Augmented Reality as Visual Communication for People with ASD

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ABSTRACT

The goal of this paper is to present a behavioral modeling method for patients with Autistic Spectrum Disorders and an implemented prototype of it. The model is automatically derived from the natural interaction between a patient and his environment. This proposal differs from current treatments and tools, in that the individual is not trained by imposing semantic patterns, but ideograms built from the patient's preferences and environment. By using Augmented Reality, the autistic is being treated in an innovative way: the model gathers the environment variables and through communication by exchange of images (PECS) the treatment becomes a agile, continuous and flexible process. The procedure is expedited since the patient does not have to select PECS, but they appear to him. The activity recording is them processed in such a way to control and describe the cognitive and social profile of the patient. It also, performs a customize performance statistics. Likewise, the special administration of these statistics is intended to lay the groundwork for more representative future work that could allow the derivation of umbiased patient´s evolution.

Keywords: Autism Spectrum Disorder, Augmented Reality, Information and Communication Technology, Computational Intelligence.

1. INTRODUCTION

Information and Communication Technology (ICT) can be applied to education and health [1]. According to the theoretical analysis of the use of the Information and Communication Technologies (ICT) [2], in the educational process a specific requirement of educational complements.

The main goal of the this paper is to show application of a model based on Augmented Reality, implemented as ARA prototype. It collects and records activity data in order to perform control and diagnosis that could help evaluation of the therapeutic strategies. Also due to its characteristics, the prototype can complement patient's therapy, according to therapist's parameter.

To understand ARA [3], it is necessary to introduce the concept of Augmented Reality, and its usage within this prototype. It provides the patient with an expanded vision of his environment, just through a daily device. Physical world's data are combined with virtual elements to creat a mixed reality in real time [4]. Through this controlled environment, it presents a simplified visual and auditory customized access to the environment. It also provides the basis to generate specific training activities for ASD, focus on those areas where they have limitations. The proposed model can :

• Provide a simple and customized representation of the environment.
• Use information to foresee situations that are likely to happen to the patient in order to help him.
• Simplify the real world for the autistic.
• Highlight relevant part aspects of the environment for the patient.
• Strengthen the visual interaction (images, photos, videos, etc.) for patients that easily communicate that way.
• Strengthen the auditory interaction (sounds, spoken voice) for patients with this communication channel.
• Enhance the patient's process of generalization / abstraction.
• Allow a better customization of the therapy.
• Extend therapeutic and home context with technology.
• Track and measure patient's evolution using analysis of certain metrics and logs.
• Profile the patient using Computational Intelligence.

This paper also presents ARA prototype, which aims to provide a customized treatment, handle innovative variables and monitor the model's metrics, in order to define how methodologies are best applied to each patient.

It is expected that it also constitutes an excellent tool to:

• Improve the patient's social communication.
• Incorporate new concepts through reinforcement learning.
• Generate, stimulate and determine interest of the patient for his environment.
• Help the patient to understand his environment.
• Generalize similar objects and make evident that generalization.
• Associate sounds and activities to objects.
• Provide the use of Augmented Reality, as a tool to assist the therapist, for a focused therapy in specific topics.
• Evaluate metrics on LOGS files, to be able to determine specific autistic verbal behavior.

Traditional therapy manages the patient to make him integrate himself into his environment. It is important since autistic persons isolates them selves in an inner world. The approach of this

proposal reverses the problem: it works with an alternate communication process, supported by new technologies. The medium is adapted to the patient's mental process thus entering into the reality of the autistic. This way the patient can better imitate concepts shown by the application [5].
Subjects with ASD have patterns of behavior, interests and activities that are restricted, repetitive and stereotyped [6]. Prototype ARA [3], is based on PECS and multimedia, to be able to transmit semantics expansion, necessary for a good communication.
ASD subjects experience a persistent concern for certain parts of objects (buttons, body parts). They can be intensely linked to some inanimate object [6]. The ARA prototype [3] provides the possibility to relate PECS with images, videos and sounds that are familiar to the patient's environment. Alternative therapies in this field can cover alternative communication systems and communicative intervention on behavioral problems in Autistic Disorder [7]. There, aggressive behaviors such as kicking, biting or hitting, are presented upon incomprehension of the physical world or the lack of ability to obtain something from it. There are also observations of self-aggressive behaviors arising when the routine is altered or interfered. These new methods of communication can expand the repertoire with more words, new gestures and behaviors along with verbal expressions. That becomes in a more fluid and functional communication. Additionally, communication systems with PECS image exchange, uses a NUI interface as part of the language therapy in the Autistic Spectrum Disorder [8]. The Natural User Interface (NUI) allows to interact with systems or applications through signs or movements replacing other commonly used input devices such as: keyboard, mouse, pencil optical, joystick, among others. The tests carried out in this work [8] show the usefulness of the system. Specialits from VOCES Foundation, obtained good results when applied for the communicative development on autistic children.

2. MODEL PROPOSAL

Working Hypothesis
This proposal is based on certain hypotheses to build the model (and therefore the prototype). Among others are:
H1.-PECS, is a communication system by exchange of images to transmit the appropriate semantics during interactions with ASD patients.
H2.-PECS is effective to overcome the barrier of understanding in severe cases of ASD.
H3.-It is possible to construct a specific descriptive model of each patient in order to perform a customized therapy.
H4.-It is possible to define a set of concrete evaluation parameters and metrics in order to track the individual and population performance.

General Architecture of ARA
One of the main contributions of this work is the new shifted paradigm: dropping out the traditional focus on getting the autistic adapts to the environment. PECS is a valid communication system that has been adapted to create an Augmented Reality, providing extra information that is not obvious for the patient.
ARA has two fold architecture with desktop and a mobile application.
The therapist is the user of the desktop module. He first registers the patient's data into the system, then, a treatment with certain sessions.
Treatments can be pre-loaded. There is also the possibility to add new treatments. Every treatment can have one or more sessions.
When a session is added, a set of PECS must be attached with sounds associated to it and a vocal utterance of a mono or bisyllabic word, working as a sound icon.
It is pending to work with aromas and textures as extensions of the original icon. Fig. 1. Is a sketch of the project.

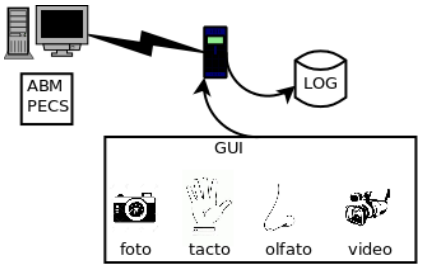

Fig. 1. Basic architecture of the ARA prototype

Graphic User Interface (GUI)
PECS is frequently used as a communication device for children with ASD. Can be of different types depending the concept or activity it represents, such as writing, washing, etc.
ARA relates PECS to all the required images, especially those that the therapist considers may motivate the patient. It is also can associate sounds, a word and a group of videos, all related to the PECS meaning. Fig. 2 shows an example of PECS. It is important to note that subset of PECS in the project, has been selected by experts because they are very used in many institutions. They have not been created from scratch, unlike the sounds, images and videos.

Fig. 2. PECS for washing hands

Interface to Mobile Device
After selection of PECS, sounds and videos, the next step is to generate the context where the patient will perform his treatment. To do that, the generated information has to be sent to the mobile device or tablet.
Despite of Augmented Reality framework do not require it, the current implementation of ARA works with QR tokens. Consequently, the QR codes associated with the generated PECS must be printed. These codes should be placed in any space where it is expected the patient would be working with the device. Fig. 3. shows a QR corresponding to the PECS in Fig. 2.


Fig.3. QR code generated by the system.

Mobile Device Operation

The Augmented Reality application starts from the mobile device or tablet. It opens and show anything the camera captures in real time. Every time the camera finds a QR code previously loaded in the session, the application recognizes it and displays on the screen the PECS related to the QR code as the current camera capture. (Fig. 4).

Fig. 4. QR code and PECS.

When the PECS appears on the screen, the sound loaded and the word will be reproduced as well. It is expeted to favor vocalization of patient. When the PECS is activated, two large and characteristic icons are presented, one for displaying images and another for inspecting videos. (see Fig. 5).

Fig. 5. Screen presenting multimedia icons

The photo camera icon allows accessing a gallery of images related to situations to which the PECS refers. The video-camera icon stands for showing one or more videos of related situations.
Every activity carried out with ARA is recorded in a Log file. Data are the following:
AAAA-MM-DD HH:MM:SS.mmm [type] [activity] [st][module][PECS] [description]
Where:
• AAAA-MM-DD. Stands for year, month and day. I.e: 2017-05-19
• HH:MM:SS.mmm denotes hour, minute, seconds. I.e.: 10:56:13.401
• [type]. Stands for the type of main application running. I.e.: [startup]
• [activity]. Is the specific function . I.e.: [loadAp]
• [st] declares the status (OK=1 or NO OK=0)
• [module] is the operation module. I.e.: [App]
• [PECS] is the name of PECS or "none". I.e.: [Computadora]
• [description] is the textual description of the system´s activity. I.e.: [Initializing the ARA application]
LOGS are automatically cleansed, eliminating special characters and tabulated using commas. The resulting dataset is processed in order to analyze, profile behavior patterns and perform data mining.

3. TESTING

The testing-follows a protocol for using ARA.
Step I: the therapist's diagnostic according to DSM-V [6].
Step II: record in the Interactive Registry Form of the degree of autism, Fig.6.

Interactive Registration Form

Therapist				
Date				
Time				
Patient				
Diagnosis				(DSM-5)
Name PECS	Time of Video	Time of Demo	Time patient	Observation

Fig. 6. Interactive Registration Form

Step III: The next step is to monitor a session with ARA. To do that it is important to take into account the considerations listed below.
• Isolate the patient from noise and external movements. Preferably in the same place as usualy sessions are performed.
• The protocol must be applied by the patient's therapist.
• The protocol is a complement of patient's therapy.
• Sessions can not be repeated or extended. This protocol has a maximum time that must be respected that way in order to preserve results.
• All equipment and preparation of the room must be done before the patient enters the room.
• The conditioning of the room should be as usual.
• Sessions must be recorded.
• The devices (videocamera, PC, etc.) should be hidden the patient.
• The PC must be loaded with the session´s data defined by the therapist for it.
• The room must contain the objects to work with the PECS.
• Videos must be loaded in advance on proper devices (PC, TV, Laptop, Tablet, etc.).
• Devices will be switched off or hidden until it is used.
• The therapist must fill in the Interactive Registration Form (Fig. 6) with the amount of time spent of each session.

Case Study

The case study with the ARA consist in two sessions, both configured with PECS related to "Computer" and "Write". Each one has images, videos and associated sounds. QR codes were printed and placed in a daily environment for the patient.

The test was performed by a patient 5 years-old volunteer.
The activity was recorded in LOGs files.
A total of 4 test were made from a Huawei cell phone model P8 Lite. LOGs were concatenated to be able to process them systematically. Data collected have 117 records and corresponds to variable as mentioned in section 2.4.
A dependent variable "Delay click" was created, which describes the time it takes for the patient / user to click on the PECS that appears on the device's screen. This variable was filled with the difference between "Time" property of the event "PECS Approach" and the "Time" of the "Click PECS" event. Records where the state is equal to 0 (null) were discarded, since they do not provide information.(See Fig.7)

Date	Time	Delay click	Activity	APP	State	Module	PECS	Description
13/06/2017	19:40:38.454	2,513	selected	tap	1	pecs_container	computadora	Click de PECS
13/06/2017	19:42:32.584	0,072	selected	tap	1	pecs_container	escribir	Click de PECS
13/06/2017	19:43:46.054	3,541	selected	tap	1	pecs_container	computadora	Click de PECS
13/06/2017	19:44:48.945	4,081	selected	tap	1	pecs_container	escribir	Click de PECS
13/06/2017	19:08:43.585	0,903	selected	tap	1	pecs_container	escribir	Click de PECS
13/06/2017	19:10:06.086	2,675	selected	tap	1	pecs_container	computadora	Click de PECS
13/06/2017	09:58:58.761	1,235	selected	tap	1	pecs_container	computadora	Click de PECS
15/06/2017	12:25:07.271	1,519	selected	tap	1	pecs_container	computadora	Click de PECS

Fig. 7. Dataset after LOG cleaning and formatting.

A frequency histogram was made for the frecuency is the seconds taken for that event. Fig. 8

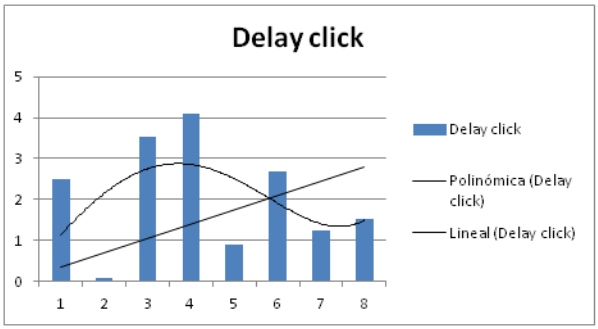

Fig. 8. Frequency diagram regarding click delay on PECS.

As can be seen the plotted curve seems to be a Normal. Then Shapiro-Wilk is used to statistically test normality. Hypothesis (H0) is a normal distribution. The analysis results with a significance level of 0.05 (α) where W0 is 0.9698 and Wt. For a sample of n = 8 is 0.818. If $Wo \leq Wt,\alpha$ then refute H0
Since: Wo> Wt, with α= 0.05, the normality is confirmed, the data can be analyzed with parametric statistics. Similar histograms for Computer and Write PECS are in Fig. 9.

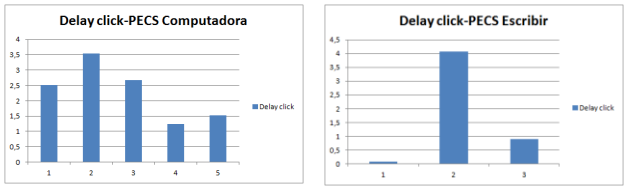

Fig. 9. Frequency diagram regarding click delay on PECS Computer.

The dependent variable "Access" was created indicating the multimedia access event related to the selected PECS (Fig. 10).

FECHA	HORA	Acceso	ACTIVIDAD	APP	ESTADO	MODULO	PECS	DESCRIPCION
13/06/2017	19:40:47.988	1	gallery	tap	1	images_button	computadora	Acceso a galeria de imagenes
13/06/2017	19:40:51.53	1	gallery	tap	1	videos_button	computadora	Acceso a galeria de videos
13/06/2017	19:41:05.124	1	gallery	tap	1	back_button	computadora	Acceso a camara
13/06/2017	19:42:36.751	1	gallery	tap	1	images_button	escribir	Acceso a galeria de imagenes
13/06/2017	19:42:39.529	1	gallery	tap	1	videos_button	escribir	Acceso a galeria de videos
13/06/2017	19:43:05.6	1	gallery	tap	1	back_button	escribir	Acceso a camara
13/06/2017	19:43:47.88	1	gallery	tap	1	images_button	computadora	Acceso a galeria de imagenes
13/06/2017	19:43:50.928	1	gallery	tap	1	videos_button	computadora	Acceso a galeria de videos
13/06/2017	19:43:56.533	1	gallery	tap	1	back_button	computadora	Acceso a camara
13/06/2017	19:44:52.538	1	gallery	tap	1	images_button	escribir	Acceso a galeria de imagenes
13/06/2017	19:44:56.436	1	gallery	tap	1	videos_button	escribir	Acceso a galeria de videos
13/06/2017	19:53:02.702	1	gallery	tap	1	back_button	escribir	Acceso a camara
13/06/2017	19:08:54.101	1	gallery	tap	1	videos_button	escribir	Acceso a galeria de videos
13/06/2017	19:09:46.657	1	gallery	tap	1	back_button	escribir	Acceso a camara
13/06/2017	19:10:09.655	1	gallery	tap	1	videos_button	computadora	Acceso a galeria de videos
13/06/2017	19:11:11.994	1	gallery	tap	1	images_button	computadora	Acceso a galeria de imagenes
13/06/2017	19:11:15.31	1	gallery	tap	1	back_button	computadora	Acceso a camara
13/06/2017	09:59:06.159	1	gallery	tap	1	back_button	computadora	Acceso a camara
15/06/2017	12:25:09.543	1	gallery	tap	1	videos_button	computadora	Acceso a galeria de videos
15/06/2017	13:36:34.059	1	gallery	tap	1	images_button	computadora	Acceso a galeria de imagenes
15/06/2017	13:36:36.361	1	gallery	tap	1	back_button	computadora	Acceso a camara

Fig. 10. Data of access events to multimedia gallery by PECS.

With the data obtained it is observed that the PECS Computer was accessed 5 times (see Fig. 7), we have to apply the corresponding filters to the PECS Computer, we obtain 13 accesses to the multimedia galleries (see Fig. 10). With which we have an average of 2.6 accesses. Although the magnitude of the test and the volume of data obtained does not allow us to perform analyzes in this regard, it is observed that the data provided by the application give us a basis for the development of future tests, where it also allows us to quantify the use of the same to measure the evolution of the use and to be able to make a more rigorous analysis with alternatives of tests varying the configuration of the images and multimedia for the PECS

4. EVALUATION AND DISCUSSION

Regarding the hypothesis H1, the PECS constitute a system of augmentative communication that is used with people who present communicative problems. In the case of people with ASD, they have the possibility of using visual supports that favor the communication of these people because many patients have better preserved visual memory [9]. However it is noteworthy that there are many other cases that are essentially auditory and do not usually have a good response with traditional PECS. ARA covers such alternates by incorporating audio and multimedia icons. PECS are used for both children and adults with different communication problems. It is a system that gives importance to interaction and communication in turn that can arouse some interest in communication in people with difficulties. This system has been used in hundreds of children with autism and other disabilities in the United States as well as other countries, for its easy handling and not involving complex materials or highly technical training or expensive equipment, and since it has been applied quite successfully in some states of the American Union [9].
Regarding hypothesis H2: According to Cordova and Socorro [10], the effectiveness of the PECS System for overcoming communication and language limitations is related to the level of autism since, according to the evidence, 40% of people With a slight level of autism, it manages to overcome communication limitations, obtaining normal communication. For people diagnosed with moderate autism, only 7% achieve it. People with mild autism only in 27% and people with moderate autism 13% improved their communication.
In relation to hypotheses H3 and H4: Although there are antecedents of models developed from biographical data and therapeutic observation tables, on which Machine Learning is applied [11] [12], in this work, the most important contribution constitutes the dynamic incorporation of information captured as

a consequence of the use of augmented reality. Statistical information together with the use of the Interactive Registration Form, the therapist has a complete record of the patient and a basis to drift from results relevant information such as delaying time of clicks. Several authors have been studying the relationship between clicking times and stress/ concentration [13][14]. It will be possible to adapt the sessions according to those finding in order to improve o the patient's therapy.

5. CONCLUSION AND FUTURE WORK

ARA combines traditional ASD therapy with Augmented Reality. From its logs it is possible to define a dataset reflecting the activity of the patient. It allows to summarize the information related to sessions, from several treatments of the same patient.

From test presented in this paper, it is possible to say that there is certain extra information that is not present in traditional therapies and that may provide new and interesting information able to be processed with different data mining techniques. That may expand behavioral profiling conclusions, and may be used to improve sessions for each patient. It also can be used to define new patterns, evaluation metrics, etc. It remains to use the relevant information that may arise from this process, in order to provide feedback to the application.

An important point to be considered is that the characteristics of ARA allow to extend the activity that can be performed in the therapist's environment. Under expert supervision, patient's environment may become a closer environment.

Based on the referenced works, and findings in this paper, it is possible to establish that the relationship ASD - Augmented Reality - PECS, is auspicious in the treatment of patients. It remains to implement the generation of smells and textures to objects and situations and to test the influence of such extensions in the evolution of the ASD patient.

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