Teaching Process for Children with Autism in Virtual Reality Environments

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ABSTRACT
This paper presents the implementation of 3D virtual environments applied to the teaching-learning process for children with autism. The virtual system implemented allows real-time bilateral interaction between the user and the virtual environment in order to stimulate the abilities of children with autism spectrum disorder. The implemented system has multiple environments and applications for interaction with the physical medium in order to increase the stimulus of the affected. The results show the benefit and usability of the implementation of virtual environments to the processes of teaching learning of children with autism.

CCS Concepts
• Applied computing→Education→Interactive learning environments.

Keywords
Virtual Reality; Education; Teaching methods; Autism.

1. INTRODUCTION
Diverse studies carried out in recent years have determined that at least one in ten children is born with some type of disability or acquires it during their growth, which limits their social, psychological, and academic formation [1]. The development of children with special talents may be hampered by limitations in abilities and dexterity; the same ones that can be strengthened with special teaching-learning processes. These processes include strategies, techniques, and methods that improved their understanding which compensates for the lack of knowledge of information, storage and understanding [2]. The integration of children with special talents in regular schools is one of the teaching techniques with higher research due to the controversy generated since children require different rules and routines than ordinary students; in spite of this, the scope of the pedagogical objectives in the children in several schools has been successfully achieved due to the technological advances [3].

The Information and Communication Technologies, TIC, has allowed the development of applications in different areas of knowledge, strengthening the teaching-learning process. The use of TIC allows specialized teachers to stimulate skills and knowledge with alternative classes that improve the attention and concentration of children with special talents. Technological intervention has made it possible to strengthen the social integration of children with special talents, through the use of learning objects, educational software, digitized materials, virtual reality, robotics, among others. They are aimed at improving the teaching-learning process through innovative pedagogical tools [4]. The technological tools used in teaching-learning processes in children with special talents can be classified according to their *i) Purpose*, there are interactive games that allow better communication, independent life simulators, among others; *ii) Resources*, the means used in the teaching-learning process, which includes animated images, audio, texts, symbols and more; and finally *iii) Special talent*, in which each child has different teaching needs due to the developmental disorders found (*e.g.*, visual, motor, auditory deficits, attention disorders, Autism, among others).

Specialists have developed different types of methods to improve the teaching-learning processes for children with Autism Spectrum Disorder. *TEA*, The methodologies range from traditional techniques such as integration with children who do not present any special talent, as the contact with other people contributes to improvement in social skills [5-6]. In other cases, children with *TEA* are treated as if they have fragile X syndrome, which is a genetic disease that fundamentally causes developmental problems including learning difficulties and mental retardation, genetically inherited; in this case, the methodology is complex and very limited in effectiveness [7].Other proposals point to body language through dance, as it adapts to the difficulty of children with *TEA* to explore various forms of expression and communication with the direct relationship of their body and the bodies of people that are part of their environment [8].

One of the most used techniques are games of sensory motor exploration of the objects of their environment, then to the functional use of the resources of the medium (generating concepts of reality outside the existence of these), and finally to development of an activity that is playful and flexible [9]. At present, with the evolution of technology and the use of methods for the treatment of this disorder, they have been shown to have flexibility and positive impact in supervised therapeutic practices such as: *i) Electronic devices* such as radios; *ii) Game console* with didactic activities for the entertainment and learning of the child with *TEA* [11]; *iii) Virtual Environments*, courses that allow to satisfactorily assist the child with *TEA* to socialize and

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contribute to interpersonal interaction [12]; *iv) Educational Software*, aimed at helping people with *TEA* to improve the social skills and abilities of their mental states', as well as to provide teachers with innovative techniques in the teaching-learning process [13]; and *v) Robotics, which* has evolved to treat various conditions of various types of disorders because the child can interact directly with the robot and improve their social relationship [14].

This article presents the implementation of an application of a virtual 3D system, focused on the teaching-learning process for children with *TEA*. The creation of the virtual environment related to a human robot focuses on capturing the patient's attention to improve the attention and communication of child with *TEA*, and the teacher can guide the interactive class, mainly focusing on games where the child manipulates a robot. These movements are presented in the virtual game environment in parallel. The design of the 3D virtual environment contains several characters and scenarios depending on the medical prescription and the proposed game.

This article is divided into 4 Sections including an introduction. Section 2 presents the proposal of teaching-learning processes in children with TEA, then Section 3 describes the methodology and analysis of the development of the proposal. Finally, the conclusions are detailed in Section 4.

2. DESCRIPTION OF THE PROPOSAL

Children with autistic disorder must present with specific social and communication deficits, which do not allow them, to varying degrees, a certain level of affection. Usually children learn how to relate to others by imitation of others. This is not possible with children who have autism. As a result, the specialist must use different strategies in order to comply with the teaching-learning process. There are techniques and methods of teaching with visual learning, therefore, it is usually working with the relation between object image, since in most cases do not relate words to the object or its specific meaning; but you have to take into consideration that the first step to reach this is to have the interest of the patient, for that you have to delve into their interests.

The development of the application constitutes a tool that allows the child with TEA to interact in traditional institutional environments, where the capture of interest and the association of images with objects is met in a flexible manner, thus achieving the objective of the interpersonal relationship.

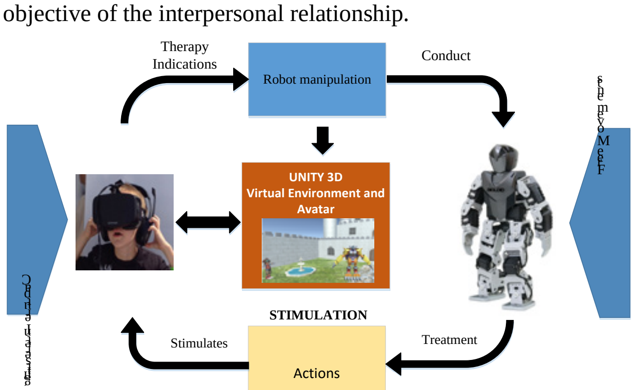


Figure 1. Behavioral intervention assisted by virtual reality.

Figure 1 shows the structure of the system developed, where the robot is programmed to perform tasks autonomously. The results are presented in the virtual environment in an avatar way, previously selected by the therapist, with the aim of stimulating the senses and the attention of the patient. The system receives this information through non-verbal channels, allowing better validation of behavior based on treatment protocols.

The interaction between the patient and the virtual environment is done through a humanoid robot that allows to be manipulated - controlled - with ease, in order to provide the inputs to the virtual environment. The development of the virtual environment should allow the interaction between the robot and an avatar. The avatar can be selected according to the interest of the patient to be treated. In the virtual environment, the movements of the avatar are executed according to the emotions of the patient, which are captured by means of a vision sensor. The proposed block diagram is divided into five parts, see Figure 2.

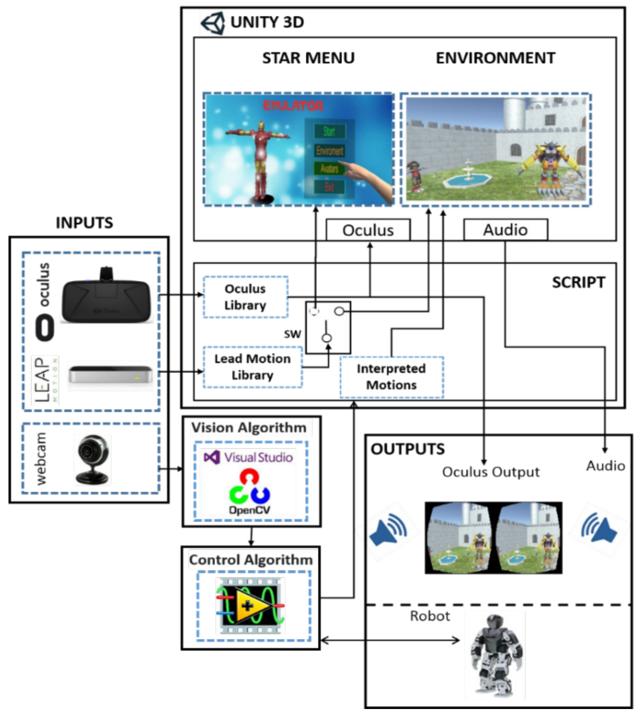


Figure 2. Operating scheme.

System Inputs, the inputs of the system are devices that capture signals to be interpreted and perform an action, (e.g., movements, emotions, sound, among others). The virtual devices used as inputs are: *i)* a virtual reality helmet, which allows the user to immerse in a virtual environment in order to stimulate the patient to perform the therapy proposed by the specialist; *ii)* a gesture control sensor, which is an electronic device that allows interaction with the virtual interface by tracking gestures performed by the user's hand; *iii)* a vision sensor, which allows the acquisition of the images of facial gestures performed by patients, with the objective of obtaining numerical information to be processed and generate an output according to the algorithms used in artificial vision, see Figure 3.

Outputs: the outputs of the system are electronic devices that emulate movements, environments, and sounds; these outputs devices of the system are: virtual reality helmet, audio speakers, and the humanoid robot BIOLOID that executes the movements according to the state of the child; and at the same time copies these, to interpret them in the avatar virtually, see Figure 4.

Virtual Environment: The VR environment is developed in order to capture the attention of the patient. The interface simulates the motion of humanoid robot real in the selected avatar virtual (see Figure 5). This environment was created in the platform of Unity 3D, where it has the respective programming scripts that allow interactions with the system inputs and outputs, see Figure 6.

Figure 3. Avatar selection.

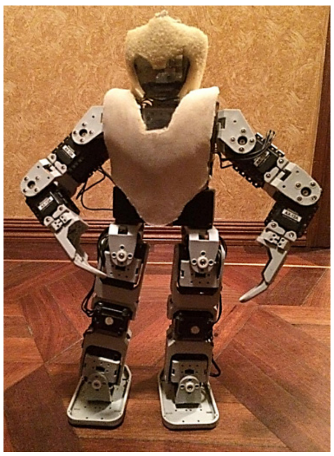


Figure 4. Humanoid robot BIOLOID.

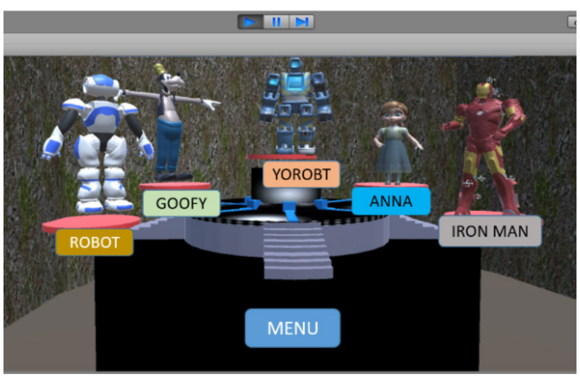
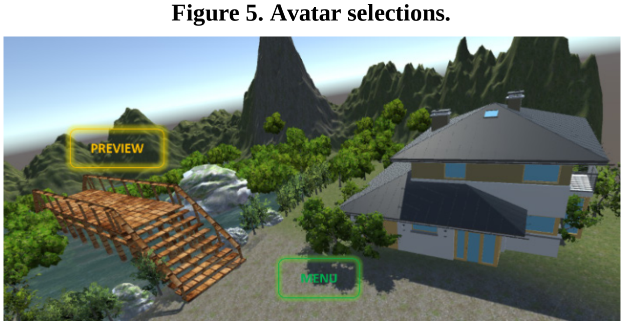
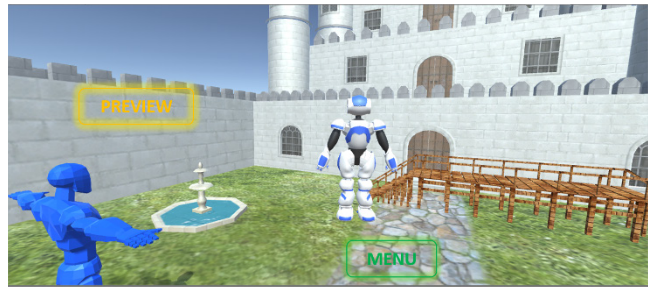


Figure 5. Avatar selections.



(a) Open environment of a forest.



(b) Environment of an opened castle.

Figure 6. Environments.

Control algorithm: receives the treatment´s data emitted by the software of artificial vision. This one is in charge to relate to the computer with the assistant (robot). The information received is from the monitoring process in patients, as well as to analyze their progress with each therapy. Robot movements will be loaded and stored in vectors by each actuator present in the humanoid that can be accessed from the user interface or from the virtual environment, see Figure 7.

Figure 7. Motions of the Humanoid Robot and Avatar virtual.

3. ANALYSIS AND RESULTS

The system allows evaluation of the teaching-learning techniques aimed at children with *TEA*, with the purpose of strengthening their cognitive development. The special characteristics of learning in children suffering from this disorder are based on the image-object relationship, due to the complexity of relating the word to the object. It uses visual support, allowing the capture of the attention and interest of the child with *TEA*. The interaction and immersion of children with TEA in the developed virtual environment allows them to strengthen social integration and communication and motor skills. This is done through a humanoid robot that is easily manipulated by providing the input signal to the virtual environment and the GearVR virtual device that allows you to observe the changes made in your learning environment. This also stimulates the child to perform the tasks defined by the teacher.

The analysis of the teaching-learning system developed for children with *TEA* is based on tasks that allow them to relate the objects to their respective names, sound or color. The administration of the movements is done by means of the manipulation of the humanoid robot and the avatar of the virtual environment is accessed, allowing the interaction with virtualized objects, for which two working groups are established. Group A will be children who will receive traditional classes *(i.e.*, with didactic visual material such as cards, puppets, among others), while group B proceeds in a virtual environment controlled by the teacher where the child can fulfill the assigned task at different levels.

The application will be evaluated according to the progress of the children with TEA focused on the teaching-learning process, for which two types of evaluation are considered. The first is through *i) Task Compliance*, which designates activities to be evaluated according to the difficulty; and *ii) Usability Test* that establishes the level of user satisfaction in the use of the developed application.

A. Task Compliance

The aim is for children with TEA to complete tasks defined by the teacher which are intended to familiarize children with diverse and unknown objects, the techniques and strategies used, are based on the teacher defines the target independently and is activated by pronouncing their name, making sounds representative of it, and finally verifying if they are recognized by children.

For the evaluation process, the groups are composed of 10 children with TEA in the range of 6 to 10 years, which present the same level of affection. The indicator to be validated is compliance with the parameters defined by the teacher, these are indicated in Table 1; once the evaluation process has been completed, the results of the two defined groups are compared.

Table 1. Parameters to evaluate

Questions
Qe1. Children with TEA completed the defined task**?**
Qe2. They recognized more than five objects when they were named?
Qe3. They name more than five objects when displayed?
Qe4. They manipulate more than five objects when prompted?

According to the data, it is observed that group B registers a higher compliance with the parameters than group A. This is due to the fact that the work in the virtual environment is interactive and the child's attention is constant due to the presence of Avatars, whose purpose is to guide the child in the teaching-learning process.

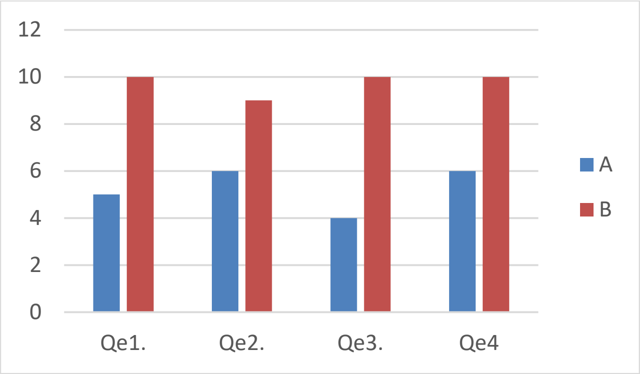


Figure 8. Results of the parameters evaluated.

B. Usability Test

The software product developed shows a didactic approach, which is based on desirable results in the teaching-learning process. Table 2 shows the parameters of the Test. The evaluation of the system involves students and teachers who use the humanoid robot with embedded code to control the virtual environment, the tasks to be performed at different levels, and the devices and components developed. The test was applied to 10 users. Figure 9 shows the results obtained from the degree of usability of the system, with ten being the highest weighting and zero the lowest weighting.

Table 2. Usability test parameters

Questions
Q1. Children with TEA are comfortable with virtual devices
Q2. The interaction with the humanoid robot is easy to perform.
Q3. Interaction with the virtual environment is easy for children.
Q4. The avatar guide adapts to the robot's movements.
Q5. Objects in the virtual environment are attractive to children.

From the results shown in Figure 9, it can be seen that the movements made by the user using a humanoid robot as an interface adapt quite well in the virtual environment, therefore, the degree of usability of the system achieved with each One of the parameters has a great acceptance by the users.

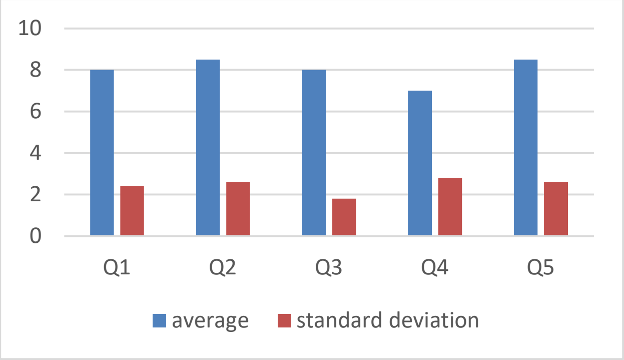


Figure 9. Results of the use of the humanoid robot interface.

4. CONCLUSIONS

The results obtained from the implementation of virtual environment for autism spectrum disorder demonstrate the efficiency of the system under the supervision of a teacher/therapist, allowing the children to increase their stimulation. The system contemplates two modes of operation: one in which it conforms to the mood of the children selected to perform a specific movement, thus improving the patient's social relationship with other people in a controlled environment. The other is fed back to perform readings of the position of the BIOLOID Humanoid robot parts, in which the therapist asks the patient to perform a repetitive action. The same was visualized in the virtual environment in order to reflect the evolution of the patient's disorder.

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