

# A Pervasive Game for Elderly People with Augmented Reality: Description and First Validation

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**Keywords:** Pervasive Games, Elderly People, Augmented Reality.

**Abstract:** The rise of videogames in our culture has caused that they are no longer seen as simple games for kids and have spread to all the segments of population. The use of videogames by elderly people can help to improve their quality of life, exercising their mental functions. Inside the field of videogames, the concept of pervasive game appeared with intensity some years ago. This kind of games exceed any of the classic dimensions of games: temporal, spatial or social. In order to achieve this evolution, pervasive games use to take advantage of non-traditional interaction technologies and novel paradigms, such as augmented reality. In this paper we introduce a novel pervasive game oriented towards elderly people that makes use of augmented reality. The game has been developed following a user-centered approach with participative design. In the game, players have to find certain elements in their environment (e.g., in a nursing home) so that they unlock memories that they store in an album and can value. Here, we describe the game in detail and show a first validation that we have carried out in order to test its usefulness. In that validation, users find the game useful and easy to play with.


## 1 INTRODUCTION


People over 65 years old are the segment of the population that has grown the most in recent years. For this reason, the most significant change in the next generation of elderly people will be their high level of education. It is now imperative to harness their learning capacity to engage them in initiatives that enable their personal development (Morillas and Martínez, 2013). In Spain, the consumption of video games represents more than half of the total audiovisual leisure, ranking at the top of the list. Over the years, the taste for video games has ceased to be the exclusive heritage of children and young people to integrate elderly people. As consequence, more and more video games are part of the daily life of the population as a tool of socialization, ceasing to have only a playful purpose and being able to be used as educational tools for their audience.


According to AEVI (Spanish Association of Video Games) 47% of the total turnover of video

games worldwide comes from mobile video games and it is also observed that they are experiencing a great growth year after year (12.8% more than in 2017) (AEVI, 2019). So right now, smartphones are presented as the main platform for the creation and consumption of video games.

The introduction of elderly people in Information and Communication Technologies is also important to eliminate the digital divide. Digital divide can be a form of exclusion and dependency for people who are not integrated into the information society. In the specific case of Spain, the elderly people are gradually entering, although much remains to be done. One of the resources used that has shown to be useful for improving certain aspects in the lives of elderly people is the video games. Thus, in (Allaire et al., 2013) a study related to video games, that was conducted among 140 people of average age 77,5 years with different profiles concluded that those who played video games regularly or occasionally showed

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better values in the socio-emotional field than those who had never played.

An emerging paradigm in video games is pervasive games. According to Montola (2005), pervasive games are a genre of play that breaks the traditional boundaries of the game, defined in terms of spatial, temporal and social dimensions. When producing games according to this new paradigm, the particularities of these games must be considered, and their specific characteristics given by the pervasive expansions in the axes of time, space and social interaction, those that are not present in traditional games.

Pervasive games have had a rapid growth in different fields, as evidenced by the proliferation of game experience designs of this type (Arango-López et al., 2017a). There are works (Kasapakis and Gavalas, 2014) that compile numerous developments resulting from design experiences in context such as education, health, entertainment and tourism, among others. Thus, from the collection of experiences emerged the definition that says that "A pervasive game offers the player a game experience enriched by an evolution of the game dynamics, expanding the space of the game according to the context in which it is played. In this way, the boundaries of the game world are broken, making reality a part of it and the elements present in that reality can have an influence on the game" (Arango-López et al., 2017b). This definition was presented based on the identification of the main elements present in this type of games, which are: devices, context, social interaction, time, space, multi-reality and crossmedia. All linked by means of a pervasive narrative.

Taking all this into account, we have designed and developed a pervasive game oriented towards elderly people, with the aim of improving their quality of life, both physically (since they will have to move around their environment to play, which stimulates physical activity) as at a cognitive level (since the game involves unlocking memories, which will stimulate your memory). The game consists of looking for certain objects (usually photos) that, when detected, generate virtual objects through augmented reality. Touching that item will unlock a memory that will become part of an album, and advance the player in his progress. Our game will be pervasive on a spatial level, having to move to be able to complete it and potentially have any location, temporary, as it could be played at any time, and also social, as people who play can interact in the meantime with other people who are not players.

In order to test the usefulness of our game, we have carried out an initial validation in which we have

worked on the technological acceptance of the game. Therefore, we have used a questionnaire based on TAM (Davis, 1989), the most popular model for technological acceptance. By means of this questionnaire, we have asked about the perceived usefulness of the game and its perceived ease of use.

The rest of the article is organized as follows. Section 2 collects related work on pervasive games for elderly people. Section 3 describes in detail the game presented. Section 4 explains the initial validation that we have carried out. And finally, in Section 5 we gather the conclusions on the work carried out and some lines of future work.

## 2 RELATED WORK

In recent years, there is a lot of activity in the development of games for elderly people. In addition, the authors of these works have drawn interesting conclusions as to what should be taken into account when developing video games for adults. Several relevant works in this area will be mentioned below. In (Cota et al., 2015), the authors conducted a study on aspects that lead elderly people to play games for the mobile phone. The study consisted of developing a catalogue of games, so that the preferred genres of elderly people were identified. From there, the authors developed a game called *Traveling the World*, with several mini-games of the genres preferred by the elders. Through this work, the authors identified several elements of motivation relevant to the elderly people, such as, for example: the interaction of the player always has an associated result, the difficulty increases gradually, the mechanics are simple, information about the benefits of playing, or aspects of usability, such as color contrast or large, clear images.

Another interesting example of game, which has certain similarities with the one we will present later, is the one described in (Mubin et al., 2008). This game, also designed for mobile phones, combines a classic game of looking for identical cards with the search for specific physical locations. In this way, we could say that there is also something pervasive about it. It is a game that can be collaborative, and thus enhance the social aspect. After the evaluation of the game, called *Walk2Win*, the authors drew certain recommendations, such as: this type of games should reach as wide an audience as possible (even if certain elders participate passively), rules should be minimized, it is interesting to introduce elements of familiar games, gender distinctions should be

eliminated, and the environment should be customizable.

Another type of games is that in which, using devices such as Microsoft Kinect or other similar, the elderly people are sought to perform some type of exercise, either within the scope of a rehabilitation plan or simply to keep them active. An example would be described in (Gerling et al., 2011). In that case, the authors used Nintendo Wii to develop a game called SilverPromenade that simulated virtual rides while posing certain mini-games to older people. From the experience, the authors drew three useful conclusions for developers of this type of game: the capabilities of the target audience should be carefully explored, the right choice of metaphors is fundamental to making it easy to enter the game, and games should be designed to suit a wide range of players and situations.

Lastly, we are going to mention another example of activity for adults which shares with the game that we will introduce some points such as the use of virtual or augmented reality and the aim of stimulating players' memory. This is the Virtual Maze Task (Cárdenas-Delgado et al., 2017). This activity is not presented by their authors as a game, but it includes some aspects that we may understand as gamification elements, as users have to learn routes in a maze. In this work, authors studied the difference in performing this activity with an immersion approach or with physical activity, regarding satisfaction, interaction and other aspects.

Thanks to this study of related work, we have been able to obtain valuable ideas that have subsequently resulted in the design of our application. In the section dedicated to the design of the application we will detail the points that we have taken into account.

### 3 THE GAME ENCUÉNTRATE

In this section, we are going to explain in detail the process of design and development of EncuentraTe, a pervasive game oriented towards elderly people that makes use of augmented reality technology so that players can move in a given environment searching for memories to be unlocked.

#### 3.1 Analysis

Our first intention when facing this project was to develop a pervasive game that might help improving life quality in elderly people, influencing on aspects as keeping them active, getting their mind exercised or boosting their social abilities. For the design and

development of the game we had the support of a residential complex for elderly people that includes apartments for non-dependent people, a residential center for dependent people and a senior day center. We followed a user-centered design approach from the very beginning of the development process, so that the final idea of game got generated among the development team, the staff in the residential complex and a group of elderly people. Thus, two meetings in which the idea of the game was thought through were organized. The first meeting included members of the development team and members of the staff of the complex. In this meeting, participants generated the idea of the game consisting on locating certain elements placed in the complex and unlocking memories when doing that, so that the memories got stored in an album and they made the game to advance. By using augmented reality, the elements of the game that allow the memories to get unlocked would appear.

Later, a second meeting was organized. This meeting was a focus group in which some residents of the complex participated, together with some staff members and members of the development team. In this meeting, the approach decided in the first meeting was validated, and a list of categories in which the memories got classified was elaborated. The categories chosen were culture, sports, history, music and cinema, and personalities. It was decided that in the election of the memories special interest would be given to memories from the region of Aragon, where the residents live.

Together with the first meeting and the focus group, the user-centered analysis included a process of observation of the elderly people in the residential complex. From this observation we could conclude that a great disparity of profiles exists in the complex, as residents that are dependent in a higher or lower degree live together with other residents with a high level of autonomy.

Specifically, these were the goals defined for the design of the app:

- To develop a pervasive mobile videogame adapted for its use by elderly people.
- That the game uses augmented reality for integrating it with the environment in which it will be played (i.e., the residential complex).
- To elaborate an album of memories with which the user gets identified. Those memories will get unlocked when playing the game.
- To develop the game experience in a way in which players get encouraged to keep exploring their environment in search of more memories to unlock.

### 3.2 Design and Implementation

Next, we are going to explain in detail the features of the design of the app. We are going to start with its architecture. The game will work over the Android operating system, the most popular one nowadays in the field of mobile devices. The environment chosen for the development of the game has been Unity, an engine for multiplatform videogames that is widely used nowadays by the community of videogame developers. Inside Unity, the platform Google Firebase has been chosen to support programming by means of its APIs, which make easier to handle authentication and other features. Lastly, regarding augmented reality, the platform that we have chosen has been Vuforia, which SDK allows tracking a great diversity of both 3D and 2D objects using almost any kind of camera integrated in a mobile device. This implies a great level of compatibility with most actual devices. In Figure 1 it can be seen a schema of the architecture of the app.

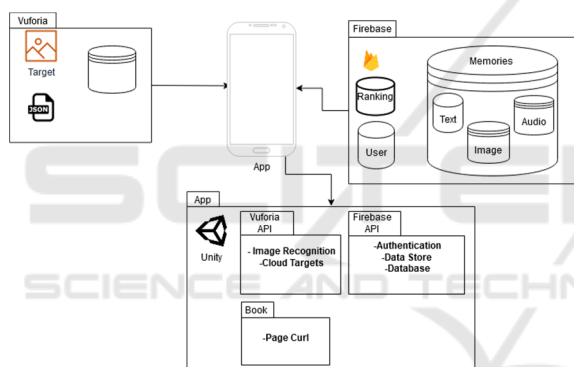


Figure 1: Architecture of the system.

Regarding user interface design, as this is an application oriented towards elderly people, we have chosen a design with big and clear buttons, simple fonts and no complex gestural navigation. The application starts with a welcome screen and another one for user login. Next, the game screen is shown. In this screen is where augmented reality is deployed. Therefore, it is not necessary to navigate through menus or other screens that may make interaction more complicated. The game screen is made up of the images provided by the camera of the device, enriched by the augmented reality elements, as we will explain now.

The way in which the game works implies that the player has to locate certain images in the real world so that, when the mobile device focuses on them, a virtual object appears on the screen. These images are photographs that are stored in the game database. The

object that appears is a button that belongs to a certain category. When this button is touched in the screen, a memory from that category gets unlocked. This implies that a screen with the information about that memory appears. This screen includes an image a brief description and the possibility to listen to the narration of the description. Also, some memories have a video instead of an image. When the player exits this screen, a positive support will be shown so that the player gets encouraged to keep on searching for memories. In this point, if the player has achieved a certain number of memories of this category, a medal will be awarded to him/her. Also, he/she will be asked about his/her opinion on the memory unlocked. This is made with a thumbs up/thumbs down system. In any moment, the player can see all memories unlocked by touching the album button in the game screen. Also, in that screen it is possible to go to a ranking screen where he/she can compare with other players.

Regarding the visual design of the application, we chose to provide it with the appearance of an old album in which paper and leather would be the textures that would predominate. Icon are quite simple, so that they can be identified in an easy way. All this work of visual design was carried out by a professional graphical designer. A more modern design was discarded as we understood that our audience preferred a more traditional appearance, and it would have not fitted well with the theme of memories and albums that supposes the common thread of the app.

Specifically, the following points, which were identified in the study of related work as beneficial in a work of this kind, have been taken into account in this design:

- Simple mechanics: the only interaction that is needed for progressing in the game is to move all around the environment searching for the goals and touching the virtual buttons that appear.
- Minimize the rules: in order to achieve goals, it is only needed to unlock memories, with no other rule.
- Big and clear images: all the elements that appear in the game have a big size in order to avoid usability problems in elderly people.
- Elimination of gender discrimination: there is no element in the game that may discriminated depending on the player's gender.
- Reaching a broad audience: as we will explain later, we have chosen a set of memories that cover a wide period of time so that players of

different ages can find some memories to get identified with.

- Elements of other games: the categories of memories can recall the ones in popular quiz games.

Next, we are going to show some screens of the app as examples of its user interface and visual appearance. To start with, in Figure 2 it can be seen an example of the game screen. In it, three fixed buttons appear. The one in the upper part of the screen is used to go to the screen in which the player can see the awards that he/she has achieved when unlocking memories. The two buttons in the lower zone of the screen are for going to the ranking of the game and to go the album with all the memories already unlocked, respectively. Regarding the central button in the figure, it is the virtual object that has appeared in the augmented reality when focusing the mobile device on an image that the game database identifies as an object to find. In this specific case, this virtual button will unlock a memory of the *sports* category.

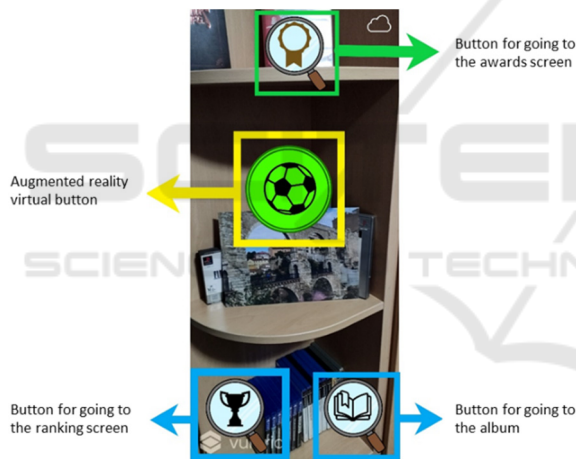


Figure 2: Game screen.

As a second example of screen in Figure 3 we depict an example of memory, specifically a memory of the *personalities* category. This memory has been shown directly after it has been unlocked. It can be seen how the user interface includes an image of the memory (in this case, the image is a person's photo), a description, and audio controls for handling the narration of the description. This way, the description can be read, listened, or both, depending on the player's preference.

Lastly, in Figure 4 another example of memory is shown. This time we have chosen a memory of the *music* category, and we have accessed it through the album. It can be seen how the user interface is similar to the one in the previous memory, but with a video

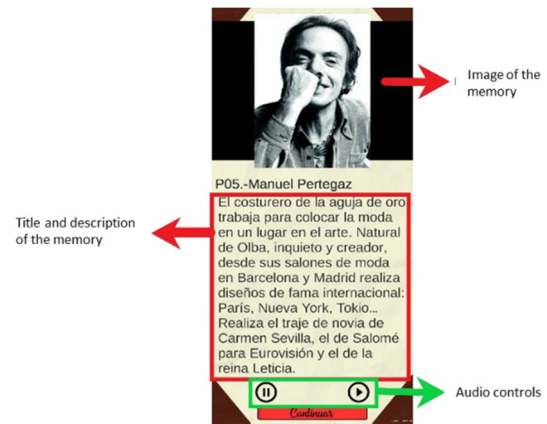


Figure 3: Memory of the *personalities* category.

of the song instead of the image of the person that we had before. The video has its own playing controls, which are shown over the video itself so that it is clear that they refer to it, and not to the narration of the description. Also, as we have reached this memory through the album (i.e., it was previously unlocked and now we are reviewing it), we have some controls for navigating through the album.



Figure 4: Memory of the *music* category.

### 3.3 Design and Implementation

As it has been mentioned previously, a critical component of the application is the collection of memories that the elderly people will unlock during their progress in the game. They should be attractive so that players get encouraged to keep on playing and find new ones. The categories were defined in the analysis phase, thanks to the focus group with potential players, and then the development team selected the specific memories. The goal was to create a collection of memories recognizable for the

residents, which help them to remember moments of their life and to learn curiosities of their environment. Thus, memories from the 50s until our days were chosen. The total number of memories for each category goes between 15 and 20.

#### 4 FIRST VALIDATION

In order to validate the application, it was tested by six people over 45 years of age (the age threshold had to be lowered to achieve a larger population). Each of these people was provided with a device with the game installed and the necessary targets (printed images) to unlock the memories. After each person used the application long enough, they filled a validation questionnaire in based on the questionnaires used in the TAM model (Davis, 1989) to verify technological acceptance. In this way, we verified the interest of the participants in having an application of this type in their daily lives. We measured the perceived usefulness and the perceived ease of use. The questions that were asked were the following:

- Question 1: I think playing “EncuentraTe” would improve my qualities such as physical condition or memory.
- Question 2: I find “EncuentraTe” game useful to me.
- Question 3: Playing “EncuentraTe” would be easy for me.
- Question 4: I see that the game “EncuentraTe” is flexible enough to interact with it.
- Question 5: It would be easy for me to master “EncuentraTe” game.

Thus, questions 1 and 2 refer to perceived usefulness, while questions 3, 4 and 5 refer to perceived ease of use. These questions were answered by the study participants, giving each one a numerical value between 1 and 5, being 1 the worst score and 5 the best. Survey results are shown in Table 1; we reflect score averages in Figure 5.

Table 1: Results of the first validation.

Quest.	User #1	User #2	User #3	User #4	User #5	User #6
#1	5	5	5	4	3	4
#2	4	4	5	4	4	5
#3	4	4	3	3	3	5
#4	5	4	3	4	3	4
#5	5	3	2	5	4	4

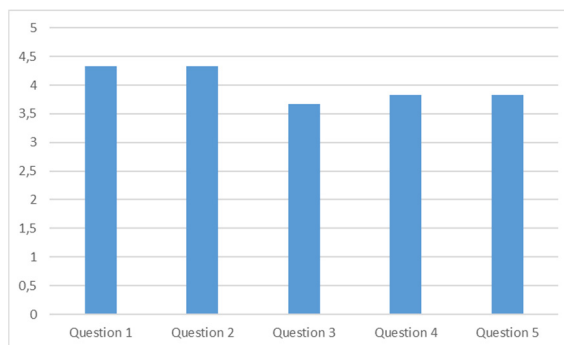


Figure 5: Questions average for the first validation.

As we have tested the application with a small population we can just show the first impressions based on these results. In the case of the questions related to perceived usefulness, the answers average is 4.33 out of 5. This seems to indicate that the participants in the study perceived the application as useful for the purposes for which it was designed. However, the result when calculating the average of the answers to the questions on perceived ease of use drops to 3.78. Thus, we could infer that the participants in the study did not perceive the application so easy of use, despite they evaluate well its usefulness. This should lead us, in future more exhaustive studies, to identify specific usability problems and correct them in order to improve this perception of ease of use of our application.

#### 5 CONCLUSIONS AND FUTURE WORK

In this work we have presented “EncuentraTe”, a pervasive mobile game aimed at elderly people. The game makes use of augmented reality and has been developed to be played in nursing homes for elderly people or similar centers. The game consists of locating in the real world a series of real images. Once found, the application is used to see different virtual objects that appear by means of augmented reality. Tapping on these virtual items users unlock memories which are displayed and can also be narrated to the player. Memories are also stored in an album. The game has an achievement and ranking system to encourage the player to keep playing. Therefore, with this game we have contributed to the development of a novel game for elderly people that uses current technologies and consider specific requirements proposed in the literature as positive in the development of games aimed at the elderly. Our game includes the ideas behind pervasive games together

with the aim of stimulating the elders' memory and having them performing physical activity. In this sense, this is a novel way in which such aspects are tackled.

We have carried out a very preliminary validation of the game. The game seems to be valued positively in terms of its usefulness, but has aspects to improve in terms of its ease of use. Therefore, it is necessary to carry out more complete studies to help us to identify the points for improvement that would change that perception. Such new studies will imply a larger number of users with a higher average age.

As future work, in addition to the aforementioned studies, we will add new functionalities to the application. Specifically, we will include some help or tutorial functionality that allows to improve the game usability. We also will intend, based on the evaluations that players make of memories, that the game can be adapted to their tastes, promoting the appearance of memories that are in line with their preferences. For example, if it is observed that the preferred memories of a user refer to a certain time period, the application would work on showing more memories in that same period. Also, the possibility for family members to include personalized memories and rewards will be also considered.

## ACKNOWLEDGEMENTS

Work partly funded by the Spanish Science and Innovation Ministry, the National Research Agency (AEI) and the EU (FEDER) through the contract RTI2018-096986-B-C31, by *Fundación Bancaria Ibercaja* through the contract JIUZ-2020-TEC-04, and by the Aragonese Government (Group T60\_20R).

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