Affective Computer-Aided Learning for Autistic Children

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ABSTRACT
Autism is a mental disability that requires early intervention by educating autistic children on the everyday social, communication and reasoning skills. Computer-aided learning has recently been considered as the most successful educational method and various CAL systems have been developed. In this paper we examine the existing CAL systems and platforms and discuss the benefits of adding an affective/emotional dimension in the interaction process between the CAL system and the autistic person. We present our work on a CAL system that is based on affective avatar interaction, as well as, a personalisation database containing user profiles and records of the educational process. The system allows the educator not only to personalise the system for each user, but also to exploit records of the learning progress for further statistical analysis. Pilots and acceptability results are already on the immediate plan in a school for autistic persons.

1. INTRODUCTION
Autism disorder is known to be characterized by a 'triad of impairments' [1]. The primary one is the social impairment: an autistic person has difficulties in relating to other people. A second one is the communication impairment: both verbal and non-verbal communication channels are hard to be understood and used by people with autism. Finally, there exist rigidness in thinking, language and behaviour. It is agreed that the common traits of autism are abnormal reaction to input stimuli, lack of human engagement and inability to generalize between environments [2].

Autism is seen as a mental disability rather than a psychiatric illness and as such it requires a particular education process than can assist autistic persons in learning basic social, communication and reasoning skills [3]. Education can be used as a tool to help autistic persons to cope with the 'theory of mind deficit – difficulty in understanding mental states of others and ascribing them to themselves or others' [4]. Successful autism "treatments" using educational interventions have been reported even a decade ago [5]. Recently, with the advancement of Information and Communication Technologies (ICT), computer-aided learning or instruction (CAL/CAI) is considered as a key method for handling autism interventions, particularly for young children.

This paper provides insights into various manifestations of CAL systems that are being developed for autistic persons. Moreover, the benefits of 'injecting' the affective dimension in such systems, thereby taking advantage of the existing affective computing technologies, are discussed. Finally, we present our CAL system developed as part of a Greek national project - EDUCATING AUTISTIC CHILDREN BY USING NEW TECHNOLOGIES. The main characteristics of the CAL system are an affective avatar as an interaction method (among others), the added Greek language text-to-speech conversion capability, and the personalisation database with user profiles and records of the learning process for the educators' facilitation.

2. CAL SYSTEMS AND AUTISM
There are many aspects of the research in the autism interventions domain that have lead to the usage of computer systems. There are evidences that autistic children enjoy using computers [6] and have affinity towards computer applications [7]. Moreover, CAL systems represent a controlled environment with minimum or no distractions that is crucial in the education process for autistic children [8].

Various successful CAL systems have been developed since the beginning of the last decade [9,10]. The social problem solving ability of autistic persons has been addressed in [11], using computer-aided instruction system. A computer-animated tutor has been developed to improve vocabulary and grammar in children with autism developed and evaluated [12]. Data showed that students were able to identify significantly more items during posttest and recall 85% of the newly learned items at least 30 days after the completion of training. Through the experiment in [13], it was found that after computer assisted learning, the majority of the autistic children could reliably identify at least 3 words when other methods had failed to promote those results. Additionally it was noticed that children spent more time on reading material when they accessed it through computer and were less resistant to its use.

Furthermore, there exist frameworks for effective ways of using technology for autistic persons in form of Autism Specific Interactive Learning Software Packages (ASILeSP), as well as software engineering guidelines for designing CAL systems [14]. Recently, collaborative virtual environments that incorporate

avatars have been seen as a successful education method for autism [4].

Adding the affective dimension in avatar expression provides more natural computer appearance and can improve the comfortness and pleasantness of autistics persons with the education system. Affect expression by avatars have been proven to have enormous significance in human-computer interaction [15]. Emotionally expressive avatars have been developed as part of the most recent applications of collaborative virtual environments for autistic persons [16].

3. THE AFFECTIVE CAL SYSTEM

The system is developed through collaboration with the ELPIDA-school specialised for educating autistic children, where it is implemented and tested. A group of highly specialised teachers has been constantly consulted regarding the functionality/purpose, contents and complexity level of the system modules.

The main goal of our system is to enhance or mediate the teacher-child education process. It is based on various interaction forms, appropriate to the level of disability of the autistic person in question. The system is comprised of individual modules, each representing a specific learning domain (Figure 1).

Figure 1: Learning modules menu.

The modules vary in their complexity and type of interaction. The first is a game-like module where the child is asked to identify the correct image (Figure 2) and the game theme varies from objects in the normal surroundings, everyday use objects, colours, words etc. The variation in the difficulty level is in terms of diversity of the content (relation) among the pictures, number of picture choices and complexity of the pictures. Furthermore, there is a module for learning emotions. The child is presented with speech and images in a specific emotion, and at the first stage it is shown the correct one while at the second stage it is asked to identify it form the several options. Another module with similar design is the everyday activities module. Simple activities such as washing teeth and preparing for bed, taking a bath, drinking or eating etc., are presented with sequences of images and videos, which afterwards have to be arranged in the correct order by the child. The more complex modules are in the form of semi-virtual environments where the child can have simple interactions in a safe and controlled setting. Moreover, there is a module for watching videos and cartoons while the child's reactions are monitored by the system.

3.1 Interaction with the System

The systems gives the instructions in form of an affective avatar, synthesized speech (in Greek), written in the screen or a combination of all three. Makaton symbols are presented together with the real images, for easier recognition of the image content. The avatar can express emotions appropriate for the situation, e.g. happiness when the correct image is selected, sadness if not (Figure 3) etc. The reactions of the system to the user input are designed to be very similar to those of the teachers in the same situations. Therefore for a success in the 'testing' the avatar with a smile on the face says: "Bravo", "Very good" etc. In the same manner, for a negative input/mistake, the avatar with a sad face asks to try again.

User input/feedback is facilitated bimodally: first by means of a mouse interaction; second, by means of a touch screen.

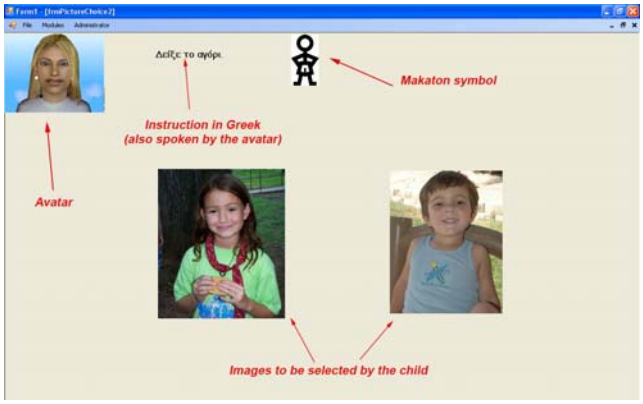

Figure 2: Prototype of a simple game interface (one module of the system).

Happy Neutral Sad

Figure 3: Avatar emotions.

3.2 User Monitoring and Profiling

The system records the interaction/education process in a database, which assists the teachers to keep track of the children progress and modify the difficulty levels accordingly. The interaction records consist of:

Modules that were run (e.g. learning through pictures, everyday activities etc.).

Sequences of multimedia that were shown (images, sound, video etc.). The database stores each pair, or group of multimedia as a separate instance (e.g. pair of images with a boy and a girl, a cat and a dog etc.). These instances can be edited by the teacher.

Form of instructions (avatar, speech, written, makaton symbols, and combinations of these).

Success rate (number of correct inputs, time of each input, which instances were correctly identified).

Difficulty level of the presented instances. The level actually corresponds to the user and is selected at the initialisation of each execution of a module.

Child's reactions while interacting with the system through movement-sensitive recorder. Two recorders are connected to the rotating chair, one behind the child and one below. The purpose is to identify the level of attention, concentration and motivation of the child during the interaction with the system.

Immediate feedback by the teacher through specific keystrokes. This option is not implemented yet even though it was one of het requests by the teachers. One option would be to divide categories of levels of attention, motivation and excitement and assign them to specific keystrokes (e.g. the function buttons). In this manner the teacher provides immediate input while monitoring the child-system interaction.

User success in task completion in terms of external (teachers) help required. Represented by teachers comments on the task completion.

The system contains a personalisation database linked through an easy to use interface to a detailed user profile mechanism. The user profiling is based on the interaction results gathered after each run. With the user profiling mechanism an educator may register specific educational or personality data for each autistic child/person. The results/reports can be adjusted according to the required information regarding a specific person. In this way, a longitudinal record may be achieved indicating "a learning curve" or a "suggested personal preferences curve" for each autistic person separately, thereby enhancing and normalising the educational procedures toward each person's needs.

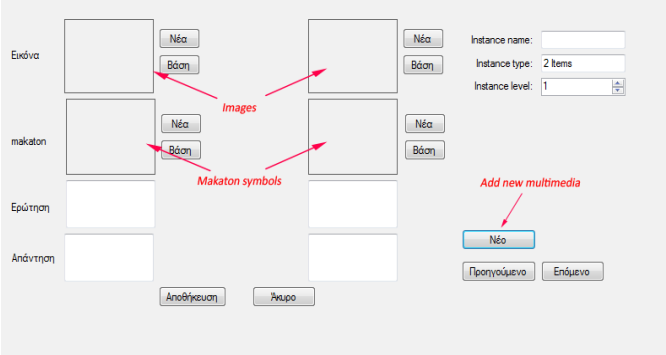

Figure 4: Adding new multimedia presentation instance.

3.3 System Administration

The system is specifically developed to be highly modular in order for it to be easily managed by the teachers or updated with new content or modules. The administrator modules enable the teachers to add, delete and modify the system elements, such as multimedia content, multimedia type, sequences, difficulty level, tasks for the user etc. Thus, the system can be easily adapted to the learning curve of the users. An example of adding new instance with specific multimedia is shown in figure 4.

4. RESULTS AND DISCUSSION

A pilot testing phase for the system is planned for the next 5 months as follows. In the first instance, "training-the-trainer" sessions are offered, where the system is presented to the educators. From a software engineering perspective, a user-centred approach has been followed, where the system development phases run in parallel with the user (educator) testing of the various prototype releases. Prototypes are given to educators for feedback, while more complete prototype versions are also given for testing to "selected" autistic persons. Different pilot tests are planned to check for each design and/or educational parameter effectiveness.

As we are finishing the initial stages of the pilot testing process, we have been given a highly positive feedback from the educators in terms of user friendliness, interaction scenarios covered, and simplicity of the interface (as one of the crucial parameters in interacting with autistic people). Additionally, the pilot tests with autistic persons have shown that system adaptability is one of the most significant characteristics. Several children were distracted by the complex multimedia presented on the screen (avatar), while others enjoyed it, and with immediate adjustment of the presentation complexity this problem was decreased (if not resolved). The next testing phase will include more autistic persons in order to obtain comprehensive results and data for system evaluation.

Last but not least, extensions of the system are already along the plan, where the autistic user feedback will be of main focus. Apart from the full implementation of the movement-based feedback module, we plan its enhancement through a combination with the level of stress or emotion of the person (biofeedback) [17]. In that case, further influences of the autistic person's emotional status along the learning process can be revealed across the various educational tasks.

5. ACKNOLEDGEMENTS

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