# SERIOUS GAME USING AUGMENTED REALITY TECHNIQUES FOR THE REHABILITATION OF CHILDREN WITH PSYCHOMOTOR DISABILITIES

FARIA, V. N. R.*, ABRAHÃO, T. A.*, SILVA, N. L.*, CHAGAS, V. G. S.*, NOGUEIRA, K. L.*, CARDOSO, A.*, LAMOUNIER JUNIOR, E. A.*

*Universidade Federal de Uberlândia (UFU), Uberlândia-MG, Brasil
e-mail: naves.vinicius@gmail.com

**Abstract:** This work presents a serious game (which is a game with ludic purposes) to help professionals who deal with children in one association called as AACD. Referred to as Improved Life, the game works as a tool to support Speech and Music therapy sessions. Based upon an assistive technology approach, the system was implemented by exploring Augmented Reality techniques, providing a more natural and intuitive interface. This paper presents the methodology adopted to develop Improved Life and discusses previous results.

**Keywords:** Augmented Reality, Serious Game, Assistive Technology, Rehabilitation, Music Therapy.

## Introduction

This work is based on the development of a system of assistive technology based on Augmented Reality (AR) for the rehabilitation of children with psychomotor pathologys. The system is configured as a serious game, in other words, a game developed that does not have as its main purpose the entertainment, pleasure or fun [1]. In this context, such games are intended to provide a self-reinforcement attractive context in order to motivate and educate the players.

The game was developed as an Assistive Technology (AT), which currently represents an increasing research area, driven mainly by the new paradigm of social inclusion that advocates the participation of people with disabilities in different environments. ATs are essential to many people as an aid to mobility, learning, work, communicate and interact with the world. Despite the importance and the growing demand of the area, in Brazil, research and AT projects are in one embryonic stage [2].

There are several AR applications for different areas such as Medicine, Engineering and others. One of them happens precisely in healthcare, both in surgical applications for treatment applications and patient rehabilitation (so-called assistive technologies) [3]. There are also Virtual Reality applications (VR). However, the focus of this research is Augmented Reality. VR is configured as an advanced interface for third generation computer applications in which the user can interact in real time, from a three-dimensional synthetic environment using multisensory devices [4]. On the other hand, AR applies to all human senses and provides a safe interaction, without the need for training, since it can bring to a real environment the virtual objects, enhancing and increasing the vision that the user has of the real world [5, 6].

Serious games have emerged as excellent learning tools in order to improve the interest of students [7]. The lucid and relaxed manner of a game causes it to become an excellent learning tool, encouraging its users to search processes, construction skills and strategies [8]. When treating children with psychomotor disabilities this strategy proves very effective.

In order to apply the concepts in rehabilitation by using serious games, as an AT, the research groups of the Computer Graphics Laboratory and Biomedical Engineering of the Federal University of Uberlândia (UFU) with the Association for Assistance to Disabled Children (AACD) have conducted a research cooperation. In the city of Uberlândia, AACD has the objective to promote the prevention, habilitation and rehabilitation of people with physical disabilities. Especially, in children, teenagers and young people, promoting social integration through the development of prosthetics and orthotics and psychomotor treatments.

The Improve Life serious game has been developed to improve the activities developed by AACD. The game was implemented to music therapy and speech therapy treatments. Thus, the system may help children with deficits in oral language, cognitive and physical rehabilitation of those who have special needs and even the social inclusion. Such system will help health professionals in therapy sessions. It also enables the extension of therapy for the patient's home, being simple to use system and executable by family members or caregivers.

## Materials and methods

The system has been implemented using a toolkit called ARToolKit, which is free from the HITL Lab at the University of Washington website [8]. This library provides Computer Vision techniques to calculate the position and orientation of a camera to trademarks (cards), so 3D virtual objects can be overlaid precisely through the brands and in real time.

First, a webcam (or similar) captures a frame, which is transformed into a binary image. Later, this image is analyzed by ARToolkit. In turn, ARToolKit thresholds an input frame into a binary image and uses a labeling algorithm to find any possible square shape objects. For the labeled object, edges and corner points are detected. Image coordinates of the four corner points are used to form line equations which represents the two perpendicular sides of the square marker. The detected marker's interior pattern is extracted and is normalized for template matching whit previously saved pattern. By using the corner points in the marker's coordinates and the points in the image screen coordinates, an interactive process is taken to find the closed rotation and translation components in the camera's extrinsic parameter. In the final step, OpenGL uses the estimated transformation matrix to overlay a virtual object on the video frames [9].

The virtual objects viewed in applications developed with the distributions of ARToolKit can be implemented with OpenGL and / or VRML. The visualization of these virtual objects is performed at the time of insertion of markers in their respective field that captures the video frame [8].

According to system requirements collected with stakeholders, a computer architecture has been developed as shown in Figure 1. The Augmented Reality module is responsible for capturing user interaction with the system and pass the sequence of musical notes collected, assembled or phrases, for the lexical analyzer module. The sound interface is responsible for issuing audible real-time feedback on user actions. The GUI (Graphic User Interface) module is divided into two windows, giving a visual feedback to both the patient and the Health professional monitoring the therapy session. This interface can send data as graphs to control learning environment. Finally, the lexical analyzer module is responsible for comparison and validation exercises. It is especially important to use AR in this case, because children with psychomotor disabilities have several physical therapy exercises that could be adapted and executed together with the application developed in this work.

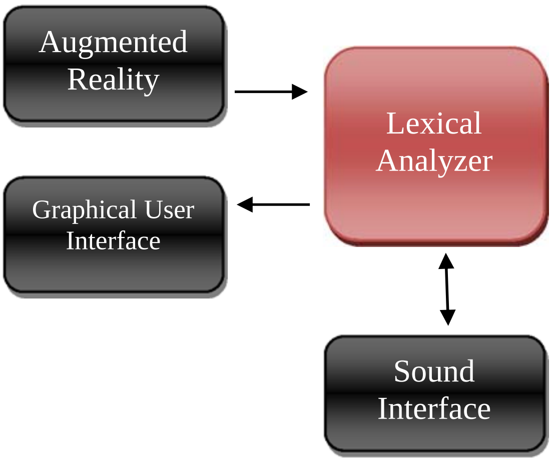


Figure 1: Proposed system architecture.

**Lexical analyzer phrases -** For the construction of verbal phrases there are rules to be clarity about the message to be conveyed. Thus, it is important to use the subject, the verb, and the complement correctly. Nevertheless, a lexical analyzer was created to assess the presence of elements of a sentence quoted above. However, without reference to the order of the elements, Figure 2. At first, this order was not considered significant because the majority of children, who should read the application, was still unaware of the grammatical rules.

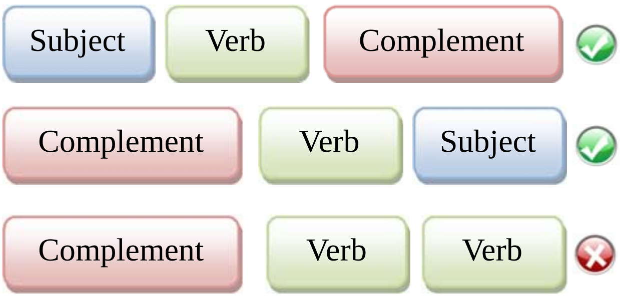


Figure 2: Lexic analizer phrases.

**Lexical Analyzer Musical Notes -** For application in Music therapy, lexical analyzer has also been created to compare musical notes, played by users associated to melodies recorded in the system. The application of musical therapy is divided into three levels as represented in Figure 3.

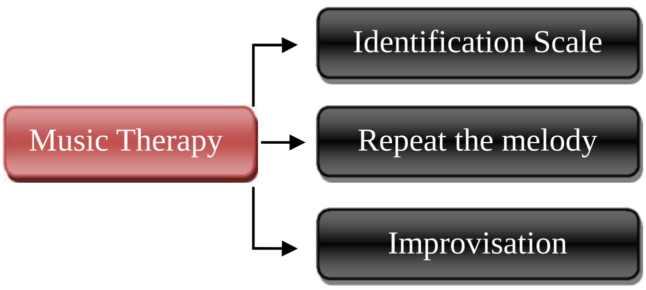


Figure 3: Music therapy implementation levels.

The creation of the game levels is intended to measure the impact of treatment on the patient. Thus, from the patient's evolution, the health professional may start treatment using the levels above. At level I, Identification of Musical Scale, the game launches ascending and descending sequence of 5 musical notes that are presented in the C major scale (the note C to the B and the B to the C). The goal is to hear the sequence, being able to identify the scale and, thus, repeat it without errors.

At level II, the Melody Repeat is the same principle of operation of the above. But, the system will play a melody. The game has two options for choosing music, *ĐÓ RÉ MI FÁ"* and *Ätirei o pau no gato:" (Portuguese lirics)*. Thus, the patient will not have to repeat an ascending or descending sequence, but a song, which requires an advance. Finally, level III, the Improvisation, does nothing more than allow the user to touch any sequence of notes he wants. This action causes the patient to explore further musical perception that it has acquired over the three levels because, improvisation requires certain musical knowledge and creativity by the patient's side.

It is important to note that the use of the developed system, since it is a technology that uses only markers, it provides great facilities in using it with patients who present psychomotor disabilities. Experiments have shown that markers are easier to handle than a normal keyboard, which provides greater a musical accessibility, as demonstrated in Figure 4 [10].

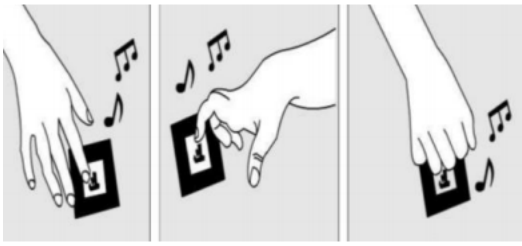

Figure 4: Musical accessibility [10].

## Results

After the implementation of the prototype system, the process of testing and validation has begun. At first, only AACD professionals interacted with the virtual environment. Figure 5 shows the system screen with 3D virtual objects in music therapy application.

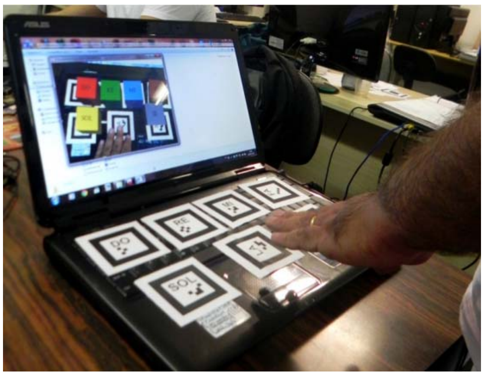

Figure 5: Interaction with markers related to musical notes.

Figure 6 shows the system screen with 3D virtual objects in the speech therapy application. Many libraries have been developed within this application. Among them, the libraries of musical instruments, toys and food can be explored.

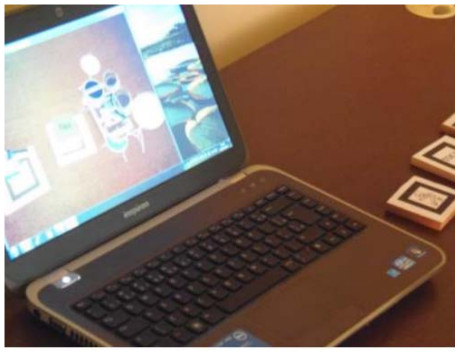

Figure 6: Speech Therapy module.

The child interacts with the markers shown in Figure 5 and Figure 6. In the case of the system in Figure 5, when a marker is hidden, the system recognizes it, processes the information and returns to the user the sound related to the occluded marker. In relation to Figure 6, the software recognizes the markers positioned by the patient, processes the information and provides, in the video, the images relating to the assembled combination. The system also outputs sound of a sentence constructed by combinations of markers. In both cases, we observe not only the work that can be developed in relation to motor skills (patient movement) but also the psychological skills (apprenticeship Portuguese and music).

An evaluation of the prototype by AACD professionals (musician therapists and speech therapists) was performed. Table 1 shows the issues that were addressed and the Figure 7 shows the results.

Table 1: Table evaluation of the proposed system.

| Question | Concept | Description |
|---|---|---|
| 1 | Efficiency | Purpose has been proposed. |
| 2 | Usability | "Setting Navigation". |
| 3 | Functionality | Ease of use (intuition). |
| 4 | Applicability | The importance it attaches to the system in the context of rehabilitation. |

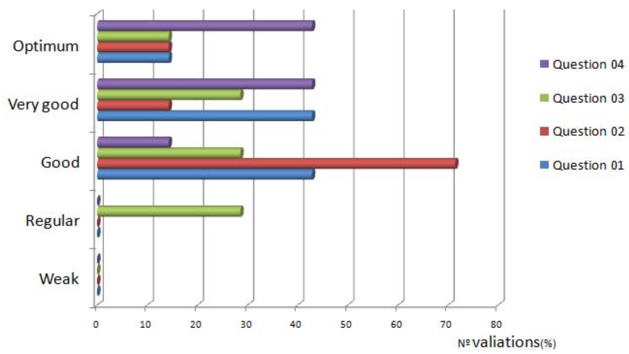


Figure 7: Statistical graph of system evaluation by professionals AACD.

The developed system was evaluated only from the perspective of professionals who could use it, the musician therapists and speech therapists of AACD. The tests with the use by children with psychomotor disabilities were not performed yet. In fact, the local Ethics committee has first to approval the proposed tests with AACD children.

## Discussion

From the evaluation above, an assessment of the comments was made in order to identify the results expressed in Figure 6. Main considerations are:

- To increase the distance between the markers music therapy in order to increase the degree of direction (less accurate);
- To create contrast in colors of the figures because there are children with visual limitations (all markers);
- To increase the time for sound reproduction, with no repetion when pressed (music therapy and speech therapy);
- If possible, to optimize virtual keyboard to solve security problems for children (all markers);
- To provide the system for use at AACD (though approval process under the committee ethics).

## Conclusions

The system behaved well in the first test, and is awaiting release from Ethics Committee of the AACD for patient trials. The fact of the flexibility of access to virtual objects provided by AR, led health professionals to identify ease movement operations. This fact contributes positively to the rehabilitation process.

Another advantage observed is that, in addition to be used by professionals to encourage the reporting of patients at rehabilitation centers, there is the possibility of using the project by users in their homes. By presenting an easy-to-use facility, the system can be installed on any computer or "tablet". Thus, it creates a continuous and interesting therapy for the child.

As future work, in addition to adapting the system under observation of professionals in the AACD, we intend to increase the music library and make adjustments from potential user suggestions when evaluating the system. Another proposal is to create other lexical analyzer modules to teach Portuguese and their structure, besides assisting speech and express desires.

## Acknowledgment

The authors acknowledge AACD for their collaboration in this work and FAPEMIG for financial support through the APQ-02934-11 project.

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