.

Mindy F. Levin et al., [13] studied about the quality of grasping and role of haptic in virtual environment. Here the target is Stroke patients. As their studies reaching and grasping parameters with or without haptic feedback varies. This variation does not affect the reaching and grasping

movement. Reach-to-grasp kinematics to smaller objects may be improved by better 3-D rendering. The objects required different arm/hand configurations and grasp types: cylindrical can, power screwdriver and for precision pen. Similar virtual objects are also developed. The VE was a 3-D immersive environment viewed through a head-mounted display (HMD). The VE was created in CAREN software (Computed Assisted Rehabilitation Environment; MOTEK). Hand position was tracked with a glove embedded with 22 strain-gauge fiber optic sensors. Haptic information about object collision was provided via a Cybergrasp device which stimulated low-threshold cutaneous mechanoreceptors when the hand contacted the virtual objects providing the subject with the sensation of touching a solid surface. The VE was calibrated so that the objects were located at the same distance as the PE.

III. METHODOLOGY

The goal of VR is to put the user in the loop of a real-time simulation, immersed in a world that can be both autonomous and responsive to its actions. In VR the research focuses on making an effective haptic nature of the virtual environment. By making effective interface the treatment towards autism remains smooth. Fig. 1 depicts the proposed methodology of the autism therapy. With the help of interactive module both autism child and Therapist will interact with the virtual environment. This virtual environment has been encircled with Gesture recording system, Audio Visual Recording System and Social emotions recording system. For Gesture recording, corresponding accelerometer sensor is used. This sensor senses the gestures of the autism child which is to fit in the child's body. These data are stored in higher end DB. For Audio and Visual tracking higher end camera and audio recording system is used. For social interaction sensing, gaze tracker can be used. This virtual environment will be developed in an acoustically prepared room because no other noises should record along with the performance of the child. All these recorded data will be stored in a standard DB. After the treatment, the Intelligent Quotient (IQ) and Behavioral Quotient (BQ) of the Autism child are monitored. These results will be compared with the standard IQ and BQ of a normal child to produce the results. Iterate the process till it reaches the target (i.e., IQ - 100). To reach the target, the interactive module can be re-designed into an interesting and creative mode. To achieve smoothness of this interactive module 3D rendering can be increased.

IV. OUTCOME OF SURVEY

Training and treatment can be provided using virtual reality so that the stress on patients while cooperating with the treatment and devices will be easy. Even though virtual reality occupies some devices, the stress felt by the patient is immediately relieved because of the smooth rendering of the interface. VR treatments highly produce positive results by increasing the IQ, BQ and Social Skills. The results of the

above survey have been recorded below. Table.1 depicts the outcome of the survey.

TABLE 1. IQ LEVELS AND ITS EFFECTS

| S.No | IQ Level | Significance | Population (%) |
|------|-----------|-------------------------|----------------|
| 1 | Below 70 | Problem in IQ | 4 |
| 2 | 90 to 110 | Average | 95 |
| 3 | Above 130 | Intellectual Giftedness | 1 |

The target is to train and treat this 4% of population to reach the average level of IQ(100). The above proposed methodology not only improvises the IQ but also induces positive behavior among the autism children.

V. CONCLUSION

The concept of virtual reality in terms of treatment or Therapy will highly leads to positive results. Usually VR treatments are not in affordable cost. But we have proposed the system in such a way that it will be cost effective in terms of User Interface instead of using other related devices such as head mounted displays, gloves, goggles, etc. Limitation of autism treatment in other mode is because of hard environment. But in VR we can provide smooth environment through interactive gaming, videos virtually.

Future study can be purely on how to improvise the smoothening of the environment and how the correlate VR in other domains.

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