Computer Games and Visually Impaired People

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Abstract

Accessibility of computer games is a Challenge. Indeed, making accessible a computer game is much more difficult than making accessible a desktop application. In this paper we first define game accessibility. Then we present a number of papers published in the last decade: specific games (audiogames, tactile games etc), games designed for all, and a few works about game accessibility. Then we will describe the work that we are currently carry out in order to propose a framework allowing mainstream games accessibility.

1 Introduction

Computer games have become an important part in child and youth culture, and most children, in developed countries, have a considerable experience of such games. Additionally these games are used by a growing part of the population, including especially young adults (in average 25 years old, including 40% of women[1]) but the proportion of players is also growing in other age groups of the population.

Indeed the mainstream commercial market for computer games and other multimedia products have shown a rather impressive development in the last years. For instance in 2002, costs for the development of a games could vary between 300,000 euros for a game on wearable device, to 30 millions for the biggest productions (involving nearly a hundred of employees) [Natkin et al., 2002, Fries, 2003, Natkin, 2006]. Since 2002, the awaiting by the players for more impressive games have even made budgets increase, with more use of new technologies.

[1]TNS Sofres, *Le marché français des jeux vidéo* (The market of video games in France). afjv, November 2006. http://www.afjv.com/press0611/061122_marche_jeux_video_france.htm

People who cannot use the ordinary graphical interface, because they are totally blind or because they have a severe visual impairment (sight rated $<$ 0.05), do not have access or have very restricted access to this important part of the youth culture [Buaud et al., 2002]. This is particularly unfortunate for two main reasons. The first is that this group of people is probably the one who can benefit the most of technology. Indeed, technological tools enables them in a lot of situations in their daily lives, at school as well as at work or at home, in mobility, etc. Therefore it seems important that children get used to using technology as early as possible. A second reason is that handicapped children can benefit a lot from the use of computer games for their psychomotor and cognitive development [Hildén and Svensson, 2002].

To give people with visual disabilities the chance to have access to multimedia games should be seen as an important issue for better inclusion and participation in society.

Designing games that work for visually impaired children is quite a challenge since the main feedback channel in games is usually visual. Indeed even if audio is more and more used in mainstream games, it has only a complementary role in a huge majority of cases. It improves the experience of the player but it is often not bringing necessary pieces of information that the player would not get visually. For instance most of these games can be played efficiently with sound switched off.

This is probably the reason why very few computer games are accessible and even very few have been developed for them. Before 2000, the only accessible games that one can find were developed by the Swedish Library of Talking Books[2].

2 Game accessibility

Accessibility of games is a more complex problem then software accessibility in general. First, and it seems obvious, it is very important that accessible games still be games.

Accessible games must still be games!

2.1 Computer access

Computer access for visually impaired people started to develop largely during the 80s, thanks to the apparition of personal computers. It was made possible by the development of speech synthesis and by the apparition of Braille refreshable displays. These tools allow to render information using alternative modalities (namely audio and touch).

To access desktop application, blind people have to use specific software applications, called screen readers, which literally reads the information on the screen to render it in an appropriate way using speech and/or Braille, according to the user settings. These software were relatively simple when we were using console operating systems (text only on screens showing 25 lines of 80 characters), but became extremely complex with the development of graphical

[2]TPB, http://www.tpb.se/english/computer_games

user interfaces. Nowadays screen readers are able to deal with multiple windows, to access client contents as well as menus, dialog boxes, etc. They allow a trained user to access efficiently most desktop textual applications (word processors, spreadsheets, Internet browsers, email software, etc), as well as system information and settings.

The improvement of screen technology during the 90s has allowed to develop enlargement software (screen magnifiers), which can enlarge text or pictures up to 32 times, which is necessary for partially sighted people. Furthermore it is possible to change colours, resolution and also to redesign the organisation of information on the screen. Used single, or in combination with speech synthesis, these software solutions enables people with really low vision to use the graphical display in an efficient way.

Additionally a number of specific devices which use the tactile modality or the haptic modality can be used together with specific software. First tactile boards are devices on which overlays can be inserted. The device transmits to the computer the location where it is pressed. Usually they are used to adapt computer games for young children. Indeed the overlays can support very rich tactile representations and therefore be very attractive for children. Tactile overlays may be prepared using various technologies, like thermoform, swallowed paper, polymerised glues etc, or simply by sticking different kinds of material. On the other hand, the major limitation with this kind of device is that is that overlays are static and not so easy to insert properly in the device.

Other tactile devices appeared recently. These are tactile graphical refreshable displays which use the same kind of pins than Braille displays, to represent a graphic surface, with 16 x 16 pins or more[3]. These are still very expensive and for now mainly used in research labs, but they might come to the market in the next decade.

Other experimental devices called tactile transducers use the principle of deforming the skin by tangential traction [Wang and Hayward, 2006]. An experimental device was designed comprising a 6 x 10 actuators array with a spatial resolution of 1.8 x 1.2 millimetre. It was successfully tested by subjects who were asked to detect virtual lines on a smooth surface.

Haptic devices include a variety of devices like vibrato tactile joysticks and gamepads, or the Senseable Phantom[4]. The Phantom is an input/output device which looks like a mechanical robot arm that is holding a stylus. When holding the stylus in the hand it is possible to touch, feel and manipulate virtual objects with 6 degrees of freedom. It uses only one point of interaction (the stylus), which means that the user will access the virtual environment through this single point, like if touching objects with a stick [Aamisepp and Nilsson, 2003].

Finally switches are very simple input devices which are used by people with very reduced motor capacities. They allow only to send one event (when it was pressed). They are very sensitive and allow a lot of precise settings.

2.2 Computer accessibility

Unfortunately these specific access software applications (screen readers and screen magnifiers) are not able to access any software whatever the way they

[3]See for instance Handytech GWP (Graphic Window Professional): http://www.handytech.de/en/normal/products/for-blind/gwp/index.html

[4]Senseable Technologies Inc.

have been developed. Indeed access software applications need to collect accessible information from the applications to render it using alternative modalities. This accessible information is mainly textual. It means that all graphics that have a function must have alternative texts, but it is also necessary to get the information when something happens on the screen (when a dialog box appears, when some information arrives somewhere in the client window, etc...). If this information is not present in an application, the use of screen readers with this application is at the best very difficult and in the most cases completely impossible.

To make applications accessible, accessibility frameworks have been developed and are available in the main environments. For instance, Microsoft has developed Microsoft Active Accessibility[5], which is a COM-based technology that provides assistive technology tools with access to the relevant information. On one side it is a collection of dynamic-link libraries that are incorporated into the operating system, on the other side is a COM interface and application programming elements. Then, to make their applications accessible, application developers have to implement the IAccessible interface.

There exist similar frameworks on Mac[6] and on Linux desktop environments: Gnome accessibility project [7], KDE accessibility project [8].

Furthermore specific development frameworks need to support accessibility. For instance the Java Accessibility API[9] or Access Mozilla [10].

2.3 Accessibility of contents

It is not enough that applications respect accessibility standards. In most cases the contents must be accessible too.

For instance in the case of a web site, the accessibility of web browser is necessary but the web contents must be accessible too. Graphical elements for instance must have textual alternatives, and this depends on the content itself. In that respect, the W3C launched the Web Accessibility Initiative to developed guidelines for Web Accessibility: WCAG[11]. (Web Content Accessibility Guidelines). These guidelines indicate how to use each of the HTML tags to make a web site accessible. For instance to support graphics, it is requested to insert alternative text within a "ALT" attribute on each IMG element.

2.4 What is different in case of games

These accessibility solutions are working satisfactorily for desktop applications but not for computer games. First the notion of "working satisfactorily" is a) not enough and b) not easy to define in that context.

Indeed, the results of a game can not be easily quantified, like in the standard case of classical desktop applications. In a word processing software, it is easy to measure the time needed by a user to write a document or to edit a document produced by a colleague. In a game we can as well observe if a player

[5] http://msdn.microsoft.com/at
[6] http://www.apple.com/accessibility/
[7] http://developer.gnome.org/projects/gap/
[8] http://accessibility.kde.org
[9] http://www-03.ibm.com/able/guidelines/java/javajfc.html
[10] http://www.mozilla.org/access/
[11] http://www.w3.org/TR/WAI-WEBCONTENT/

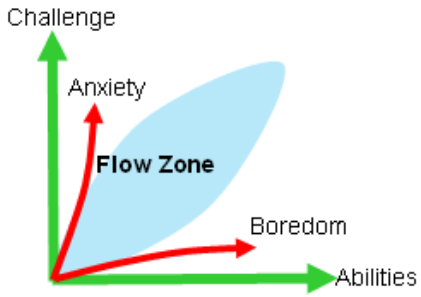

Figure 2.4: About flow in games [Jenova, 2001]

succeeds, and measure the time to finish a level or any case relevant for the game considered. But this is far not enough. Unlike others software, games have to provides special good feelings to players. There are probably some emotional factors to consider in the desktop applications, but they are usually not taken into account, or at least unless they affect the productivity. In the case of a game these factors are the most important.

It is not obvious to describe the nature of these types of feelings: it is a large field of research and studies describe it through two main concepts: the concept of presence and the state of flow. Both describe a state where the player feels totally immersed in the game universe. The presence concept is the ability of the game to provide the illusion for the player that he/she is in the virtual environment [Witmer and Singer, 1998]. The presence sensation can be evaluated according to the goals of the game [Gaggioli et al., 2003]. The efficiency of the interaction is also an essential point [Retaux, 2003]. There are many others ways to approach this particular type of sensation felt by the player.

The other concept is the state of flow. This concept could appear very similar to the presence concept, but it is more oriented on a sensation of intense pleasure rather than an illusion to be elsewhere. It can be defined as a state of concentration, deep enjoyment and total absorption in an activity [Johnson and Wiles, 2003]. Flow is the result of the balance between two different psychological states, anxiety and boredom, themselves produced by the gathering of two aspects of gaming: the challenge of a task versus the abilities of the player [Jenova, 2001] (see figure 2.4).

In other terms, as we stated at the beginning of this section: Accessible games must still be games! Adults in work situation accept relatively big constraint on usability to be able to use the same software as their sighted work mates and to work on the same documents.

The example of a word processing software is quite interesting to illustrate this. Usually the simple access to character properties (like to know if a word is in bold face or not) necessitates some complex manipulations. What is immediate by sight on any WYSIWYG word processing application, necessitates to select the word, to open a dialog window and then to navigate in the various boxes of this character properties dialog in order to check the various settings currently selected. There exist other software solutions for word processing, like LaTeX, which allow much simpler access to this kind of information for a blind

person, but they are usable only if the work mates of this person use the same! Otherwise, it's globally more important to be able to use the same software than the others even if the usability is not so good.

This is not the case with children, especially playing. In other terms it is not enough to find a technical way allowing to access to all information needed in the interface, the result must be as interesting and as usable as the original game.

Another important reason, which is as important as the previous one, is that it must be possible to succeed! Once again it seems obvious. In the example of a screen reader with a desktop application the user has to explore the content of the screen or of a window to know its contents. In the case of a game, let us consider a shooting game for instance, if an enemy enter the screen, a sighted person will perceive it visually within seconds, together with its location. But if a blind user needs to scan the screen to get the same information, the enemy will have plenty of time to defeat him/her and the game will be over very soon.

In the current mainstream market a huge majority of computer games are totally inaccessible to blind users as well as to most partially sighted users, and even to people having a large variety of different impairments.

2.5 Playable alternative modalities

To handle the special needs of the impaired players, new ways of interacting and communicating have to be found. The different modalities available for visually impaired users have to be studied in order to see what kind of interaction can be done with each device and how.

2.5.1 Audio

The first modality which comes to mind is obviously the audio. Considerable progress have been made in audio possibilities of computers, and what has largely contributed to these progress are the needs for the development of computer games. Then these audio possibilities have been used for a quite large number of audiogames, these are games, that only rely on audio. We'll see a number of them in section 3.1.

Unfortunately these developments have been exclusively driven by use cases where the audio is a complement to a visual experience, which is supposed to enhance the feeling of the situation for the player.

2.5.2 Tactile

The tactile modality can be used to design tactile or audio-tactile games. We'll see in section 3.2 some games using tactile boards. Braille devices are usually not used to design games. Nevertheless some research is currently carried out in order to find models to represent a 2D space on a linear Braille display [Sepchat et al., 2006]. A few experimental games were designed in order to evaluate these models, for instance a snake game and a maze game.

2.5.3 Haptics

[Sjöström, 1999] studied the possibilities offered by haptic technologies for creating new interactions usable by blind people. He worked especially with the Senseable Phantom.

[Johansson and Linde, 1999] used an inexpensive force feedback joystick in a virtual maze. [Wang et al., 2006] have designed an experimental memory game in order to assess the possibilities of their tactile transducers. [Raisamo et al., 2007] presents the same kind of memory game using a low cost vibrato-tactile device (a force feedback gamepad). In the three cases, the interest of the researchers is not in the game development itself, but they use the game as a tool to study the haptic perception. Nevertheless the players were able to successfully play the games and showed an interest in the devices, so they could be used in future accessible games.

[Evreinov et al., 2004] designed a vibro-tactile pen and software to create tactons and semantic sequences of vibro-tactile patterns on mobile devices (iPAQ pocket PC). They propose special games to facilitate learning and manipulation by these tactons. The techniques are based on gesture recognition and spatial-temporal mapping for imaging vibro-tactile signals.

The Phantom was used in several game experiments. [Aamisepp and Nilsson, 2003] built a plugin for an open source 3D game engine (Crystal Space) that allows to use to navigate in the 3D environment and to touch the surroundings with the Phantom. The authors conclude that their system can be used with 3D environments specially build for the haptic environment but that it would not really work with existing environment used in 3D games like Half-life or Quake. The reason is in the fact, that the Phantom uses a single point of interaction, which makes it very difficult to understand a 3D shape.

[Crossan and Brewster, 2006] describe a research about the possibility of using two hands with two different devices. They were using their dominant hand to move a cursor with a phantom and their other hand to receive tactile information from a device offering a 4×8 array of pins[12]. A maze game was designed for the experimentation. They conclude that most users could solve the task with little training, which tends to show that such combination can be used to make accessible games or accessible versions of games.

The Phase project [Rodet et al., 2005] is an experimental game using haptic feedback. It has been successfully played by visually impaired people in various exhibitions. The game refers to function of a phonograph: Phase offers visual stereoscopic landscape wherein a player moves a kind of play head that produces sounds, according to its position over the landscape. It can be used as a musical toy that users just listen or as a challenging game. To beat the game, players have to increase speed by trying to reach the lowest location of the landscape. The haptic device (Senseable Phantom) allows to feel the relief and to find acceleration zones. It enables visually impaired players to successfully handle the game.

About the Phantom, we must also mention the BattlePong, which is a pong game where the players use a Phantom to handle the racket. BattlePong was presented at the Experimental Gameplay Workshop at GDC 2004 (Game Developers Conference).

[12] Virtouch VTPlayer

3 Specific games

This section focusses with games specifically designed for visually impaired people. These games are usually funded by foundations or non-profit organisations. Most of them are very nice for visually impaired people but have little interest for mainstream, except maybe a few of the audiogames.

3.1 Audiogames

Audiogames are games, in which the main play modality is audio, which includes three different concepts. The first meaning involve mainstream video rhythm games like "guitar hero II"[13]. The second definition is related to artistic musical experimentations. The web site audiogame.net refers interesting interactive works. In this paper we will focus on the third concept that is audiogames which can be played with audio only and without visual, and therefore are accessible to visually impaired players.

In 10 years, over 400 audiogames have been developed, which is very small as compared to video games. Indeed, compared to the market of computer games, audiogames are a tiny market, profitability of such projects is smaller and development teams contain generally only between one and four persons. Nonetheless, the production rate has dramatically increased those last few years and the community of players and developers strengthens with sites such as Audiogames.net, which seems to imply that this new medium is in a very promising phase of expansion.

Researchers could have an important role to play in that expansion process, by contributing to develop innovative features like a more pleasant audio rendering, by projecting audiogames in a futuristic point of view by using uncommon technology like GPS for instance and by participate in the elaboration of games which can interest both visually and visually impaired community [Velleman et al., 2004]. There exist a few visual audiogames which can be very impressive and playable as well with or without sight. "Terraformers" [14] [Westin, 2004] was developed with accessibility as part of the original concept of the game. On the other hand, "Audioquake" [Atkinson et al., 2006] (see section 5.5) was developed as a research project to make a non accessible game accessible.

3.1.1 Audiogames categorisation

Audiogames, like video games, can be categorised. The categorisation of audiogames provides conceptual tools allowing to apprehend better the interaction mechanisms used for the players to have fun. In order to categorise audiogames, we use a categorisation of video games as a theoretical basis of thinking [Natkin, 2006]. Natkin distinguishes four main types of games that can be played alone: action games, adventure games, puzzle games and strategy games. These categories will be described more precisely below. Natkin mentions that these types of games can be mixed together and it is true that numerous video games belong to several categories.

The categorisation of audiogames proposed in [Gaudy et al., 2006] looks similar, with four matching categories, but they are not exactly the same as

[13] http://www.guitarherogame.com
[14] http://www.terraformers.nu

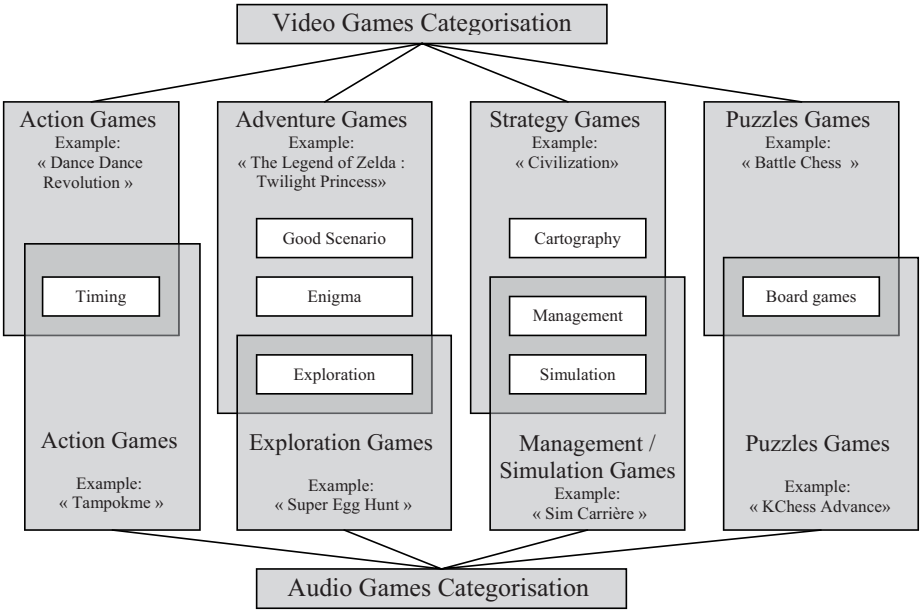

Figure 3.1.1: Comparison of video games categorisation and audio games categorisation

video games categories (figure 3.1.1). Indeed audiogames do not have the same history as video games. They have not had the same evolution. Audiogames owe their existence to video games but also to textual games. Without the visual, texts are the best means to give the players the rules of the game. Audiogames with more complex rules, such as parlour games or management/ simulation games, are therefore naturally more textual than audio. Games with more simple rules, such as action and exploration games, have more recourse to non-verbal sounds. Most of the games that are more non-verbal audio than textual can be considered as a mixture at different levels of the interaction mechanisms of action and exploration games. Some interactions have to be based on a precise timing (temporal dimension of the interaction) and some interactions permit the exploration of a geographic space. Thus, current audiogames can be studied with three factors: their dependency on verbal information, their dependency on interaction mechanisms based on timing and their dependency on the interaction mechanisms of exploration.

3.1.2 Action games

Action games directly refer to games coming from and inspired by arcade games and require a good dexterity of the player. One example of such games is "Dance Dance Revolution" (DDR). DDR is the first of a important series of musical video games. Playing these games requires a good synchronisation with a tempo given by the music. They are not accessible because the kind of action to be done is given visually. The visual information allows the player to anticipate the time of the interaction. The tempo of the game can be rather fast and really challenging. The concept of timing is very important but it depends at the same time on audio and visual perception.

There are also audio action games, where the success of the player depends on an interaction based on a precise timing. "Tampokme"[15] is such an accessible audiogame. The principles of the game are very simple compared to DDR. There is no possibility of anticipating but timing is essential. The player has to identify various kinds of audio signals and react accordingly and in fixed time. The state of flow is not as intense as in DDR but the potential of improvement is high and it is fully accessible to visually impaired people as well as to people who have mobility troubles (it can be played with a single button).

3.1.3 Adventure games/Exploration audiogames

Adventure games offer players to take part in a quest. This type of game combines three essential features: an interesting scenario, the exploration of new worlds and activities of riddle solving. A typical example is the series "Zelda". The enigmas and the scenarios of this kind of game are important but not as much as the action of moving around of the avatar of the player in a virtual environment.

There are also adventure audiogames, though the scenarios of these games, as compared to video games, are still very little developed and that the activity of puzzle solving is clearly secondary. The primordial aspect of these games is, most often, the exploration of a new geographic environment. That is why we call this category "exploration games" in the case of audiogames.

"Super Egg Hunt"[16] focuses on the move of the avatar on a grid, where the players must locate objects only from audio feedback. A quite clever use of stereo, volume and pitch of the sounds allows an easy and pleasant handling.

3.1.4 Strategy games/Management-simulation audiogames

Strategy games require that the players control an army, a territory and resources by manipulating maps. The game "Civilization" allows the player to control a large number of characters, spread on a large number of places. The player manipulates a lot of parameters in order to ensure that the population survives and develops.

There are a few strategy audiogames but the manipulation of maps is rather difficult without the visual. It is still possible: galaxy ranger and AMA Tank Commander are two audio games that offers an interesting approach of strategy games, but they are isolated [Feir, 2006]. The aspects that are the most put forward for these games are the management of resources and simulation.

The game "simcarriere"[17] ignores the map aspect and focusses on the simulation/management side. The player has to manage a lawyer's office by buying consumable, hiring personal, and choosing the kind of cases to defend.

3.1.5 Puzzle games

Finally puzzle games are inspired from games. There are puzzle audiogames which directly refer to parlour games that are not accessible in their usual

[15] Tampokme, the audio multi-players one-key mosquito eater, CECIAA/CNAM CEDRIC/UPMC INOVA, http://www.ceciaa.com/?cat=lois&page=action

[16] Egg Hunt, LWorks, http://www.l-works.net/egghunt.php

[17] SimCarriere: http://www.simcarriere.com/

material form. Nevertheless audio and video puzzle games are quite similar in their principles.

The game "Battle Chess" is an adaptation of the Chess game into a video game. "K-Chess advance"[18] is also an adaptation of the Chess game, but focussing on audio. In those cases, the feeling of flow does not rely on principles of reactivity in front of audio or video signals, but on entertaining principles that have stood the test of time before the advent of computers.

3.2 Tactile games

Tactile games are games, where the inputs and/or the outputs are done by tactile boards or by Braille displays, in combination with usually audio feedback.

As mentioned in 2.5.2, the use of Braille displays for gaming is only experimental by now. So we will only mention projects that involve tactile boards.

Back in 99, we have developed a first software workshop[Archambault and Burger, 1999] allowing to design software games using a tactile board for the input. A scripting language was used to define regions on the tactile board and to attach sounds to these regions. It was also possible to design several scenes and to link them together, which allowed to design audio/tactile discovery games as well as matching games, quizzes and interactive stories.

Then during the TiM project [Archambault, 2004] we developed several tactile games. One was an accessible version of "Reader rabbit's Toddler", where the children can feel tactile buttons on the tactile board, and then drive the game from this board. This adaptation have been designed with the support of the publisher of the original game. This work allowed us to realise how important it is to compensate the lack of visual information in order to ensure that the adapted game has enough attractive feedback for the visually impaired children[Archambault et al., 2005]. Indeed in a first version we had only adapted the tactile interfaces, so the game was usable by the children, but all the audio output were only the original ones. It was clearly not enough, the children did not consider it as a game actually. In a second version we added a lot of audio content, which had been written by an author. This version was much appreciated by the children.

Another game developed within the TiM project was FindIt, which was a very simple audio/tactile discovery and matching game. It is intended for very young children or children with additional disabilities. The player must associate sounds with pictures on the screen or tactile information on a tactile board. Recorded comments and clues are associated with the items. From this game we developed a game generator [Puret et al., 2006] which is currently being evaluated with practitioners working with visually impaired children. The generator allows educators and teachers who work with visually impaired children to design their own scenarios and to associate them with tactile sheets (that they design themselves manually).

Tomteboda resource centre in Sweden have published a report where they try to stimulate parents and educators to develop their own games using tactile boards[Hammarlund, 1999].

[18] KChess Advance, ARK_Angles, http://www.arkangles.com/kchess/advance.html

4 Games designed for all

The goal of games being developed under the title of "designed for all" is to give players with all different kinds of abilities or disabilities the opportunity to play these games. This requires a very advanced game setting and configuration.

4.1 UA-Chess

UA-Chess[19] (Universally Accessibility Chess) [Grammenos et al., 2005] is a universally accessible Internet-based chess game that can be concurrently played by two gamers with different (dis)abilities, using a variety of alternative input/output modalities and techniques in any combination. It was developed by the Human-Computer Interaction Laboratory of ICS-FORTH in close cooperation with the Centre for Universal access & Assistive Technologies.

The game supports a collection of possible input devices like keyboard (including switch devices), mouse and even speech recognition (recognise more then one hundred words). Within these input devices, several configuration and combinations are possible. As examples, the keyboard can be used, beside the standard input, for input scanning. Furthermore, keyboard shortcuts help the gamers to control the game and the game menus quick.

The possible two output channels are visual and auditory through speech synthesis. An integrated screen reader makes it possible to play the game without visual information. The player can decide which information he/she wants to be read. UA-Chess gives the opportunity to save these customised information in profiles. The game provides a default, a blind and two switch-input profiles. Furthermore, two user profiles will be supported. Certainly, each of the two player can select its own profile. As already mentioned, it is a two player game, which can be played together (or better against each other) on one computer or over the Internet.

The programming language and technique is Macromedia Flash MX Professional 7. Flash was chosen because the plug-in is available for all important web browsers on several operating systems (Windows, Mac OS, Linux and Solaris). Flash does not support speech input or output, so to support speech recognition and synthesis Speech Application Language Tags (SALT) technology[20] was used.

4.2 Access Invaders

Access Invaders[21] is a designed for all implementation of the famous computer games Space Invaders, with the target groups of people with hand-motor impairments, blind people, people with deteriorated vision, people with mild memory/cognitive impairments and novice players[Grammenos et al., 2006]. Furthermore people belonging in more than one of the previous groups. Like UA-Chess, this game is developed by the Human-Computer Interaction Laboratory of ICS-FORTH. Universal Access will achieved by supporting (alternative) input/output modalities and interaction techniques that can co-exist and co-operate in its user interface, in combination with configurable player profiles.

[19] http://www.ics.forth.gr/hci/ua-games/ua-chess/
[20] http://www.saltforum.org
[21] http://www.ics.forth.gr/hci/ua-games/access-invaders

Each game parameter can be adapted both based on the player's profile and the current game level. Non-visual gameplay is also supported by full acoustic rendering of game information and a built-in screen reader.

Multi-player games are available, where people with different (dis)abilities can play cooperatively, sharing the same computer. In this case, the games interaction parameters can be independently adjusted for each player. An unlimited number of concurrent players is supported. This will reached by the concept of the so called *Parallel Game Universe*. Different kinds of aliens (various by amount and strength) belongs to the different players. A player just can kill aliens belonging to him/her and vice versa.

Future development will cover the support of tactile output trough a Braille display and a force feedback joystick and stylus. Furthermore, an interactive editor for user profiles and dynamic gameplay adaptation, which includes monitoring the players actions and dynamically adjusting the gameplay to better match the players skills.

4.3 Tic Tac Toe

The approach of [Ossmann et al., 2006] was not to develop a new, designed for all game, it was the approach to make an already published game accessible and show, if this is possible and how big the effort is. So an open source implementation of Tic Tac Toe was chosen. The accessible functionality bases on *Guidelines for the Development of Accessible Computer Games* (see 5.2 Guidelines for the Development of Accessible Computer Games) and was a good test for the usability and completeness of these guidelines. The so called *Descriptive Language* was used to realise the accessible features during the implementation.

This language connects (alternative) input/output devices with the game engine with the possibility to use several input devices simultaneously and present the game output on several output devices. This means that, as an example, the game player can decide if he/she wants to have all graphical objects presented on screen, described over speaker or be on both output devices. Additionally covers the Descriptive Language the option for an extensive configuration of the game, so that the game can be customised to the special needs of a (dis)abled person. This configuration ranges from game speed to the number of opponents to many other game options, depending on the kind of game. The Descriptive Language is, as the Tic Tac Toe game itself, still under development and this game is the first example, using this language.

The game provides, beside the already mentioned full sound output of all objects on the game field, also the possibility to use input scanning in connection with (one) switch devices. The future development will cover the support of visual impairments and full accessible game configuration.

5 Game accessibility

The goal of games accessibility is to bring the idea of accessible games (or games designed for all) to the mainstream and show different approaches. Here is an overview of papers about research work and development on this topic.

5.1 Accessibility in Games: Motivations and Approaches

[IGDA, 2004] is a white paper published by the Games Accessibility Special Interest Group[22] (GA-SIG) of the IGDA (International Game Developer Association) in 2004. Firstly they give the following definition about games accessibility: "Game Accessibility can be defined as the ability to play a game even when functioning under limiting conditions. Limiting conditions can be functional limitations, or disabilities such as blindness, deafness, or mobility limitations." Furthermore definitions of the different kinds of (dis)abilities are given followed by statistics about (dis)abilities in the population and the possibilities of game based learning.

The paper also covers a collection of hints and suggestions (guidelines) how accessible games can be developed. Moreover there is a collection of accessible games with a short description of each game and a categorisation which (dis)abilities are supported. A listing of assistive technologies and an overview of state of the art research completes the paper.

It is the first famous publication that waked up the mainstream game developers and was showing them that it is possible and necessity to include more users to the mainstream games.

5.2 Guidelines for the Development of Accessible Computer Games

Guidelines are an important tools to bring games accessibility to the mainstream. [Ossmann and Miesenberger, 2006] shows a set of guidelines[23], based on the already mentioned guidelines from IGDA and a set of guidelines from the Norwegian company MediaLT[24], and there development process. The guidelines are a collection of rules, hints and suggestions how to develop accessible computer games, divided in the categories level/progression, input, graphics, sound, and installation and settings.

The guidelines have, beside the rules itself, a categorisation in three classes of priorities: a) must have, which means, that it is absolutely necessary for the listed group of gamers. Otherwise the game is not accessible for them, b) should have, which means, that it is a big help for the listed group of gamers and c) may have, which means, that it is a help of feature for the listed group of gamers. Furthermore there are four groups of (dis)abilities: visual, auditory, mobility and cognitive (dis)abilities. These (dis)abilities are allocated to the priorities, e.g. one rule can have priority 1 for visually impaired people and priority 3 for auditory impaired people. The next steps will be adding code samples and best practice methods, how to fulfil the rules. An other step will be making a stronger integration of assistive technologies in the guidelines, specially adding an input device section to them.

The future goal is to have a useful and usable set of guidelines for game development like the web accessibility guidelines for web pages are.

[22] www.igda.org/accessibility
[23] http://gameaccess.medialt.no/guide.php
[24] www.medialt.no

5.3 Computer Games that work for visually impaired children

[Archambault et al., 2005] describes the work on computer games for blind or severely visually impaired children from 3 to 10 years old. The research and development work was done during the TiM project, which was a co-operation of several European institutes and organisations, funded by the European Commission. Various mainstream games had been studied and several of them were adapted to be playable for the target group. Also new ones were developed. Several case studies were accomplished, one with the game "Reader Rabbit's Toddler". In the original version of this game, the player can have access to 9 different educational activities. From these 9 different activities in original version, 4 could be adapted plus the navigation in the main menu.

All output was converted to alternative modalities (basically audio in this game) and for the input, a device called tactile board was used. Its an input device on which a rectangular sensitive area is divided into 256 cells. On top of the sensitive area, a tactile overlay may be inserted. Rich tactile overlays were designed, using pieces of various materials, stuck on a robust PVC sheet, and Braille labels.

A second game, called Mudsplat, which based on the classic arcade game "Space Invaders", was developed. The game has a various degrees of difficulty and traditional features of arcade games were implemented (like high score, extra lives, levels, bonus objects, bonus levels,...).

Furthermore the paper includes 14 rules for games, being developed for the already mentioned target group. These rules based on the results of research and test cases with children, including information about the game play itself, about the navigation in the menus and about content for the sighted.

5.4 Internet and Accessible Entertainment

[Tollefsen and Flyen, 2006] based on a project, which is aimed at adapting and developing entertainment software for young people with (dis)abilities, includes those with mental (dis)abilities, or a combination of severe motor handicaps and perceptual losses. Entertainment was chosen, because entertaining software may provide good motivation e.g. for learning assistive devices and standard computer skills. During the project, a new product should be developed following the principles entertaining, simple (not childish), accessible and flexible.

Deciding for an Internet game using Macromedia Flash based on the following considerations: support for different platforms, no client installation and only one source to maintain in combination with Flash's built-in tools for creating graphics and animations, using mp3-files for music, the accessibility support is fairly good and the easy distribution to different medias like Internet and CD-ROM. The developed game (called "HeiPipLerke") can in short be described as a music composer adjusted to meet the requirements of the target group. It provides input scanning and audio output by default.

Some problems and challenges occurred, e.g. the implementation of input scanning and speech output, which was not available in Flash. Furthermore pointing and selecting items on the screen using a touch screen, followed by some problems changing the colours of all objects for people with visual impairments. The game based on the Guidelines for Accessible Games (see 5.2 Guidelines

for the Development of Accessible Computer Games) and "Best Practices for Accessible Flash Design" guidelines. The future work on the game will include more content and the support of hearing impaired by including sign language in addition to speech.

5.5 Making the Mainstream Accessible: Whats in a Game?

[Atkinson et al., 2006] describes the work of the AGRIP project – an effort to develop techniques for making mainstream games accessible to blind and vision-impaired gamers. *AudioQuake* is the first adaption of an existing mainstream game (Quake from id-Software) designed specifically for sighted people that has been made playable by blind gamers by adding an "accessibility layer". During the development of this layer, one of the issues, has to be solved, was navigation. Navigation issues were divided in global navigation towards one's ultimate goal (e.g. the red teams flag, ...) and local navigation (e.g. how do I get out of this room?). At the low-level game accessibility stage of the project's development, the primary concern was to develop the support of effective local navigation.

One "tool" that was implemented for the local navigation was the EtherScan Radar. It warns players of nearby enemies and team mates using a RADAR-like metaphor: sounds emanate from the position of the enemy and have a gain and repetition speed proportional to the players distance from them. An other topic is serialisation. It reduces multidimensional problems into single-dimensional problems, which is important for the two most popular accessible output formats — speech and 1-dimensional Braille displays. Serialisation has a close connection to prioritisation. This means, that different kinds of information (enemies, walls, ...) will get different kinds of priorities on order to being serialised. Several priority paradigms are discussed there.

6 Game accessibility today

We have seen (section 3) that a number of games have been developed specifically for visually impaired users. These are mostly audio games but a few tactile games exist. These games have two interest: firstly of course they are of tremendous interest for visually impaired players (especially since the number of such games is extremely limited regarding the number of mainstream games), and secondly in the research field they are as many experiments or demonstrations of how to render various interaction situations with alternative modalities. This can be completed by the number of research papers about new uses of modalities in the game play (Braille devices, haptic...) described in 2.5.

In the specific case of audiogames some more progresses could be achieved. Indeed they still don't use the specifics musicality aspects of sounds. Multi-player audio games are required for better communication between players[Feir, 2006]. In order to progress it is necessary that audiogames start to interest a larger community of players.

Then in section 4 we have presented 3 research projects focussed of games designed for all. These games must be seen as a good practice examples, demonstrating that Universal Access is a challenge and not utopia. In this projects we have to admit that the alternative access to these games requires more development than the rest of the game.

We assist to a general awakening of accessibility need by the mainstream game developers. Some first efforts were started to improve accessibility of mainstream game, with in particular guidelines, supported by the International Games Developer Association. If they are eve, partially implemented we can expect that the general accessibility level will be raised, which mean that for a large number of people having a slight to moderate visual impairment, more games will be playable.

Now, if we want to go further in this field, which means we want to make more mainstream games accessible, and if we want to make them accessible to all, we need that support for accessibility is included in the mainstream games themselves. This is the only way that will allow to build accessible interfaces to mainstream games.

For now, considering Windows desktop applications, we have seen in 2.2 that it is necessary to have accessibility support embedded in the applications in order to make them accessible to alternative interfaces, supporting alternative modalities, like screen readers. This was achieved through the Microsoft Active Accessibility. But if this technology is well suited to desktop text-based applications, it is clearly not enough for games (see 2.4).

In the close future we need to design a framework that will allow to develop accessible solutions for games, that we call Active Game Accessibility (AGA). The goal of AGA is to allow mainstream game developers to offer support to accessibility solutions, without increasing significantly the development charge for those games. This support will be used by Accessibility specialists to design accessibility solutions. These solutions will be various depending of each game.

For instance AGA will allow to design some kind of game screen readers which will make accessible the most simple games. The AGA framework will concern a much larger group than visually impaired people, but support all kind of impairments. Then specific access software for various kind of handicap can be developed.

These generic accessibility software solutions will be necessary but will not be enough to make accessible any kind of games. Indeed in the most complex cases it will still be necessary to develop specific interfaces to the games. We have seen in 3.2 that in most cases it is necessary at least to add some audio feedback in order to compensate the lack of visual information. In more complex games it will be necessary to adapt the gameplay it self. The AGA framework will allow to design such interfaces that can communicate with the mainstream games themselves.

Today more and more actors of the game industry are aware that something must be done in the near future to improve the accessibility of computer games. We can reasonably be optimistic since we set up collaborations with specialists of Game Accessibility (for all handicaps), with several companies working in mainstream, and with Assistive Technology providers. So Game is not over yet!

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