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Luis Valente

Bruno Feijó

Departamento de Informática

PONTIFÍCIA UNIVERSIDADE CATÓLICA DO RIO DE JANEIRO

RUA MARQUÊS DE SÃO VICENTE, 225 - CEP 22453-900

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Luis Valente, Bruno Feijó

lvalente@inf.puc-rio.br, bfeijo@inf.puc-rio.br

Abstract. This work presents an outline for a mobile multiplayer non-visual game. This new game builds upon a former game named "The Audio Flashlight". The main difference in the new version is the multiplayer functionality, where two players are able to cooperate to reach a common goal. As far as we are concerned, this represents the first non-visual multiplayer game for mobile devices.

We are concerned to explore a number of issues on tactile feedback. For example: how it helps the player in identifying game elements; how its use relates to spatial localization; how players will negotiate in a collaborative setting, where the tasks are split among them and they depend on each other to advance in the game.

Keywords: Mobile non-visual games, accessibility, haptics and gestures, visually-impaired users, multiplayer games, Bluetooth.

Resumo. Este trabalho apresenta um resumo para um jogo não-visual e multiusuário para telefones celulares. Este jogo é um aprimoramento de um jogo anterior conhecido como "The Audio Flashlight". O diferencial principal da nova versão é o componente multiusuário, onde dois jogadores cooperam entre si para chegar ao final do jogo. Até onde sabemos, trata-se do primeiro jogo não-visual e multiusuário para telefones celulares.

Nós queremos explorar algumas questões sobre feedback tátil. Por exemplo: verificar como isso pode ajudar os jogadores a identificar elementos do jogo; como o seu uso pode se relacionar com localização espacial; como os jogadores irão negociar entre si uma vez que as tarefas do jogo são distribuídas entre eles e eles dependem um do outro para conseguir avançar no jogo.

Palavras-chave: Jogos não-visuais para celular, acessibilidade, gestos e feedback tátil, usuários com deficiência visual, Bluetooth, jogos multiusuário.

In charge for publications:

Rosane Teles Lins Castilho
Assessoria de Biblioteca, Documentação e Informação
PUC-Rio Departamento de Informática
Rua Marquês de São Vicente, 225 - Gávea
22453-900 Rio de Janeiro RJ Brasil
Tel. +55 21 3114-1516 Fax: +55 21 3114-1530
E-mail: bib-di@inf.puc-rio.br
Web site: http://bib-di.inf.puc-rio.br/techreports/

1 Introduction

Non-visual games for mobile platforms are rare. Exploring this technology has at least two appealing characteristics:

- Including visually-impaired users in the game play; and
- Providing new kinds of gaming experiences for sighted players.

This paper reports on a preliminary research prototype for combining non-visual mobile games and multiplayer features. Our main objective is to experiment and start learning about the possibilities and challenges in designing and implementing those kinds of games where networking is a major feature. At the same time, we want to spark new game styles and opportunities for gaming where it is rare or non-existent, for example, games for visually-impaired people.

As far as the authors are concerned, this is the first prototype of non-visual multiplayer game for mobile devices.

1.1 Game HCI

In recent years, game graphics and sound have reached an amazing level of realism and received most of the attention from the game community. However, computer game research still lacks a robust theoretical foundation, in spite of game itself being as old as human culture [Huizinga 1966]. Modern game design fundamentals [Adams and Rollings 2003; Salen and Zimmerman 2004] have greatly expanded the early theoretical concepts of Chris Crawford [1982], but they are yet far from being a complete conceptual framework. One of the areas that need further development is HCI in computer games [Zaphiris 2007] specifically which is surprising, because interaction shares many characteristics that prevail in games. Crawford [1982] even says that "interactiveness is an index of gaminess"

The traditional focus of HCI has been set almost exclusively on usability, which underlines ease of use and productivity for accomplishing tasks. Software interfaces should be easy to learn, use, and master, which is somehow opposite to games that are usually easy to learn, but difficult to master [Malone 1982]. Barr and co-authors [2007] point out that computer games are not made to support external, user-defined tasks, but instead define their own activities for players to engage in. Understanding these differences is the starting point for Game HCI.

Among a number of different research topics in Game HCI, works on game semiotics [Myers 2003], heuristics [Desurvire et al 2004], accessibility [IDGA 2008], and presence [Ravaja 2006] deserve special attention from the game research community and industry.

Semiotic analyses of computer games have been done by several researchers. The work by Myers [Myers 2003] very convincingly characterizes playing computer games as a form of semiosis. Caldwell [2004] analyzes the user interface of a particular turn-based strategy game (Civilization II) using semiotics. But, as far as the authors know, the present study is the first one to employ semiotic engineering principles specifically to designing mobile games.

Presence is a key for games. It is the perception of being in a particular space or place. Presence has been studied from different perspectives [Bystrom et al 1999; Lombard et al 1997; Witmer and Singer 1998], but most of the approaches are related to the sensorial experience of users in general-purpose virtual environments. Specific research on presence in games, however, is scarce [Ravaja et al 2006].

Among existing works, one proposes that presence can be enhanced by the expansion of the game Magic Circle, the mental universe created when the player enters the game. This term was first introduced by Salen and Zimmermann [2004], inspired by Huizinga's play-ground [Huizinga 1966] and Roger Caillois' "second-order reality" [Caillois 2001]. The Magic Circle is expanded by imagination, which allows users to experience collisions through joystick vibrations, or even a flight over the scene without any sort of feedback. Liljedahl and co-authors [2007] propose an explanation in terms of what they call the "scary shadow syndrome" – the fact that an event may cause greater impact imagined than seen.

The prevalence of sight over other senses in gaming is widespread. It becomes clearer when we think that many games have an option to "turn off sound" completely. In this case, the game can still be played and enjoyed. Sound can be regarded as a subsidiary resource. But, how many games have the option to turn off the graphics?

Haptics have also been extensively used to enhance the sensorial experience of gamers. Video game consoles have long been supporting "force feedback" joysticks and other input devices since early works in the second half of the 90's. Ouhyoung and co-authors [1995] presented a game-like flight simulator with vibration feedback in 1995. In 1997 Nintendo released the Rumble Pak, an accessory to connect to the Nintendo 64 joystick to produce tactile feedback. More recent and complex haptic-based games can be found elsewhere [Faust et al 2006]. However, there are few works on haptics for mobile phones [ur-Rehman 2007; VibeTonz 2008].

Integrating mobile games, audio, haptics feedback and excluding visuals is the subject of the original *The Audio Flashlight* study [Valente et al 2009; Valente et al 2008]. That work also employed Semiotic Engineering [de Souza 2005] to design the corresponding signals to the events that happen in the game.

1.2 Mobile Games

Mobile game design is several steps behind personal computers (PC) and console game design. In particular, mobile phones still remain a casual gaming platform despite recent technological advancements [Cai 2008]. Problems with haptics and game accessibility are especially acute.

In the mobile world, haptics has typically not been used in game interfaces, despite the built-in motors available in many phone models. Only recently has it caught the attention of the mobile game market, through such initiatives as the VibeTonz system [VibeTonz 2008]. VibeTonz provides a tool to implement applications on mobile phones that use haptics feedback.

Mobile phones probably are the most pervasive kind of device nowadays. This opens up the possibility of reaching out for a large user base, visually-impaired people in particular.

Traditionally, PC and console games often feature advanced graphics, physics and AI simulations due to high processing power available on those platforms. This is not the case with mobile phones, which have simpler hardware and limited input methods. For example, mobile phones (compared to PCs) have low processing power and tiny screens. Another issue is that phones have been designed mainly for making calls, and thus those devices usually have keyboards optimized for that. In many cases, when using such keyboards it is not possible to detect when two or more keys are pressed simultaneously, making it difficult to design key-based interfaces for action-games.

However, mobile phones design is getting more and more sophisticated when it comes to feature convergence. For example, the mobile phone used to test the game prototype features cameras (two, for pictures and video), music player, network connections (3G, WiFi and Bluetooth), acceleration sensor, GPS receiver, reasonable memory capacity (up to 48GB), and other accessories.

This opens up new possibilities for designing games that exploit the above-mentioned features of mobile phones, one being that mobile phones are always connected to some network. Thus, developing multi-player games for those devices is a natural move, and can be an opportunity to increase social inclusion and interaction among players (both sighted and visually-impaired).

1.3 Mobile Games and Accessibility

According to the IGDA [2008], Game Accessibility can be defined as the ability to play a game even when functioning under limiting conditions, which can be functional limitations, or disabilities – such as blindness, deafness, or mobility limitations.

The work by Glinert and Wyse [2007] claims that there are fewer than 300 games available for visually-impaired, known to the general public. Compared to regular games, this is too few. An important source of games for users with special needs can be found in the AudioGames web site [http://www.audiogames.net]. In the specific case of visually-impaired users, games roughly fall into three categories [Game Accessibility 2008]: games not designed to be accessible (like conventional games); games designed to be accessible (like audio games); and games adapted to be accessible.

Although audio games are designed to be *accessible*, they are not necessarily designed *specifically* for visually-impaired users. Because they do not rely on visual information, they seem to be an excellent alternative for such users. However, because not much is known about *other* needs and desires that visually-impaired players might have, audio games still represent an open field for research, as suggested by Friberg and Gärdenfors [2004], and Drewes and co-authors [2000], for example. None of these proposals, however, focuses on games for mobile phones.

Accessible mobile games are scarce. Although mobile devices are rapidly becoming more powerful, with more memory, more processing power, and more multimedia functionalities, such resources have not yet been used to promote accessible gaming interfaces. Additionally, as is the case with most accessible technologies [Vanderheiden 2000], explorations with non-visual game interaction clearly opens up novel possibilities for sighted users as well.

1.4 Benefits of Non-visual Games

Research on non-visual games can generate various kinds of benefit:

- An opportunity to include a visually-impaired audience in the play, by fostering game designs and environments that boost their participation;
- An opportunity for gameplay innovation in trying to represent the game environment, characters and events, using audio and tactile feedback;
- An opportunity to explore and exercise other senses;
- An opportunity to create more personalized experiences, as people imagine things in different ways; and
- An opportunity to increase the immersive experiences in games.

Some authors [Ekman et al 2005] point out that accessibility is the main motivation for research on game audio. However, another important motivation may be finding new means for richer interaction. For example, exploring audio and haptics may lead to innovative game designs that minimize issues like display limitations on mobile phones.

2 Network technology for mobile games

Mobile phones are by definition, connected devices. We are concerned with the mobile phone class known as "smartphones". The smartphones are higher end devices that feature more memory, more processing power, more multimedia capabilities and network connectivity.

Network connectivity available on smartphones can be of two broad types: global and local.

Global connectivity enables the smartphone to access the Internet and to communicate with devices located far away physically. Technologies that enable this functionality include wireless networking (WiFi) and 3G.

Local connectivity enables the device to communicate with other nearby devices, on a limited range. For example, technologies that make this possible are Bluetooth and WiFi.

In this work, we are concerned with enabling local users to interact together in the non-visual game, hence we chose to use Bluetooth.

2.1 Using Bluetooth

Bluetooth is an open standard developed in 1994 to enable data exchange among devices in short distance. Bluetooth is maintained and developed by a Special Interest Group (http://www.bluetooth.org).

In this research, we started experimenting with Bluetooth by using Nokia S60 5th Edition touch screen devices and the Qt framework [http://qt.nokia.com].

2.2 Challenges and first impressions

Every Bluetooth device is identified by a unique address, in the form of 00:00:00:00:00:00. Hence, to establish communication among devices it is necessary to know their addresses.

In order to find out those addresses, it is necessary to perform a device discovery step first. In this process, the device enters a "inquiry state" and keeps on searching for other Bluetooth devices in the vicinity. According to our experiments, this task can take a long time, and the number of Bluetooth devices in the neighborhood heavily influences this operation (more devices means possible longer times and missed findings). It is possible to develop an application with hard-coded addresses (for known devices), which would speed-up the process, but this greatly limit the application.

Another problem we faced is that when a device (smartphone) enters the "inquiry state", other devices are not able to find it. This problem was also reported by [Nishkam et al 2005]. It seems that when the device perform the discovery, it uses all available bandwidth in this process and then cannot respond to discovery queries coming from other devices.

Faced with those features and limitations of Bluetooth technology, we wanted to design a system that would:

- Define which device would be the server, and which one would be the client in a subtle way that would not require the user to manually perform a query
- Make the client find the server with minimal "intrusion"

Those requirements are important because this game is a non-visual game, and one potential target group would be people who were visually-impaired.

2.2.1 Bluetooth profiles

A Bluetooth profile is a definition of a possible type of application and behaviors that the devices must understand in order to implement it. There are profiles for many uses like file sharing, dial-up networking, communication with headsets, and others.

For *The Audio Flashlight*, we chose to use the Serial Port Profile. This profile simulates the behavior of a serial port, enabling us to exchange streams of data among the devices. Programming for this profile is similar to Internet socket programming. Based on that, we have implemented a custom Bluetooth service for the game.

3 The Audio Flashlight revisited

The Audio Flashlight [Valente et al 2009; Valente et al 2008] is a "treasure hunt" game developed to explore issues related to non-visual mobile games. The game takes place in a dark room, where the treasure is lying somewhere.

While inside the room, the player cannot see anything. All s/he can use to find the treasure is a special device called "The Audio Flashlight". This device can be regarded as a kind of radar that guides the player to the treasure through sound.

Occasionally, the player may bump into walls or other internal obstacles that lie around the room. The player should dodge these obstacles and keep walking in search of the treasure. Figure 1 illustrates a typical map for a room in this game.

The game is being developed and tested using two Nokia S60 5th Edition devices, namely a Nokia X6 and a Nokia 5800 XpressMusic. Both devices have a touch screen (single-touch only), that is able to generate tactile feedback on it.

The game starts by presenting an audio menu to the user. The user is able to hear instructions or start the game. The selection is maybe by tilting the device to the left (instructions) or to the right (start the game).

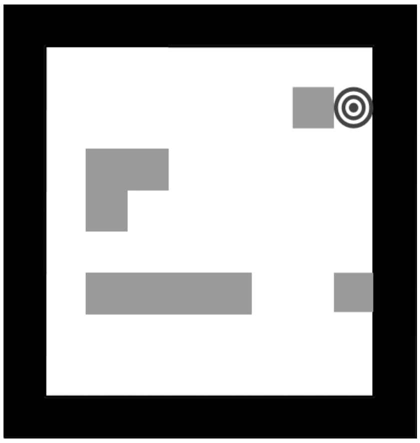

Figure 1: A typical room in the game. Gray squares are internal obstacles and the bull's eye is the treasure location.

While in the game, the user is able to pause the game by touching the screen anytime. Touching the screen again resumes the game. If the user wants to quit the game, s/he should tilt the device with the screen pointing to the ground.

When the player starts the game, a starting location is chosen. This location is always besides one of the walls. To indicate that the game session begun, the game plays the sound of an opening door. A corresponding event is when the player quits the game. In this case, the game plays a "closing door" sound effect. We thought these were good metaphors to indicate the events, which we confirmed on previous research [Valente et al 2009].

The player guides him/herself to the treasure by hearing the "audio radar". This radar is designed as a set of music files with varying volume and rhythm. Figure 2 illustrates a schematic view of the audio radar.

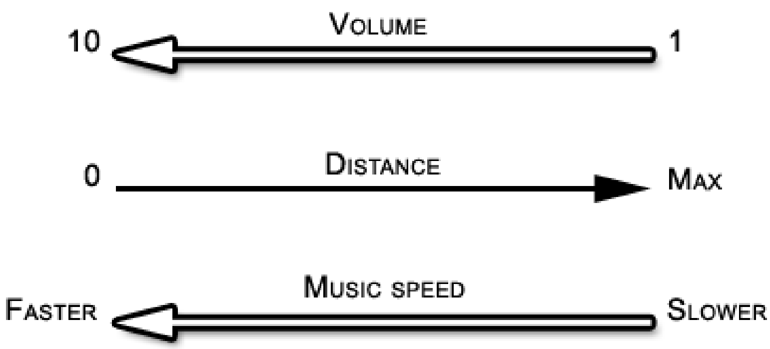

Figure 2: Schematic view of the audio radar.

The music spectrum is divided into five musical patterns. All of them are very similar, but they differ in rhythm. The radar selects the pattern according to the distance between the player and the secluded treasure. The closer the player gets, the faster the music plays. The radar also changes the music volume using this strategy. The closer the player gets to the target, the louder the music.

In the game, the user can walk around the environment in four basic directions: forward, backward, left, and right. The user communicates this command to the game by turning the mobile phone screen in the desired direction. For example, when turning the mobile phone screen to his/her chest, the player walks backward. When turning the mobile phone screen forward, as trying to point out something on the ground, the player walks forward. Figure 3 illustrates these gestures. The player is not required to walk physically in the environment to play the game.

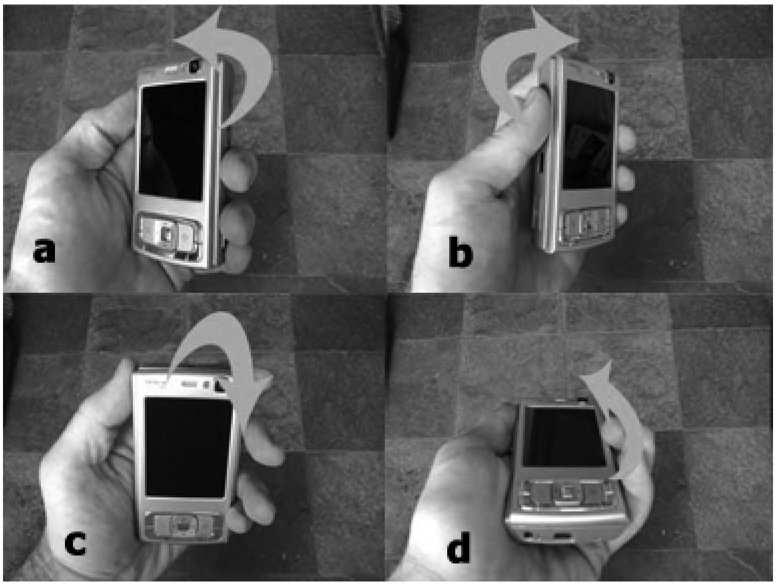

Figure 3: Gestures for walking in the environment: (a) left, (b) right, (c) backward, (d) forward.

While the player is walking, s/he hears the sound footsteps in constant pace. The player remains walking while keeping the phone screen turned to the desired direction. The player stops walking by positioning the phone screen up, parallel to the ground. This is the "idle" position, and while the player remains on it, the footstep sound is not heard.

The command to communicate that the player wants to abandon the game is to position the phone screen facing the ground.

The main motivation to adopt a gestural interface is to provide a more natural way to interact with the phone. Compared to pressing buttons to signal those commands, for instance, gestures are clearly more direct and expected to be easier to perform.

Inside the room there might some obstacles, and the room is closed: it is surrounded by walls. Hence, the player can collide these things while playing. The game represents collisions with vibrations. The motivation to use vibrations is to associate the idea of "physical collision" with the physical sensation provided by vibration. When the player collides against a wall, the device makes a stronger and longer vibration. When the player collides against an obstacle, the device vibrates quickly and softly. The obstacles do not hurt the player, they only make things harder.

When the player finds the treasure, the game plays the sound of applauses. Then, the player is transported to another room, and it all begins again.

3.1 Extending the game in the multiplayer world

In this new version, the game adds an element to world, which we represented as a "mine". The room now is augmented with "land mines", and if the players step on it, it is game over.

We decided to split the game tasks between two players. They both walk together in the virtual world as if they were superimposed. However, each one is responsible for specific things and need to collaborate to get to the goal. There are two roles in the game: the *Miner* and the *Flashlight*.

The Flashlight acts as the previous version of the game. The player tilts the device in four directions to walk in the virtual world, and the music guides them to the treasure location. However, this player knows nothing about the mines, s/he is not able to detect them.

To solve this problem, the Miner comes in. The Miner is responsible for detecting the mines and alerting the other player about it. The Miner, however, is not able to move in the virtual world. In this sense the Miner is "piggybacked" by the Flashlight.

The Miner device acts as a "tactile window" to the game world. This window corresponds to a 3x3 grid and its contents depend on the location and movement direction of the Flashlight. Figure 4 illustrates the possible configurations.

The Miner is able to detect the mines by sliding his/her finger across the screen, and if there is a mine on a square, the screen vibrates at that square. The window contents change as the Flashlight player moves in the virtual world.

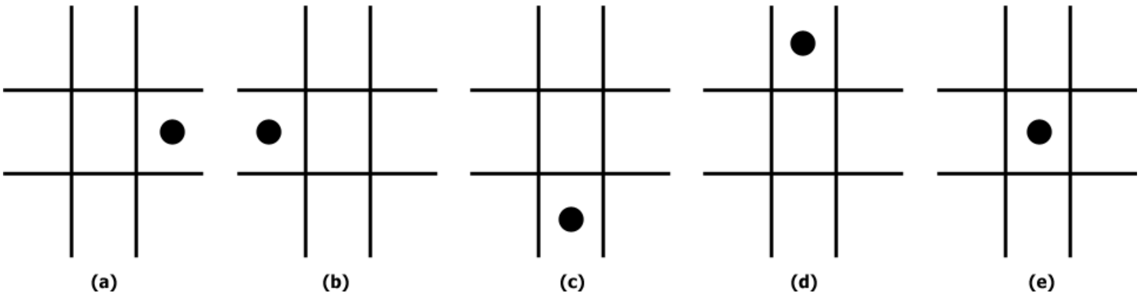

Figure 4: Miner window configuration when the Flashlight is moving: left (a), right (b), forward (c), and backwards (d). The idle position is represented in (e).

When the Flashlight is in the idle position, the Miner window allows the player to have a 360^{o} perception around him/her. However, the range of this perception is limited to one square only. The Flashlight moves, the Miner window range of perception increases in the direction of movement. However, if the Flashlight moves like this, it can be more risky for the players, if the Miner is not able to detect a mine on time. The black dot in Figure 4 indicates where the players are relative to the Miner window. We added an aural sign to indicate where the players are relative to the window. When the Miner touches the square where they are, the game (in the Miner device) plays a sound effect. Notice, however, that the game does not display the grid nor the black dot.

If the players step on a mine, a game over sound effect is played on both devices, and the games goes back to the intro.

3.2 Selecting roles

The players are able to select roles by pressing the touch screen in the introduction menu for a predetermined amount of time. In the current release, if the players keep the screen pressed for two seconds, the game selects the Miner role. It announces it by playing a voice sound effect that says "miner". If the players continue to press the screen for more two seconds, the game selects the Flashlight role. It also announces this event by playing another voice sound effect that says "flashlight".

The games keep the selected roles until another one is selected. If the game is played and game over is reached, the selection is reset. By default, there are no roles selected and the game refuses to start if this is the case. When the user tries to start the game (by tilting the device to the right), the game plays a sound effect that says "please select role".

After selecting the roles, the players have to tilt the device to the right to start the game. The Miner acts as a server, and thus keeps on waiting for the other player to connect. The Flashlight starts the device search, and keeps on this state until it finds a partner (the Miner). Notice that the players are not required to indicate which devices are participating in the game, nor which one is the server and which one is the client. The game makes the decision based on the roles the players selected by holding their fingers on the device screen.

4 Conclusions and future works

The design of non-visual games is a compelling task and still not very explored, especially in mobile phones. The research in non-visual games can help to bring visually-impaired people into play, and also benefit gaming as a whole due to the opportunity of exploring other senses beyond vision.

Current mobile phones have interesting capabilities regarding audio, vibration motors, acceleration sensors and connectivity that may help to spark novel approaches to designing games. The first attempt at exploring this territory was carried out by the original *The Audio Flashlight* study. Now we are building on that initiative by adding a multiplayer component to the game.

Programming multiplayer mobile games adds its own set of challenges and paradigms. We want to explore this and how it carries out when mixed with a non-visual game style.

We tried to split tasks between players to force them to cooperate. We need now to check how this proves to be by conducting user tests. For example, we would like to explore some of these questions:

- How the players will react? Will they find this funny and/or challenging?
- How about loading more tasks to the Miner (yet giving this player more responsibility)?
- What if we invite visually-impaired and sighted players to play together?

Yet there is a long road ahead on possible research scenarios.

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