

# Design of Personalized Virtual Home to Teach Fire Safety Skill for Children with Autism Spectrum Disorder

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**Abstract**—Virtual Reality is nowadays embraced as a pivotal therapy tool to help children with Autism Spectrum Disorder (ASD) to develop skills to communication and build their social and safety skills. Children with ASD exhibit impairments related to brain maturing that causes deformities in cognitive skills, sensory and emotional balancing. This proposed study contributes virtual reality technology to children affected with ASD to improve their self-safety awareness on fire by giving them tasks to find an exit, by identifying the given virtual room is about to cause a fire accident. As short durational sessions and unembellished visuals are admonished in VR for such chaos, the work is attempted to design a 360° virtual model living room of each participant in Unity 3d Engine. This creates awareness towards the improvisation of safety on fire by completing the tasks given through stages and monitor them to analyze their task performances and make participants to actively immerse into virtual experiences. The participants were 100 young children aged six to eight years diagnosed with mild symptoms of ASD. Each child is given a training series that comprised of a video model and cartoons displaying fire safety and necessary precautions. Following training, it was anticipated that the participants can initiate exiting behaviors while they spot a flame inside the room. The results showed that more than 70% of children met the criteria by following training after attending three sessions.

**Index Terms**— autism, fire, safety, virtual reality.

## I. INTRODUCTION

Autism Spectrum Disorder is a neurological and developmental inability with a constellation of physiologic and behavioural symptoms. The two essential symptom domains are 1) restrictive and repetitive behaviours; 2) difficulty in social communication and interaction [1]. Furthermore the disorder has a broad impact on cognitive and predominantly involves central nervous system dysfunction [2]. The growing current unanimity and components of effective early childhood intervention for children with ASD include a definitive diagnosis rather than deferring a non-serious intervention, inclusion of a family component (mainly parent members) and ongoing measurement and documentation of individual child's progress towards daily predictable routine so that it can result in adjustments in program changes [3]. Virtual Reality aims to immerse the users into a virtual environment as a model of reality to make the person interact and receive the information of human senses such as sight, sound, and touch by controlling the environment [4]. Autistic children are unable to recognize the

complications of their actions when related to fire accidents. So it is the responsibility of the parents or caretakers in the house and outside like schools to evince a safe environment and properly guide them at all situations cautiously. Some of the precautions that should be taken are 1) use locks and alarms where apposite 2) make electrical outlets and appliances shielded 3) organize and label their daily necessary things 4) take precautions for fire safety measures [5]. The interactive physical world can be enhanced with sensors, actuators, and novel displays that are seamlessly embedded with the latest communication technologies. This type of smart environments can be augmented with applications and treatments that target challenges associated with such children. The recent technological advancements and various automated and computerized therapies gradually impact traditional therapy practices. Though assigning such computerized tasks to children with autism is hard because most of them have inabilities of cognition and behavioural activities [6]. Within the similar work, several studies researched actual fire safety skills for autistic and mentally profound children which are: (i) For creating the alertness and making the autistic children learn the safety skills of fire, this research work creates the awareness to react to the environment where a fire accident is about to happen. The work is based on the development of a house in a country-side view where the participant has to sense the given virtual environment is about to cause a fire accident. Evaluation is done to monitor the involvement and the cooperation of the participant to complete the task within a given time at each session conducted. Finally, after the required sessions, the participants can identify the fire environment and escape from the situation without any interruptions [7]. (ii) The experiment was to initiate the mentally profound adult participants for 3-16 months to exit from their homes from different rooms to outside by hearing a surprise fire alarm. Three participants were chosen for this evaluation with the client chosen rewards as encouragement. As a result each participant was able to complete the task successfully [8]. (iii) This study is about training emergency fire safety skills to mentally retarded adult persons who reside in community-based group homes. Initially training protocols were developed and each person was tested to relevant fire safety behaviours as the trainers instruct and describe the tasks carefully as possible. The results of this study demonstrated 26 successful participants to reach the goal in a cost-effective method [9].

## II. SYSTEM FRAMEWORK

This article focuses on the implementation of a system where the children with ASD are allowed to experience the role-play simulated immersive virtual environment for practicing the fire safety skill and the ability to find an exit from a place that is about to cause a fire accident, by using personalized 360° photographs of each participant own living residence. This helps the participants to improve managing their safety awareness in the fire environment and the system is designed in the way by having the possibilities to control and gradually increase task complexity or even to suspend stages based on their performance. The results are represented in graphs and stored for future references. This system developed is based on the interaction between the participants and the activities performed in virtual environment given as tasks. The methodology follows protocols which are performed after an analysis of the participant's state and with options depending on the state in which the levels can be increased based on their interests. A therapist also contributes through all sessions with the children to ensure their safety and to stimulate to responses to given tasks. Initially, the tasks conducted required additional teaching and interaction with the participants before making them to undergo the study. More than three sessions were taken in order to fraternize with them. With the help of the therapist the tasks were conversed to both the participants and their parents. A detailed explanation about the purpose and benefit of their role in this study were discussed with the respective LAR's and parents. With participants for the better task accomplishment, through visual cartoons and oral speech about the fire and its impact were taught to them by the therapist. After ensuring their comprehension and volitional decision the study conducted.

An overview of the system developed, refers to Fig. 1. The work can be depicted in three phases by playing the 360° virtual video of their own living room area designed personally for each of the participant using Unity 3D software and imported into a mobile application so that it can be easily played through smartphones by using unmounted virtual headsets. The first phase stated as stage 1 the participant has to look around the living room through the headset and identify where exactly the virtual flame bursts in their living room. Next, once the flame pops an alert sound is beeped as a part of the video that is playing in the mobile application, after 1min 30 seconds of time. By recognizing the fire alarm, as a final task the participant should try to find an exit in the given virtual room by orally pointing the available doorway out.

Until the end of the study their respective Parents/LAR will be near the children's comfort ability and ease. The therapist makes sure the children's state of mind and permissive interest to participate and if something is unstable, found with them immediately the therapist asks to quit. Finally after each session the evaluation of the

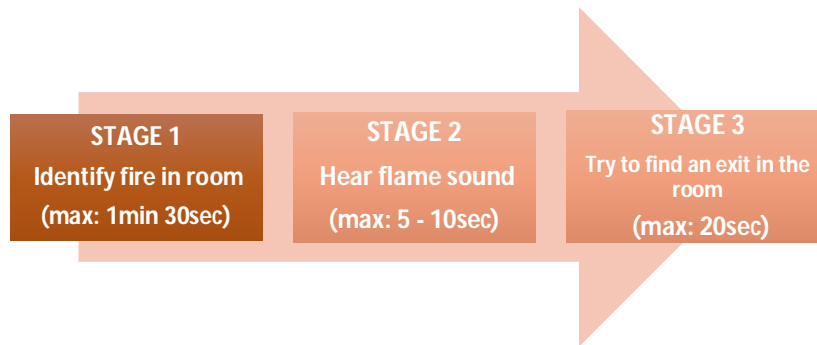


Figure 1. System overview

performed tasks is analyzed. The final results are conveyed to the LAR at the end of the study. To the participants a positive reinforcement is given beyond revealing the exact details of their performance as a way to encourage for better involvement in the future.

### III. STUDY METHODOLOGY

In this section, the methodology of the study is explained;

*Study setting/ Location:* A total of 100 children with various level of ASD, were referred by Steps Rehabilitation Center across Coimbatore. Parents and children were met personally on their convenient days given by them to an information session while the parents provided written consent for their child to participate in the study. All personal information was kept confidential. The children and parents understood that their participation was voluntary and that they reserved the right to withdraw from the study at any time. *Eligibility criteria:* The participants with milder symptoms of ASD and should not have problems with the understanding language of English/Tamil and blind disability within the age group 5 to 14 years.

*Ethical considerations:* The institutional Scientific and Ethical Committee of Sri Ramakrishna Hospital members reviewed the study proposal and declared no conflict of interest.

*Inform Consent procedure:* The details of the study are presented in bilingual languages (English/ Tamil) for assuring the full consent with voluntary participation to proceed in the study.

*Parental opinions:* parents will be informed that the details of the children will be strictly confidential. Two weeks before conducting the sessions a mail was sent to parents in a questionnaire form to evaluate the child's knowledge and usual behaviour towards fire and awareness.

*Safeguard Measures:* Oral skill training was conducted during the interaction session with children as they received small awards for attending with good engagement.

*Confidentiality:* The user responses and details of this research will be anonymous. Every effort will be made by the researcher to preserve confidentiality. Participant data will be kept confidential except in cases where the researcher is legally obligated to report specific incidents. Electronic data collected as a result of users will be stored in secure folders accessible to only the concerned members of the institution and also it will be presented as the research work for the academic year by the Principle Investigator of this study.

*Duration categorization:* For result analysis the outcome is based on two components. 1) The engagement towards the task can be determined as poor, satisfactory, and good based on time allotted. 2) Within the given time (1min 30sec) each of the tasks should be completed or it will be repeated.

*Result analysis method:* by making the participant attend the tasks based on the fixed time duration and how well they engage with the instructions. Each task will be assigned predefined minutes to seconds to complete the given respective task. Each time they complete the evaluation analysis can be observed in a bar graph which determines the overall performance at each session.

### IV. IMPLEMENTATION DESIGN

This section is composed of two modules; a) To design the personalized virtual environment b) To develop the application for evaluation. To create awareness about how to escape fire accidents from their residence living room by using the virtual reality technology for autism children. The system's working of designing the virtual environment, refers to Fig 2.

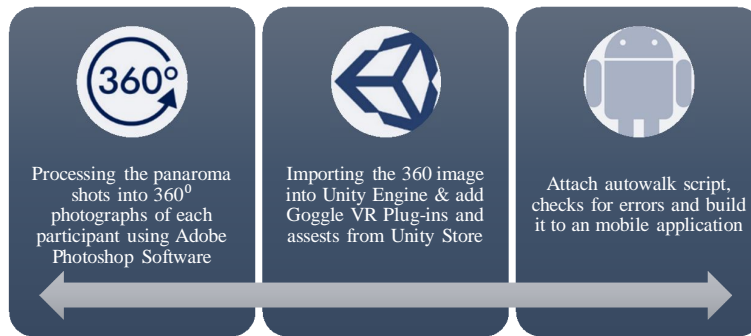


Figure 2. Architecture of virtual environment

Converting panorama shots to 360° images, the virtual environment is designed personally for each of the participant’s own residence living room. The panoramic shots were taken using a fish-eye lens. The taken panoramic shots were converted into 360° images using Adobe Photoshop software. They were processed to editable jpeg images. For designing the virtual environment the software called Unity Engine is used. Unity is a cross-platform game engine developed by Unity Technologies. The inputs of the system are unmounted virtual reality headsets devices that work by clipping the android mobile and perform an action, e.g., movements, emotions, sound. The control system for children consists of the controller and auto walk script. While nausea, headache, eye-strain and dizziness are the most common symptoms of motion sickness in VR, this happens in virtual reality headsets mostly because of the effects of latency and disorientation in DoF. These difficulties are mostly faced in gaming based virtual applications like first person shooter games, which cause sensory conflict between body and brain.

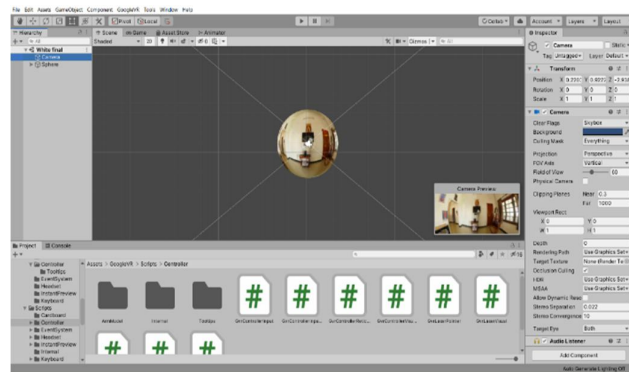


Figure 3. Processing panoramic shots into 360° virtual outputs in Unity Imported house image into Unity

In case of children with autism are nearly prone to these kind of conditions because of their sensory impairments, so in order to minimise the chances of experiencing such disabilities the precautions taken in this study are: (i) here the whole time taken to do the task once require two minutes and no body movements are required, so the plausibility of encountering such issues are minimal (ii) Though they undergo such discomfortness while on task they are identified by the therapist since they are being monitored all time, so immediately tasks are withdrawn from them. The VR environment is developed in order to capture the attention of the participant, the interface simulates the motion, this environment was created in the platform of Unity 3d and Inside the phone view the participant can view the image of his/her house as 360° virtual view refers to Fig. 3, where the programming scripts that allow interacting with the system inputs and outputs. The system is developed into an android mobile application to share with the parents for the convenience of future usages.

The Fig 4. Shows one of the user’s virtual house that is caught flames and initiate them to participate in the tasks actively. The outputs of the system are virtual reality headsets that emulate movements, environments, sounds, among others; these outputs devices of the system are android mobile phones which have the APK installed and clipped with VR headset as mentioned earlier.



Figure 4. Users virtual view of flames in one of the participants house

## V. CONCLUSIONS

The measures taken were administered prior to the start of the intervention and all procedures were done as per the guidelines given by the Institutional Ethical Committee board at Sri Ramakrishna Hospital. All the procedural settings were conducted at their own residences. For conducting each of the sessions in their houses, the time management was followed as per the parents scheduled. Other than quantitative data, ongoing qualitative data from the communication log and in-class observation log will be retrieved. The briefing and debriefing sessions were essential as a gateway to bridge and generalize learned skills from VR to reality. The consent form and undertakings will be given for them and the purpose of their study was clearly explained to them. The parents will be advised that, based on the experiences felt by children tasks can be adjusted and even session suspension can be opted when they are not comfortable to continue. The VR headsets used in this study ranges from 5 to 68 USD, compatible to android and iOS. In the next three sessions evaluation taken place by asking them to follow the exact instructions given to them during task time as given. (i) The first task is to identify the flame inside the room by giving a 360-degree view by wearing a simple VR headset with the installed developed mobile application. (ii) The next one is trying to hear the alert audios (flame sound) so that the awareness towards such sound can also be developed to recognize the dangers in their environment. (iii) The final task is to spot the exit (doorway) available in the given virtual room and should get the ability to make decision orally to move out from there.

The experimental study for analysis of each student will take place for three days. In all three sessions the participants were monitored lively by the therapist and principal investigator of this study analyses and calculates immediately the participants responses towards each of the task based on the performance engagement by the specially developed software for storing and evaluation and results are monitored represented in bar graphs for each of them. No statistical measures have been applied to derive the results. The actual results are based upon the fixed duration given to complete the tasks at each stage and the estimation of the fixed duration values is purely theoretical based. This work and results of this study may inform the future to conduct the experimental study on average of thirty children (both boys and girls) diagnosed with Autism Spectrum Disorder and evaluate them accordingly to the system developed and this research is believed to develop the awareness of safety skills among ASD children.

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