A novel audio based approach to game control to encourage musical instrument practice.

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Keywords: *Audio, Interface, Music, Game.*

Abstract

A technical summary is presented of work in progress that aims to develop an applied educational game for improving engagement with the learning of a musical instrument. The proposed system is novel through its use of the audio signal from an electroacoustic guitar as the control mechanism for game interaction. The interface mechanism is described together with an outline of the signal processing required to convert the audio signals into game control signals. Some examples, of simple prototype games targeted at novice child musicians in the 8 to 12 years age group are described to demonstrate the educational concept.

1.0 Introduction

According to a recent study by the Associated Board of the Royal Schools of Music (ABRSM) nearly 70% of children in the UK are now learning to play a musical instrument (ABRSM 2014). This increase is thought, in part, to have been motivated by the well documented developmental benefits that have been shown to result from learning to play an instrument. For example, a study by Bergman-Nutley et al. (2013) demonstrated a strong link between music practice and improved development of working memory during childhood and adolescence.

However, the number of children estimated to quit learning a musical instrument within one to two years of commencing is estimated to be as high as 50%. Yet, a report (Youth Music 2008) by the UK's largest music charity, Youth Music, indicated that of the 12 million young people in the UK, aged between three and 18, more than half play music games on computer consoles. This suggests that music based computer games may enable increased and sustained engagement for learning a musical instrument compared to traditional practice based playing.

A key limitation of existing music based games is that they employ either a standard games controller or a custom interface that emulates a real instrument. For example, the popular Guitar Hero franchise games use a custom made guitar controller with buttons instead of strings. Such an approach is limited in respect of developing the physical skills needed to play a real guitar. In this paper the development of a novel gaming interface that uses the audio signal from a guitar to control game interaction is described. The goal of this work is to provide increased motivation for routine practice of a musical instrument through game play, to overcome the tediousness often associated with traditional instrument practice.

2.0 Development of the gaming interface

Audio data from an electroacoustic guitar was acquired via a sound interface (M-Audio) connected to a PC computer via a USB connection. Signal processing algorithms (Kamenov 2011, Giannakopoulos and Pikrakis 2014) were developed to extract key features from the audio signals, which were then used as control data inputs into the various music games. These algorithms were developed in the Matlab / Simulink environment using the DSP toolbox (Mathworks) and then compiled as 'C' routines to optimise runtime performance.

It was found empirically that the system could not incorporate frequency domain based algorithms needing the DFT due to the inherent latency of the approach which proved detrimental in achieving consistent game play performance. Therefore, the algorithms used in the current implementation only use time domain based signal processing techniques.

A pitch detection algorithm utilising a bank of narrow band filters each centred on the frequency of a specific pitch was developed. These filters were designed using the Filter Design and Analysis Tool (FDA tool) in Matlab and the filter coefficients were exported for use in the digital filters implemented in the C source code.

Several of the games developed focus on practicing rhythm skills by requiring the user play a note for the correct duration. This proved challenging to implement as it requires precise synchronisation between the audio events and game events. In the current implementation this task is simplified by requiring the user to play against a metronome. Furthermore, time stamping of the audio events proved necessary so that their occurrence relative to game events could be accurately determined.

3.0 Development of test games

To evaluate the suitability of the system as a tool for improving practice of playing a musical instrument, several game levels were developed using a graphical interface programmed using the Allegro 4 game engine. In designing the various practice games it was decided to use a left to right scene scrolling format to reflect the process of reading musical score. In particular it is desirable for instrument playing students to learn the technique of 'looking ahead' when reading a score. This means that whilst a student is playing a bar of music they are reading the notes of the subsequent bar in preparation for required hand movements to new positions on the fret board.

A scene from a simple pitch based game is shown in figure 1 this evaluates the user's ability to play simple melodies without any rhythm constraints. The level is rendered as a maze through which an animated sprite is manoeuvred. The correct path through the maze is associated with an indicated pitch which needs to be played to get the sprite to take that path. Incorrectly played notes cause the sprite to take a less efficient path. If two subsequent pitches are played incorrectly the sprite returns to the start of the current section of the maze. After initial testing it was found necessary to display intended paths through the maze (red arrows) so that the user is able to concentrate on playing the correct pitch rather than concentrating on selecting a suitable path. Thus the cognitive focus is carefully balanced between practicing the instrument and playing the game.

The time taken to traverse the maze is displayed to the user and used as a score. Playing statistics are also recorded so that in game messages can be given regarding instrument playing performance. These analytics are also used to adapt the game between iterations. For example, if the playing of an interval between two notes is frequently played incorrectly it can be generated more often in the game to focus practice of that playing weakness. The basic pitch based game was easily extended to include practice of playing chords and scales which are implemented as progressive game levels.

Figure 2 shows an example of a prototype level for an instrument practice game that introduces simple rhythm concepts. The player represented by the guitar sprite is required to jump across the 'note islands' to reach the chequered flag representing the end of the played bar. This is achieved by avoiding the hazards between the note islands through playing each note for the correct duration against a background metronome reference. For example, the first note must be played on the first beat of the bar to avoid the crocodile sprite. Similarly the final note in this sequence must be played on the third beat of the bar to avoid the crab and sustained until the end of the fourth beat of the bar to avoid the squid. Playing errors require the bar to be played again and sustained errors force the player to practice a less demanding rhythm. Higher levels combine pitch and rhythm challenges.

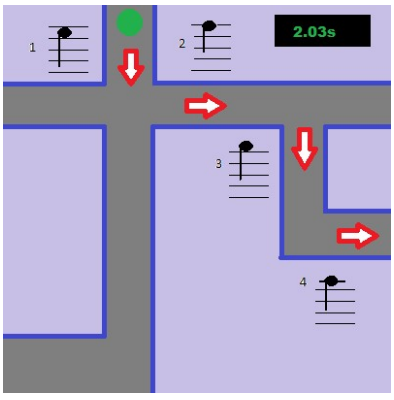

Figure 1: Section of a simple maze based pitch playing game. In this instance the user is required to read and play the pitches E, F, G, A on the first string of a guitar in order to traverse the maze correctly. Note that the traversal is sequenced left to right to follow the musical score convention.

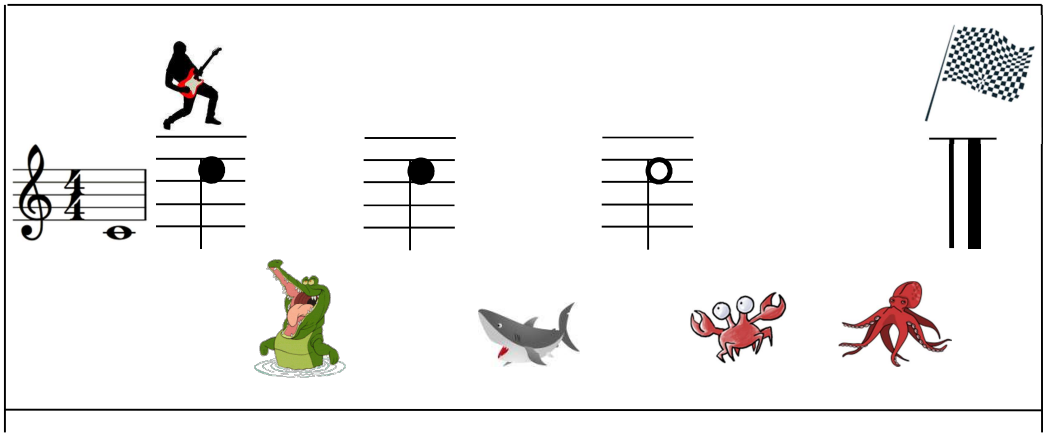

Figure 2: Example of a simple traversing game.

Preliminary testing and results

Preliminary testing of the prototype games was conducted by a primary school music teacher with a group of five children aged 10-11yrs. The inclusion criteria required that the participants had prior experience of playing a guitar and were conversant with basic music notation. Following a short demonstration and learning cycle they were asked to practice playing a range of tunes by conventional score reading and using the games previously outlined. The teacher observed their progress and made a subjective evaluation of their experience. The children were also asked to comment on their experience of the two approaches to practice.

The teacher reported that over the short one hour evaluation period of the test the children remained more engaged during the second half hour when the game based practice was introduced than would normally have been the case for a traditional practice session. It was also noted that a further benefit of the system was that it quickly forced children to focus on 'score reading' i.e. visual focus on the game rather than looking to find note fingering positions. The children were unanimous in their verdict that game based practice was preferable.

Conclusion

The developmental work described here has demonstrated the efficacy of using a real musical instrument as a game controller through processing of the audio signal. The natural extension of this concept is its application in educational gaming for teaching and practice in the learning of a musical instrument. The approach reported here was restricted to an electroacoustic guitar as the input control instrument however the audio signal could easily be obtained from any acoustic instrument simply by using a microphone.

Simple games have been developed to validate the concept and preliminary testing has provided encouraging responses through subjective evaluation with older primary age children.

Future work will focus on extending the range and qualities of the games and in targeting different age groups. These will then be assessed through a more extensive objective study to measure engagement and progress with musical instrument learning in a larger test group.

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