Information and Communication Technologies (ICT) for Enhanced Education of Children with Autism Spectrum Disorders

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ABSTRACT

Recent developments in the area of information and communication technologies for people with special needs led to significant changes in the way specialists and educators face the daily impairments posed by abnormal behaviors. Computer based educative methods have recently been considered as a key element for educating people with autistic spectrum disorders (ASDs). Latest literature reveals that persons with autism, especially children, enjoy interacting with computers and consider them as a “safe” environment due to the lack of expectations and judgments that make social interaction problematic. Virtual Environments (VEs), usually accompanied by 3D humanoid characters have been proven to play essential role in special education and social interventions. In addition, emotionally expressive avatars advance the quality of tutor-learner interaction. Furthermore, unobtrusive wireless sensors often integrate autistic person’s feedback and reaction. This paper attempts to demonstrate specific artifacts in a proof of concept fashion with a long term purpose to improve the educational process of people with ASDs.

KEYWORDS: Computer-aided learning, affective computing, autism, emotions, human-computer interaction, avatars.

INTRODUCTION

During the last years there is considerable advance in the research on innovative computer technologies for the education of people with special needs such as patients suffering from ASD. The specialists and educators are aided by interactive environments in facing the daily abnormal reactions by autistic

persons [1], which can generally be classified as problematic social interaction, communication impairment dealing with verbal and non-verbal channels. Inflexibility in thinking, language and behavior is the third main autism impairment [2]. Autistic persons realize both world and human behavior uniquely since they react in an abnormal way to input stimuli while there is problematic human engagement and inability in the environmental generalization [3].

A particular patient group is that of autistic children. According to previous studies [4], education is considered as the most effective therapeutic strategy. More specifically, early stage education has proven helpful in coping with difficulties in understanding the mental state of other people [2]. Towards this direction, computer tools may be a beneficial aiding instrument. Consequently, during the last years the field of collaborative interactive environments, such as virtual environments (VE), is of key importance. Their advances are the control of the input stimuli and the monitoring of the child's behavior. A recent effort led to the development of an interactive computer game aiming at the enhancement of the collaboration between multiple users like children with ASD, [Cospatial]. The game makes have used puzzles for providing both auditory and visual feedback.

Moreover, the human-computer interaction (HCI) is regarded as a "safe" and enjoyable experience. This can be explained by the fact that the interaction with computers does not pose severe expectations and judgment issues in contrast to the social interaction. So, computer systems tend to be a controlled environment with minimal distractions and therefore an attractive one for the education of autistic children [5]. This is further supported by several reports which mention that this type of interaction elicits positive feelings, whereas the communication with human is highly problematic [6]. Moreover, this feeling is a generic and uncorrelated with the type of the software interfaces.

Furthermore, tutors often report that behavioral alterations during the educational process are a common phenomenon among autistic persons [7]. The person state may be described by specific educational parameters such as the time and the processes needed to complete a goal and the percentage of success. Moreover, the behavior monitoring during a period of time may reveal important factors for the children's progress. A large portion of the traditional educational tools employs real world environments, hardening the task of autistic children [8], since it requires rapid and flexible thinking. Moreover, real world environments cannot be fully controlled because of the lack to provide the same set of conditions more than one times.

The aim of this paper is to review recent trends in the education of children with special needs and to mention the work carried out in the Lab of Medical Informatics at the Aristotle University of Thessaloniki regarding educational issues for autistic persons. Moreover, the further work is expected to provide the specialists and educators with significant conclusions about how autistic persons behave in a virtual environment in contrast to the real world.

RELATED WOK

Interactive Environments / Software Platforms

Various interactive environments have been developed for the rehabilitation of children with autism. In most of the cases, these environments are introduced by means of software educating platforms [9,10]. In order to provide knowledge in an attractive way, these platforms use entertaining content in educational settings (edutainment). Photos of real objects (used in daily life) or sketches of them are presented on the monitor of a computer so as to encourage people with autism to distinguish objects based on their size, color, type, etc. Moreover, this kind of interactive learning platforms motivate the children to correlate the objects with sounds and words. For adding to the attractiveness, platforms make use of animated pictures or videos. The comprehension of the task is supported by verbal and visual (usually makaton symbols) guidance in order to minimize the role of the monitoring teacher [11].

Robotic Systems

Robotic systems are often included in the interactive environments [12]. Developed as interactive toys for children, humanoid robots are used as research platforms for studying how a human can teach a robot, using imitation, speech and gestures. Increasingly, robotic platforms are developed as interactive playmates for children. Recent literature reveals that robots generate a high degree of motivation and engagement in autistic persons, including those who are unlikely or unwilling to interact socially with human educators and therapists [13]. Additionally, studies over a long period of time allowed the children to explore the interaction space of robot–human, as well as human–human interaction. Repeated exposure to an interactive small humanoid robot increased basic social interaction skills in children with autism [12].

Virtual environments

VEs have proven to be another active area of research for social interventions., Various successful software platforms with virtual environment for autistic people have been developed since in the last decade [14,15]. VEs are able to mimic specific social situations in which the user can role-play. The stable and predictable environment provides such types of interaction that eliminate the anxiety [16]. Moreover, VEs offer safe, realistic-looking 3-D scenarios that can be built to depict everyday social scenarios. Recent articles have demonstrated the ability of participants with ASDs to use and interpret VEs successfully, and learn simple social skills using the technology [17]. Additionally, one of the most important aspects of VEs used by participants with ASDs in educational settings, is their level of enjoyment. It has been realized that persons with ASDs, especially children, are more interested in interacting with computers more than other toys [18]. Moreover, virtual peers [19], life-sized, language-enabled, computer-generated, animated characters that look like a child, are frequently a part of a virtual environment. For example, a virtual peer accompanies a child with ASDs during a game or a storing telling scenario.

Avatars

Playing in most cases essential role as instructor, emotionally expressive avatars are one of the most interesting options of such an educating system. Current literature reveals that avatars, being humanoid or not, advance the educational process [18]. Additionally, educators suggest that most of the times persons with ASDs are able to recognize the avatar's mental and emotional state provided by facial expressions [18]. Avatars, as inhabitants of the virtual space, can enhance the interaction level in VE. Their behavioral capabilities are envisaged with emotional and facial expressions [20]. The use of emotional expressive avatar is of crucial importance in the educational process, since their ability to show emotions and empathy enhances the quality of tutor-learner and learner-learner interaction [21]. Therefore, emotion-aware computers are regarded as a considerable and valuable educational technique [3].A significant effort has been done in using emotionally avatars due to the findings in psychology and neurology that suggests emotions as important factor in decision-making, problem solving, cognition and intelligence in general. Results of surveys among educators of autistic children in recent literature illustrate that not only most of the children recognize the avatars emotion but also the avatar's emotional state advances the educational process [18]. Moreover, the findings are better in case of the avatar using native voice [18]. Apart from the instructor form, the avatar is responsible for providing feedback to the user's action by means of the appropriate emotion (happy for success and sad for failure). Training studies in [22] have suggested that children with autism show greater improvements in emotion recognition when programs include cartoons rather than photographs of real faces. Moreover clinical and parental reports also state that autistic children spend long periods of time looking at cartoons [22].

Additionally, parents and professionals often report that “autistic children know more about cartoons than about people” [22].

TEACCH Method

A widely used method for educating people with ASDs, TEACCH (Treatment and Education of Autistic and related Communication handicapped CHildren), tries to provide a controlled environment to the children during their normal educational process in order not to confuse the autistic children. The approach of this method involves a structured teaching method and the use of visual materials [23]. In addition, TEACCH principles involve changing the behaviour and skill level of the person as well as developing an environment that matches the person’s unique needs. A wide variety of the interactive and virtual environments espouse the principles of this method by targeting to the person’s visual processing strengths by organizing the environment and providing a visual conduct to supply information about activities. Moreover, visual structure is provided at a variety of levels such as organizing areas of the environment, providing a daily schedule using pictures or written words, as well as visual instructions and visual organization signalling the beginning and end of tasks. This technique is based upon the observation that children with autism learn and connect information differently than other children.

Special Input Devices

While people with ASDs enjoy interacting with computers, more attractive forms of input are used. Most of the recent research projects use as input feedback a touch screen instead of the common mouse device [18]. a multi-user touchable interface that detects multiple simultaneous touches by two to four users was used in [24]. Each user sits or stands on a receiver (a thin pad) such that touching the table surface activates an array of antennas embedded in its surface (capacitive touch detection) [24]. The function of this screen was very easy to be obtained by people with ASDs. Moreover, big colored buttons subserve user selection. Moreover, studies in using virtual reality for the rehabilitation of people with ASDs include visual devices that represent the 3D virtual world [25]. Alternative interaction methods include remote controllers like the Wiimote (part of a commercial game console) like in [26]. This device is capable of monitoring not only remote buttons’ selection but also movements (based on internal accelerometer). Furthermore, external devices are used in order to measure and monitor user’s internal and emotional state, such as wearable measurement devices [27]. In [28] web camera, eye tracker and data glove is used for this purpose. Besides that, scientists try to provide more attractive virtual worlds by using video projectors and depicting the educational material in a wall of a room [29].
As it is mentioned above, TEACCH principles involve changing the behavior and skill level of the person based on his personal unique needs. In order for a platform to achieve this goal it has to be capable of recording the user’s interaction/education process. By using all the records in the proper way, a longitudinal record may be achieved indicating “a learning curve” for each autistic person separately, thereby enhancing and normalising the educational procedures toward each person’s needs. Consequently, the educators are enabled with track record of the users’ progress and modify the difficulty levels accordingly.

OUR APPROACH

Carried out in the Lab of Medical Informatics at the Aristotle University of Thessaloniki, Greece (LOMI-AUTH), our approach is based on a platform that is intended to enhance or mediate the teacher-child educational process [9]. Including a variety of interaction procedures according to the disability level of autistic, the platform consists of several modules. There are modules where the child is asked to identify the correct image between two or more images (Fig. 1), to put images in the correct sequence (according to time), identify emotions by visual expressions etc. Furthermore, the more complex

modules are in the form of semi-virtual environments. The theme of the modules varies from objects in the normal surroundings, daily objects and activities, colors, words, etc, which are integrated in sessions. An avatar with synthesized speech in autistic person's native language was chosen as the main instructor. Other communication forms that accompany the instructor include text written in the screen, the corresponding makaton symbol and related sounds as options (based on special needs of the person with ASDs). Recent research results about emotion are adopted by our avatar which can express emotions depending on the situations, e.g. happiness when the correct image is selected, sadness if not. Moreover, the user's input/feedback is being recorded by the supporting database system which integrates the platform. Due to this, the instruction and the difficulty level can be personalized for each user.

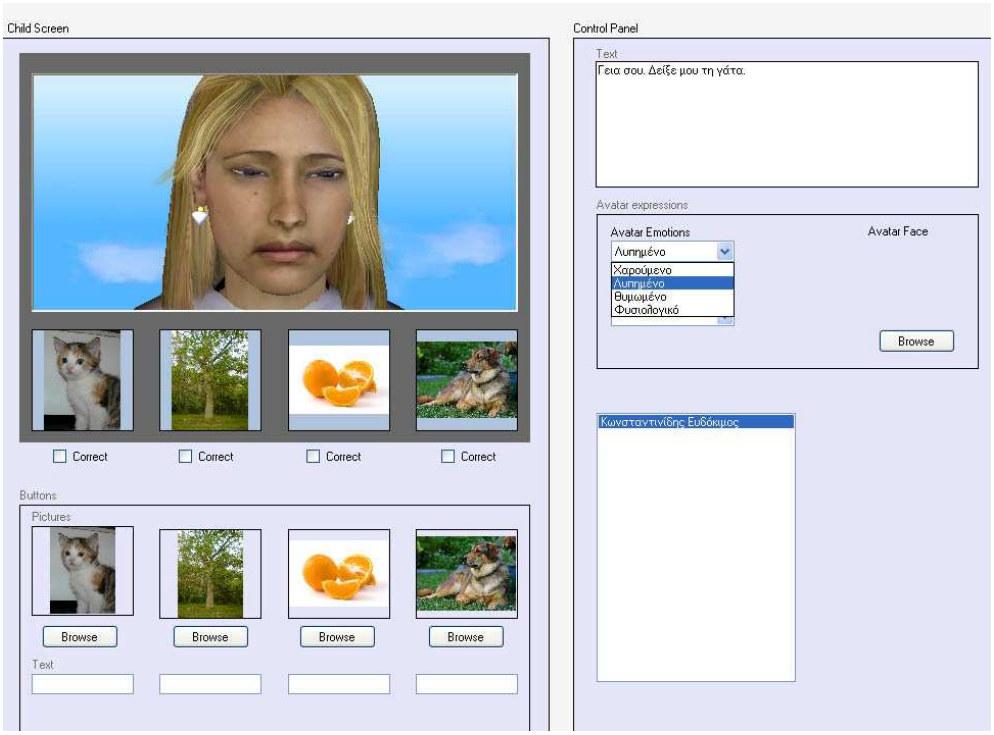

Fig. 1 Educator can interact with current logged in users

Furthermore, our current interest is towards an interactive semi-controlled real world environment [30]. Such an environment consists not only by an interactive virtual environment but also from objects and data of the real life that can be tracked by means of wireless sensors. The major difference between this and VEs is that in the semi controlled one the system cannot initialize the environment with the initial set of conditions although it can monitor all the performed activities. So, a semi-controlled real world environment is hypothesized to be beneficial for the education of autistic children. Furthermore, according to the related research it may be useful tool for the specialists helping them to understand better the abnormal reactions.

CONCLUSION

Successful autism "treatments" using educational interventions have been reported even a decade ago [31]. As we have seen in the paper, recent years have witnessed ICT-based approaches and methods for therapy and education of autistic children. The current research focus has been on innovative interactive

and virtual software or hardware platforms that employ avatars and can simulate real world situations but in rather safe and controlled manner.

Individuals with autism have lately been included in the main focus in the area of Affective Computing (AC) or "computing that relates to, arises from, or deliberately influences emotions" [32]. Technologies, algorithms, interfaces and sensors that can sense emotions or express and thereby influence users' (autistic persons') emotions have been continuously developed. Among the pioneers in this field of research are the Affective Computing Group (ACG) at MIT and the Autism Research Centre (ACR) at Cambridge. Working closely with autistic persons has lead to development of various significant methods, applications and technologies for emotion recognition and expression. Innovative wearable sensors along with algorithms for efficient recognition of human affective states have been developed by the ACG, applicable for autistic individuals [33]. Additionally, the Affective Social Quotient project has helped autistic children learn emotions using physical objects such as dolls [34]. A DVD with educational software for emotions, called the Trasporters, has been created at ACR, which is one of the most extensively used commercial applications for this purpose [35].

However, much has yet to be improved in order to have a significant success in treating individuals with autism. This depends on two aspects: theoretical and practical. The first signifies the theoretical knowledge on autism, the triad of impairments, and the individual difference in coping with such disabilities in the modern complex world. From the practical perspective, many of the existing technologies have limited capabilities in their performance and thus, limit the success in the education of autistic persons. This is especially significant for wearable hardware sensors that can provide feedback from the autistic individuals in the educational process. Much has to be done in order to have a reliable emotional, attentional, behavioural or any type of feedback that can be essential in the alteration of the educational method to better suit the people with autism. Nevertheless, the realisation of autism as a significant health topic in the modern world is nothing but promising fact for the future trends of improvement in the usage of educational ICT to help the autistic people in coping with the everyday surroundings.

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