ABSTRACT

Rhythm based music games such as Guitar Hero are hugely popular and allow gamers to take on the role of a famous musician. To play such games you must press keys on virtual guitars in various combinations in time with the music. Gamers with severe physical disabilities cannot always use traditional input devices so alternative methods of input are required to play such games. Eye-gaze is a high bandwidth modality that can support this if suitable interaction techniques exist. By analysing actual gameplay a suitable eye-gaze interaction technique is designed for a Guitar Hero style game. We present results from a user study demonstrating that users are able to score higher with the gaze technique than using a keyboard for game input, albeit at the cost of gameplay. The experiment concludes with a case study in which a young person with physical disabilities is able to successfully play the game using only eye movements.

Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces; Input Devices and Strategies

Keywords

eye tracking, eye gaze, gaze control, gaze gaming, disability

1. INTRODUCTION

1.1 Rhythm Based Music Games

Rhythm based or beat matching music games have become increasingly popular with the range of available game types available; from the early days of Simon in 1978, to Dance Dance Revolution in 1998, and Guitar Hero in 2005. Whether you are dancing, DJing, drumming or playing the guitar the challenge is to press, hit, strum, slide on buttons at the correct time. Players are presented on screen with the next button presses required and they are scored on their accuracy on matching their selection with the beat of the music. Many other modern game genres require far more complex play methods and control combinations in order to give the player the necessary sense of enjoyment and immersion. The simplistic and natural interaction required for rhythm based games allows the genre to rely less on complex interactivity and gameplay and more on engagement of the player.

1.2 Why Eye Gaze?

Eye movements are both fast as an input device and are natural as a means of pointing when compared to other input devices. Users will typically look at the area of the screen where they wish to move to before they physically operate a mouse. Eye gaze is also intuitive, easy and fun to use with virtually no training required. Using eye-gaze as an additional input device to mouse and keyboard has the potential to add new levels of gaming immersion. It can be used in a direct input and control manner (e.g. controlling the gun sight in a First Person Shooter) or by using a more passive attentive approach (e.g. making Non Player Characters aware of where you are looking and having them respond accordingly). Eye-gaze can also be used as a single computer input device by people with severe physical disabilities such as cerebral palsy, muscular dystrophy and ALS. These users cannot always operate a standard mouse or keyboard; however, many retain good control over their eyes. The high bandwidth offered by eye-gaze means that many game tasks can be performed if a suitable gaze interaction technique exists. In this paper, we present an eye-gaze interaction technique that is developed through actual gameplay task analysis and evaluated through a user study.

2. RELATED WORK

2.1 Eye Gaze as an Input Device

There have been several investigations into using eye-gaze as an additional input device for gaming but few that examine using eye gaze on its own. Isokoski et al. [3] used a First Person Shooter game in order to assess the performance of eye gaze as an extra input modality to mouse and keyboard. Their findings showed that using eye-gaze for aiming will not always improve the performance of the players but that gaze was an entertaining and immersive method of input. The same benefit of eye-gaze for increasing a player’s sense of immersion was also reported by Smith and Graham [7] and Jönsson [6] who both performed similar studies.

There have been implementations of gaze based paddle style games in which, the paddle follows the gaze position of
the user. In these type of games there has been much success with gaze. In Dorr et al. [2] study, they had gaze players winning two-thirds of the time when competing against mouse players.

Our previous work has focused on enabling young people with physical disabilities to access MMOG’s (Massively Multiplayer Online Games) through the use of eye gaze only. Games such as World of Warcraft and Second Life consist of a large range of tasks that require different interaction techniques and often need to be performed in real-time [1]. We designed several novel eye-gaze interaction techniques that allow a basic level of gameplay to take place in these games [5]. Additionally, we developed a method of switching between the different interaction techniques quickly by the user performing simple off-screen gestures [4].

3. ANALYSIS OF ACTUAL GAMEPLAY

To help develop a suitable eye-gaze interaction technique for a rhythm based music game we performed a task analysis using the open source rhythm based Guitar Hero clone: Frets on Fire. Although, this genre of game is designed to be played with a virtual guitar, gamers have made novel use of an ordinary computer keyboard to replicate the standard virtual guitar interaction technique. This is accomplished by turning the keyboard on its side and holding it like a guitar. The left hand uses the first five Function keys as the fret buttons and the right hand uses Space bar to strum the notes. The following data was collected simultaneously:

- Eye gaze position
- Think-aloud and retrospective think-aloud protocols
- Video capture of the game window
- Logging of low level event data

3.1 Participants and Apparatus

Five male computer science students from within the university were recruited for the study. On this occasion we wanted to examine novice and expert gameplay therefore, two were experts in the game and three were either novices or beginners to the game.

3.2 Results from Task Analysis

Within the actual task of playing the song, two sub-tasks exist: select note and strum note. Note selection, takes place by pressing either single Function keys or two Function keys in parallel. Strumming the note, involves an additional input event (Space Bar) in tandem to the Function keys. Upon analysis of the eye-gaze data several AOI’s (Areas Of Interest) immediately became apparent. Figure 1, show gaze heat maps from one of the expert and novice participants highlighting where the AOI’s lay. This method of gaze data visualization is created by showing all of the participant’s eye fixations and showing where they are most and least concentrated (red being high concentration of fixations; yellow being low concentration) relative to frequency and time. The AOI’s can be seen as a series of channels, with each channel represented by the path that each note takes as it falls down the screen. The expert (and higher scoring) players had greater fixation concentrations higher up on the channel than the novice/beginner users. This suggests that the expert players were thinking further ahead than the novice players, similar to expert chess players who think several moves ahead. There were also many similarities between all participants when examining the gaze scan paths. During times when few notes were appearing on screen, participants followed the notes partly down the screen with smooth pursuit like eye movements before performing a saccade (the fast eye movements performed between fixations) to the next note, which can assumed to have been established with the individual’s parafoveal and peripheral vision. When many notes appeared on screen, participants did not have the time to smooth pursuit each note thus resulting in a short fixation on the current note and then a saccadic jump to the next note. The areas to the left and right sides of the play area received no user attention; as did the area below the note strum point, and at the base of each note.

4. DEVELOPING EYE GAZE ONLY INTERACTION TECHNIQUES

The lack of complexity found in rhythm based music video games is an ideal characteristic for an eye-gaze controlled game, as it allows the interface to be significantly simpler than needed to support gaze only play with other game genres. However, the deliberate use of gaze to invoke commands should divert the user’s visual attention as little as possible from where they would look during game play. The data collected in the previous section helps to guide the design process of an appropriate gaze only interaction techniques.

Several candidate techniques were developed but the one chosen for evaluation worked as follows. The user gazes at the notes as they travel down screen. An onscreen paddle graphic moves below the note strum point in relation to the users gaze position and how far down the fretboard they are looking. The fretboard ‘highway’ shows notes coming from a distance along a 3D virtual road, creating a triangular shape. Therefore, the paddles horizontal movement is non-linear as it moves with the gaze position following the notes. The user is notified of the current note selection by the colour of a large on-screen bar that appears above the play area. The note is strummed automatically as it passes the strum bar.

4.1 Implementation of EyeGuitar

Snap Clutch [4] is a framework that acts as middleware and runs independently of the eye tracker and the target game. It works by taking the user’s gaze position and processing the data to detect fixations, saccades and gestures [5] before using them to activate combinations of key and mouse
events as needed by the game. This works well if the target game takes input messages from the Windows message queue but some games do not such as, those that make use of Microsoft’s DirectInput. As Frets Of Fire uses DirectInput, we had to test our implementation with an alternative rhythm based guitar game: Strings on Speed. Selection of notes simply required the necessary key-down and key-up events to take place as and when the note selections were detected using the eye-gaze data. In order to perform the strum action we used pixel color recognition to determine when the note reaches the strum line. When this occurs, then the necessary key-down event is sent to the game (under the condition that the correct note has been selected). Figure 2 shows how the implementation appears within Strings on Speed. Three Snap Clutch indicators and controls are visible: the top note selection indicator; the bottom note selection indicator; and the paddle bar.

5. AN EXPERIMENT TO EVALUATE THE GAZE INTERACTION TECHNIQUE

There are several limitations with the gaze interaction technique. Firstly, it does not allow for multiple notes to be selected at a time and secondly, when notes are very close together the pixel detection and automatic strum is unable to operate in time. Therefore, we chose two songs that only required one note to be played at a time and which, had a minimal number of consecutive notes close together.

5.1 Comparing The Gaze Interaction Technique with Keyboard

5.1.1 Participants and Apparatus

Ten participants were recruited from within the university; nine were male and one was female. The average age of the participants was 27 and all were able-bodied. The participants had varying levels of experience in playing a guitar simulator game using the virtual guitar input method. Only one participant had experience with Frets on Fire. None had previously played Strings on Speed. We used a Tobii X120 eye tracker mounted below a 19” monitor of which, participants sat approximately 600mm away, see Figure 2. Two participants were experienced users of gaze interaction; four had some experience and the remainder had never used an eye tracker.

5.1.2 Procedure

Before the start of the trial, each participant was told that they would be playing a song twice within a genre similar to Guitar Hero using two different input methods; keyboard or eye tracker. An explanation of how the game functioned and how the two input methods worked was briefly shown. After eye tracker calibration each participant was given two minutes to practice each method before the experiment began. The order of which method was used alternated between each user to even out any improvement made by learning the song.

5.1.3 Results and Discussion

To measure performance of the interaction techniques we used the Strings on Speed’s own scoring system. That is, total score which is based upon the current note streak (the current number of successful notes hit consecutively) and the length of each note. The results collected are summarised in Figure 3. Only one participant scored higher when using the keyboard method over the eye-gaze method. This participant was very experienced with this genre of games and so found it very easy using the keyboard. The other 90% of the participants scored higher using the eye-gaze method (eye-gaze \( t = 13,789 \)) than they did when using the keyboard method (keyboard \( t = 9,772 \)). Willcoxon’s Matched Pairs Signed Ranks Test shows the difference in scores to be significant (\( p < 0.014 \)). Participants 1 and 3 were the experienced gaze interaction users and thus scored very highly when using the eye-gaze method. All participants found the eye-gaze method fun and intuitive, with the majority being able to hit notes successfully, early during the practice session. One participant explained that because you have to control the paddle along the bottom of the screen it felt like you were playing two games in one (Pong or Breakout and Strings on Speed). Another participant suggested that he slipped into a ‘trance’ when playing the game, and that it was during this time that he was able to score higher points. Although, this can suggest that the level of skill required to play the game using the eye-gaze method was lacking. However, the purpose of this research was to develop a gaze only interaction technique that allows a user to play the game using only their eyes. The eye-gaze method that we designed takes away one of the fundamental skill requirements that this genre of game is designed to test; rhythm. The keyboard method requires users to press the strum key at exactly the right moment in time with the music and this is something that several of the participants struggled with. An initial version of the interaction technique did incorporate the necessity to select notes at the correct time to some extent. However, this method was far too tiring and difficult to perform and demonstrated that there is a careful balance requirement between complexity, fatigue, and automation. The interaction technique used in the study is far less tiring and much easier to perform but comes at a cost of the technique being more automated. Increasing the levels in automation of the gaze interaction technique reduces the levels of gameplay, and perhaps potential enjoyment.

5.2 Preliminary Case Study

5.2.1 Procedure

Figure 2: User study setup with screenshot of the paddle interaction technique in EyeGuitar being used to play Strings on Speed.
This preliminary case study involved a male aged 17 with severe physical disabilities. Although he is unable to use a mouse, keyboard or joystick he is extremely independent and is able to use a head switch very effectively to control his wheelchair. He uses a respirator to aid breathing but has excellent verbal communication skills. He is also a very keen gamer and uses a head tracker and his head switch to play simple computer games.

### 5.2.2 Results and Discussion

The purpose of performing this preliminary study was so that we could get a good idea on how usable the gaze interaction technique is by a person with severe physical disabilities. The main body of the study allowed us to quickly assess and develop techniques using able bodied participants. This is an important step as it will provide us with some confidence that the techniques do have potential. However, the purpose of gaze only interaction is to allow disabled gamers gain access to such games. Therefore, verification on a case study basis is the preferred next step.

This user’s particular condition and respirator means that his head is tilted quite far back into the wheelchair. This required the user to tilt his chair forward slightly so that the eye tracker was able to get a good view of his eye. This is an issue with the experimental setup and the positioning of the eye tracker rather than with the user. However, it did have an effect on the eye tracker calibration procedure. After an acceptable calibration was achieved the user played the game for several minutes experimenting with the different songs. The user did struggle to get used to the technique and he commented on how he was distracted by the paddle moving along the bottom of the screen. This distraction problem meant that he was scoring poorly to begin with, with most of the notes being missed. However, this improved and the distraction of the paddle became less a problem and he was able to achieve more than 50% Hit Percentage. Although, Strings on Speed is a guitar based music game he commented that it did not feel like he was playing or pretending to play the guitar. He suggested that it was playing with your eyes and not like playing any musical instrument at all. However, he did enjoy the game and believed that the interaction technique worked well although, being able to turn the paddle off may improve the learning process.

### 6. CONCLUSIONS

In this paper, we have presented an eye-gaze interaction technique that was developed through actual gameplay task analysis. We have been able to demonstrate that it is feasible to use eye-gaze as a single input device for playing Guitar Hero style games. In comparison with the keyboard method of play we noted a significant difference in performance when using our proposed eye-gaze method. However, there is a careful balance requirement between automation of the gaze interaction technique and retaining elements of the gameplay. By taking away the element of rhythm from the game task a part of the gameplay was also removed. The purpose though, was to develop a method that would allow young people with severe physical disabilities play music based games such as Guitar Hero. The individual case study showed that this was possible although there is still some work to be done on improving the interaction technique.

Our future work will look at ways of adapting the gaze interaction technique for an individual user and for lower quality eye trackers. The current method assumes a good calibration and a highly accurate eye tracker but these two elements are not always found together. However, the greatest challenge is being able to retain the gameplay whilst keeping the interaction technique simple. All participants enjoyed using the eye-gaze method and although it wasn’t anything like playing a guitar simulator it was certainly a fun way of playing music.

### 7. REFERENCES