

Audio Games: New perspectives on game audio

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ABSTRACT

This paper discusses the design of audio games, a quite new computer game category that originates from games for players with visual impairments as well as from mainstream music games. In the TiM project (Tactile Interactive Multimedia), SITREC develops three sound-based games that point out new directions for game audio design. The TiM games demonstrate different ways in which games can be designed around an auditory experience. Several unique features of audio games are presented emphasising unexplored potentials for interactivity and future development areas are suggested.

SITREC proposes an approach to the design of auditory interfaces that takes three listening modes into consideration: casual listening, semantic listening and reduced listening. A semiotic model is presented that illustrates this view on sound object design and ways in which sounds can be combined. The discourse focuses on issues of continuous display, musicality and clarity, and introduces the notion of "spatialised game soundtracks," as opposed to separated background music and game effect sounds.

The main challenge when developing auditory interfaces is to balance functionality and aesthetics. Other important issues are the inclusion of meta-level information in order to achieve a high level of complexity and to provide elements of open-endedness. This refers to planning the overall gameplay, as well as to designing individual sound objects and combining them into complex, interactive soundscapes.

Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces—*auditory (non-speech) feedback, theory and methods, user-centered design*; H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—*audio input/output*; J.5 [Computer Applications]: Arts and Humanities—*performing arts, music*

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General Terms

Design, Human Factors, Theory

Keywords

Audio game, Auditory interface, Sound design, Game audio, E-inclusion, Visual impairment, Spatial soundtrack, Soundscape

1. INTRODUCTION

Commercially available, mainstream computer games can generally not be played by people with visual impairment, since the essential game content is conveyed with graphics. Therefore, the TiM project (Tactile Interactive Multimedia) [22] has been dedicated to the production of prototypes of computer games for visually impaired children. Within TiM, SITREC (Stockholm International Toy Research Center, at KTH, Royal Institute of Technology) [17] is responsible for the design of three audio games: *Mudsplat*, *X-tune* and *Tim's Journey*.

Audio games are computer games that feature complete auditory interfaces, so they can be played without the use of graphics. We believe that this type of applications carry a great potential for the development of new forms of computer entertainment. Many issues raised during the development of the TiM games can also have an impact on other areas, such as interfaces for ubiquitous technologies and special need aids.

Whereas the TiM games are primarily developed for people with visual impairment, we believe that it is possible to create sound-based computer entertainment for everyone. This requires careful attention to the aesthetics as well as to the functionality of the applications.

The TiM games illustrate different aspects of audio game design. *Mudsplat* features an easy-to-learn interface and other characteristic elements of the arcade game genre. *X-Tune* is a toy music sequencer built on an extendable, menu-based interface.

The closest examined game in this paper is *Tim's Journey*, a work in progress and the most complex and ambitious application of the TiM project. *Tim's Journey* is a surround sound adventure game that combines elements of non-linear narration with open-ended gameplay, in which the player explores an island and slowly reveals a mystery. The game shows how augmented audio features can form the foundation of a large game concept, covering all aspects of the gameplay.

2. BACKGROUND

Over the last couple of years, there has been a rapid development of advanced audio chips and 3D sound engines for computer games [11]. Users as well as developers today pay serious attention to the sound content of computer games.

Sound is an expressive narrative medium, essentially as flexible as graphics and animations. Sonic landscapes, or "soundscapes," can be as immersive as advanced three-dimensional visual environments. Sounds can also communicate very specific information and generate suggestive musical environments or subtle moods.

There seems to be a tendency towards an increasing use of carefully designed audio content in computer games. Most top-shelf games, such as *Myst III - Exile* [23] and *Halo* [12], today feature ambitious and advanced soundtracks that follow the narrative development of the games. Furthermore, several mainstream computer games where sound is a central medium have emerged over the last couple of years. An important game category today is music games, especially the so called "rhythm action" games, where the players coordinate their input with the rhythm of the a soundtrack. This genre includes games such as *PaRappa the Rapper 2* [18] and *Dance Dance Revolution* [9]. Other visionary computer games that revolve around musical experiences are *Rez* [16], *Amplitude* [20] and *Vib Ribbon* [19].

Despite these tendencies, the audio content of mainstream computer games is still underdeveloped when compared to their visual contents. This is probably due both to user and developer prejudice and, consequently, sound remains a relatively unexplored medium in interactive "multi-media" applications.

The development of game audio has, however, opened up possibilities for people with visual impairment to play computer games, provided that the games are developed with regard to their abilities. There is a growing scene for sound-based games that convey all necessary information through auditory interfaces. Among the more popular titles are the games *Shades of Doom* [7] and *Terraformers* [14]. New, increasingly advanced audio games appear regularly and, as the visually impaired gaming community expands and grows more established, the content and game interfaces of the mature [2]. One effect of this is that new audio games can start building upon older titles and become more advanced. Yet, the complexity of today's audio games is still far behind that of mainstream games.

With the development of the three TiM computer games, SITREC has two main goals: (1) to show that games for visually impaired players can be as advanced, complex and aesthetic as mainstream games, and (2) to indicate new areas of development for mainstream games, by paying more careful attention to audio-based gameplay.

By providing auditory interfaces, and treating sound with a concern equal to what normally is exclusive for the graphics, we believe that it is possible to develop not only functional games, but also aesthetic gaming experiences. This is an important design principle, in particular since toys for children with special needs today often has a focus on therapeutic aspects. We want to show that computer games for visually impaired children do not need to be simplified to such an extent that they resemble the games sighted children played 10-15 years ago.

3. THE TIM GAMES

When developing computer games for visually impaired children, the output cannot be based on animated graphics as in mainstream games. The only option today for advanced game development is to build the games around sound output.

In some cases, SITREC has chosen to combine the game audio with visual output, but it is always the sounds that are central to the game. Thus, the visuals of the TiM games are used to complement the sounds, which is the opposite approach to that of mainstream games where the audio content usually is added in the end of a design process, and mainly as a decoration to the graphics or to enhance certain moods.

The three TiM games developed by SITREC are quite different from one another and cover many different aspects of computer gaming. Amongst the three games, Tim's Journey offers the most complex and challenging gameplay, whereas the other games emphasise ease of access and extendable functionality.

3.1 Mudsplat

In Mudsplat, the player controls an avatar that has to defeat monsters that try to throw mud at him/her. To protect him/herself, the avatar has a hose, with which he/she can spurt water at the monsters. The player reaches different game levels by defeating a certain number of monsters. To be successful in playing Mudsplat one has to locate the monsters quickly, and fire at them before they throw mud.

In total, there are 25 different levels in Mudsplat, divided into five "worlds" with five levels in each world. Each world is characterised by its background music, which continuously increases in intensity, making it harder to locate the monsters. At the end of the fifth level of each world the player has to defeat a "boss," which is an extra tough and difficult monster.

Mudsplat uses a lot of the conventions from the arcade game category. The terminology and features used are, for example, levels, bosses, extra lives and power-ups. The gameplay is planned to be very easy to learn; the objective can be grasped quickly, as well as the simple input system, which only uses three keys to control the avatar.

It is essential for the player to obtain a mental image of the game space. This can be done by moving the avatar around to localise the limits of the available space. All sounds are heard from a first person perspective, and the amount of stereo panning and sound intensity are continuously modified to give a "realistic" impression of distance and movement, so the player can estimate how many steps he/she needs to move the avatar in order to face and aim at a monster.

Mudsplat is developed to see if an entire concept/genre is "translatable" to audio information only. The main challenge in this process is to plan all the necessary agreements with the player for him/her to understand the gameplay. Since only a few of the sounds used in the game are self-explanatory, agreements must be established early, and as far as possible be built upon metaphors and associative patterns. Mudsplat contains various examples of such agreements, from the sounds heard when moving backwards in menus, to the sounds intended to give the player a sense of the sizes of monsters, how dangerous they are and the scores awarded when defeating them.

3.2 X-tune

X-tune is more of a software toy than a traditional computer game, since it contains no competition or specific tasks to be solved. X-tune is open-ended in the sense of being usable in many, not predefined, ways. This includes making musical compositions, recording and manipulating sounds or voices, creating sound collections, or simply playing with sounds.

In X-tune, one plays with different sound environments, or "styles." These styles consist of 15 sounds from a theme, such as a "kitchen" or a "ghost house." The player creates music by manipulating sounds and arranging them into rhythmical patterns. The player can manipulate the sounds, add effects and finally save his/her compositions to share the audio files with his/her friends.

The software contains a "style editor" where the player can create his/her own styles. This is done either by combining sounds from the predefined styles or by recording and uploading new sounds. The game engine uses .wav sound files, which means that the player can use sounds found on the Internet or on his/her computer and upload them to the style editor.

X-tune has two simultaneous virtual interfaces, one sound-based and one graphical, although the game is fully playable without using the graphics (see Figure 1).

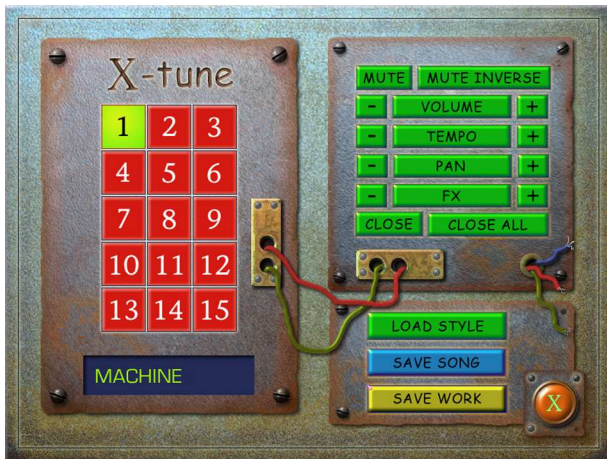


Figure 1: Example from the graphic interface of X-tune.

The auditory interface uses audio "tool-tips" when a post in a menu is highlighted. This means that the player gets feedback to all movements within the menus and for every choice he/she makes. The audio tool-tips are recorded spoken explanations of the menu posts.

The menu-based interface structure enables the developers to add or remove features from X-Tune. Thus, X-Tune provides a framework of features that can be altered and recombined into different sound-based tools or toys that do not require visual displays. This approach provides possibilities for easy adjustments of the software, to target the needs of various age groups.

3.3 Tim's Journey

Tim's Journey is a computer game that lets the player explore a complex world made up of sounds. The main idea is to move the avatar around in three-dimensional sound-

scapes and to unravel a hidden mystery. The game space is an island, which is divided into different "scenes," or areas of certain identities, such as harbours, a forest and a mill. Each scene has a specific musical "theme" that is easy to recognise. The sounds are played through a surround sound system and the player hears them from a first person perspective.

In Tim's Journey, we aim to give the player an impression of moving around freely in a continuously changing piece of music. By treating all present sounds in a scene as musical components, the soundtrack is composed from environmental sounds. The sound objects, and the ways in which they are positioned, reflect musical structures such as themes, choruses and bridges, and all sounds fit into percussive and melodic patterns. The music is thus generated from the combination of all present sound objects in the game space. This enables the player to create music by moving the avatar around in a "spatialised soundtrack," consisting of numerous positioned sounds. Thus, the player co-produces of the soundtrack in real time, while navigating the game space.

This approach is quite different to those of other audio games. Most games designed for visually impaired players reduce the number of simultaneous sounds to a minimum and avoid ornamental soundtracks in order to facilitate navigation [1]. In Tim's Journey, there is a multitude of sound objects present at all times. The sounds vary in importance, which is reflected by their character, intensity and how often they are triggered in the soundtrack loops.

Navigation in itself is an important part of the gameplay in Tim's Journey. Frequently, the player needs to find out where the avatar is and how to locate important objects. The player also needs to know what objects in the game space are possible to interact with. Therefore, the game features several help systems and non-player characters that provide hints and encourage the player throughout the game. SITREC has tried to balance the help systems against the intended mysterious gameplay. This is done by providing help with basic navigation but keeping the sense of being lost and not knowing what to do next. The navigational aids are:

Ambience Reductor: a device that allows the player to temporarily reduce the volume of all sound that he/she cannot directly interact with.

Footsteps: help in navigation by providing information about the kind of surface the avatar currently is walking on.

Helpers: different non-player characters that the avatar encounters. They can provide information or clues to the plot.

Foghorns: in every quarter point of the compass there is a foghorn that can be heard at any distance.

The gameplay in Tim's Journey is open-ended, as it is open for different playing styles and allows non-linear exploration of the game space. The player can move around freely, solve tasks and explore the environment in his/her own pace and direction. As the player does not know where he/she is, or why, at the beginning of the game, the actual story and meaning is revealed through clues and explored situations.

4. GAME AUDIO DESIGN

When designing audio games, it can be important to emphasise the differences between different kinds of auditory information. In graphical interfaces this is done by sepa-

rating different kinds of buttons and interface objects by borders, colour coding and other design variations. During the development of Mudsplat and Tim's Journey, we find it useful to categorise the different kinds of sounds used within the games to help us emphasise the differences between the various auditory messages.

This categorisation system, suggested by SITREC, explains some of the differences between sounds used in the TiM games.

Avatar sounds refer to the effects of avatar activity, such as footsteps sounds, shooting or bumping into objects.

Object sounds indicate the presence of objects. They can be brief, recurring sounds or long, continuous sounds, depending on the chosen object presentation strategy (discussed in chapter 4.2).

Character sounds are sounds generated by non-player characters.

Ornamental sounds are sounds that are not necessary for conveying gameplay information, such as ambient music, although they enrich the atmosphere and add to the complexity of the game.

Instructions are usually speech recordings providing information about how to solve certain tasks, such as the helpers' advice in Tim's Journey.

Tim's Journey is designed to maintain an ambiguity between what are object sounds and what are ornamental sounds. Still, it is important to communicate to the player whether a sound is generated by his/her activities or by the computer. In the TiM games, this is generally done in two ways. Firstly, sounds that are generated by the avatar are likely to be positioned in the centre of the stereo or surround sound space. Secondly, all sounds generated by avatar activity are instantaneously connected to the player's input, by pressing keys on the keyboard or the game pad. This instant connection between all input activity and auditory feedback is very important to inform the player that the system has registered his/her actions. For this reason, pressing an active key should always give some sort of feedback in an auditory interface.

In the TiM games, we have pursued consistent aesthetics within each game, with variations in the different game levels or "scenes." To achieve this, we have tried to approach the design of individual sounds as if composing music. The sounds are chosen to complement one another and the overall timing is planned to emphasise musicality. Music can be an efficient carrier of emotional qualities, which is very useful when trying to set the mood of a game or game element. Here, one can find a lot of established narrative conventions in film music.

4.1 Sounding objects

Tim's Journey requires a large variety of sounds to represent all objects and actions within the game. Since it is a very complex audio game, where sounds are included for many different reasons, we try to incorporate several different design strategies. There are two well-established design methods for auditory interfaces: the "auditory icon" approach, which uses as recognisable sounds as possible, often based on authentic recordings [6, 5], and the "earcon" approach, which associates information with short musical phrases [3]. These design strategies are very useful, though somewhat limiting, as they are not primarily developed for computer game contexts.

A more flexible framework for sound design can be found in the film sound theories of Michel Chion [4]. Based on Pierre Schaeffer's analyses of sound objects [15], Chion divides human listening into three modes: casual listening, semantic listening and reduced listening. Here, casual listening refers to listening for the source of the sound, attempting to understand what caused the sound. Semantic listening is used when understanding auditory codes such as speech or Morse code. Reduced listening is less common. This third listening mode is used when listening to qualities of a sound without considering its source. Thus, reduced listening is involved when appreciating music by listening to pitches, harmonies and rhythms.

Tim's Journey aims to incorporate all three listening modes: casual listening when the player recognises the presence of objects, semantic listening when interpreting sonic codes, and reduced listening when enjoying purely ornamental sounds.

Chion suggests that it is possible to listen to sound sequences using more than one listening mode simultaneously [4]. This is central to Tim's Journey, since sounds are frequently included to encourage more than one way of listening, such as when hiding codes in the sound of water dripping, or adding ornamental objects that can function as navigational aids. Attempting to fulfil certain aesthetic or functional intentions, we often find it useful to "cartoonise" authentic sounds to different extents, depending on the context. When no authentic sound can be found that accompanies the desired event or object, sounds can be based on metaphors or invented from scratch [8].

Moving freely between the listening modes, mixing authentic, iconic and absolute sounds, we envision a triangular sonic "vocabulary," based on a system by cartoon and comic scholar Scott McCloud [10] (see Figure 2). McCloud's semiotic model describes the visual vocabulary available to cartoonists and is clearly indebted to Peirce's theories of icons, symbols and indices [13].

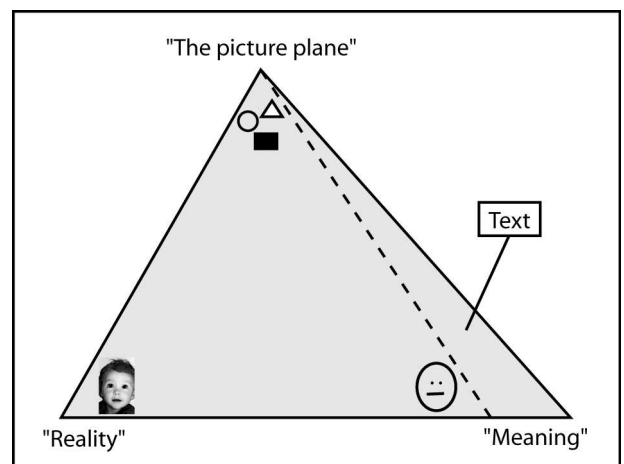


Figure 2: McCloud's triangular vocabulary of visual cartoons [10]. The hatched line indicates the border between images and written text. (Graphics by SITREC)

By replacing the three vertices of McCloud's triangle with Chion's three listening modes, we obtain a model of the sonic vocabulary available to sound designers. Thus, a system

originally designed to categorise different ways of drawing comics, helps us visualise the flexibility of the ways in which sounds can be "cartoonised." With the three listening modes as vertices, this system covers musical sounds, authentic sounds, cartoonised sounds, and speech (see Figure 3). This is also suggested by McCloud [10], although referring to written text.

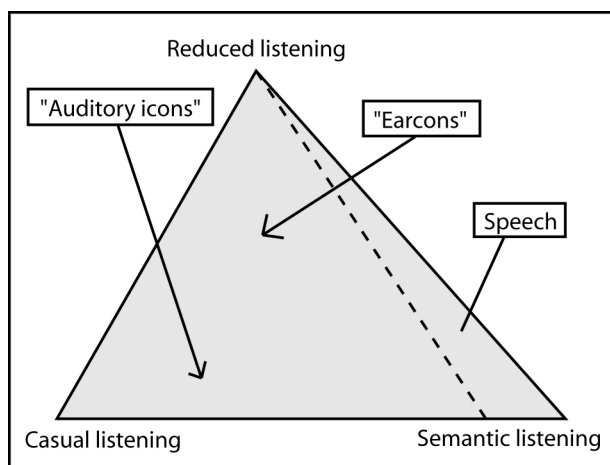


Figure 3: Triangular sonic vocabulary, indicating the fields of musical, authentic and cartoonised sounds, including speech. (Authors' modification, after McCloud [10])

This view upon the three listening modes helps us illustrate several design issues faced when developing sounds for Tim's Journey. Depending on what sound materials are available and how functionality or aesthetics are emphasised, we keep within certain "fields" of the triangle, sometimes aiming for "natural-sounding" environments, at other times for more "cartoonised" or abstract soundscapes. Generally, casual listening is emphasised regarding individual sound objects, while on a larger scale, sounds are combined and sequenced in a way that is intended to encourage reduced listening.

As all sounds are triggered one or several times in a loop, it is possible to create different levels of realism or "cartoon" effects in the resulting rhythmical patterns. This means more freedom for the game developers to load the soundscape with information on different layers.

4.1.1 Layered information

Visual art relies on subjective interpretations, and uses and exploits conventions to create situations that challenge the beholder. The lack of established conventions for auditory display makes it necessary for us to find other ways to maintain a multi-faceted and open-ended game play experience.

In mainstream games, the graphical representations provide the player with complex information, while the audio information is simplified and reduced to very few sources. This simplification of audio content trivialises the information by reducing the possibilities for the player to make subjective interpretations. Neither does the simplification make use of the large potential of sound as a provider of interactive content.

Besides the fact that a context can add new meanings

to an object or expand the interpretation possibilities, game developers have the possibility to include several layers of information in some sounds, when intending to enhance complexity. The sound objects of Tim's Journey often carry different layers of information in addition to their primary functional aspects. This meta-level information is subjective and not always based on previously established agreements with the player, as functional information generally is. For example, the functional information in the sound of a machine can, apart from displaying the presence of the machine, reveal its level of activity, its constitution and its locality. Additionally, the machine can also be dangerous, malfunctioning or in other ways important for the game, and its sound can reflect this on a meta-level. These layers of information can be conveyed by adjustments either to the sound itself, to its rhythmical pattern over time, or by a combination of both. Layered information is highly context dependent, however we find it indispensable when trying to provide the player with a high level of freedom, and also to maintain our artistic ambitions.

4.2 The spatialised soundtrack

The sound objects of an audio game are always heard in a context. Firstly, there is the context of the game plot, where the individual sounds should be intelligible and distinguishable. Secondly, there is a musical context where each sound object is accompanied by the other sounds of the game. The later context is seldom emphasised in game audio design, especially not in games accessible to visually impaired players. However, in Tim's Journey, the way in which sound objects interact rhythmically is a key feature that affects the entire game design.

In addition to making the game clear and playable, we intend navigation in itself to be a fun, open-ended part of the gameplay. Exploration of the spatialised soundtrack is meant to be a central aspect of the game and the player should be able to influence the game music by making the avatar move around, triggering new sounds and rhythmical patterns, picking up and moving sound objects.

There are several possible ways to represent the presence of objects in a game using auditory display [25]. One option is to make the objects emit continuous sounds, so that the player can hear all things present at any given moment. However, listening to several parallel audio signals simultaneously can be confusing. Authentic object sounds tend to quite brief, and looping a convincing sound into a constant signal can thoroughly reduce its level of realism. A more lifelike approach is to associate the emission of short object sounds with some form of impact. However this is unsatisfactory for most types of audio games, since it does not easily provide the player with an overview of the game space.

Tim's Journey uses an approach between the two strategies above. In this game, static objects are mainly associated with brief sounds that are triggered in rhythmical patterns in recurring loops. All sounds that are positioned in the game space become virtual objects, since the avatar can approach or pass them. Still, as very few sounds can actually be interacted with or bumped into it is essential to find ways to make the important sounds stand out from the others.

This approach generates a quite slow game pace, since the player has to explore the game environments gradually, listening to several loops of the soundtrack to get an overview

of the situation. It also requires a stable and repetitive soundtrack to enable the player to obtain an overview.

4.3 Auditory interfaces

All interface design is about establishing agreements between the designer and the user. This process gets easier over time, as conventions develop and several different applications begin to use similar interfaces. Today most sighted people can interpret numerous pictograms, symbols and icons in computer applications. Usually, this communication occurs so effortlessly that we do not think about the underlying conventions and agreements that the simplified images are based on. However, when it comes to auditory interfaces, there is a great lack of such conventions. For designers of non-speech, auditory interfaces, there is only a very small auditory iconography to draw material from, such as telephone signals, alarms and fanfares. Therefore, many auditory interfaces have to be invented from scratch.

Because of the fundamental differences between vision and hearing, no elements of visual computer interfaces can be instantly translated into audio adaptations without major changes to their features. Even in simple structures, such as the menus of the TiM games, the visual and auditory counterparts function quite differently. For sighted users, it is possible to overview entire menus, while visually impaired users only can "focus" on one menu item at a time. It is difficult to communicate how long the list of items is in an auditory menu. Essentially, the auditory menus of the TiM games correspond more closely to visual menus where the menu items only are revealed very briefly, one at a time, when the player moves the pointer, or "focus," one step.

Many visual interfaces are based on a "button" analogy, where a clickable surface is designed to look like a button. The convention is that clicking on a virtual button causes an event, such as switching something on or off, or moving into a sub-menu.

The "button" analogy of visual interfaces is based on a spatial metaphor, which relies on the possibility to move a pointer with a mouse over a two-dimensional surface. The auditory interfaces of the menus in the TiM games, including the main interface of X-Tune, are non-spatial. Still, by using the arrow keys to navigate through lists of menu items, players might envision some type of spatial representation of the menu layout.

4.4 Rethinking game audio

The TiM games demonstrate several ways in which sound content and auditory interfaces can be designed. Still, there is a large, unexplored potential for development in this area and there are several reasons for creators of computer entertainment to consider the possibilities offered by an extensive use of audio content [24].

Firstly, sound offers a spatial freedom, as it is not limited to the realm of a computer display. In sound-based games, the game space can cover entire rooms and even larger spaces without depending on very expensive equipment. The players of sound based games can be encouraged to move around, as the omni-directional aspects of sound frees them from the situation of sitting down, facing a screen. Using headphones and a portable game controller, the hardware devices for audio games can be extremely small, without any display.

Secondly, the spatial flexibility of sound opens up the possibility to develop new input interfaces to computer

games that encourage movement. This development has already started with the commercialisation of pressure sensitive dance mats for rhythm action games such as *Dance Dance Revolution* [9] and camera-based motion sensors such as *Sony Eye Toy* [21].

Furthermore, audio games can offer other ergonomic advantages compared to mainstream games, such as relieving the eyes when playing computer games.

SITREC will explore these areas thoroughly and has in 2004 submitted an application to the European Commission to enable further research of sound and toy related issues.

Since sound is a less explored medium than graphics in computer game contexts, we believe that it has a great potential as source of new game content. With sounds, suggestive narratives can be developed that evoke vivid "inner vision" experiences for the listener.

The soundtracks of mainstream computer games are today often generative compositions, positioned in the centre of the game space. This creates an advanced auditory backdrop, which is complemented with a few avatar and character sounds and occasional objects sounds, positioned individually in the game space. In most games, casual listening is thus clearly separated from reduced listening. We believe that a sound design approach similar to that of Tim's Journey could enhance the use of audio in mainstream games, by closely integrating sound with the gameplay and providing multi-faceted soundscapes that rely on more than one listening mode.

Audio games for visually impaired players could benefit from and increased concern for aesthetics. Today, most audio games are very oriented towards functionality, and mainly encourage players to understand the game space by using casual listening and semantic listening. By bringing reduced listening into these games, it is possible to create more immersive and open-ended gaming experiences.

5. CONCLUSIONS

With the three TiM games *Mudsplat*, *X-Tune* and *Tim's Journey*, SITREC aims to demonstrate that there are many uses of game audio yet to be explored. Whereas recent developments in mainstream music games and games for visually impaired players involve creative uses of sound, the medium is still not used to its full potential. SITREC believes that a constructive approach is to merge the functionalistic design approach of sound-based games with the more ornamental sound design of mainstream games.

The TiM games are in various states of progress, with *Mudsplat* being closest to completion. Testing situations with visually impaired children in the Sweden, United Kingdom and France show, apart from a large interest from the children, that the design solutions are functional. The games confirm that visually impaired children can handle complex interfaces.

The TiM project intends to demonstrate that sound-based games do not have to be developed only for players with visual impairments. When developing audio for any kind of interactive application, we think that the triangular vocabulary of sound design, based on Chion's [4] and McCloud's [10] theories, can be a useful model. This system can help designers of auditory interfaces overview the various types of information that sound objects can convey. By targeting more than one listening mode, sounds can carry several layers of information, resulting in a more multi-faceted and

appealing game audio content.

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