Advances in Game Accessibility from 2005 to 2010

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Abstract. The research in the area of game accessibility has grown significantly since the last time it was examined in 2005. This paper examines the body of work between 2005 and 2010. We selected a set of papers on topics we felt represented the scope of the field, but were not able to include all papers on the subject. A summary of the research we examined is provided, along with suggestions for future work in game accessibility. It is hoped that this summary will prompt others to perform further research in this area.

Keywords: game, accessibility, disability, multimodality.

1 Introduction

Game accessibility is about adapting a game's hardware and software (such as game controllers, difficulty level, or feedback modality) to individual needs, regardless of having a disability or not. This makes the target group potentially large. The need for game accessibility may become more urgent with certain disabilities for some game genres. As gamers grow older, they are more likely to become disabled. Further, with the advent of using games in public schools, accessibility may become mandatory for games where accessibility is required by law. This paper presents a literature study of the advances in game accessibility research, based upon 38 published papers between 2005 and 2010. This is done to follow up our previous paper for HCI International 2005 [1]. While great effort has been put into making a fairly complete description, this paper does not claim to include every single research effort in this field.

The research can be broadly grouped in two categories: (a) papers related to creating games concurrently accessible by several groups of people with disabilities; and (b) papers presenting games or interaction techniques targeted to people with a specific disability.

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2 Comparison of Selected Research between 2005 to 2010

2.1 Visual Disability

Savidis et al. [2] discuss the development of a 2D pong-type game space that supports directional auditory and haptic feedback to enable blind users perceive the position of moving targets, also offering a visual interface for sighted players. The game is fully configurable, regarding the auditory grid, the behavior of the force feedback, the graphical appearance and various sound effects. Moreover, different levels of difficulty are supported, affecting speed and the game arena (i.e., circular top-bottom sides).

Atkinson et al. [3] describe how they managed to make a commercial 3D game (Quake) accessible to blind gamers. The paper mainly focuses on rendering techniques, focused on facilitating fast-paced gameplay and was based on the idea of "earcons", employing three different features: (a) consistency within referent types, where a basic earcon is defined for each type of object or event and some properties of it according to each state or type; (b) variance across reference types, i.e. different types of objects use distinctively dissimilar earcons; and (c) natural reference points, where earcons include an in-built point of reference. The authors also suggest techniques for allowing vision-impaired users to edit 3D structures, which might also benefit non-impaired users.

Archambault and Olivier [4] discuss the creation of "Blindstation" developed in order to function as a way to help redesign games by separating game components (e.g., buttons) from game logic in order to allow them to work with any kind of input/output device such as tactile boards and Braille devices. Several games were adapted and designed using the "Blindstation" system. The authors note that adapting games using this system results in a higher cost due to having to redesign the game but feels it is worthwhile because it allows visually impaired children to share their gaming experience with their sighted peers.

White et al [5] interviewed computer literate blind and visually impaired users to identify mobility and orientation skills needed in (1) the real world, (2) virtual environments, and (3) learn about their expectations and desires for virtual worlds such as SecondLife with regard to user interface, use scenarios, and interaction with others. Navigation issues were considered as a much greater issue compared to features like content creation and trade, since navivation is a recurrent issue for most blind and visually impaired users and a core concern for all MUVEs. The authors present an excellent overview of alternative navigation systems, including multi-modal audio and haptic interfaces.

In [6] Gutschmidt et al use haptics and audio to make the game of Sudoku accessible for blind, to try out how to use haptics for conveying common accessibility issues for blind like overview and state feedback. The haptics is implemented with a two-dimensional braille display with 60 rows of 120 dots each. It can represent both text and graphics. Vibrations, pulsations and other dynamic effects can be generated, and it accepts gestures as input. The two-dimensional display alone helped in emulating the sighted player's game, but using both audio and haptic modalities were found to be better.

The paper by Sepchat et al [7] presents their work with tactile video games for blind using a one-dimensional Braille display alone (without audio). It has just one row which consists of pins in four lines and two columns per sign. These pins can be raised or lowered to form e.g. a maze in a game. A semi-automatic game generator was developed, to ease the development of tactile games. Evaluation shows that sighted gamers quickly understood how to play the game presented on a regular display. Sight disabled had harder to understand the braille display, but a 5 to 10 minutes of explanations helped.

In [8] Archambault et al define game accessibility and provides an overview of research made in different game genres, mainly for visually impaired people. Further, they describe their work in proposing a programming framework to simplify the process of making mainstream games accessible for all.

Roden and Parberry [9] propose a framework for creating interactive narrative-based, 3D audio only adventure game aimed not only at the visually impaired but as an augmented-reality game for a mass audience with implications for mobile computing and devices, such as smart phones and iPods.

Sanchez & Saenz [10] relied on a 3D sounds system to help users orient, avoid obstacles, and identify the position(s) of objects and other people within a virtual edutainment environment. The players experienced that the 3D sound helped with spatial orientation. Additionally, the authors included a 3D versus 2D visual format, additional audio cues (such as sound associated with opening a door being the opposite of the sound associated with closing a door), and increased visual contrast greatly helped those players with some residual vision.

Morelli et al [11] evaluates the effectiveness of using multimodal (tactile/audio) cues versus unimodal (audio only) cues for visually impaired with VI Tennis, a Wiimote based exercise game ("exergame") which emulates the game play of Wii Tennis. Results from an accessibility point of view, was that the children "scored significantly better with the tactile/audio version and also enjoyed playing this version more".

Oren et al [12] created a 2D, side-scrolling game world where the player navigates by hopping on platforms, based on the same concepts as early Mario Brothers platform games. The researchers created two versions of the game: (1) an audio-only version, which two experimental groups played by one group of gamers with normal vision and one group of legally blind gamers and (2) an audio-visual version played only by gamers with normal vision. The authors were interested in finding out if "mental maps" of game levels differed after playing each level. Interestingly, the mean scores of mental map accuracy did not vary significantly between groups, suggesting that neither game type presented difficulties in perceiving spatial relationships and routing information.

Sanchez and Elias [13] took a look at real world navigation aids such as the "white cane" and Electronic Travel Aids (ETAs). This was done as a way to explore issues present with ETAs in an effort to create a games that would allow for a better orientation system. The primary issue that the authors focused on was that ETAs often convey too much information causing cognitive overload and, thus, confusion. The authors interviewed blind children and conclude with the recommendation that a game-oriented approach allows children to become exposed to unknown virtual environments that can help to improve navigation and orientation skills in the real world.

Folmer et al [14] looked into the problems encountered by visually impaired people when accessing virtual worlds. They developed a text based interface for Second Life. They discovered that many of the objects found in a virtual world did not provide sufficient information about themselves to allow the researchers to easily generate a text description. In areas with a large number of objects remained an issue, since it was difficult to aggregate information. Finally, the use of a text interface was slower than the usual direct manipulation of objects that a sighted person was able perform.

Pascale et al [15] propose two haptic-based input modes – supporting most major haptic devices – to help the visually impaired navigate and explore Second Life through exploiting the force feedback capabilities in many haptic devices. Two new input modes were created: (1) Blind Walk, which uses a standard joystick to control in-world walking and flying with force feedback used to indicate collisions and (2) Blind Vision in which objects and other avatars are felt via different speed, strength, and type of vibration frequencies. Sighted, blindfolded players reported being satisfied by their experiences and found that finding and reaching other avatars easy. However, like Folmer et al [14] found, telling how large groups of avatars and objects were proved difficult.

The AudioOdyssey game by Glinert and Wyse [16] was interesting because it allowed sighted and visually impaired players to use the game together. The game allows the players to create songs as a DJ at a club. There was also an online version of the game that masks what set of controls a player is using, so a sighted player may not know their opponent has a disability. The game is also set up to allow the use of the Wiimote as a controller.

Miller et all [17] developed “Finger Dance” as a way to create an audio-only of “Dance Dance Revolution”. To replace on-screen visual information to indicate which keys/buttons to press, players would press one of four keyboard keys mapped to sound pitch (high or low) and speaker (left or right. The version first used variable drum rolls that lasted either one, one half, or one quarter of a beat, presented before the user was to press the key that correctly corresponded to the audio cue given. The second version had a constant (ie, one beat long) synthesized sound. Blind gamers enjoyed the challenge of the first version even though it was much more difficult while the sound cues in the second version were preferred but the game was found to be too easy.

Allman et al [18] modified Rock Band® for players with visual disabilities. In order to provide the players with feedback about which drums to strike in the game, the researches created bands that could strap on the player’s arms and legs. These bands contained a small vibrator that was activated when the player needed to perform a specific action. The players found that this approach was effective and did not require much effort in order to remember the required actions. The users did indicate that the ability to alter the audio feedback would be a welcome addition to the game.

Yuan and Folmer [19] created “Blind Hero”, av version of Guitar Hero. The researchers created a glove that “re-routed” visual information by placing pager motors on the tips of each finger to indicate to the player that they needed to press the corresponding button on the guitar controller. Despite having to make game play compromises (e.g. having to leave out the “look ahead” feature), Blind Hero was reported by the players – both blind and sighted, to be a fun an enjoyable experience.

A different use of a custom haptic device was seen in the work of Sanchez, Saenz and Ripoll [20]. A “Digital Clock Carpet” was developed to teach blind children navigation skills. Because of the device’s similarity to a clock and through the use of time type of commands, the children were able to use the device easily. Audio feedback was used to tell the students how well they did in accurately lacing their feet. A sandpaper like texture was placed in the middle of the device to help the student know where to place their feet when starting to use the device. A navigation game, MOVA3D, was created for use with the device and met with enthusiastic acceptance by the students.

2.2 Hearing Disability

Brashear et al [21] developed a game to teach American Sign Language to students. One of the interesting features of this research was the use of wireless gloves with accelerometers to help the computer recognize the signs being shown by the students. In addition, a machine learning technique was used to allow the program to learn to recognize the signs in use. By allowing the program to learn the signs, it is possible to have unscripted conversations.

2.3 Motor/Dexterity Disability

Lepicard et al. [22] designed a Virtual Paddle, as a generic tool for making some types of games accessible to motor-impaired players. The paddle includes four arrow buttons and eight action buttons. Alternative versions of the concept were designed., Four of them were implemented and evaluated with nine users with motoric impairments. Based on the evaluation results, an improved (but not tested) design prototype is suggested.

Sporka et al [23] experimented with controlling the game Tetris using either speech or humming to which was more effective. It was determined that humming worked better than speech. This type of work could easily be adapted to players who cannot utilize a keyboard.

Norte and Lobo [24] developed a version of Sudoku that used two alternatives to controlling the game using either speech or a single switch/button system, the latter making use of a scanning system. One interesting feature that the experimenters found was that including the addition of a "sound scanning" system in concert with the visual scanning system increased the usability of the game.

2.4 Cognitive Disability

Unfortunately, the research literature on games and approaches for those with cognitive disabilities remains lacking, which is of great concern to the authors of this paper. This is obviously a rich opportunity for research work in the game research community and it is our hopes that this is remedied in the near future.

2.5 Multiple Disabilities

Archambault et al. [25], provide an overview of game accessibility and explain how it differentiates from the accessibility of mainstream applications. Subsequently, they review previous approaches and state of the art, and suggest the creation of a new "Game Accessibility Framework", allowing game developers to design accessible games. As first steps, they suggest: (a) the development of a typology of game interaction situations and (b) a characterization of Accessibility in terms of functional requirements.

Grammenos et al. [26] are also concerned with proactively designing games to be concurrently accessible by people with a wide range of diverse (dis)abilities. They introduce a structured design method. The basic steps include: (1) Abstract task-based game design; (2) Polymorphic specialization with design alternatives; (3) Appropriateness analysis for the design alternatives; (4) Compatibility analysis among design alternatives; (5) Prototyping and Usability and Accessibility Evaluation. The process is participatory, user-centred, and iterative involving various stake holders and allowing evaluation and backtracking at each step.

In [27], the method presented in [26] is further elaborated and tested through four case studies: a web-based chess game, a space invaders-type action game, [28] a universally inaccessible game used as an educational tool, and an improved version of the invaders game. Although most of the examples included in this article refer to 2D games, the concept and principles of UA-Games are not bound to any particular game technology or genre.

In contrast to the aforementioned approaches, Ossmann et al. [29] re-use the code of an existing game, and making the appropriate adaptations to make it accessible to several groups of people with disabilities. The game was adapted to support various input and output modalities, as well an automatic movement feature of the focused object (for a single switch mode). Additionally, an accessible configuration feature has been added to set the user preferences. The paper's findings reinforce the fact that games designed for all are possible, but also that in order for the development effort to be time and cost- effective, accessibility aspects need to be considered since the very early design stages.

In [30], Trewin et al attempted to create a virtual world with features that could support players with a variety of disabilities. An important set of findings were gathered from the set of players who played games. Players described issues they had with games in the past and described strategies they used to address the problems described. In addition, they provided a list of possible design implications. Further, a set of core accessibility features they implemented in their game were described.

Ossmann et al [31] propose a new type of assistive software that is also fun to use. Instead of focusing on a particular disabilities, their Assistive Game Interfaces (AGI) tool would (1) consider the type of game (e.g., racing) and the interactions specific to games in that game genre and (2) objects generic to games using the same game engine (e.g., the Unreal Engine) and what systems such as captioning could be standard for all games using that particular engine.

The paper "Accessibility in Virtual Worlds" by Trewin et al [32] was a description of the work that was described in more detail in [30]. This paper provides a very readable summary of many of the challenges gamers with disabilities may encounter within a virtual world.

2.6 Tools for Game Accessibility Development

The AGI [31] by Ossman et al would be a part of a larger effort toward achieving a Game Accessibility Framework (GAF) that would create games accessible for more but not necessarily focused on creating a universally accessible gaming framework.

In [33] Westin and Näckros propose a Game Accessibility Implementation Model, based upon a comparison of four games, with accessibility features for either blind or deaf. The paper concludes that accessibility solutions for games within the same genre and the same disability group may be quite different. Also, solutions for either group may have similar solutions on an abstract level. This framework is further elaborated upon by Westin and Nordeson [34] with a subsystem for serializing operations in C++.

In [35] Tollefsen and Flyen present a project with the aim of creating guidelines for game accessibility, based upon development of an accessible computer game for those with mental disabilities, or a combination of severe motor and perceptual disabilities.

In [36] Yuan et al presents a survey of game accessibility which includes a generalized game interaction model and estimates of how many in the United States who may have difficulties playing games due to a disability. The interaction model illustrates what problems disabled gamers have when playing games and is used to find the number of people "who are estimated to have their disability affect their ability to play games" [36]. Combined with estimates of how many play computer games (e.g. by age), ~0.4% are unable to play computer games while ~2.3% "suffer from a reduced gaming experience" [36].

In [37] Westin presents the results of a survey to which 500 gamers responded, most of them non-disabled. The purpose with the survey was to find out in what way (if any) do non-disabled gamers find games inaccessible? The most obvious result shows that gamers had trouble handling controls and/or understanding what to do, in one way or another, although the issues were less urgent than for disabled.

In [38] Torrente et al presents how an educational game can be made accessible for visual, hearing, motor and cognitive disabilities. Based upon a user model, a game adaptation profile with rules is included in a game adaptation engine. Adaptation encompasses input/output, game flow and in-game tools. The user model provides input to the system about which adaptation is needed. In the user model, a student profile takes the individual's condition into consideration. Further, an environmental profile takes the conditions of the context where the game is being played into consideration.

In [39] Trewin et al presents a requirements gathering based upon a survey, which include requirements of players who are/have blind, low vision, deaf, hard of hearing and cognitive impairments. The requirements are structured into "Problems/ Preferences", "Strategies" and "Design implications" which is useful as a tool for designing accessibility features for other virtual worlds and games. These requirements were used and evaluated while creating the accessibility features of the virtual world PowerUp.

3 Discussion and Further Research

Exploring ways to use haptics or tactile as complimentary feedback to sound is a promising approach for blind, especially when the hardware gets cheaper. Although lack of vision is an area which has got much focus of research, it is among the groups which has very few accessible mainstream titles. Adapting the visuals (e.g. high-contrast or large fonts) and using audio like speech and sound effects are useful approaches [39] which has the added benefit of working with regular hardware. The use of braille displays with one or two dimensions should be explored more, used in conjunction with audio to present information [6-7]. A recurring pattern was found regarding the benefits of multimodal presentation of information for visually disabled, (audio and tactile/haptic). While using haptic or tactile feedback alone was possible, it was harder to understand without explanations [7]. A careful balance of presenting some information with audio was found to be better [6]. It was more enjoyable and easier to get higher scores with a multimodal approach [11].

Hearing is one of the easiest things to implement accessibility for, as it is mainly about presenting text and visuals on the screen [38]. However, there are still many games which does not include closed captioning or even subtitling of dialogue. Hence it is vital to reach out to society with sources like [36] to convince publishers about the potential for reaching new groups of gamers.

Motor or dexterity related accessibility features can be achieved by allowing a remap of controllers. Allowing modification of the response speed is also important. For cognitive disabilities, finding ways to accommodate for different levels of understanding are essential, e.g. a bread-crumb trail or hints. [39]. Very little research has been found in the selected papers about cognitive games, so it might also be a good subject for further research, which is also proposed in [36].

Research should also focus on a development framework and code libraries which could enable developers to more easily implement features [8, 38], as well as end user tools like a game generator [7].

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