An Open-Source Spanish Video Game as a Case Study for the Development of an Interface for Users with Visual Impairment

Estefanía Güimil, Yesica Sacristán, Dana K. Urribarri, Martín L. Larrea

Laboratorio de Investigación y Desarrollo en Visualización y Computación Gráfica – VyGLab
Departamento de Ciencias e Ingeniería de la Computación,
Universidad Nacional del Sur, Bahía Blanca, Buenos Aires, Argentina
estefaniaguimil@yahoo.com.ar, yesi.sacristan@gmail.com,
dku@cs.uns.edu.ar, mll@cs.uns.edu.ar

Abstract. With the growth of information provided through computer systems, it is fundamental and legally necessary, that everyone have equal access to the information in order to live fairly. For the last few years there have been a positive trend in the software industry to include people with disabilities as their target users. As a consequence of this, access for visually impaired users to software is improving. This brings new challenges from the Human Computer Interaction viewpoint. This paper describes the design, development and evaluation of an open source video game for visually impaired users in Spanish. This game was conceived as a case study for the Human Computer Interaction theory applied to those with visual problems.

Keywords: human computer interaction, video games, visually impaired

1 Introduction

Human Computer Interaction (HCI) is the field of study that involves the design, implementation and use of computer technology, emphasizing the interfaces between humans and computers ([6]). Every time a human uses a computer, there is a dialog between them. This dialog is the interaction, and what the computer presents to the user is the interface. There are many ways in which a human can interact with a computer; and the interface between them is crucial to facilitating this interaction. Nowadays the prevalent user interface is the graphical user interface (GUI). Desktop applications, web pages, web apps, mobile applications, and general electronic devices make use of some type of GUI. Our perception of the world comes, mainly, from our ability to see it. But, how do we perceive the world when our vision is disabled or heavily reduce? More important to us, how can a user interact with a computer when a GUI is not an option because the user is visually impaired? Designing human computer interactions for visually impaired users is a great challenge. Without the sight sense, other senses must

be used as input channels for the human, hearing being the main one. Video games are playing a large and growing part in the leisure activities of the public. In Argentina, the video game industry has a US$ 30 millions total annual turnover, with 95% of its local production for the export market[1]. As their popularity increases, the exclusion of visually impaired people from these activities is becoming more of an issue. In this work we present the development of a video game for the visually impaired users. In particularly, the development of a special interface for this type of users and the results from our users evaluations. Our work allows disabled users to enjoy a video game as an individual activity or with the companion of their relatives as a family activity. In the remaining parts of this article, we first review some basic concepts of HCI and visual impairment. Section 3 provides some background on previous works. Then, in Section 4, we describe our proposal for a video game for the visually impaired users; followed by implementation details and usability results in Section 5 and Section 6. We conclude in Section 7 with a brief discussion on limitations and advantages of our proposal and future work.

2 Background

2.1 Human Computer Interaction

Human Computer Interaction (HCI) can be defined in many possible ways; from [7] in 1992 *"HCI is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them"* to [5] in 2017 *"HCI is the intersection of the cultural, the social, the cognitive, and the aesthetic with computing and information technology. It encompasses a huge range of issues, theories, technologies, designs, tools, environments, and human experiences in knowledge work, recreation and leisure activity, teaching and learning, and the potpourri of everyday life"*.

Although its definition has evolved over the years, in its core HCI aims to support people's performance and experiences by optimizing human-system interactions. An important application of HCI is the design and evaluation of interactive computing technologies across different domains to ensure their usability. The main approach for achieving system usability in HCI field is user-centered design.

2.2 Visual Impairment

Worldwide 285 million people are estimated to be visually impaired, with 39 million blind and 246 with low vision. About 90% of the world's visually impaired live in low-income settings. According to the World Health Organization, there are 4 levels of visual function:

[1] http://adva.com.ar/en/acerca/

– normal vision
– moderate visual impairment
– severe visual impairment
– blindness

Moderate visual impairment combined with severe visual impairment are grouped under the term *low vision*: low vision taken together with blindness represents all visual impairment.

Today, interactive system usage is predominantly based on graphical interaction, where the visual presentation of information is essential for input, hand-eye coordination when using a computer mouse, and output, seeing the information on a screen. This can create difficulties for visually impaired users [14], both at an individual level when interacting with a system, and also when collaborating with other users.

When making alternative non-visual presentations for blind computer users, touch and hearing are the most obvious candidates for presenting information. With today's interaction technology, the combination of tactile and auditory information is the approach commonly available for blind users.

2.3 Video Games

Video games are a form of software and thus an obvious object of study in HCI. Interaction with video games differs from the usual understanding of HCI, because people play video games rather than use them. They are an extremely influential form of software ([1]). They earn enormous amounts of money, generate heated controversy and debate, and their players pour huge amounts of time and effort into them: they are permeating everyday life. This level of popular importance has led to a steadily increasing interest from the academic community in understanding how games work, what they do, and what they could do.

Video games have great positive potential in addition to their entertainment value. There has been considerable success ([4]) using games to address a specific problem or to teach a certain skill. They can clearly consume the attention of children and adolescents. They have the capacity to engage children in learning experiences: just by watching the children it becomes very clear that they prefer this type of approach to learning.

3 Previous Work

What follows is a list of video games that were design for the visually impaired and are reviewed in the context of our work. The first two cases are the ones that most resemble our proposal. The main questions that we ask for each case are, *Is it a free game?*, *Is it an open source game?* and *Is it available in Spanish?*.

Quacky's Quest ([11]) is a video game designed by an eleven-year-old boy for his blind grandmother. He designed and implemented the game by using the free starter version of design app called GameMaker ([9]). In it, the user plays as a

duck where he weaves through a series of mazes to find a Golden Egg. Sound cues help to find the way. If the player picks up gems, he hears a cash register sound. If he hits a wall, a deep unpleasant noise is played. If the user goes the wrong way down a passage, a spider noises is heard. If he goes too far down a passage, he set off dynamite. The game is not currently available for download. The only information available about it is on web pages that talk about it or a video filmed by its creator Dylan Viale. The game doesn't have any menu or tutorial to introduce its functionality. Although these are drawbacks to the game, it is important to remark that is a very impressive work for an eleven-year-old boy.

The Explorer and the Mystery of the Diamond Scarab ([13]) is a Nintendo Wii Game for visually impaired and fully sighted children. In this game the user plays as Ben the Archaeologist who is searching for the Temple of the Diamond Scarab. Once he is in the temple he meets Tiri, an enchanting Egyptian princess. Going through a maze of underground passages they look for ancient Egyptian treasures and confront various challenges. The game is played on a Balance Board, a standard Wii accessory. With this the user can move through the maze, find treasures and enter challenging situations. The game feedback is provided by different sounds that are played based on the user actions. The game was developed with an User Center Design approach, where several visually impaired children were involved in its design and testing. The game is only available in Duch or English. Because is design for the Wii console, it's not open source neither free to play.

Zomblind ([2]) is a Spanish video game designed by Antonio Fernández, a young researcher from Universidad de Granada. In this game, the player must survive a zombie apocalypses by using a smart phone as a gun. Unlike previous examples, this game does not have a GUI. All feedback is sound based and all inputs is done by the smart phone sensors. It was only available for Android phones and its source code is publicly available. Unfortunately its latest update is from 2013 and is not longer available in Android's store.

AudioDisc [8] is an ability game created in Spanish by Javier Mairena. It designed for visually impaired and fully sighted people, because it has a GUI and is also sound based. It is a two-player game where each one must receive and throw a disk trying to be faster than the opponent; the opponent can be the computer. Before throwing the disk, the player can choose a direction using the keyboard. Different sounds indicate different throwing directions: a high-pitched tone indicates upward, a medium-pitched tone indicates toward the middle, and a low-pitched tone indicates downward. This sound allows the opponent to recognize where the disk is going. It also uses stereo sound to indicate position in the screen. A voice-over narrator gives instruction to select between the different options of the game. The game was originally available for several Operating Systems, now it is possible to download only a Windows version and an Adobe Flash one. Moreover, the last update for the games is from 2008. Even the game is a free software, there is no source code available for download.

Terraformers [12] was a successful attempt to create an environment in which the same information is accessible via realistic 3D graphics and via audio. With

a complex set of sounds and voice menus, the player is able to know where are the different objects (doors, walls, etc) in the scene and recognize them. It includes a high-contrast mode for low-vision gamers and a no-graphics mode for blind gamers. The plot of the game takes place in the future. Rebel robots not only captured the professor but also dismantled the computer that the professor needs to defeat the rebels. The goal is to find the pieces of the computer and free the professor. Terraformers is now a free Windows game, although at the beginning it was a commercial game. However, the last update of the game is from 2003. The source code of the game is not currently available and the game is in English.

Open Field Echo Sounder [3] is a payed application for Smartphones which allows blind children to play outdoors in open field. The gamer uses the GPS and sounds through headphones to find virtual objects. There is very few information available about the game online, its source code was not found and the information available is in English.

Although there are games for visually impaired users in Spanish ([2, 8]), the majority of the games are in English. In relation with the availability of the games, several are free-downloadable games but out-of-dated or not open-source ones. Some founded games require special hardware, like a game console ([13]) or a smartphone ([2, 3]). In both cases, a special hardware means an extra cost for the user.

4 Our proposal

The goal in creating this game arises from the real need of a particular user who is blind and does not have games according to his needs. Currently he plays with a SEGA console, and he adapts to the video games since they are not designed for his characteristics. The only interaction he has with these types of games is through sounds. However, sounds are an additional effect that complements the visual interface of the game and are not specifically designed to guide the player. On the other hand, the user does not read Braille so we can not use this resource. We approach this enterprise with an user-center design strategy. After two meetings with the user we detected the following functional and non-functional requirements:

- Game's instruction must be available at all time during the game.
- Game's instruction must be delivered by using a clear Spanish voice.
- At any time during the game, the user can exit the game by pressing the ESC key.
- The game must run on a Core i3, 2GB of ram PC with Windows 7 OS. Which is the PC the user has.
- The game should not require any installation. It should be a single portable file in order to facilitate its movement from PC to PC.

Based on this situation, we propose to develop a free open-source video game design for a visually impaired user. The proposal is a simple game with clear

audio-based instructions that are easy to learn and remember. This results in a game that can be played by a visually impaired person without the help of a sighted one. In this scenario, better user experience implies more independence for visually impaired people. Based on a follow-up interview with the user and his family, we design several user cases for the game (Figure 1). The intention is to make an Arcade adventure game based on the player's skill. The game consists of a maze where the main character (the player) has to collect objects while avoiding the villain who wants to catch him.

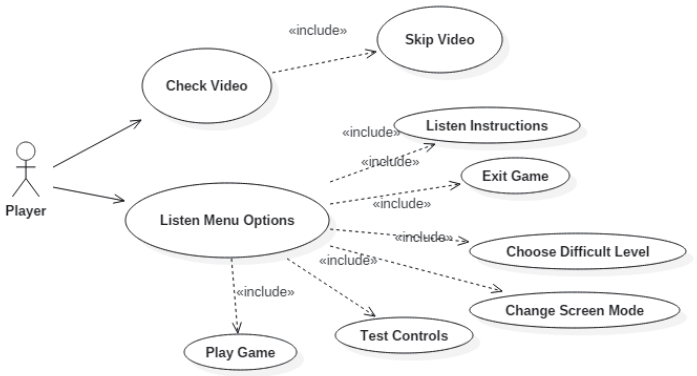


Fig. 1. Use cases detected for the game.

The scenario for the game is a farm, therefore the main character is a farmer named Neri who must gather animals while is pursued by a wolf. The goal is to go through the maze and gather all the animals. If the wolf reaches the farmer and he has animals in his basket, they are released to random positions; if he has no animals, the character dies and the game ends. The player wins when he has managed to collect all the animals. To facilitate the user orientation in the maze, the configuration of the maze is not random. There are a fixed number of mazes that differs in the location of the walls.

Sounds are used to guide the player in the search of the animals. Each animal emits its typical sound, but the player will only be able to listen to the nearest one when it is within a certain range. The further away the animal is to the farmer the lower it sounds. We also used sound to identify the walls on the maze. Every time the user moves and hits a wall, a specific sound is played.

On each maze there are 13 animals that are placed each time at random locations. If the player manages to collect all the animals the game gives the user two possibilities, to choose a scenario other than the current one or to repeat the same maze. This design decision was made considering that the player may prefer to always play in the same scenario and thus be able to memorize the

position of the walls and facilitate orientation. In total there are 10 different mazes that differ in the location of the walls.

We include three aids to help the user in the game, those are *GPS*, *Super Hearing* and *Shield*. The *GPS* aid is always available and when requested it will tell the user how to reach the nearest animal. All instructions in the game are in Spanish, but as an open-source project they can be easily change to other languages. *Super Hearing* allows the user to hear animals from a greater distance and *Shield* protects the player from the wolf. These last two aids only last 20 seconds.

The game provides three levels of difficulty, *easy*, *normal* and *hard*. The difference between each level is only on the behavior of the wolf. On the *easy* level the wolf moves randomly, on the *normal* level the wolf moves to the user and finally, on the *hard* level, a second wolf appears. On this last level one wolf behaves like a wolf of the *easy* level and the second one, like the wolf of the *normal* level.

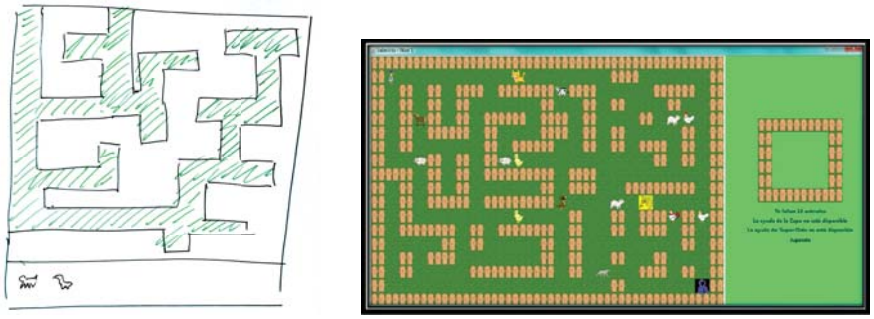
Although the game was designed for visually impaired users, we decided that it should also be played by sighted users. In this way, the game can be seen as a family activity. For this reason, the game has a GUI which will be detailed in the next section. It is possible to blackout the entire GUI in order to give any user the experience of a visually impaired one, this is known as *blind game mode*.

5 Implementation

The language chosen for the development of this game was Java, which allowed us to develop a multiplatform game with as few implementation dependencies as possible. In order to support the use of a joystick or gamepad, the JInput [10] library was included. All the images used in the game were created by hand, scanned and painted digitally. All audio messages were recorded by the authors. The game can be downloaded for free[2]. Its source code is publicly available for download[3].

Three sprites were used in the game. One for the main character movements, another for the wolf movement and the last one for the rest of the graphics. Figure 2(b) shows a screenshot of the game. Figure 2(a) shows the first prototype of the GUI on paper. This prototype was used to test the interfaces with the sighted users. On this first version the general layout of the game was vertical, with the maze on the top part and on the bottom the area where the found animal were stock. On interviewing the sighted users we noticed that a horizontal approach would make more efficient use of space on a computer monitor. On the final version of the GUI, the maze is on the left and the stock area on the right. The game contains ten level, where each one is stored separately in a text files. Each line of the file represents a row of the matrix that is a level. The files contain only "p" or "s" characters, the "p" represents a wall and the "s" represents floor.

[2] `http://cs.uns.edu.ar/~mll/lagranjadeneri/`
[3] `http://www.cs.uns.edu.ar/~mll/lagranjadeneri/files/neri_source_code.zip`



(a) First prototype for the GUI in paper.

(b) Screenshot of the final GUI of the game. All visual elements were created by the authors.

Fig. 2. Evolution of the GUI from first paper prototype to final result.

6 Usability test

For the usability test, 4 participants (3 sighted and 1 blind) were recruited for the study. Their ages were between 20 and 55 and they had different educational backgrounds. The blind user was 26 years old at the time of the test and has a cerebral injury from birth. Such a small number of users is insufficient to provide any statistically meaningful results but some conclusions can still be achieved from the experiment results.

A brief training was given to the participants to familiarize them with the game and the audio system. They were introduced to the game story, goals and game play. The sighted participants were also introduced to the *blind game mode*. All users performed training without problem, although the blind user required more attention.

We considered that evaluating the video game for the sighted users as a conventional video game with graphical interfaces will not be meaningful, so we decided that they played in *blind game mode* only.

6.1 User Experience Feedback

#	Task	Success/Failure
1	Test the controls	
2	Listen to instructions	
3	Exit the game	

Table 1. Tasks evaluated in the test. For each task it was marked if the user could accomplish it successfully or not.

Each participant had to accomplish three basic tasks while using the game (see Table 1). And after experiencing the game, they answered a follow-up us-

ability review. In particular, the usability review for blind users consisted in a survey (see Table 2) and the one for sighted users consisted in an interview.

The blind participant usually plays console games that are not prepared for his characteristics. At first, it was difficult for him to get accustom to the game interface. However, once he played several times, the interface got easier to use.

The sighted participants were asked to play the game in blind mode to obtain more feedback about the understanding of spoken menus and sounds. In this mode the gamers were confused and intrigued about their location in the screen. Moreover, they did not pay enough attention neither to the spoken menus nor to the sounds of the game. This lack of attention resulted in more required time to comprehend the usage and mechanics of the game and then, to be able to actually play.

#	**Question**	**yes/no**
1	Was the first thing the user tried to play?	No
2	Did the user listen to all options from the menu?	Yes
3	Did the user test every difficult levels?	No
4	Did the user listen to all the instructions?	Yes
5	Did the user understand that the wolf is bad?	Yes
6	Did the user make the correct association between sound and animals?	Yes
7	Was the user distracted by the sounds?	No
8	Did the user finish the game?	Yes
9	Was the user still well oriented after hitting a wall?	Yes
10	Once the user won, did he want to change the map?	Yes
11	When the user listen an animal, did he try to catch it?	No
12	Did the user use the GPS?	Yes
13	Did the user attend to the orders of the GPS?	Yes
14	Did the user abuse of the usage of the GPS?	Yes
15	If the user did not use the GPS, was it because he did not want to?	No
16	If the user did not use the GPS, was it because he forgot about it?	Yes
17	Did the user follow the instructions?	Yes
18	Did the user prefer to use the keyboard?	No
19	Did the user prefer to use the joystick?	Yes
20	Did the user remember the keys of buttons from the device?	Yes

Table 2. List of yes-no question asked to the user after using the game.

7 Conclusion and future work

In a world where technology is part of every person's daily life, where from the moment we get up to when we go to bed electronic devices join our routine, access to them should be possible for visual impaired users. If used in the right way, video games can inspire learning and improve skills. A good video game is challenging, entertaining, and complicated. Video games can also be a source of

family entertainment, with parents, children, and grandparents all participating on it.

In this work we presented the development of an Spanish open-source video game for visual impaired users. As we presented in Section 3 open-source video games for this type of user are rare, specially in Spanish. With this game, visual impaired users both children and adults, can enjoy a video game created for them. The game can also be seen as a social and family activity, because of the game's GUI all users can share the experience. As the usability test proved, the game was very well received. This result is a simple game but with a wide target audience. As for future work, we would like to include more audio options for the instructions, like the possibility to have a familiar voice giving the instruction (like a parent, friend or relative) and conduct more usability testing.

References

1. Pippin Barr, James Noble, and Robert Biddle. Video game values: Human–computer interaction and games. *Interacting with Computers*, 19(2):180–195, 2007.
2. Antonio Fernández. Zomblind, 2012. URL: `http://web.deantares.es/zomblind/`.
3. Mark Frauenfelder. open-field-echo-sounder, 2014. URL: `http://boingboing.net/2014/10/03/open-field-echo-sounder-game.html`.
4. Mark Griffiths. The educational benefits of videogames. *Education and Health*, 20(3):47–51, 2002.
5. Jonathan Grudin. From tool to partner: The evolution of human-computer interaction. *Synthesis Lectures on Human-Centered Interaction*, 10(1):i–183, 2017.
6. Martin G Helander. *Handbook of human-computer interaction*. Elsevier, 2014.
7. Thomas T Hewett, Ronald Baecker, Stuart Card, Tom Carey, Jean Gasen, Marilyn Mantei, Gary Perlman, Gary Strong, and William Verplank. *ACM SIGCHI curricula for human-computer interaction*. ACM, 1992.
8. Javier Mairena. Audiodisc, 2008. URL: `http://www.javiermairena.net/`.
9. Mark Overmars. Teaching computer science through game design. *Computer*, 37(4):81–83, 2004.
10. Unknown. Jinput, 2016. URL: `https://github.com/jinput/jinput`.
11. Dylan Viale. Quacky's quest, 2012. URL: `https://www.youtube.com/watch?v=1YV21D0JjCY`.
12. T Westin. Game accessibility case study: Terraformers – a real-time 3d graphic game. In *In Proc. of the The Fifth International Conference on Disability, Virtual Reality and Associated Technologies*, pages 95–100, 2004. URL: `http://www.terraformers.nu`.
13. R Willems, C Pinkster, L Kuiper-Hoyng, et al. The explorer and the mystery of the diamond scarab: A serious wii game. 2012.
14. Fredrik Winberg. *Contextualizing Accessibility: Interaction for Blind Computer Users*. PhD thesis, KTH, 2008.