Project Part 1: Smart Instruments

A New Type of Human Computer Interaction

Human-Computer Interaction

September 17th, 2017

Youbeen Shim (ys3ep@virginia.edu)

Abstract

With the advancement in technology, the momentum towards portability and convenient access to musical instruments have been undeniable. However, much of the development have stalled after the development of electrical versions of popular instruments. Electric keyboard, electric guitar/bass, and electric violin are all notable examples for this trend. Very limited study has been put into replacing the physical need of an instrument altogether. Through the use of mature libraries such as NITE and Kinect SKD[1] which enables the fundamentals of human skeleton tracking, in conjunction with 3D sensing devices (i.e. Kinect) or Virtual Reality Controllers (i.e. Oculus, VIVO), it is now possible to eliminate the physical instrument. While rudimentary development towards this purpose has been ongoing, the authors' experimental and explorative efforts focus on providing realistic feedback mimicking the experience of an actual instrument and accommodating disabilities and disadvantages that could previously not occur due to physical limitations of the instruments. After the completion of the project, the authors' following objectives include wider array of instruments and finer integration of feedback mechanisms that will provide a more unified experience.

Mission Statement: To provide the user with a premier, and authentic instrument playing experience and use the technology to inspire new musicians to create music.

[1] http://ieeexplore.ieee.org/document/6916339/?reload=true; Real-Time Finger Tracking for Virtual Instruments

Problem Definition

When first taking up the challenge to design a novel form of human computer interaction it is important to first understand the challenge space. The challenge the group faces is how can we use technology to mimic the feedback that we expect when playing instruments. Music has been an integral part of human culture for thousands of years and replicating the stimuli we receive while playing requires knowledge of human sensory perception and what current computer feedback systems provide.

Music is the manipulation of sound and how our auditory system receives and retains the information. When playing an instrument we must also take into account the physical sensation of touch as well as the visual sensation of performing musical operations (strumming, pressing keys, drumming, etc.). The benefits of this new virtual interaction method are widespread. More people of all backgrounds can be exposed to music without the need for entire collections of physical instruments where it would normally be difficult or impossible to acquire them. Also the modularity of a solution could allow for those with disabilities to customize how they interact with the virtual instrument interface and provide them with new access of instruments they would otherwise be unable to play. Previously significant physical disadvantages, such as length of the fingers or width of the arm span, no longer would be able to inhibit individual's ability to create music. Implementation of this technology would also enable its users to freely experiment with different types of instruments and potentially set up a new market of all-inclusive instrumental software.

Possible stakeholders that would be interested in supporting our challenge space would include: musicians of all backgrounds, local and national cultural agencies, non-profit charity organizations, companies with interest in the music industry, and individuals who lack access to musical instruments.

To limit our research and development process, the initial scope of the project will be recreating a “virtual piano” with our new interaction controls. When trying to design and develop a novel way of interaction, it is important to look at all elements of usability (Nielsen 2001) to ensure the solution can be used effectively and best follow our mission statement. It is also important to examine solution usability to determine design requirements. The three most important elements that we can apply during the planning stage are 1) match between system and the real world, 2) user control and freedom, and 3) visibility of system status.

Our mission statement and goals are centered around creating an authentic instrument playing experience and this involves matching the system to the real world as closely as possible. The system will follow real-world music conventions and have appropriate feedback depending on each note played. User and control freedom will be managed by having clearly marked exits for users to leave unwanted states and quickly continue producing the sound they intended. The solution will also be required to provide visibility of system status through responsive feedback about what is being played at all times.

Prototype Brainstorming

When evaluating the effectiveness of the “smart” instrument, one of the main components for what is deemed as successful is the device’s accuracy in replicating the experience for the user as well as accurately mimicking the sounds. Feedback for the users stands as a top priority when in the process to development of this device to maximize user comfort and satisfaction. Along with the familiarity of the classic piano, aspects of it may be improved such that it is better suited for the individual.

For ordinary instruments, feedback is instantly received in the form of sound. However, the device would provide multiple forms of feedback, auditorily and visually. Similar to a music synthesizer, the notes that are played would be displayed onto a music timeline. The timeline would act as a record for the user who could possibility be composing a piece or simply practicing. To enhance visual feedback, the smart instrument, itself, would have LED bulbs attached to each fingers. The bulbs would light up as one of the seven colors of the rainbow, depending on the note played. This additional form of feedback may potentially serve as a new way of learning through association similarly to learning “tabs” on a guitar.

Touch sensors would also be attached to the bottom of the fingertips. This touch sensors would receive input from the user, and the output would be dependent on the amount of pressure the sensor receives. This would allow the dynamic mechanism of pianos to be emulated.

To properly display the input from the user, the device either have to be linked to a smartphone or computer with proper software. However, a computer would act best as a medium between the user and the device, due to greater usability and visibility in terms of changing settings and display size and quality. Many aspects of the input may be recorded and displayed simultaneously on screen such as the note, dynamic, duration, and position relative to other keys.

What will be most controversial would be the ability to allow the user to customize the settings to suit their preferences. At the most basic level, the user may change the color of the lights for each keys to their liking, but at a more practical standpoint, the threshold for the pressure touch sensors may be changed such as requiring more pressure to produce a sound in forte for those who tend to tap too forcefully. People with shorter finger span may also alter the width of each of the keys in order to allow their whole hand to stretch one octave. By allowing the user to adjust their smart instrument to their own personal needs, a higher overall satisfaction will be reached.

Expected Results

With this project, we hope to gain a fuller understanding of all the components that contribute to making the full experience of a smart instrument and those enhance a user's interaction with it. Through increased and expanded feedback modes, we will be able to analyze which mode/sense of feedback user's find most helpful and enriching. Because these 'instruments' will allow for users to mimic the playing without the physical instrument itself, affordances such as the form factors will be made. We intend to analyze the benefits of different affordances through separate software and display options to see what will minimize the learning curve while fully teaching the users the capabilities and options of the 'instrument'. Through user testing, we can find which methods are most effective and will best fulfill our mission statement.

Because some instruments are too heavy to carry around, especially with instruments such as the piano, the purpose of the design of this smart instrument is to increase convenience. No longer will musicians need to carry around heavy instruments - they will be able to play wherever and whenever they want.

In addition, because this is a relatively novel form of human computer interaction, we want explore different features that will best mirror outputs from physical instruments while also enhancing that experience by adding other forms of feedback and options such that users can expand beyond the traditional methods of playing. Multiple modes and tones of the instruments will allow for instant feedback on different sounds and styles of music that the user chooses, providing flexibility and versatility.

The final solution should be able to provide musicians (pianists in the scope of this project) with a portable solution that provides full, authentic playing instruments with various features that will enhance the playing experience and promote creativity.

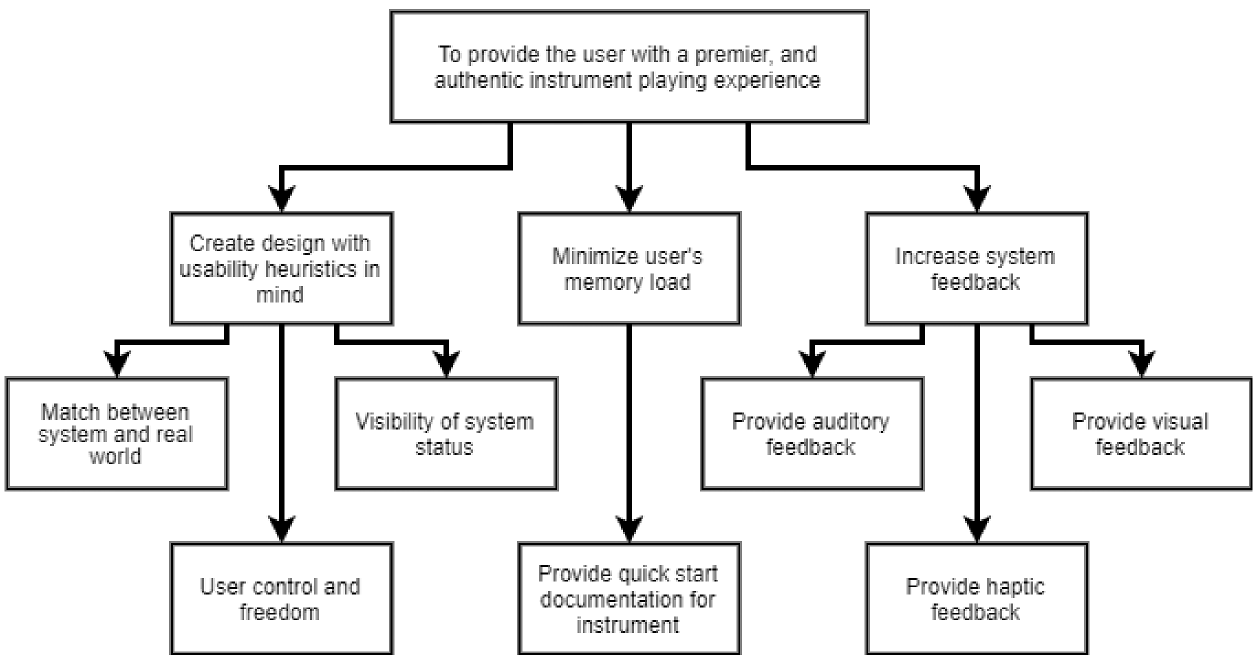

Figure 1. Objectives Tree for Smart Instrument Solution, moving down the tree from the top we see how we can achieve our top level goals. Moving up the tree from the bottom we see why we perform each action.