An Augmented Reality Based Learning Assistant for Electric Bass Guitar

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ABSTRACT

We present a system that assists beginner level musicians in learning of electric bass guitar. Using an electric bass guitar as a case study, one goal of our system is to accelerate the process of associating a musical score, sounds represented by that score and the fingerboard. The general idea is to synthesize the bass part of a score, one note at a time, using the sound hardware on a computer and visually put a red mark, for that note in time, on the fingerboard through a head-worn display. Upon marking a note, our system will wait until the user finds that note and puts their finger on that note. Using computer vision techniques, we can evaluate if the user is pressing on the correct fret at that point in time. We believe that augmented reality has the potential to eliminate the perceptual and cognitive discontinuities, that occur during the conventional way (without augmented reality) of learning of instruments, by dynamically overlaying appropriate information in the same field of view.

Keywords

Augmented reality, personal guitar tutor, human-computer interaction, computer based instruction

INTRODUCTION

Augmented reality is a concept within the computer science community, referring to the addition or removal of information to the physical world[1]. In general, *augmentation* can be done for any sense (i.e., aural, tactile, olfactory, visual and taste). In this paper, we are using augmented reality only for the addition of visual and aural information. Specifically, our aim is to build an aid that will accelerate the association of musical notes with the fingerboard of an electric bass guitar.

MOTIVATION

Our motivation for building this system is to overcome the perceptual discontinuities[4] introduced by dispersed sources of information during the learning process. A bass player learning how to associate written music with the finger board would need to piece several pieces of information together such as a diagram showing the notes as they appear on their instrument and an understanding of reading sheet music. It is often the case that these seperate pieces of information appear on different books or different pages in the same book. Scattered information causes interruptions in playing the instrument since the bass player must use their hands to search for relevant information and come back to the instrument upon finding that piece of information. Our motivation is to eliminate this searching process

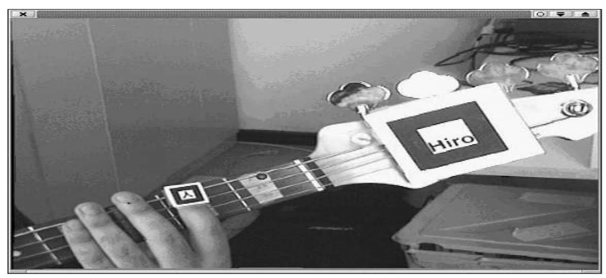

Figure 1. Prototype monitor based AR setup

and provide the relevant information, in a transparent way, as the bass players are holding their instrument.

RELATED WORK

State of the art (conventional) literature for learning how to play an electric bass includes cd-roms, video tapes, books and private lessons. Beginning level players often combine several sources of information and work with different representations of a piece (e.g., musical score and tableture).

In the research and art communities, there exist several musical applications of augmented reality. We found two systems that focus on teaching or assisting musicians. Rest of the literature include systems aiming at tangible manipulation of electronic music[6] or systems aiming at social interaction and artistic expression. Cheng and Robinson [2] built a system called Handel to overlay sheet music partitioned for right and left hand on a piano as a memory aid for pianists. Handel uses computer vision to detect the hand of the user (i.e., left or right hand) and overlays the sheet music for that hand. Our system takes the extra step to mark the notes, written on sheet music, on the instrument. Dannenberg [3] et.al. developed an expert system for teaching piano to novices. Piano is the main input device and a computer monitor is the output device. This system incoorporates score following, a lesson database with an expert system. Piano tutor can analyze error(s) during the lesson and offers suggestions.

Except the piano tutor, most of these systems differ in their goals from ours, as Handel is designed as a memory aid and Augmented Groove provides tangible means to manipulate electronic music and we are not aiming (directly) at developing a system for artistic expression.

OVERVIEW OF THE SYSTEM ARCHITECTURE

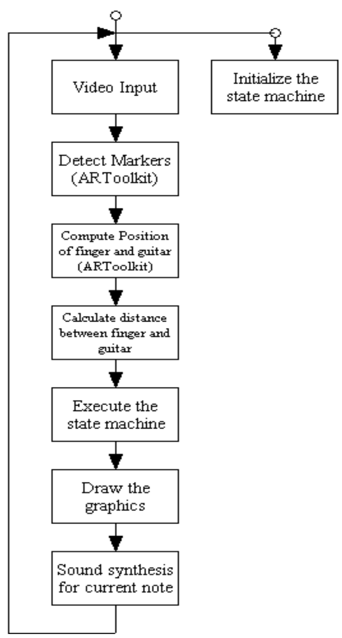

Figure 2. Software Architecture

Main components of our system consist of tracking the position of the bass guitar and the finger and overlaying graphical annotations synchronized with sound. At each frame, we compute the distance between the target note and the current finger position. Based on this distance, our finite state machine decides whether to move on to the next note or wait on the current note. When the distance is reasonably small, the finite state machine advances to the next note. Marker tracking is achieved with the publicly available Augmented Reality Toolkit[5]. Using a single camera, Augmented Reality Toolkit provides the detection and tracking of markers and their position and orientation relative to the camera. There is a marker on the bass guitar and another marker on a finger of the user. See figure 1 for an image of the running setup. Note the overlaid annotation (small dot between the marker on the guitar and the finger) indicating the next note to play. We are running our system on a dual-pentium III 866 Mhz computer with 512Mb RAM. The system runs at 5 frames/second, however, this is expected to increase upto 25-30 fps once we switch to the head-word display based setup, since displaying the video stream using OpenGL slows down our system.

State Machines for Representing Musical Sequences

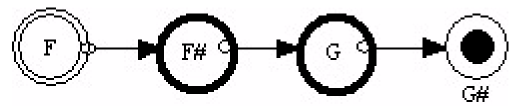

Figure 3. Example State Machine

We are using finite state machines to represent a sequence of notes. See figure 3 for an example of a four state machine that represents the sequence of F, F#, G and G#. As the systems enters the starting state, it plays the note F, overlays a small dot to the user, showing where the note is on the fingerboard, and waits until the user puts his or her finger on the same note. The process is repeated until the state machine terminates via reaching the final state.

CONCLUSIONS AND FUTURE WORK

We believe that the strength of our interface is the notion of placing information where it is needed while trying not to interfere with the task at hand. Our prototoype is based on markers to test the initial feasibility of the user interface. Technical improvements to our system could be replacing markers with vision algorithms and adding sound analysis for a better evaluation of what the user is playing. We are planning on adding a better score following algorithm to enable teaching of rhythms of musical pieces. We are hoping to report back on the validation of our hypothesis with user studies.

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