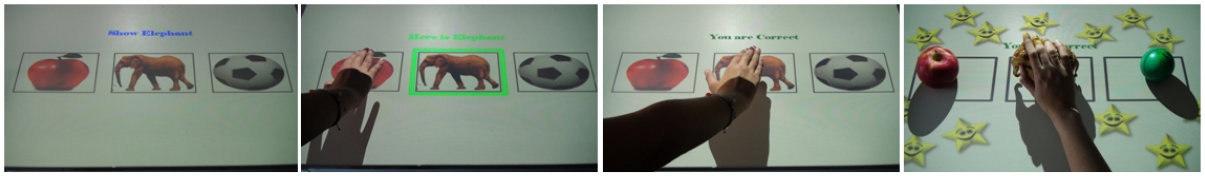
[Poster] An Augmented and Virtual Reality System for Training Autistic Children

Lakshmiprabha N. S.* Alexandre Santos† Dimitar Mladenov‡ Olga Beltramello§

European Organization for Nuclear Research, CERN, Switzerland



(a) (b) (c) (d)

Figure 1: The working of proposed AR/VR system (a) The system instructing the child with a keyword to be associated with three displayed pictures (b) The child wrong action is identified and the correct picture is prompted (c) The child correct action is reinforced with verbal phrase (d) Child is instructed to associate a keyword with an object and the correct action is reinforced with verbal phrase and cartoons.

ABSTRACT

Autism or Autism Spectrum disorder (ASD) is a pervasive development disorder causing impairment in thinking, feeling, hearing, speaking and social interaction. For this reason, children suffering from autism need to follow special training in order to increase their ability to learn new skills and knowledge. These children have propensity to be attracted by the technology devices especially virtual animations. The interest of this research work is to explore and study the use of Augmented and Virtual Reality (AR/VR) system for training the children with ASD based on Applied Behavior Analysis (ABA) techniques. This system assists in teaching children about new pictures or objects along with the associated keyword or matching sentence in an immersive way with fast interaction. The preliminary prototype demonstrates satisfactory performance of the proposed AR/VR system working in laboratory conditions.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, Augmented, and Virtual Realities;

1 INTRODUCTION

Autism Spectrum Disorder (ASD) is a general term for a group of complex brain disorders, which are characterized in varying degrees by difficulties in social interaction, verbal and nonverbal communication and repetitive behaviors. Several studies say that autistic children are quite attracted to technology devices (e.g. computers, PDAs, etc.) rather than conventional training tools like pictograms [2]. Furthermore, the study also demonstrates that the technology device creates a positive improvement in terms of enjoyment, involvement, development of imagination and learning skills to the autistic children. This makes the employment of AR/VR tools a perfect match for training ASD children.

*e-mail: ns.lakshmiprabha@cern.ch
†e-mail:a.alvsantos@cern.ch
‡e-mail:dimitar.mladenov@cern.ch
§e-mail:olga.beltramello@cern.ch

IEEE International Symposium on Mixed and Augmented Reality 2014
Science and Technology Proceedings
10 - 12 September 2014, Munich, Germany
978-1-4799-6184-9/13/$31.00 ©2014 IEEE

The autistic children also have a propensity to excel in music, math, art and visual skills [1]. It is essential to understand the skills they excel and the skills that require special attentive training. For this reason, a great amount of effort have been spent from researchers all over the world on developing training techniques to help autistic children in learning new skills that can improve their life's quality [1]. One of these techniques is Applied Behavior Analysis (ABA). This technique principle is based on the idea that any correct behavior is more likely to be repeated if followed by some sort of reward. One of the most well known ABA method is Discrete trial introduced by Ivan Lovaas [4]. This discrete trial has three major steps: (1) Instruct the task to the child, (2) Monitor the child response, (3) Reinforce the child action or prompt if necessary. The training under discrete trial starts by showing a set of pictures (usually three) or real objects (Elephant toy for example) that child should learn/acquire. The child is requested to associate a keyword with those picture or objects. They are monitored by prompting or reinforcing based on their performed actions. These steps are repeated several times by shuffling the pictures or objects and requesting them to show the keyword item. This repetitive training process along with the reward motivates the child to learn and remember the keyword with its associated picture or object.

The discrete trial training method can be enhanced by using AR/VR technology that will aid in grasping the child attention by engrossing them to the training process. The hypothesis is to examine the AR/VR system that could replace the teachers or mentors effort and to automate the training and reporting process. This will help the parents to train their child with ease and the child to immerse without any barrier. The proposed AR/VR system works in following way; firstly it displays a set of pictures and instructs the child with a keyword that has to be associated with the given pictures. The child action is monitored for the correctness evaluation. Based on the decision, their action is rewarded or the correct answer is prompted. Further, the recorded training data can then be used to review the child's progress.

As a starting point, our interest is to examine the potential positive impact of AR/VR technology in training the autistic children based on discrete trail ABA method. This paper presents the design, experimental setup and the implementation of the proposed system.

[1]National Autistic Society, http://www.autism.org.uk

2 Augmented and Virtual Reality System Design

The main objective of the design is to develop a user-friendly AR/VR system for training the children with ASD. This training system stimulates the child to imitate, interact, and respond to the basic request such as keyword association and matching sentence to a picture or an object. It is a well established fact that any equipment that is to be used by children must be robust enough to withstand their abuse, something that becomes even more important with ASD children. Thus, it is preferable to have a system that provides all the training information sparingly to them without any intrusive hardware interactions. Additionally, the system must be user-friendly with the augmentation on the real scene with real object (Elephant toy for example). All the aspect mentioned before, make the use of PDAs, Tablets and other handheld devices unsuitable for this application. On the other hand, a projector as display interface would satisfy these requirements as it allow to convert child's usual working table as a display interface.

Following the common practice in discrete trial training, we propose to use a table as working area where query pictures are displayed or real objects are placed. A camera is used as a natural user interface to monitor the child action by detecting and tracking their hand. Thus, the system provides a visual feedback on the table by tangible hand movements with no barrier between the child and the system. This can ease them to interact effortlessly without any requirement on practicing the new system.

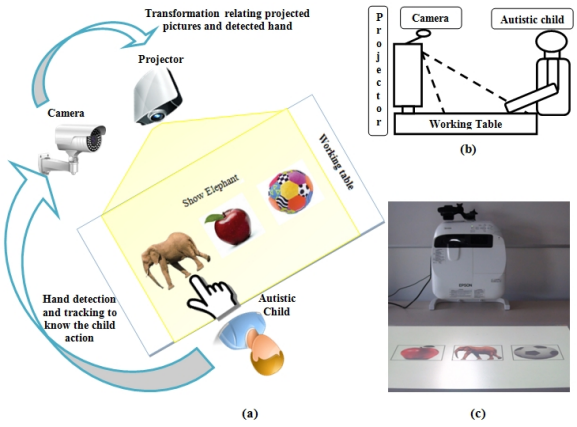


Figure 2: The AR/VR system for training ASD children (a) System design (b) Profile system setup (c) Real system setup.

The overall system design is shown in Fig. 2(a). The system starts by displaying pictures or by placing objects and then instructs child to select one among them. The child action is monitored and the correct action is reinforced to motivate and encourage them to respond in the same way again. In case of time out or wrong answer, the system will prompt by highlighting the queried picture until the child does it correctly. Additional, in order to assist psychologist and researchers to efficiently evaluate the child learning performance, the system also records the child action and time taken to complete the training session.

The two main components of AR/VR system are, (1) user interface and (2) calibration between camera and table.

User interface: The child action is monitored by using vision based algorithms on images captured from the camera. In most cases, ASD children do not like to attach fiducial markers or color gloves on their hands. They may either remove or get distracted from their task. Hence, it is important to have a natural interface between the child and the system. Therefore hand is considered as a major cue to detect their action. It is also well known that the children with ASD perform unwanted hand movements to elude from answering the question. Furthermore, the psychologists are more interested in analyzing the hand trajectory information (saved as a plot) which in turn helps them to understand the progress of child's learning rate. In this paper, the Adaboost-learning algorithm with Haar-like features is used for hand detection [5]. We use the OpenCV implementation of Adaboost classifier for training and detecting the hand.

Calibration between camera and table: The transformation of hand position from camera or pixel coordinate system to the projector or table coordinate system is important so that appropriate content can be properly augmented or highlighted. In this work, homography based transformation [3] is used that makes the system simple and fast to initialize.

3 Experimental Setup

The proposed AR/VR system setup with a camera, projector and working table arrangement in the laboratory environment is shown in Fig. 2(b) and 2(c). At first, the system allows 3 seconds to complete the keyword association task by moving their hand over the queried picture or object (see Fig. 1(a) and 1(d)). Whenever the child moves their hand over the query picture, the system acknowledges the correct action by rewarding them with verbal praise or by playing their desired music (as in Fig. 1(c)). If there is a wrong answer (no hand detected on the query picture) within 3 seconds, the system prompts by highlighting (see Fig. 1(b)) after which the child is again given with 3 seconds to complete the task. All hand action performed during this session will be saved as a plot showing the hand trajectories to facilitate the analysis of child's learning progress by teachers and psychologist. Also the correctness is evaluated not by just considering hand in one frame over the queried picture, i.e. the child has to keep his/her hand continuously over it for at least 1.5 seconds. This helps in avoiding the wavy and unwanted hand movements made by the child.

4 System Evaluation and Outlook

The AR/VR system was demonstrated to the ASD psychologists and teachers to have their constructive feedback. They were satisfied to know about this system which will immerse the child attention and will help them learn new things without their perception. From teachers and psychologists point of view, the proposed system will help the child in developing, (1) Generic competencies, (2) Keyword and sentence association with a picture, (3) Identification and recognition capability. The psychologists were pleased to see the monitoring and reinforcing capability of the system together with the recorded information of the child's hand action trajectories.

As a further step, we plan to assist the psychologists and teachers to evaluate the system with ASD children to study on its usefulness in terms of interaction and learning. Also, the proposed AR/VR system will be demonstrated to collect feedback from parents (in terms of usefulness to the child), teachers (to analyze on ease to teach the child or use the system) and psychologists (in the assessment of the child progress).

References

[1] C. M. Corsello. Early intervention in autism. *Infants & Young Children*, 18(2), 2005.

[2] T. R. Goldsmith and L. A. Leblanc. Use of technology in interventions for children with autism. *Journal of Early and Intensive Behavior Intervention*, 1:166–178, 2004.

[3] R. I. Hartley and A. Zisserman. *Multiple View Geometry in Computer Vision*. Cambridge University Press, 2nd edition, 2004.

[4] O. I. Lovaas. Behavioral treatment and normal educational and intellectual functioning in young autistic children. *Journal of Consulting and Clinical Psychology*, 55(1), 1987.

[5] P. Viola and M. Jones. Rapid object detection using a boosted cascade of simple features. In *Proc. of the IEEE Conference on Computer Vision and Pattern Recognition*, pages I–511 – I–518 vol.1, 2001.