Application of the GAMeNT Framework for the Development of a Serious Game Prototype aimed at Older Adults
Aplicación del Framework GAMeNT para el Desarrollo de un Prototipo de Juego Serio dirigido a Adultos Mayores

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Summary. One of the biggest problems that will be faced in the world in the coming years is the demand for care in the field of physical and mental health in older people, serious games are presented as a tool to support occupational therapies for preservation of health and activities of daily living (ADL) in this group.

This work breaks down the process of designing and implementing a serious game using the GAMeNT framework, which was developed with the objective of producing serious games that integrate socio-emotional virtual agents in an interactive narration. The software prototype that was implemented to improve shoulder tendons and exercising short term memory considers an aesthetic and dynamic design centered on the user and the integration of a virtual agent that guides the game. It is highlighted that the use of the GAMeNT Framework facilitates the implementation of serious games.

Keywords: Serious Games, Occupational Therapy, Older Adults, GAMeNT.

Resumen. Uno de los mayores problemas que se enfrentarán en el mundo en los próximos años es la demanda de cuidados en el campo de la salud física y mental en las personas mayores, los juegos serios se presentan como una herramienta de apoyo a las terapias ocupacionales para la preservación de la salud y las actividades. de la vida diaria (AVD) en este grupo.

Este trabajo desglosa el proceso de diseño e implementación de un juego serio utilizando el framework GAMeNT, el cual fue desarrollado con el objetivo de producir juegos serios que integren agentes virtuales socioemocionales en una narración interactiva. El prototipo de software que se implementó para mejorar los tendones del hombro y ejercitar la memoria a corto plazo considera un diseño estético y dinámico centrado en el usuario y la integración de un agente virtual que guía el juego. Se destaca que el uso del Framework GAMeNT facilita la implementación de juegos serios.

Palabras clave: Juegos serios, Terapia ocupacional, Adultos mayores, GAMeNT.

1   Introduction

The population worldwide is aging, and this accompanied by the decrease in groups of young people under 15 years, has made possible modify the world population pyramid in its structure by age. Far from being a problem, this situation is the successful product of global government policies regarding birth control and the increase in the life expectancy of its population. Due to the synergy generated between these two factors, planning to meet the health challenges of an aging population is of vital importance.

A problem related to this stage of life is functional dependence. However, it is possible to extend autonomy in older adults, increase development and prevent disability through occupational therapy. Currently, due to the reduction in costs and evolution of technology, different types of occupational therapies have benefited from the use of video games, software and hardware products, although the impact of most of them is limit because they were not conceived for that purpose.

This article describes the application of GAMeNT framework to guide the development process of a serious game aimed at older people, as a support tool in occupational therapies aimed at stimulating the physical and cognitive functions of this group.

2   State of the Art

There are several studies in the literature on the physical, cognitive and emotional advantages that represent the incorporation of TICs in the quality of life of older people [1][2]. There are different approaches of TIC´s uses in this area, like adaptation of commercial video games with Wii and Xbox to exercise motor skills, virtual reality applications [3], augmented reality [4] and Internet of things for aging care.

Some organizations in EU and North American countries [5][6][7] promote the design and implementation of technological solutions aimed at helping the people of the Third Age. Research results from these projects are now being used in Europe and AL, some examples are:

- Cognifit, Mental training, and games application that allows you to evaluate and improve the memory and cognitive abilities of older people.
- Kwido is a cognitive stimulation platform designed by and for psychologists and geriatricians.
- Oroi Sync applies virtual reality in older people, as a tool for entertainment and cognitive stimulation.
- Virtualrehab body is a platform to support therapy for the rehabilitation of the upper and lower extremities.
- TDAH Trainer adult version is cognitive exercises for the treatment of attention-deficit in adults.

In Spain, in the Etorkizuna Eraikiz region, AdinBerri strategy [6] was started , which is a project that includes an innovation unit that houses research and testing space to improve the older people's life.

In Mexico, the gerontotechnology approach, which is the development of technology for the diagnosis and prevention of the deterioration of functional autonomy, is still in an incipient state; however, government policies have begun to show signs of incorporation into this global trend. In 2018, the director of the National Institute of Geriatrics (INGE), said that the gerontotechnological approach has recently been incorporated to develop applications to promote functional autonomy.

3   Theoretical Framework

This section defines the following elements: 1) Occupational therapy for older people and 2) GAMeNT framework. These elements introduce the reader in the context problem, occupational therapy, and the characteristics of the framework on which we base the development of our tool.

3.1 Occupational therapy

The human being, as the years go by, reaches the condition of an older adult, a stage of life in which the first symptoms of aging begin to appear, which implies the decrease of their cognitive abilities, such as memory loss, lack of attention, slow processing of things, in addition to problems in their motor capacity, among others.[8]

Cognitive impairment, when mild, can be improved and prevented through any physical activity or cognitive stimulation, among some of the measures that can be taken to generate benefits in mental health and disease prevention.

These conditions can be treated by non-pharmacological means such as occupational therapies (OT), which allow to provide a benefit for older people, so that the transit through the aging stage allows them to be active, capable of performing the daily living activities independently, as well as healthy, since through them it is possible to prevent or reverse in some cases, the disability that may arise. [9]

3.2 GAMeNT Architecture

The five modules of the GAMeNT architecture: Gameplay, Learning, Goal, Narratives, and Technology (**G**ameplay, **A**prendizaje, **Me**tas, **N**arrativas, and **T**ecnología in Spanish) named the framework.

Three layers make up the modules: Game, Emergent Player-Game interaction, and finally, the Player. GAMeNT (Fig. 1) provides a methodology that guides the design and development of the serious game, allowing players to immerse themselves in the game through the integration of socio-emotional virtual agents in an interactive narrative. [10].

In the Goal module, defines the objective of the Learning Content to be pursued. It supports the Gameplay, Learning, and Narratives modules.
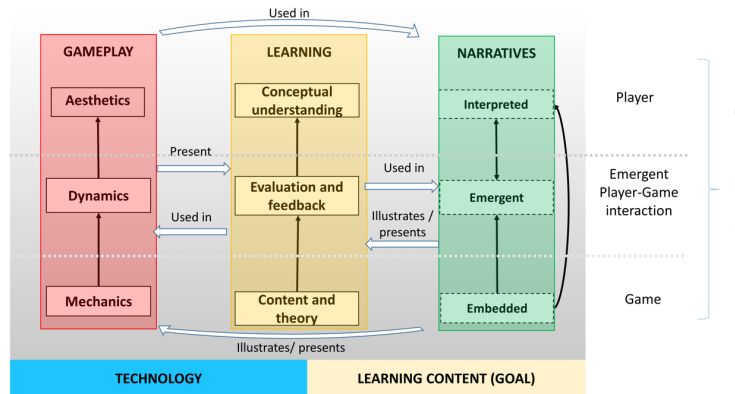
Fig. 1. Graphical Scheme of the GAMeNT architecture

The Technology module defines the interfaces, controls, games and development platforms, graphic environment, language, among others, that influence the scope and limitations of the serious game.

In the Gameplay module, it groups mechanics, dynamics, and aesthetics, where emotional responses are specified in players and visual and auditory aesthetics to help a better immersion of the player. Mechanics refers to the particular components of a game, which represent specific objects or qualities. The Dynamics describes the mechanic's runtime behavior, acting with the players' entrances as well as the other exits in time. Aesthetics describe the desirable emotional responses evoked in the player when he interacts with the system. [11]

Learning is the module where training objectives are explicitly defined based on the theoretical concepts. Evaluation and feedback are an essential since they allow us to identify the improvement areas.

In the Narratives module, it is where the story is narrated to present the game and the learning components pleasantly and entertainingly for the player.

The methodology and architecture describe how the elements of a serious game interact, such as narratives, static objects, dynamic objects, events, agents or virtual characters, and interactive history. [10]

4   Methodology

GAMeNT framework [10] is used in this work, which consists of nine main steps:

1. Set the goal and theme of the game.
2. Investigate and prepare the contents of the learning and the subject.
3. Create ideas or concepts to be used in the game.
4. Prepare the design.
5. Create a physical prototype to corroborate that the machinery develops its task.
6. Create the digital prototype to corroborate that the core of the serious game is the desired one.
7. Test the system.
8. Verify functionality.
9. Test the usability and compliance with the desired experience.

5   Experimental Results

This section describes the follow-up of the nine steps of the GAMeNT framework methodology to design and implement the serious game to support occupational therapies for older adults.

5.1 Set the goal and theme of the game.

Considering the problem that frequently occurs in older adults regarding the lack of mobility and loss of memory, characteristic of the age, the goal is that the user performs a series of physical activities that involve the exercise of arms and shoulders and work the concentration to preserve short-term memory.

The theme of the proposed game involves activities on a ranch. The serious game shows various scenarios that use augmented reality libraries, and under the instructions of a virtual agent, the user has to interact in the game through an avatar.

5.2 Investigate and prepare the learning contents and the subject.

Learning contents are the activities, experiences, and disciplinary knowledge which you aspire to achieve the goal. The proposed activities correspond to the physical conditioning of arms and shoulders through play, as well as retention exercises to strengthen short term memory to achieve the established goal.

In the game design, the environment, dynamics, and aesthetics. The field was defined as the environment, precisely one day at a ranch. Through the presentation of small stories in various scenarios of the ranch such as the garden, the corrals, the animal farms, the player's interaction is given, in which the activities he has to perform are indicated, ensuring that through these, the player enjoys the story and feels motivated to perform physical and mental exercises.

5.3 Create ideas or concepts to be used in the game.

This stage makes the initial proposal of the components to which the GAMeNT architecture refers. In the game environments, propose the theoretical content, the visual and auditory elements, the form of evaluation and feedback, the narrative idea of the game, the levels of the game are determined, in addition to the elements present in this serious game as agents or characters virtual events that involve learning content, interactive history and evaluation content, each of them composed of its mechanics, aesthetics and dynamics as appropriate.

Define detail of the environment design, narrative, and evaluation based on theoretical content. The theoretical content that supports the game corresponds to occupational therapy aimed at stimulating the physical and cognitive functions of older adults. Arms movements are promoted, strengthen the muscles of the arm and tendons of the shoulder, and thus avoid the lack of mobility or diseases such as tendonitis. Tendonitis, among other causes, is caused by the aging of the tendons, which lose elasticity until they degenerate. Occupational therapy involves a warm-up and shoulder strengthening exercises, to prevent future injuries.

Another issue to consider by occupational therapy is intervention through activities to prevent and maintain short-term memory capacity, which usually diminishes in old age for various reasons such as stress, anxiety, depression, or illness, such as dementia, ictus, Parkinson, between others.

Serious game is developed in a ranch environment, and the use of static elements are for the graphic design of the scenarios according to the proposed story, plus two virtual characters that allow interacting with it.

Some of the static elements are country houses, the stable, mountains, a vegetable garden, trees, vehicles, and some others, while the virtual characters are the representation of the occupational therapist and the user's avatar.

In the narrative of the game, the user can navigate with an avatar through three different scenarios. The vegetable garden where the user must accommodate vegetables in a basket that are at different distances and height levels. The corral's stage where the user needs to catch animals and put them inside a cage. In the third stage inside a barn, the user has to stack hay blocks forming a tower. Virtual character guides the user in the narrative for realization and overcoming activities that he has to perform in each scenario.

The different levels of the game represented by scenarios contemplate an evaluation part. In each scenario, the player must overcome the corresponding challenges. As the user manages to pass the tests, he is helped to continue advancing in history, which is giving feedback to the player at each stage. In case of failure, the user has to repeat the activities. Mechanics used in-game consist of QR codes located in the arm or hand of the player, which interact with the webcam of the computer and the software records and evaluates the movements of the arm and shoulder. The dynamics of the established levels are the interactions with the virtual agent, who inform the progress that the user takes and provide feedback on the performance of the exercise. The desired aesthetic in the levels is an adventure so that the player feels immersed in the scene presented in the story.

Learning content design is implicitly in the activities of the game so that the strengthening of the shoulder area and the short-term memory is carried out.

Game elements design. In the <u>design of virtual agents</u>, their role in interactive and learning storytelling is defined, as well as mechanics, dynamics, and aesthetics. For this work, the characters of the game Ralph and Zoe are predefined models in the Panda3D game engine.

The avatar Ralph is the main character in the interactive narration and responsible for most of the events in the story; the user has to help him perform the tasks of the game. It has a learning role in the execution of tasks to improve short-term memory and physical exercise of the user. The mechanics of this character is the motor expression through animations and movements in the environment.

Zoe's character has a role in interactive guide narration through instructions, helping the user to achieve the goal. The mechanics of the agent are verbal and motor expression, through audios and body expressions to assign the task to the user. Agent's dynamic offers feedback to the user regarding the performance of the activity.

The <u>event</u>'s design shows the content throughout the interaction between the player and the game environment and allows the user to evaluate and provide feedback on their performance.

Several events are depending on the scenarios. In the first scenario, which corresponds to the harvest in a vegetable garden, the user must harvest a list of vegetables, in the order provided by the therapist agent — the dynamic consists of accommodating the vegetables in the virtual basket. In the second scenario, the dynamic takes place when the user virtually touches the chickens so that they enter the pen, and the user must follow the order defined by the avatar based on the colors of the chickens. In the third scenario, the dynamic consists of virtually indicating to the avatar the bale of hay to be stacked.

The visual aesthetics proposed in the events are objects that are usually found on a farm or ranch. Other objects which the user interacts like vegetables in the first stage, the hens in the second stage, and the bales of hay in the third are highlighted to focus attention on them.

The <u>design of the elements for user evaluation and feedback</u> is detailed below. The evaluation is carried out in each of the three scenarios through the activities that the user must face. In the first scenario, that is a vegetable garden; the user performs abduction and adduction movements to move the vegetables to the basket in the order suggested by the therapist. The evaluation is carried out by measuring the lateral opening angle concerning the midline of the user's trunk. To evaluate the exercise of memory, consider the number of successes and errors in the collection of vegetables concerning the order defined by the therapist.

Pen's scenario, the objective is to relax the arm muscle a bit, so the evaluation only consists of achieving the proposed activity that is to touch the chicken and put it inside the cage. Activity memory exercise evaluation consists in respecting the order color hens defined by the therapist In the last exercise of stacking hay blocks, there are four levels so that the opening angle of the arms increases, and the user can notice its limitations.

For feedback, if the goal fails, the therapist encourages the user to keep trying, and the event restarts.

5.4 Design phase.

The design is described below in terms of game structure, input-output structures, program structure, and design evaluation.

At the beginning, the user selects an option from a menu through the keyboard that allows him to watch and hear an animated introduction about the objective of the game. Augmented reality is implemented by QR codes, which are detected by the computer camera. The user has placed them in the correct position when interacting with the elements of the story in various scenarios. The exercises proposed are linked to routines that support the user in strengthening the shoulder tendon and exercising short term memory.

There is no program structure predefined by the Panda3D game engine, so a single folder is used for the project, with subfolders to store images, audios, models, and actors necessary for development.

For the design evaluation, Crawford's proposal [12] was used to answer 3 questions: Does the design satisfy my goals? Do you do what I want you to do? And will the player experience the experience I want? The operation of the game was tested, considering that the objective is for the user to perform physical exercises for strengthening the shoulder tendon and mental exercises to improve concentration and short term memory. For the player to experience immersion, the story of why one day in the field is explained by trying to experience the desired aesthetics through visual and auditory elements.

5.5 Physical prototype

The use of a freehand scheme of the scenarios in which the story takes place allows us to understand the purpose of each one for the achievement of good design. It is necessary to confirm that the mechanics of the game perform the desired task.

5.6 Digital prototype

In this phase we develop the prototype with aesthetics corresponding to the narrative of the game. The static elements just represent the concept. In this phase we develop the prototype with aesthetics corresponding to the narrative of the game. The static elements selected do not necessarily correspond to those included in the final phase; it is just to represent the concept. In this phase, we evaluate dynamics, static, and narrative of the game in general and verify that the central system of the game is what we desired.

The prototype must consider the scope of the goal through the learning contents and include all ideas or concepts necessary for the game.

The final prototype as seen in Figure 2, Figure 3 uses the Panda3D game engine in version 1.9.4. and it tests the use of augmented reality (AR) technology to move the avatar that develops the task that was indicated by the virtual agent. Mainly in this project, ARToolKit library experimentation and the verification of the feasibility of use during the implementation of the serious game is carried out.

5.7 Game test

The developers performed serious game tests. Perform verification of user interaction with the game through input and output devices, such as audio, keyboard, and camera. It was experimented with the augmented reality ARToolkit library to interact with the game. To achieve a proper reading of the QR codes through the camera's sensor, we use a calibration routine to adjust some parameters such as light and distance.

5.8 Functionality test

The functionality of the game was tested and verified to be complete and balanced. Testing the augmented reality modules and adding calibration routines at the beginning of the game ensures that the computer camera detects the necessary QR codes to manipulate the avatar. The software was reviewed by an adult clinic therapist, because we plan to probe it under thraphist supervision instead of patients playing alone at home.

Fig. 2. Corral arrangement scenario with AR Technology.

Fig. 3. Vegetable harvest scenario with AR Technology.

5.9 Experience and usability test

The prototype was evaluated by two therapists that work in a Day Centre with traditional therapies to help elderlies. They gave us some feedback about the problems that could happen with the technology used by elderly and the kind of temas that we could try in order to motivate and engage elderly with the game.

The serious game was not executed for the target user, so the software has to be tested in the future. We will measure the experience of use to know how easily the game is to task and the experience play to know if the game enjoys patients.

6. Conclusions and future work

Considering the health of older people by the Mexican government as well as worldwide is a priority focus of attention for several years and since short-term expectations show an even higher growth of the population in this sector, it is necessary to strengthening of the plans for their attention, with the objective of achieving an active and healthy aging in the population.

In the world, there is a clear trend in the design and implementation of technological solutions aimed at helping older adults to have a full and independent life. Particularly in Mexico, the improvement of the quality of life of older people is considered necessary by the government, organizations such as INAPAM and INGER realize this; however, gerontechnology is a little addressed area.

The characteristic of older population at present is that they do not have ample knowledge in technological tools management, however, the situation may be different in a few more years, when present active adults, who are use to use technology will become older, so it is a priority the incursion of technological research applied to the development of tools that help older adults have a healthy life and improve their quality of life.

With this idea in mind, this article presents the detailed design of a supportive serious game for occupational therapy of older adults using the GAMeNT architecture. As an innovative element of the technology applied to occupational therapy in older adults, augmented reality routines are used for the adult to interact in the game through an avatar. The only hardware required is a video camera integrated in the computer where the serious game is running, so that is an economic factor to be taken in count, especially in an emerging economy country.

We can conclude that the use of the GAMeNT framework facilitates the implementation of the serious game since it not only provides its architecture but also offers a design methodology that allows anticipating the needs and characteristics of the end-user, as well as planning all the elements of the serious game before the programming and testing phase.

Future work includes the usability testing phase and experience with a group of senior citizens, as well as experimental research to verify results.

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