Scratch-Off: A gesture based mobile music game with tactile feedback

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Abstract

This paper presents "Scratch-Off", a new musical multiplayer DJ game that has been designed for a mobile phone. We describe how the game is used as a test platform for experimenting with various types of multimodal feedback. The game uses movement gestures made by the players to scratch a record and control cross-fades between tracks, with the objective of the game to make the correct scratch at the correct time in relation to the music. Gestures are detected using the devices built-in tri-axis accelerometer and multi-touch screen display. The players receive visual, audio and various types of vibrotactile feedback to help them make the correct scratch on the beat of the music track. We also discuss the results of a pilot study using this interface.

Keywords: Mobile devices, gesture, audio games.

1. Introduction

Mobile phones now perform an elementary role in many people's lives. Their function has transformed rapidly over the last decade, moving from simply a means of mobile communication, through camera phone and mp3 player, to their current status as a device that can browse the web, give us directions using GPS, play video and even act as a musical instrument. In particular the last year has shown an explosion of such applications for the iPhone platform, many of which have their origins in academia, like Smule's Ocarina (Stanford, Princeton), RjDj (UPF Barcelona) or Zoozloop (GaTech). Methods of interacting with mobile devices have also greatly improved, with many new devices featuring sensors such as accelerometers (that can be used to detect the orientation of the device) or multi-touch screens (that can be used to detect a stylus or user's finger).

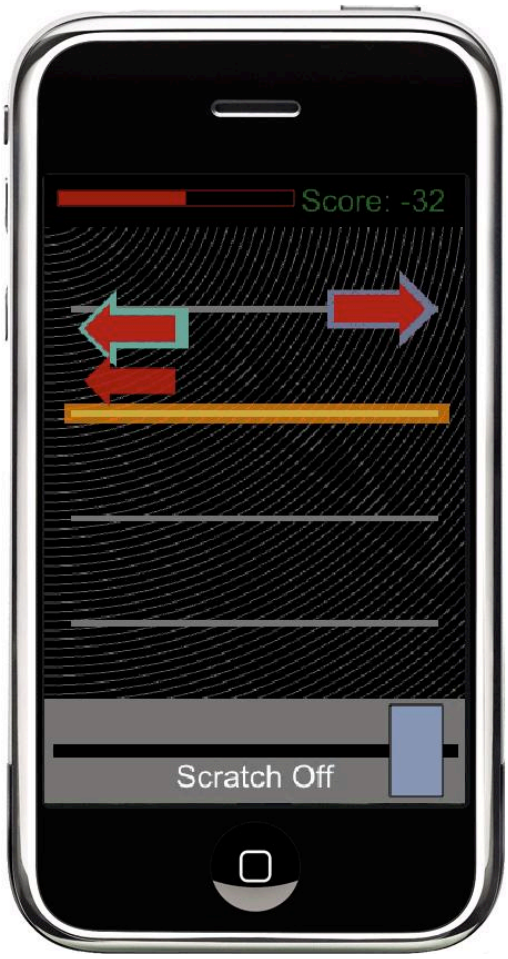

Figure 1 Scratch-Off Game in Action

New paradigms for interacting with mobile devices have evolved with these new sensors, such as the user tilting to scroll through a document [1], shaking the device to check its current status [2], or using rhythmic tapping to select songs from a media library [3]. These new interaction paradigms can also be used effectively for mobile games, adding an extra skill factor for the user to learn and master, possibly making the games more engaging and fun to play. In this paper we present a new mobile musical multiplayer DJ game called "Scratch-Off that uses these new interaction paradigms.

We have created Scratch-Off to use as a platform for experimenting with the impact of tactile and multi-modal displays in mobile gesture-based interactions. The final objective of this research is to create new methods of communicating information to a mobile user using non-visual modalities, allowing the mobile user to interact with the device without having to look at the screen all the time.

2. Related Work

This game is certainly inspired by previous music games like Dance Dance Revolution, or Guitar Hero, were dancing or playing to an existing score and scoring per match is the main gaming idea. It also is related to the iPhone app MixMaster Scratch which offers a virtual turntable scratching solution. ShaMus [4] and MoGMI [5] also offered gesture-based interactive music making. Non-mobile turntable interfaces have long been a subject of interest. A force-feedback turntable interface called video-drum was introduced for video editing [7] and for generic turntable interactions [13]. Lippit discusses combined software and hardware solutions to replace the traditional turntable interface [12]. Various optically based turntable interfaces have been proposed [9,10,11]. HDDJ converted old hard drives into physical turntables [14]. The possibility of beneficial performance results from haptic feedback was shown in O'Modhrain's thesis [8].

3. Design Considerations

Scratch-Off replaces but leans on the traditional turn-table interaction paradigm. It retains familiar gestures for scratching and cross-fading between the two audio tracks. Strategies for interfacing with more common placed DJ devices are quite intuitive and are not a simple one-to-one mapping. Instead, one hand controls the playback speed of the record by pushing and dragging it with fast and short movements, whilst the other hand is used to control the sound level that is sent to the speakers [6]. This is reflected in Scratch-Off by the two different methods of interacting with the game, using the flick or pinch gestures.

4. Game Description

Scratch-Off is an interactive music game in which players have to make "scratching" gestures like a DJ in order to earn points. The player who performs the most correct gestures by the end of the track will win the game. The game instructs each player to make a series of rhythmic gestures. Each series of gestures is built from two basic left or right "flick of the wrist" type gestures (see Figure 2), which the player must then perform in time with the music track the player is scratching along with. For example the player may be asked to perform a LEFT-LEFT-RIGHT gesture with the first LEFT gesture starting on beat 1 of the bar and the RIGHT gesture falling on beat 2 of the bar. The player can also use a finger to move an on screen cross fader that adjusts the mix of the scratch track and the main music track.

The game will indicate to the player which type of gesture they next have to make via the devices display, with the next four beats of music visible. The display will scroll in time with the music as the track is played, enabling the player to visually see the beat of the track and indicating which type of gesture they need to perform.

Four types of feedback are presented to the player to enable them to make the correct gesture on the correct beat: visual feedback, two types of vibrotactile feedback and audio feedback. The visual feedback is presented as four lines on the screen that represent the next four beats of music, with the current beat of the bar highlighted yellow. The cue for the player to make a gesture is presented as one of two types of arrows. A red arrow pointing to the left or right represents the flick-lift or flick-right scratch gesture. A gesture cue will move from the bottom to the top of the screen with the player having to make the gesture at the indicated bar line.

If the player successfully performs the correct gesture within a gesture time window, the arrow will be highlighted purple indicating a scored point. If however the player makes the wrong gesture or misses the gesture completely, the arrow will be highlighted blue, indicating a lost point.

Two different types of vibrotactile feedback are presented to the player at different times within the game. The first type of feedback involves a tactile pulse being triggered on the first beat of every bar, helping the player determine the speed of the music track they are scratching along with. The second type of tactile feedback indicates to the player which type of flick gesture they need to make, with a short tactile pulse indicating left and a longer pulse indicating right. The player then has to count two bars of music in their head from receiving this pulse and then make that indicated gesture. This second type of tactile feedback allows the player to depend less on looking at the screen for the arrow gesture information, a task which is difficult due to a mobile devices small screen and which is exacerbated by the movement of the player's hand in order for them to perform the scratch gestures.

Figure 2 Flick Gesture

The player also receives audio feedback in two forms, the first being the music from the track the player is trying to scratch to and the second is the scratch sound created when a gesture is detected. The scratch audio track is rendered in real-time, creating a different sound based on the type of gesture made by the player. If the player is able to scratch on the beat (i.e. if the are able to make the correct gesture at the correct time) then they will hear a sound indicating that the outcome is 'good' and will score points. However, if the player either makes the correct gesture at the wrong time or the wrong gesture at the right time then they will hear a 'bad' indicator and will loose points. The player with the most points at the end of the track wins the game.

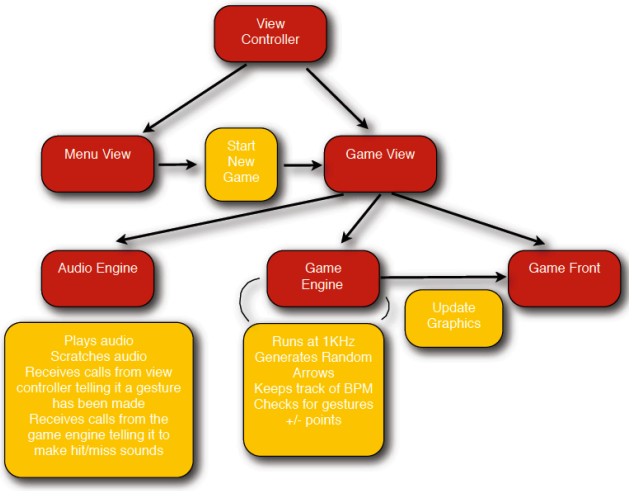

Figure 3 Game Architecture

5. Technical Details

"Scratch-Off" was originally prototyped for Nokia N95 phones in C++ and Apple iPhones using a combination of Objective C and C++. Both phones feature a tri-axis accelerometer, which detects acceleration and earth's acceleration due to gravity, with the iPhone also featuring a multi-touch screen. Both models also include vibrotactile feedback and small speakers as well as a headphone output. The flick type gestures are detected using the devices accelerometers, whilst the multi-touch screen is used to detect the cross-fader gestures. The flick type gesture is detected by filtering the accelerometer signal using a high pass filter. This removes the low frequency components of the signal, preventing false gestures from being detected if the user moves or tilts the phone slowly in any direction. A gesture is detected if the filtered signal in the X-axis of the accelerometer passes a given threshold value, with the signal needing to make a zero crossing before the next gesture can be detected.

The two audio tracks (one containing the sound that can be scratched through and the second containing the main beats to scratch along with) are both loaded from two wav files and stored in memory. This audio data can then be rendered in real-time by moving a pointer through the two buffers allowing the tracks to be scratched or slowed down or speeded up.

Gestures are judged as being on the beat by comparing the time of the gesture with a BPM clock. The game features various levels of difficulty, ranging from easy to extreme. Increasing the level of difficulty in the game reduces the time window in which a gesture is judged as being on the beat and also increases the amount and type of gestures required per bar of music. The time window for the hardest difficulty is 133ms and 333ms for easiest.

6. Pilot Study

A pilot study was carried out to test the various combinations of multimodal feedback and their possible impact on game-play. The study involved N=10 participants, one being female and nine male, all aged between 25-31. Eight of the participants had at least 10 years musical experience with the remaining two participants having no musical experience. All were college students.

Participants were asked via a pre-experiment questionnaire to rate their sense of rhythm on a scale from 1 to 10, 1 being poor and 10 being excellent. The average rhythm rating was 6.8 with a variance of 0.84. None of the participants had any visual or auditory impairments that would affect the results of this study. One participant's data had to be discarded due to a software error.

Three feedback conditions were tested in this pilot, audio+haptics (AH), audio+visual (AV) and audio+ haptics+visual (AHV). Participant was asked to perform two trials of each condition in a random order, in order to counter for learning effects typical for within-subject experimental designs. Each trial lasted 35 seconds (16 bars of music) and was followed by a 10 second recovery period before the next random trial commenced. In each trial the player was asked to make a scratch gesture (either left or right was counted) on each of the four beats of the bar of a simple drumbeat with a BPM of 110Hz. If the player made this scratch gesture within a 250ms time window of the beat they would hear a scratch noise indicating they had performed a 'good' scratch and would also score points. The number of points scored was calculated as 250-*absolute time from beat*, so if the player made the gesture 1ms from the beat they would score 249 points or if they made the gesture 240ms from the beat they would score 10 points. If the participant made the gesture outside of this time window then they would not gain any points. The total points scored for each trial condition was then recorded by the device. Prior to running the test, each participant was given a 7 minute period over which they could practice scratching, with 140 seconds per test condition.

The total score for each conditions across all subjects was for AH = 90056, AV= 89061 and for AHV= 83853. Hence somewhat surprisingly the pure haptics conditions

performed slightly better than the visual condition. Even more surprising is the drop-off for the mixed modality. Unfortunately the pilot study is too small to establish significance of these observations. Treating these conditions as single factor in a between-study ANOVA we find that the differences are not statistically significant ($F(2,24) = 0.233$ $p<0.794$) and we find for pairwise comparisons between AH vs AV $p< 0.9151$, AH vs AHV $p< 0.5291$ and AV vs AHV $p< 0.6231$.

User subjectively rated that the tactile feedback was very useful in assisting them to make the scratch gesture on the required beat of the music. There was no participant that rated tactile feedback negatively. Participants rated the visual feedback as not that useful and in post-experiment interviews reported that they only used the visual feedback to guide them on the initial first two beats after each condition commenced to get a sense of the speed of the music. It is interesting that the users felt that the tactile feedback greatly helped their game-play, when in fact the results show that the AH condition only scored marginally higher than the AV condition. We believe that this strong subjective opinion of the tactile feedback may be related to an increased sense of realism (as the feedback occurred at the maxima of their movement, perhaps giving the impression that the user was hitting an object) or it may just have made the task more fun.

There are two obvious improvements to be made to future studies. For one the sample size needs to be increased. Should that sample size increase allow to identify a significant difference in conditions, the experimental design should be changed to a two-factor (or potentially three-factor) design to allow to establish significance of modalities even through mixed conditions. For this one would also need to introduce a forth condition which just plays audio to complete the factorial design. A three-factor design would add audio as a third factor.

7. Conclusion and Future Work

This paper presented a new multiplayer musical DJ game, called "Scratch-Off", which is controlled by four different interactive gestures. We see this as a platform for experimenting with the impact of tactile and multi-modal display in mobile gesture-based interactions.

However there are still many open questions. Our pilot study does not conclusively show difference in modalities. We plan to conduct a full study with sufficiently large subject pool in a fully factored experimental design to come to a conclusion about this. It could be that haptic and visual display is interchangeable for these type of rhythmic gesture tasks.

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