Interactive Music: Teaching People Guitar Through Gaming Software

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1. Introduction

This paper presents a Silverlight-based, interactive, computer video game that teaches a user how to play guitar. The seven major goals for this system is that it is 1) entertaining, 2) intuitive, 3) educational, 4) easy to set-up, 5) requires no special equipment, 6) runs on any operating system, and 7) uses a real electric guitar.

There are two components to this game; a major component (Note Tester), and a minor component (Guitar Arrangement Creator). Note Tester consists of displaying notes for the user to play on a guitar, and testing if the user played the notes correctly. The Note Tester interface, which is described in detail in Section 3, is a "sliding-notes with background music" interface. This type of interface has been proven to be entertaining and intuitive through the success of video games that use a similar interface, such as Guitar Hero [1], and Rock Band [2].

Guitar Arrangement Creator is optional and the user uses it only if she wants to create her own unique note sequences, known as "guitar arrangements". This is also described in more detail in Section 3.

Both Note Tester and Guitar Arrangement Creator are developed in C#.NET 4.0 with Silverlight 4.0. This enables both components to run on a Windows, Mac, or Linux computer.

There have been several video games already developed that are similar to the system proposed on this paper. However, none of them satisfy all seven of the goals meant for this system.

For example, two very popular video games that used a similar interface were Guitar Hero and Rock Band. However, these games do not use a real guitar, but a plastic guitar with colored buttons. Therefore, they do not satisfy goals "7" and "5". Also, the games are not educational, and hence do not satisfy goal "3".

A few systems that use a more realistic guitar include Disney and US Music Corp.'s "Disney Star Guitarist" [3], and "Power Gig", which will be released in October, 2010 by Seven45 Studios [4]. However, both of these require a guitar that is custom built for their respective games and hence do not satisfy goal "5".

2. Theory

2.1 Overall Approach

As mentioned previously, this system has two components: Note Tester and Guitar Arrangement Creator.

Note Tester's main purpose is to test whether or not a user plays certain notes correctly on an electric guitar at the right time. Note Tester does this by analyzing the electric guitar's output signal when the user is told to play a particular note through Note Tester's interface. Figure 1 shows this process.

For Note Tester to be able to analyze the guitar's signal, there must be a hardware connection between the guitar and the computer. This connection is as follows: the guitar output connects to a guitar cable, which connects to a simple adapter to convert the 6.3mm male phone plug of the guitar cable to a 2.5mm male microphone plug, which connects to the computer's microphone input. The computer sound card can than sample the signal from the microphone input, and Note Tester can analyze the resultant digitized data. Figure 2 shows an overall description of this process.

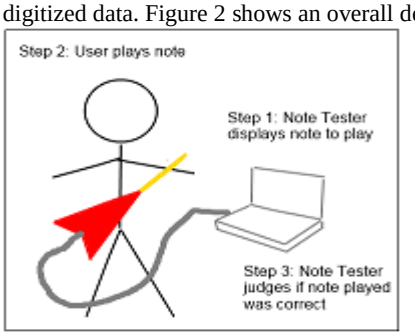

Figure 1) Note Tester displays a note for user to play and tests user's ability to play the given note

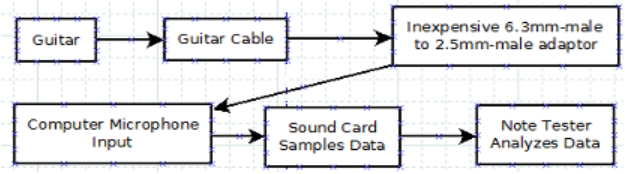

Figure 2) Flow diagram of hardware connection

Guitar Arrangement Creator's main purpose is to create guitar arrangements to be used in Note Tester. An arrangement can be combined with a song of the user's choosing and loaded and played from Note Tester. This satisfies goal "1" for users who feel the default guitar arrangements available are not entertaining enough.

It is now clear that this system satisfies all seven goals. The "sliding-notes with background music" interface is entertaining (1) and intuitive (2), the game is educational (3) because it helps the user learn how to play notes on a real guitar (7), it is easy to set-up as there are no complicated components or special equipment to put together (4 and 5), and it is platform independent (6).

2.2 Guitar Output

The guitar outputs an electrical signal that has the frequency characteristics of the note strummed with a few harmonics added. For example; if an A4 is strummed, which has a frequency of 440 Hz, the electrical signal output from the guitar will have a frequency of 440 Hz with a few harmonic frequencies added onto the signal. This can be seen in Figure 3.

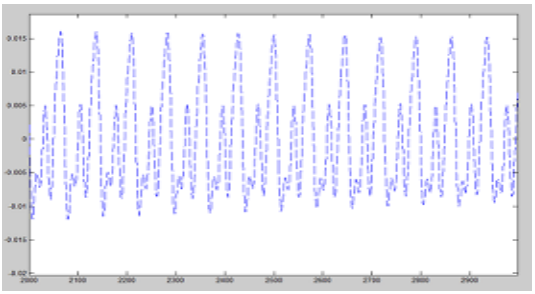

Figure 3: a plot of the A4 note (440 Hz) from an electric guitar

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The guitar output signal is sent is sampled by the sound card at 16-bit resolution and 44.1 KHz when it enters the microphone input.

2.3 Signal Analysis

A multi-rate IIR filtering scheme is used to determine the frequency of the guitar output signal. Using this scheme, it is possible to distinguish between two close notes using a low-order IIR filter, which reduces processing time.

For example, filtering between a low E (82.41 Hz) and an F (87.31 Hz) requires a high-order filter if the sampling rate is not down-sampled from the sound-card's 44.1 KHz sampling rate. This is because the difference between the notes in digital frequency is very small as this sampling rate: .0019 (82.41/44100) and .0020 (87.31/44100), for a difference of about .001. However, by using a multi-rate filtering scheme, the sampling rate can be down-sampled to 344.5 Hz. Then the difference in digital frequency between the two notes is .239 (82.41/344.5) and .253 (87.31/344.5), for a difference of .014. Since the latter contains a 14 times larger difference between the frequencies, a much lower order filter can be used to distinguish between the two frequencies.

To prevent aliasing, a low-pass filter is used before each down-sample operation. After certain down-sample operations, a range of frequencies is analyzed using IIR filters to determine which notes were played. A diagram of the scheme is shown in Figure 3.

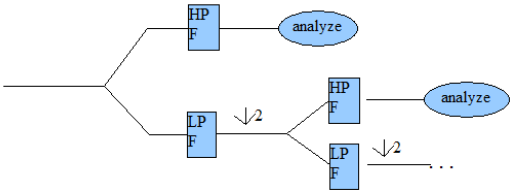

Figure 4: Multi-rate filtering scheme used to identify notes played from a electric guitar signal

3. Game Play

3.1 Note Tester Interface

This interface is a "sliding notes with background music" interface. In this type of interface, there is background music and notes sliding toward the user. When the notes reach a designated area, the user must play the note. If the user plays the note correctly, the music continues as normal. Otherwise, a buzzer sound is played with a version of the song with that note filtered out.

1) To start the game, a user chooses a song to play
2) Then, graphical objects overlaid with a number (graphical frets) slide toward the user from the back of the screen to the front along a "guitar string". The "guitar string" the objects slide on correspond to the guitar string the user should eventually strum. The numbers overlaid onto the graphical objects correspond to the fret of the guitar neck where the user's fingers should be placed. The fret number and string combined correspond to a particular note. For example, a fret number 2 on the D string corresponds to an E note. These notes correspond to guitar notes in the playing background song.
3) When a graphical fret enters a designated area, the user must strum the corresponding note on his/her guitar. If the user plays the note correctly, the song continues to play as normal. If the user plays the note incorrectly, a version of the song with that note filtered out and replaced with a buzzer sound is played.

An illustration of this can be seen in Figure 4.

Figure 4: Shows a series of notes that the user must play. When the graphical frets are within the black lines (the designated area), the notes must be played. In this example, the user will soon play the 12th fret on the A string, followed by the 10th fret on the D string, etc…

3.2) Guitar Arrangement Creator

This option component allows the user to develop an original guitar arrangement that can be combined with a song of the user's choosing. This provides the user flexibility to add more song options. For example, the user may want to play with a song that is not a default song, therefore the user will use this component of the software to create a guitar arrangement for the song. The song/guitar arrangement combination can then be loaded into Note Tester and played.

4. Conclusion And Future Plans

This system is designed to help people learn and practice guitar in a fun and entertaining way. It is able to utilize modern technology such as Silverlight to have the potential to be more accessible for more people then comparative systems.

However, several improvements are necessary. For example, a computer-vision based hand-tracking component would be very useful for checking that the user's hand position is correct. In a future release of this software, we hope to add that component. Also, we hope to create a web-based application where users can keep track of their scores and share guitar arrangements.

References

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