AuthorAR: Authoring Tool For Building Educational Activities Based On Augmented Reality

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***Abstract*—This paper presents an authoring tool for creating educational activities based on Augmented Reality (AR), called AuthorAR. Due to its possibilities to create exploratory and structuring phrases activities, it could be use in special education to favor language acquisition and the development of communication skills.**

In this paper, an introduction is presented, where a detailed background on the use of Augmented Reality for the educational scenario mentioned above is provided, along with some previous works of the authors in the area. Then, AuthorAR is described accompanied by some examples of activities created for special education context. Finally, a brief description of the assessment plan to be implemented is given.

Keywords: disability; authoring tools; augmented reality, education technology.

I. INTRODUCTION

The technological development makes everyday life activities easier and more accessible for any person. This is even more so for people with disabilities, since technology can contribute to their autonomy and improve their quality of life. For this to be possible, it is essential that technology tools are developed that can turn communication or accessibility barriers into opportunities. That is, technology should be developed following universal design patterns, favoring true social inclusion. This is relevant because, as stated by Grau [1], technologies have been traditionally conceived, projected, produced and applied with the average person in mind, disregarding, or considering to a lesser extent, the differences derived from disabilities, which sometimes forces the introduction of technical adaptations or using additional resources for the technologies to be usable by certain people or under certain situations [2].

In the last decade, many systems that are classified as assistive technology have been developed, and it has been shown that they can help considerably improve the quality of life for disabled people [3].

Augmented Reality (AR) is a growing technology that allows overlapping any type of digital content over a real scenario. It has impacted the educational scenario, particularly, the special education scenario. As Lin, Chao and Wei at [4] point out, AR is a highly effective assistive technology for handicapped children, offering them an innovative and interesting learning medium.

Based on a review of the background for Augmented Reality applications in the area of disabilities, systems can be classified as [5]:

- Oriented to visually disabled people
- Oriented to hearing-impaired people
- Oriented to the learning process of intellectually challenged people.
- Oriented to favoring interaction with the computer.

In this paper, we present an authoring tool to design educational activities, in general, but that is useful for improving the work of teachers and students in the area of special education. This is possible because the tool is based on the interaction features offered by Augmented Reality, which offer various advantages to the educational scenario being studied. In particular, the exploratory activities allowed by the tool presented here are believed to be highly valuable as support to vocabulary acquisition and communication training for people with complex communication needs, users of alternative and augmentative communication1. Also, structuring phrases activities allowed by AuthorAR are oriented to people with difficulties in language acquisition.

In Section II, a brief review on AR concepts is given and Section III includes a background review of some AR applications for people with some kind of disability. Section IV presents AuthorAR and its possibilities for teachers and students, along with some examples of activities for special education scenario. Finally, the assessment plan and some conclusions and future work are described.

II. AUGMENTED REALITY

AR allows the user to see the real world, with virtual objects superimposed upon or composited with the real world. Therefore, AR supplements reality, rather than completely replacing it. Basically, it consists of a set of devices that add virtual information to the already existing physical information.

Following the definition proposed by Ronald Azuma, an AR system has 3 requirements [6]:

- It combines reality and virtuality. Synthetic objects are added to the real world; these can be visual objects such as text or 3D objects (wireframe or photo-real), sound, haptics (touch) and/or smells.
- It is interactive in real time. Users see a real world in real time with synthetic objects that have been added to help them interact with reality [7].
- It involves images recorded in 3D spaces. Virtual information must be spatially linked to the real world in a coherent manner. The position of the user in the real world must be known at all times to be able to record the combination of real and synthetic information.

Any AR system executes the following tasks sequentially: a. Scenario capture, b. Scene identification, c. Combination of reality with synthetic information, and d. Visualization of the augmented scene [8].

To capture the scenarios, video cameras or GPS devices are used.

There are three ways to recognize scenarios:

- The visual method uses what are known as markers. Markers are visual signs that are recognized by the camera in the computer or mobile device being used, and then interpreted.
- Artificial vision techniques are also used for scene recognition. Their recognition power is higher, but intense calculation and larger memories are required, with longer processing times. Its use is not too widespread in AR systems.
- Geo-positioning is the most commonly used technique in mobile devices; through the use of GPS, the position and orientation of the device are determined.

  The device sends its absolute position to a server, and the server returns information about nearby objects. The device calculates its orientation and chooses which object to augment, thus mixing real and virtual information for visualization.

Finally, there is a hybrid method that combines visual recognition with GPS techniques. A quick recognition of the scene is carried out, and the reduced image is sent to a server together with its GPS position to assess the object observed.

The task of combining reality with synthetic information consists on overlapping the real scene, already recognized, with the digital information associated to it.

The final task is viewing the augmented scene, showing the user the original scene together with the augmentative digital information. There are two kinds of visualization devices: low-cost devices, which are suitable for mobile devices (smart phones, desktop computers, portable computers, etc.), and high-cost devices, which offer high-quality images and allow 2D and 3D visualization.

The following section presents a review of some of the contributions of Information and Communication Technologies (ICTs) to special education, as a way of offering greater context for this work. In particular, some previous works carried out by the authors in special education scenario and some AR applications are described.

III. SPECIAL EDUCATION BACKGROUND

Several researches and studies underline the potential of ICTs in special education context [9][10][11]. Some previous works of the authors in the area of special education are briefly presented here, as an example of the possibilities of ICTs in this context. The adaptation of authoring tools was focused in one of them, in order to support the resolution of educational activities using voice commands. As a consequence, JClicVoice was developed, which is an adaptation to the authoring tool JClic [12], aimed at incorporating a new mode of interaction to this application, namely, voice commands. JClicVoice is aimed at people with motor problems, but with little or no consequences in language development. This subset of people was selected because there is a wider variety of technical aides for people with motor disability that use various parts of the body, and we considered that the use of voice would be a good alternative if the person affected by the disability had no difficulty in oral expression.

JClicVoice allows carrying out simple association, complex association, swapping puzzle, and sliding puzzle activities using voice commands. It is available for download at: https://projectes.lafarga.cat/projects/jclicvoice/downloads.

The authors have also been working in several other projects within the special education context. In particular, some of them are oriented to users of alternative and augmentative communication, such as the ones mentioned in [13][14].

The following paragraphs are intended to give some background of AR and Education.

One of the most promising aspects of AR is that it can be used to favor several interactive learning methods and that synthetic data are easily combined with real world data, thus allowing the simulation of dynamic processes.

A second key feature is its ability to respond to user input. This interactivity grants a great potential for learning. AR forces the person to be involved; it is not a passive technology. It can then be stated that AR is attractive because it is aligned with active learning.

Lastly, AR based on mobile devices takes advantage of this tool that is omnipresent not only for social interaction, but also for learning and research, blurring the boundaries between formal and informal learning, which in turn allows contributing to the evolution of a learning ecology that transcends educational institutions [7][15].

We will mention here some examples of applications, based on Augmented Reality, that help people with some kind of limitation, be this physical or mental, as a review of specific AR background in the area of special education.

PictogramRoom [16] is a project that involves an augmented reality room to teach how to interpret the pictograms that allow communication with people affected by autism and related disorders. Pictograms form alternative communication systems, but autistic people may have recognition difficulties when pictograms present slight changes such as thickness, color, and so on. The project proposes that, with the help of augmented reality, the possibility of using pictograms that are placed on top of real objects can help these people see the connection between the real image and the pictogram in real time.

Eyering [17], is a creation of MIT Media Lab. This is an augmented reality ring equipped with a small camera, a processor, Bluetooth connectivity, and auditory feedback through a portable device that could help the visually impaired to identify objects and read text. However, it could also be used as navigation help or translation tool for any person, as well as aid to teach children how to read. An example of its use in the field of disabilities would be a case when people cannot see well enough what is in front of them, so they can use the EyeRing which, through the device, will tell them the object that the camera has captured by adding sound information to the captured scene. In addition to this functionality, it can also create three-dimensional maps of the area around the user, which can be very useful mobility-wise for blind people, since they will know what is around them by hearing what their smartphone describes for them.

Other Augmented Reality projects in the field of disability have also been reviewed, such as Babelfisk [18], Elcano [19], and so on. There are also some other projects, more general in nature, that are related to AR and its application in Education [20][21].

Although, the previous applications presented are particularly related with AR and people with special needs, none of them are oriented to the educational activities creation. There are an increasing number of authoring tools intended to reduce the effort needed from professors, teacher, educators, etc. by offering clues, guidelines, predefined elements and templates, helps, and a user-friendly interface to create educational material in digital format [22]. Some of these authoring tools oriented to the educational context are: jClic, Ardora, HotPotatoes, Lim, Malted, Adobe Director, ExeLearning, Constructor, Cuadernia, etc. Teachers and speech therapists used them for the generation of educational activities for people with special needs [23].

However, only few of them allow the generation of educational activities including AR technology as a way of interaction. Cuadernia, DART (Designer's Augmented Reality Toolkit), ComposAR and Atomic provide an example of AR authoring tools. Only Cuadernia has a specific design for educational scenario. It allows an AR scene in which teachers have to select an existing 3D object from a gallery (or upload a new one with .DAE format). However, none of them have specific templates like the one of structuring phrases.

Seichter [24], presents an interesting analysis of AR authoring tools, and proposes ComposAR as a tool for all kind of users.

The following section is dedicated to describe AuthorAR as an AR authoring tool, focusing specifically special education scenario.

IV. AUTHORAR: AUGMENTED REALITY AUTHORING TOOL

In this section, we describe an authoring tool for creating educational activities, based on Augmented Reality, that we have called AuthorAR. It was conceived as a free desktop application, capable of running in any personal computer. It is based on visual recognition techniques using markers, as we explained in section II. It was thought as a teacher tool, as we incorporated specific templates in order to create educational activities. Particularly, it is oriented to the special education scenario.

AuthorAR was developed using ActionSript. For each activity generated in AuthorAR, an xml file is created. The schema used by these files is part of the design of this tool. AuthorAR is composed by the activities generator and the player. The player allows activity resolution. AuthorAR is oriented to help teachers build, in an intuitive and simple manner, educational activities that are based on AR. The first version of this tool allows the creation of two kinds of activities: exploratory activities and structuring phrases activities.

A. Exploratory Activities

Exploratory activities are those in which teachers can set up a relation between a multimedia content and an AR marker. Later, students could use the marker as an interaction element with the computer.

In general, any activity that helps learn something new, such as a new concept, rule, formula, knowledge, etc., can be classified as an exploratory activity [25].

From the students' standpoint, they are the main actors of an exploratory activity, inasmuch as they are the ones that carry out the activity rather than the teacher.

Exploratory activities in AuthorAR are based on a set of elements that, when presented to the web camera connected to the PC, offer additional information about the scenario that is being captured in real time. First, during the activity resolution, an activity statement designed by the teacher appears in the screen. This will help to understand the purpose of the activity. Second, the student has to show a marker in order to incorporate the additional information in the real scene. Finally, a close phase of the activity takes place. The teacher for example can prepare some questions to end up the activity.

B. Structuring phrases activities

Structuring phrases templates allow teachers to create those kind of activities in which students have to compose a phrase. The phrase must be structured in a subject-verb-object way.

First, an activity statement is presented to the students. Second, they have to compose a phrase using three printed images. One of the images is representing a subject, other a verb, and the last one, is representing an object. Students have to show to the webcam the three markers in the right position in

order to structure the phrase. On the real scene, when the phrase is well structured, it is possible to incorporate an animation of the subject doing the action with the corresponding object. This relation was previously defined by the teachers. In addition to that, it is possible to define a different feedback for incorrect phrases.

This kind of activities is specially design for students with language acquisition difficulties.

C. *Designing exploratory and structuring phrases activities*

The proposal of AuthorAR is allowing teachers to generate the activities, selecting which contents to show in each case, and establishing relations between an AR marker and multimedia contents. The marker will be the element that allows interaction between the student and the computer. It can be stuck onto a physical object.

Below, the possibilities offered by AuthorAR to the teacher are described, as well as the steps that should be followed when working with this tool:

1) First, you should choose the option to create a new AR activity (exploratory or structuring phrases), or edit an existing one.

2) To create a new exploratory activity, first you must choose the type of multimedia content to be used in the exploratory activity, and then upload that content to the application. The multimedia content can be a flash animation, a 3D object, etc. A sound can also be added that will be played when the marker is presented. Figure 1 shows a part of the upload screen for multimedia content.

3) To create a new structuring phrases activity, you must write the phrase to be composed. AuthorAR provides three text fields labeled as subject, verb and object to incorporate each one. In addition to that, it is possible to upload an image for each of these elements. Later, you could print these images to work with them during the activity resolution. Besides, you must associate a multimedia content to each of these fields. When the marker corresponding to the subject, for example, is shown to the webcam, the multimedia content is displayed in the real scene. Finally, you must incorporate the information that will be shown when the student arrives to the correct phrase, as well as the one for incorrect phrases.

4) For both kinds of activities, AuthorAR will automatically generate the AR markers required.

5) Teacher can then print out these markers to distribute it among the students and achieve interaction with the application. At the bottom of the screen there is a "Get Markers" button that the teacher can use with this purpose. Each marker can be stuck onto any object that might be of interest so that the student can relate the multimedia content with the physical object.

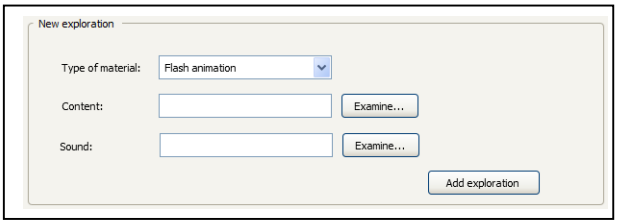

Figure 1. Upload screen for multimedia content to be presented during an exploratory activity

From the point of view of the students, they will receive either physical objects with markers that have been added, or papers or cardboard cards with a graphic on one side and a marker on the other.

D. *Examples of AuthorAR activities*

This tool is believed to be of essential importance in special education, since it could be used by teachers to tackle, for instance, activities to train communication processes and vocabulary improvement as well as language acquisition processes. Thus, it would be possible to work with special communication needs students by associating real objects with their respective pictograms that are usually used for their communication practices. We are currently working with AuthorAR on the design of this type of activities in collaboration with experts from the area of special education. In particular, we are creating explorations that link real objects with various representations, animations that represent contexts of use, and so on.

Activities oriented to colors and shapes recognition are also designed. This kind of practice is important for those users of AAC. They help them to identify and choose the proper pictograms to communicate with others.

Finally, we are working with structuring phrases activities with a speech therapist who works with students with difficulties in language acquisition.

The advantage of having a tool of this type is that teachers can create their own activities with no need to resort to a technology expert.

Currently, this tool is being assessed and it will evolve based on the results obtained. The following section presents the assessment proposal that was designed.

V. ASSESSMENT PROPOSAL

As mentioned before, we have already been working in various projects involving educational tools for the field of disabilities, so we are already collaborating with teachers and students from this educational area. Additionally, we have been working with a group of experts (special education teachers, speech therapist- some of them specialized in AAC, researchers in ICT and Education) who are willing to validate this type of applications.

Our assessment proposal includes: two steps. A first step is to implement a validation carried out by experts in the area. We will ask experts to use AuthorAR and complete a web

formulary, with a series of questions. Experts can review and express their opinion regarding the application being assessed.

After improvements have been implemented based on the feedback obtained from the experts, as a second step, tests would be carried out with the end users at the special education schools with which are already working for other projects.

VI. CONCLUSIONS AND FUTURE WORK

This work is a first step on the road to offering new possibilities for using ICTs in the educational environment. So far, we have designed the authoring tool proposed and produced a first prototype, together with a compilation and comparative analysis of augmented reality libraries that have not been included in this article. We have developed a series of activities specifically oriented to special education area. We are currently going through the first stage of the assessment process; the results obtained will be published in the future.

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