Audio space invaders

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ABSTRACT

Whilst advances are underway in various areas to ease and encourage disabled uptake of new technology, very little emphasis to date has been placed on making the games market accessible to all. The aims of the described work have been twofold. Firstly, to prove that the standard features of a traditional space invader game can be replicated using a 3-D audio (ambisonic) environment. Secondly, through combining audio and visual interfaces with force feedback joystick movement that it is possible to produce a multi-modal game that can be played by both sighted and non-sighted users, thereby enabling them to share the same gaming experience. This paper describes the development and features of the resultant *Audio Space Invaders* game.

1. INTRODUCTION

Digital technologies such as hypermedia, virtual reality, digital video broadcasting, video conferencing, co-operative working and the world wide web have been the subject of intense development over recent years and together may be said to comprise the second information technology revolution. These developments coupled with the continually decreasing costs of the enabling technology have resulted in significant expansion in their use (Harlow and Gadher, 1999). One such area of expansion is that of the home entertainment industry and in particular the video games market, to the extent that computer games are played by almost all children, with many families having a home computer or games console. Most of these games involve the use of computer graphics to navigate a fantasy world. Consequently, whilst the graphical technology of these games has become very advanced and sophisticated, the audio component is often mediocre and only used to add to the realism of a game rather than to assist play it. This can leave blind and partially sighted children feeling excluded and set apart from their peers, as they are unable to participate in these games.

That the inclusion of disabled users in all areas of the new technological revolution is of prime importance is evidenced through the increasing awareness of the requirements and rights of the disabled including those related to inclusive product design (UK Government, 1995; DRC, 2000; W3C, 2000; Disability Now, 1999; FEFC, 1996; FEDA, 1998). With inclusive software design (McCrindle, 1999) in mind we have developed a multimodal games interface for a space invader type of game. In contrast to traditional games development, design of the *Audio Space Invaders* game has been based primarily around a 3-D surround sound environment, with the graphical interface being added later. Force feedback controls further enhance the playing experience of the game.

2. EXISTING WORK

Whilst advances are underway in various areas to ease disabled uptake of new technology, for example use of the World Wide Web (W3C, 2000), very little emphasis to date has been placed on making the games market accessible to all. That such a concept is possible, has been demonstrated by Lumberas and Sánchez (1998) who developed a 3D aural interactive hyperstory specifically aimed at blind children. The project proved that blind children could interact with a computer using an audio interface. It also showed that playing the game helped children build up a model of the fantasy world in which they were playing and resultantly improved their spatial awareness of the real world. Another study into audio interfaces (Mereu and Kazman, 1996) found that by using a 3D audio interface a blind person could locate a point in 3D space as accurately as a sighted person could using a graphical interface, although the time taken by the blind person was

significantly longer. It was also found that in a sound only environment visually impaired users were very much more accurate than sighted users. Other ambisonic research (Cooper and Taylor, 1998; Lumberas et al, 1996) also substantiates the effectiveness of 3-D audio environments. Use of force feedback has also been used to guide users through a representation of a GUI (Ramstein et al, 1996) and manipulate the environment. By producing the *Audio Space Invaders* game we have taken the 3-D audio gaming concept a stage further by combining audio and visual interfaces with force feedback joystick movement to produce a game that can be played by both sighted and non-sighted users, thereby enabling them to share the same gaming experience.

3. THE AUDIO SPACE INVADERS GAME

Audio Space Invaders has been implemented in Visual C++ combined with the APIs from Aureal's A3D Software Development Kit (SDK) 2.0 (1999) and Microsoft's DirectX SDK 6.1 (1998, 1999). This has proved to be a very powerful combination allowing the programming of advanced PC gaming features, relatively good portability and excellent driver support.

As the primary aim of this project has been to prove that the standard features of a traditional space invader game can be replicated using an audio environment, incorporation of the following game requirements were deemed to be important:

- The game should be based on a player who his defending himself against may enemy foes.
- The enemy may shoot at a player. This will decrease the player's life, when the player's life reaches zero the player dies and the game ends.
- The player may shoot at the enemy, who also have a life that decreases when they are shot. When the enemy dies, the player's score is increased.
- The game should have a number of different levels each of increasing difficulty.
- The level reached and total score should enable players to rate themselves against each other.

4. GAME SPECIFICATION

The features currently incorporated in a fully working prototype may be briefly summarised as:

4.1 Type of Game

A *shoot 'em up* style of game based on a futuristic space adventure has been developed, as such games are currently very popular with the teenage gaming community. The game incorporates a number of scenario levels, each one based around a player fighting against different types of enemy ships. Each ship type has a certain 'life' that is automatically set to a particular value when the ship is created and decreased every time it is shot. When the 'life' of a ship reaches zero the ship is destroyed. The ships also have different velocities, directions of attack, flight patterns and firing rates. The scenarios are of increasing difficulty and are presented to the player in sequence. For enhanced variability, enjoyment and challenge, each scenario possesses its own unique difficulties and features and to proceed from one level to the next a number of objectives must be met. Each scenario is guided by audio/textual information and played via interaction with a 3-D audio/graphical/tactile interface. Points are obtained by shooting enemy vehicles and by completing the mission objectives. The game can be considered complete when the player has completed the final mission. A total score enables players to rate themselves against each other and against previous plays.

4.2 Adjusting Levels of Difficulty

The scenario levels are initially set with default values, however to adjust the complexity of the game to suit different age groups, disabilities and experience levels, each scenario may be customised using the *Level Editor* supplied with the game (see Figure 1). For example once a player has mastered the inbuilt scenarios, they may be extended by adding extra missiles to the players arsenal.

4.3 Audio Interface

The game is based mainly around a 3-D audio environment. In order to achieve this most effectively, the audio interface was the first part of the program to be designed and implemented. This ensured that other parts of the program were an accurate representation of the audio data. This is in contrast to traditional games development, which tends to concentrate development on the graphical interface, and then tries to associate an audio interface with it. Ideally to give the highest sense of reality to the player, the audio environment consists of a four-speaker surround sound set-up. However the program will also work adequately on sound

cards that only support two speakers – in this mode it is especially effective with headphones. For further ease of use instructions are given audibly, audio clues as to what is happening within the game are implemented, and the control system has been made as simple as possible.

4.4 Visual Interface

The *Audio Space Invaders* game does not require a graphical interface for playing purposes. However, a graphical interface has been included for a number of reasons: firstly to provide a more natural mode of interaction for sighted users; secondly to provide a training mechanism to the game for both sighted and non-sighted users; and thirdly to provide a comparative test-bed for research into human computer interaction issues across sighted and non-sighted user communities. During testing it was found that newcomers to the game often experienced initial difficulty in getting their bearings in the audio world. The graphical interface allowed sighted people to work out their relative position to other objects in the game and it is envisaged that via this method a sighted person would help a visually impaired person also learn the game. It may also be of use during game play by partially sighted users. The visual interface may be turned off completely if desired.

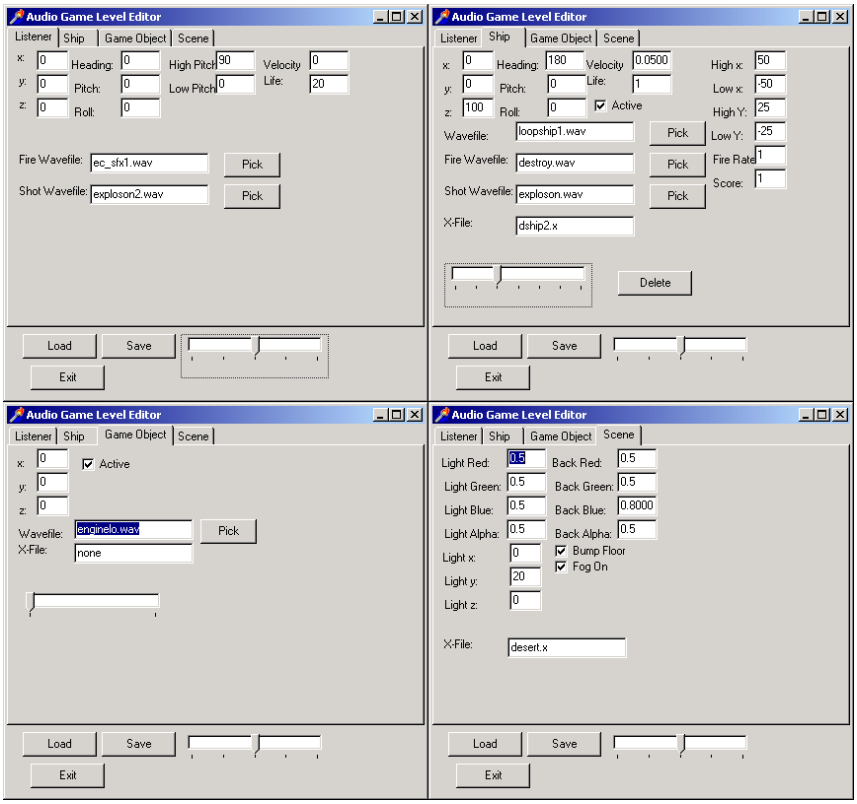

Figure 1. *Level-editor to set degree of difficulty of game and establish new scenarios*

4.5 Interaction

There are two possible control methods for the game – a keyboard or joystick. The keyboard can be used to replicate a number of basic controls: - up, down, left, right and fire. The joystick enables more sophisticated interaction with the game since it allows more than one signal to be processed at once, so for example the user can shoot and move at the same time. Simple keyboard interaction rather than a mouse driven interface has been incorporated as it also assists users with co-ordination impairment since it eliminates the needs for physical dexterity and accuracy that are associated with the use of a mouse. Additionally, blind users who may not feel completely confident with a mouse or joystick may also prefer this method of interaction.

4.6 Force Feedback

The use of an optional force feedback joystick provides extra information and clues to the game situation if the user has one of these devices. Through different movements of the stick the player is able to feel themselves being shot, the shots they are firing etc. and in the future may be used to guide the user through certain events or as a training mechanism. This extra information can be very useful, especially at higher levels of the game when there are several activities going on and hence a variety of different sounds being produced.

4.7 Universality and Affordability

The game has been designed to run on a Windows 95/98 PC of average specification. The recommended minimum specification is a Pentium II with 64mb RAM, Aureal 2.0 compatible sound card (4-speaker) and a force feedback joystick. However acceptable performance is also achieved on a Pentium MMX or equivalent with 32mb RAM and a standard sound card (2-speaker). A player can also turn off features such as the graphics to improve the speed of the game. Although a force feedback joystick is very useful in supplying extra sensory information to a player, it is an expensive device and hence is an optional feature of the game. Additionally, research has also shown that some blind children find a keyboard a more natural method of interaction and hence this is always an available control option.

5. GAME SCENARIO IMPLEMENTATION

There are currently six scenario levels, including an initial training level, each representing the defence of a different planet from increasingly complex formations of enemy ships. Essentially, the player is positioned in a turret on each planet's surface, which is then attacked by the enemy ships. The player has the choice of being reactive and firing at the enemy ships when they are detected audibly or visually within range, or they may be proactive and seek out enemy ships to destroy.

Purposefully, the first scenario level is a training level to teach the users the basic controls and how to play the game. At this level the user is in a turret with four stationary ships placed around them. A ship is placed in front, behind and to either side of the turret. There is also a more powerful enemy ship incorporated into this level to enable the player to recognise the difference between these ships and the normal ships. This level is essential to help players not using the graphical interface learn how to locate ships by listening to where the sounds come from and to differentiate between the different types of ships. Unlike the graphical interface, which is a common way of playing games, the audio interface is quite different to anything else the players will have used before. For example the more powerful ships are given a louder and more high-pitched sound than the normal ships and must be distinguished as they are harder to destroy. Additionally, the turret is given a long life-span in this level. This gives the user ample time to get used to the controls and the ideas of the game. The training level also introduces Molly, a female robotic companion, who instructs the user what to do at each level and what dangers are present at each level of the game. She also offers words of encouragement and gives the user a sense of continuity throughout the game.

Figure 2. *Snapshots of level-2 to show mission instructions, game in play and debriefing*

Figure 2 shows four screenshots taken at various points during Level-2 of the game. The first quadrant shows the start of the scenario with Molly alerting the player to an imminent attack. Information in this mission brief is given about the players position as well as the direction of the incoming ships. Quadrants 2 and 3 show snapshots of the game in progress. Quadrant 2 shows an approaching wave of ships, whilst quadrant 3 shows a ship that has flown over from behind the player. To make the ships sound as though they fly towards and away from the player the Doppler effect is applied to the sound. This effect, which is apparent in normal life, increases the pitch of the sound of the object as it comes towards them and decreases the pitch as the sound moves away. The remaining player life-span and their score are given in the left and right corners of the screen respectively. Such information is also accessible audibly by pressing a keyboard control key and is given automatically should the life-span level become dangerously low. Once the mission has been successfully completed, Molly gives an encouraging debrief to the players as shown in quadrant 4.

Scenario levels-3 to 6 take place on different planets and have increasingly complex flight patterns for the enemy ships, shorter player life-spans, more of the powerful ships etc. However they all purposefully incorporate a similar look-and-feel as shown in Figure 3, which incorporates screen shots taken from level-4. Another 'twist-in-the-tail' for pitting blind players against sighted players is that as the levels become progressively more difficult the degree of graphical help for sighted players is lessened by making the planets very dark such that the approach of enemy ships cannot be so readily detected by visual means as shown in Figure 4.

Figure 3. *Consistent look & feel but increasing complexity.*

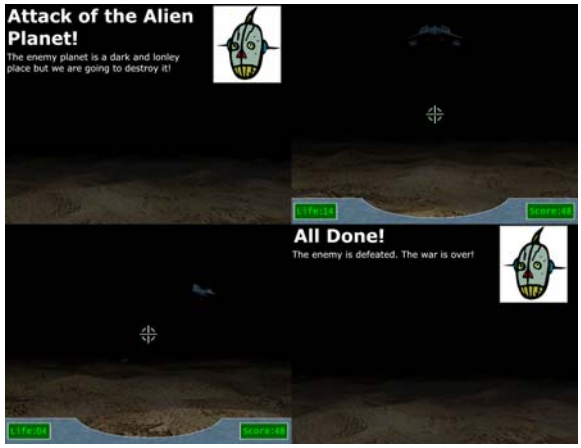

Figure 4. *Difficult visual interface.*

The game may be played using audio and visual information in combination or in isolation of each other. The different models can be switched in real-time by pressing a single control key. The game play resulting solely from using the audio interface is shown in Figure5. A series of menus, instruction files and other feedback information screens such as those for game statistics are also incorporated into the game, some of which are shown in Figure 6.

Figure 5. *Game play solely through audio interface.*

Figure 6. *Introductory and summary screens.*

5. TESTING

Testing has been ongoing throughout development and a number of important observations have been made. In particular users initially found it difficult to distinguish between different sounds and from where they were coming. However, with a little practice they soon became able to locate and shoot the enemy ships. The graphical interface proved a useful training mechanism even for non-sighted users since with the help of a sighted friend they were able to gain an understanding of where the sounds were coming from and what they represented.

Other results were also gleaned about the type of sounds and general game play that were most effective, for example:

- Sounds with a smooth varying pitch were very difficult to locate. It gave the impression that these sounds were moving when they were in fact not.
- Sounds that changed could be located as long as the change was quite harsh. A helicopter's propellers or some other sort of machine were easy to locate whereas a sound like siren was not.
- With more than two sounds the quieter or less distinguishable sounds became masked and were not easy to hear until objects making the louder sounds were destroyed.
- Two or more sounds which were the same or very similar were also difficult to locate, although not impossible.
- Too many sources of sound were found to be detrimental to the game. Originally every time a players score increased or their life-span decreased the information was communicated audibly to the player. This proved to mask out the ship sounds and disadvantage the player. This feature was therefore subsequently changed to the score being read out on demand via a control key and only automatically when a players life was becoming dangerously low.
- There was a very steep initial learning curve particular for sighted people trying the play the game on audio alone, as the task is quite peculiar to a lot of sighted people who rely mainly on images to locate items.
- The game became rapidly more challenging as ships flew with circular motions in addition to straight lines. Further challenges were provided, by having ships flying in both directions over the user and approaching from both sides simultaneously.
- The game is playable using only two speakers although it is obviously better with four speakers. If only two speakers are available it is best to use headphones instead.
- Changing the height of the object has proved very difficult to use with a 4-speaker set-up. The difference in sound is very small and so is currently not used. Further testing is required, possibly within a CAVE environment, to make full use of this feature.
- The positioning of the speakers was found to be essential for maximum efficiency and enjoyment of the game. The speakers should be positioned at approximately head height with the player an equal distance from each speaker.

The initial version of the game has been completed, is comparatively portable across a wide range of PC specifications and is very robust. Preliminary feedback has been exceedingly encouraging. Unfortunately, the more extensive and formal evaluations with blind/visually impaired teenagers originally scheduled for March/April 2000 have had to delayed slightly due to the logistics of term-times and exam timetables. However, these will shortly be underway and all feedback obtained will impact on the continued development of the game.

6. FUTURE WORK

A number of advanced features are also planned for implementation such as incorporation of Artificial Intelligence (AI) techniques to provide added realism to the game and to support help facilities; improved text to speech and speech recognition functions; an increased number of joystick functions; three dimensional graphics; and a networked version of the game to enable several players to interact simultaneously within the same gaming environment. Additionally, exploitation of the new facilities in the recent releases of Aureal's A3D SDK (1999) and Microsoft's DirectX 7.0 (1999) will improve the audio interface and force feedback interfaces respectively.

7. SUMMARY

This paper has introduced the work associated with the creation of an *Audio Space Invaders* game. Substantial progress has been made in a very short space of time and a fully working version of the game produced which successfully incorporates the features described in Section 4 and proves that interactive gaming features can be incorporated within an audio environment. Indeed, such is its success that discussions are underway with a digital company with a view to professional production of the game and its movement into the market place. Further user trails are continuing; a number of other audio games are being developed; and further research into human computer interaction techniques for blind and visually impaired users being conducted.

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