Pitch Canvas: Touchscreen Based Mobile Music Instrument

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ABSTRACT

Mobile music applications are typically quite limiting to musicians, as they either attempt to mimic non-touchscreen interfaces or do not offer enough control. Pitch Canvas is a musical interface that was built specifically for the touchscreen, with the goal of providing the same depth and flexibility as traditional instruments without virtualizing an existing physical interface. Pitches are laid out in a hexagonal pattern that allow for easy scale, chord, and arpeggiation patterns, while notes are played by touch but sustained through continuous movement. Pitch bends can be achieved by passing through the space between the notes, allowing slides, slurs, and rudimentary vibrato. The current implementation of the interface runs only on Apple iPad tablet computers using libPd [1] to convert user interaction into audio. An iPad overlay offers physical feedback for the circles as well as the pitch bend area between the circles. A performable version of the application has been built, though several active developments allow alternative sonic interpretation of the gestures, enhanced visual response to user interaction, and the ability to control the instrument with multiple devices.

Keywords

NIME, Mobile Music, Touchscreen instrument, geometric pitch space

1. INTRODUCTION

Performing musicians rely primarily on traditional musical interfaces, which have the advantage of several centuries of developments and improvements resulting in a well-understood acoustic manner of producing sound. Over the past few years, the ownership and computing power of tablet computers has expanded, and with the relative ease of application development, has inspired a new generation of musical interfaces. Music applications built for tablet computers have tended to offer a touchscreen-simplified version of a traditional interface, as musically-trained users will already understand how to control these interfaces. Examples include Ocarina by Smule[1] and Garageband by Apple[2].

[1] http://www.smule.com/apps
[2] http://www.apple.com/ios/garageband/

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Fewer music applications explore the touchscreen and its affordances for interaction as the foundation for a new interface, developed independently of established instruments, although a number of frameworks allow for this. The urMus project at the University of Michigan enables novel touch based paradigms through openGL and lua scripting [3], as does the MoMu Toolkit from Stanford [2]. Both projects enable development of unique touch experiences, however instruments developed on them still tend to gravitate towards dividing the screen up into key-like regions for interaction. Inspired by such mobile applications that do break the key-press paradigm, Pitch Canvas is an attempt at developing a musical interface similar in depth, flexibility, and playability to traditional music interfaces but based on quintessential touchscreen interactions.

2. MOTIVATION & PRIOR WORK

Atau Tanaka outlined the existing paradigm of mobile instrument design at the 2010 NIME conference. In his paper, the concept of affordances inherent in Mobile devices was elucidated as "objects that project perceived possibilities of usage" [9] based on ideas developed by Gibson [4] and Norman [7]. When applied to touch based tablets, we find that many apparent touch interactions such as key-press interactions are quite deceptive. It appears as an affordance due to the visual division of the screen, however the tactile response from pressing the screen is the same anywhere on the device even though the sonic response may change. As an extension of this, a dragging motion quite natural to touch screens often produces a similar disconcerting effect: that of moving across visual elements without any link to touch, speed, or sound. As a result of the disconnect, constant visual focus must be placed on the screen and interaction with the device can occlude the interface.

Emerging from these ideas, two main motivations, non-skeuomorphism and full user control, inspired the original conception of the Pitch Canvas interface. Touch events have a distinct evolution - the initial touch, hold and/or drag, and release. As natural elements of a touchscreen interface, these became the building blocks for musical interaction. To take advantage of this, Pitch Canvas was envisioned as a hybrid application, fully functioning both as a musical instrument and as a drawing interface. As a natural mode of touchscreen interaction, drawing offers an intuitive way to dictate a musical gesture, and has a potential application as a means of communicating a musical score with a user unfamiliar with reading music.

2.1 Non-skeuomorphism

Contrary to many mobile music applications which attempt to digitize the physical aspects of traditional interfaces, Pitch Canvas was intended as a non-skeuomorphic instrumental interface. Popular music applications often provide virtual

representations of established traditional interfaces, as seen in GarageBand's suite of virtual guitars, keyboards, and drums. Borrowing an interface design allows many users instant familiarity with the manner of controlling the instrument, but without the physical components of their predecessors, in migrating to a touchscreen can lose playability. As such, very few musicians attempt to use these mobile applications in recordings and performances, finding the physical interfaces easier to control. With the goal of creating an instrument that could take full advantage of the touchscreen's unique properties, Pitch Canvas was designed as a non-skeuomorph, which with original structure and mapping would sacrifice potential user familiarity for touchscreen compatibility. The representation of notes as circles requires less precision than other virtual controller shapes (such as guitar strings), and the hexagonal layout allows easy transitions between notes in the same key.

Because the device represents discrete notes in circles that can be pressed like piano keys, many first-time users compare the interface instrument to a keyboard interface optimized for the touchscreen. However, as a touchscreen-based instrument, Pitch Canvas makes use of the potential for expression through sustained gestures and internal timbre and filter control, which are more difficult to replicate in real time on a keyboard and require supplementary controls such as knobs and x-y pads. The current version of the application limits the audible presence of key-press control, and the planned directions for the project explore the potential of artistic expression through highly location-specific gestural interaction.

2.2 Full User Control

The second motivation shaping the design of Pitch Canvas was providing the user with full control of produced audio. Most mobile music applications that avoid borrowing aspects of actual interfaces can compensate for the conversion to a touchscreen by delegating many musical functions to the computer, as with repeating patterns and loops. Many of these applications, such as Reactable Mobile [5], have been well designed and can offer the user an intuitive way to create music, but presets impose limitations on the real-time manipulation of audio. In order to restore user control of audio in real time, Pitch Canvas was constructed to delegate as little audio production as possible, generating sound only when user interaction explicitly demands a specific type of note. The resulting interface plays much like traditional physical instrumentation, and with all audio configured in real time can prove useful to performing musicians.

Musix [8], by Brett Park and David Gerhard, and *Hex Player* [6]are examples of non-skeuomorphic iOS instruments. They utilize hexagonal-based pitch structures to experiment with multiple harmonic layouts or geometric pitch spaces. The instruments offer several synthesized sounds and many customizable settings, and employ a touch-based interaction. However, performing with the instruments tend to be key-press interaction oriented and appear to have limited gestural control over the resulting sound beyond pitch and amplitude.

3. IMPLEMENTATION

3.1 Device

The initial version of the interface was developed for Apple's iPad for a variety of reasons. Using a commercially produced tablet guaranteed reliable hardware, allowing time to be spent on designing and programming the instrument. Apple's tablet computers claim the largest market share, offering a wide potential user base. Also, future research will explore inter-device implementations of the instrument, which would require using Wi-Fi, Bluetooth, or OSC connections, all offered on the iPad. Finally, by using a commercial tablet with a large market share, Pitch Canvas offers a costless musical instrument to a large number of people unlikely or unwilling to commit money towards purchasing a traditional instrument.

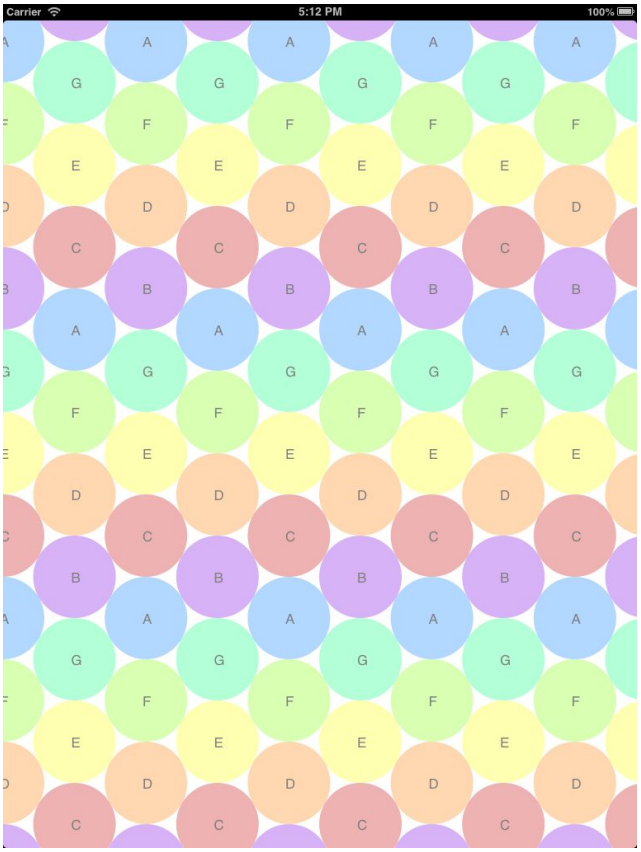

Figure 1: Pitch Canvas hexagonal pitch map.

3.2 Interface Design

The Pitch Canvas interface consists of numerous circles, each of which contains a certain note, arranged in a hexagonal layout (Figure 1). Currently, all notes are within a user-specified major key with pitch increasing vertically, and the vertical pattern repeats every other column. The circles are arranged so that circles adjacent on either side will be only a whole or half tone in distance, and vertically adjacent circles will be a major or minor third. The triangular areas between the circles carry pitches intermediate to those of the bordering circles, allowing for slides, bends, and slurs between adjacent notes. When the program is first run, pitches are mapped to each pixel on the screen, and as the user plays a gesture, the corresponding pitches are sent to a Pure Data patch that generates the audio. In addition to mapping the frequency of a note to circle location, Pitch Canvas maps volume to gesture speed and feedback and overdrive to horizontal position. The layout of the interface allows many common harmonic relationships to be played easily, including scales, triads, arpeggios, and trills. Simple major and minor chords can be played as three vertically-adjacent circles, and inversions can also be constructed without difficulty. In addition, the interface enables the guiding of a melody through different tones and effects throughout its lifetime, and facilitates polyphony and

counterpoint when controlled with two hands.

3.3 Audio Production

The application produces audio in a Pure Data patch, using libPd. The Objective-C code sends control messages to the patch on twenty-four different channels. The patch contains eight audio channels for eight finger multitouch gestures, accepting three values on each channel: the midi number of the gesture's current circle, the velocity of the gesture, and the gesture's current horizontal location. These three values are then mapped to the frequency, gain and harmonic activation, and the overdrive and feedback amounts. Each new gesture first initiates a synthesized attack and then transfers to a feedback loop with overdrive thus providing tap-responsive and motion-responsive styles of performance.

3.4 Haptic Feedback

The initial design plan offered the user one method of identifying interaction, requiring the user to watch themselves play the instrument to ensure their fingers aligned as intended with the circles. This is less than ideal, as it limits the ability of a musician to sightread or communicate with other musicians while maintaining control of the interface. Furthermore, because fingertips have size comparable to the size of the circles, there is a recognizable uncertainty as to where exactly the finger is on the screen. This makes bound motion difficult to control, and when using continuous gestures for polyphony, synchronizing transitions becomes difficult. A custom iPad case was developed to improve usability by providing haptic feedback, offering an intuitive mode of identifying notes(Figure 2). A laser cutter was used to cut circles out of a sheet of paper in a pattern based on the interface's structure. After attaching the paper to the tablet, the interface was placed beneath a vellum overlay which would allow a recognizable border without demanding too much effort to transition to a new circle. The paper and vellum layers did not cause a noticeable interruption in interaction with the controller. The haptic feedback offered by the overlay decreases uncertainty in touch location relative to the interface and eases the demand on visual attention.

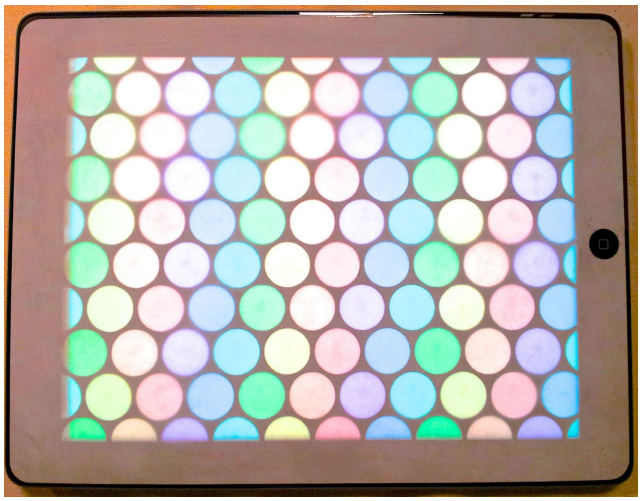

Figure 2: Haptic feedback iPad overlay.

4. PERFORMANCE

Pitch Canvas was used in the composition *Recombinant Features* by Jesse Allison and performed by the Laptop Orchestra of Louisiana in November 2013 (Figure 3). The composition was a quartet piece of four Pitch Canvases at different tunings and transpositions. It was a structured improvisation in two parts taking advantage of the rhythmic qualities of the tap-based attack, and the organic sound of swirling multiple fingers slowly across the canvas.

Figure 3: LOLs Performing *Recombinant Features*.

5. FUTURE DIRECTIONS

In August, a stable version of the interface was completed that could perform capably even on the first generation iPads. This version has been submitted to Apple for review, and should soon be available through their app store. Several additional affordances are also planned as the subject of future research, which should improve the instrument's virtuosity and performance capabilities.

5.1 Trans-Device Instrumentation

User control will be expanded by allowing multiple devices to connect to the same interface using OSC via Bluetooth or Wi-Fi. Additional devices would allow multi-modal interaction, and the planned developments would afford greater specification of audio in real time. One mode, currently in development, would record the current gesture and redraw the gesture at the location of the next touch. This would offer repeated use of a visual pattern, and the retranslation at a different sonic location would allow exploration of harmonic relationships. A second mode will allow application and specification of multiple audio settings and effects, offering binary and fader controls beyond the scope of single-device interaction. A third mode will enable real-time redesigning of the interface's visual aspects, enabling simultaneous artistic expression in both the sonic and visual dimensions. With the iPad's pre-existing screen-sharing capabilities, this will allow greater artistic expressibility and further audience immersion. These multi-modal improvements were mainly designed with the goal of improving performance value, as the incorporation of multiple devices will offer a stronger real-time control of the instrument.

5.2 Visual Feedback

Since conception, visual feedback has been one of the cornerstones of the Pitch Canvas interface as gesture-based interaction translates easily to drawing. The primary goal in improving visual feedback is enabling drawing as the simple visual record of previous gestures. Although a drawing capability has been implemented in the current app framework, the redrawing processes greatly overwhelms the synthesis capabilities of the device, rendering the application unusable as either a drawing or musical application. Optimization will need to occur to make drawing images a viable mode of interaction.

Once this functionality exists, visual representation will be expanded across multiple modes, also allowing effects such as the brightening of a circle upon initiation of a touch or a diffused, fading trail behind a gesture. With a second device, the visual representation of the gesture can be controlled in real time, allowing an aesthetic expression of

audio. With an established visual expression of specific settings, linking subtle audio effects to graphics parameters such as texture and brush type, complex compositions can be communicated to other musicians in a natural and understandable manner. As a real-time drawing application, Pitch Canvas will encourage compositions arranged both visually and musically, and as a translator of a visual gesture to a sonic expression, will also encourage gesture-based improvisation. Implementation of drawing will offer multiple dimensions for artistic expression, and with pre-existing haptic feedback, Pitch Canvas will become a more robust, performable interface.

5.3 Degrees of Freedom

The current Pitch Canvas interface utilizes three degrees of freedom: circle/pixel location mapped to pitch, gesture speed mapped to gain and level of harmonics, and horizontal location mapped to feedback and overdrive. Further degrees of freedom, including proximity to center of circle, curvature, direction, and tablet orientation will be mapped to the tone of the produced note and further audio effects. As the relation between gesture and audio will become much more precise, custom settings to control how degrees of freedom are mapped to aspects of the audio will be explored. Currently, the two degrees of freedom requiring function-based relationships, velocity and horizontal location, relate linearly to their audio attributes. In future iterations, the mapping function, such as parabolic or exponential relationships, will be specifiable improving playability in a variety of performance situations. Finally, the scale of the relationship will be adjustable so that small deviations from the intended gesture have a variable significance on the produced audio.

6. CONCLUSION

Built in a non-skeuomorphic approach to mobile music applications, the Pitch Canvas interface offers users complete control of produced audio through touch gesture. The circular interface takes advantage of the touchscreen layout, and the positioning of the notes allows users to easily create many musical patterns. Although the ultimate goal of the project was to create a new interface that musicians will find useful, user feedback has suggested that the instrument also has applications in multiple fields, including music education and therapy. As a free instrument requiring no physical components, Pitch Canvas will be available to thousands of users wishing to explore an interest in music. With trans-device interaction, audio visualization, and more degrees of freedom, Pitch Canvas will offer musicians more specific, real-time control, and will hopefully prove useful when composing, recording, and performing.

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