Finger Dance: A sound game for blind people

Daniel Miller
Computer & Information Science Dept.
University of Oregon
Eugene, OR 97403
dmillerh@gmail.com

Aaron Parecki
Computer & Information Science Dept.
University of Oregon
Eugene, OR 97403
aaron@parecki.com

Sarah A. Douglas
Computer & Information Science Dept.
University of Oregon
Eugene, OR 97403
1-541-346-3974
douglas@cs.uoregon.edu

ABSTRACT
The usual approach to developing video games for people with visual impairment is sensory substitution. Elements of the visual display are replaced with auditory and/or haptic displays. Our approach differs. The purpose of the Finger Dance project is to research and develop accessible solutions to games that are inherently audio: musical rhythm-action games such as *Dance Dance Revolution*. However, these games still rely on visual cues that instruct the user on how to play along with musical rhythms. *Finger Dance* is an original audio-based rhythm-action game we developed specifically for visually impaired people. Working with both blind and sighted gamers using a human-centered development approach, players are able to play the game on their own and are enthusiastic about it. This paper discusses the game's design, development process and user studies.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]: User Interfaces – *Auditory feedback, Interaction styles*; K.8.0 [Computing Milieux]: Personal Computing – *Games*

General Terms
Design, Experimentation, Human Factors

Keywords
Accessibility, visual disabilities, audio games.

1. INTRODUCTION
During the past two decades, video games have boomed into a multi-billion dollar industry. This growth has led to the use of new and diverse technologies that allow gamers richer experiences than ever before. However, much of this growth revolves around the use and development of powerful graphical engines that can support three-dimensional worlds and visually immersive games.

This trend has made it very difficult for video game developers to find accessible solutions to their products for gamers with visual disabilities [2]. In fact, while a few developers are finding incentives to include accessibility features in their games, the extreme competition and market demand they face during their development cycle causes most to believe that these features would be too costly [6]. This leaves visually impaired gamers with little to satisfy their appetite for social, recreational or educational computer games.

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The usual approach to developing games for people with visual impairment is sensory substitution. Elements of the visual display are replaced with auditory and/or haptic displays. (See Archambault [1] for a development environment.) For example, Sánchez et al. [5] developed a collaborative version of the traditional visual game *Battleship* substituting audio for visual cues. Audio cues are usually spatially distributed 3D sound sources that are iconic (earconic) representations of objects.

Our approach differs. The purpose of the *Finger Dance* project is to research and develop accessible solutions to games that are inherently audio: musical rhythm-action games. We believe that these types of games can provide a rich source of enjoyment to persons otherwise excluded from video gaming.

Rhythm-action games are often characterized as games that have users make rhythmic inputs to the computer based on the beat of a song, using an input device such as a keyboard or game pad. Games such as *Dance Dance Revolution*, *Guitar Hero*, and *PaRappa the Rapper* are very popular in the video game market. However, they still rely heavily on visual cues that tell the player when and how to press a series of input patterns.

Finger Dance is an original audio-based rhythm-action game we developed specifically for visually impaired people. In the following sections we will describe *Finger Dance*, its development and user studies.

2. FINGER DANCE
In *Finger Dance* players listen to music, and match the rhythm with keystroke patterns in response to unexpected auditory cues. We also developed an audio-based menu, a scoring system, and a testing environment to study different types of auditory cues.

2.1 The Game
Drum rolls using MIDI percussive sounds define the cues. These drum rolls start playing one beat, half a beat, or a quarter of a beat before the player must make a keystroke. The drum roll will stop on the beat in which the player must make the keystroke.

Figure 1 shows two partial musical measures in 4/4 time. The player is required to make one keystroke on the first beat of the measure, after being given a lead-in of four sixteenth notes starting on the fourth beat of the previous measure. The grey notes represent the drum roll that acts as the cue for the player. In this example, the drum roll starts playing one beat before the time when the user must make a keystroke.

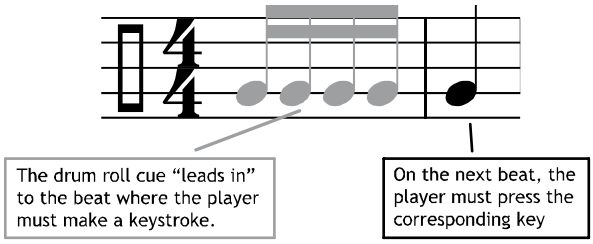

Figure 1. Matching rhythm

Depending on the pitch of the cue sound and the speaker that it originates from, the user must press one of the four keys:

- High pitched drum roll, left speaker, 'Q' key.
- Low pitched drum roll, left speaker, 'A' key.
- High pitched drum roll, right speaker, 'W' key.
- Low pitched drum roll, right speaker, 'S' key.

Each time the user makes a keystroke in rhythm with the music, a "clap" sound plays as the key is hit. If the player hits a wrong key or is out of rhythm with the music, an error sound plays. Correct keystrokes score points for the player. Incorrect keystrokes detract from their score. The goal of the game is a perfect score.

2.2 Menu System

The menu system allows the player to listen to a brief description of the game and the instructions, and to start the game. The player uses the left and right arrow keys to browse menu options and the enter key for selection. The menus were created to be fast to use and easy to understand. The design of the navigation scheme is based on other popular audio games, a guidelines document for accessible game development, and the ideas of several papers regarding accessible game development [3, 4]. To convey information to the user, the menu options are described using a synthesized voice developed by Cepstral LLC. These voices allow for more natural pronunciation of typed text than traditional text-to-speech voices, such as Microsoft Sam. This menu system was designed to easily accommodate changes to the menu structure which is a linked list of associated sound files.

2.3 Scoring & Data Collection

The data collection tools developed for the Finger Dance project analyze the effectiveness of different play styles and report scoring information to the user when they finish the game level. When a user presses a key, the game records whether the key was pressed in the proper time interval and whether or not it was the correct key. It also records the actual keystroke time. Using this data, the analyzer can detect if users are more likely to make a keystroke earlier or later than the actual beat. This information is used to study the effectiveness of different game and cue styles.

3. USER STUDIES

Finger Dance was developed as a project for a computer science class using human-centered development with a focus on our blind gaming users. It is implemented in Java JDK 5.0. Early in the project we discovered the International Game Developers Association (IGDA) Accessibility SIG www.igda.org/accessibility and through discussion boards on forum.audiogames.net and www.game-accessibility.com we talked with blind gamers about what they wanted in games.

Usability tests were conducted on a prototype of the software. Three sighted participants were videotaped using the menu system and playing the game. These tests showed the game's learning curve similar to other rhythm-action video games. Many problems were discovered. The game was too difficult for some and the menu voice was hard to understand. Users quickly grasped the navigation and appreciated the use of sound effects that offered feedback regarding their keystrokes. Overall, participants found the game fun to play and challenging enough for repeated use.

We built a second prototype with better presentation of cues and an improved synthesized voice. Instead of percussive sounds we used synthesized waveforms. We also made the cue time constant rather than variable. We made both downloadable prototypes available from our website. We announced availability on forum.audiogames.net. We requested that anyone playing the game answer seven questions about ease of learning and usability of instructions, menu and game, and whether they thought the game was fun. Finally, we asked about improvements.

We have received responses from three blind gamers. They all really liked the games and the concept. They found the menu navigation and instructions very easy. As we expected they preferred the sounds on the first prototype, but found it much harder to play. They found the second prototype too easy. They have also made many helpful suggestions about the types of sound cues and how to make other versions of this type of game.

4. FUTURE DEVELOPMENT

With these gradual improvements driven by our focus on users we have developed two very fun and playable rhythm-action games. Future development suggests that we add levels of play, different sound cues and several new varieties of this game type.

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