CYCLIC-N, A REAL-TIME MOBILE MULTI-TOUCH APPLICATION FOR COMPOSITION, IMPROVISATION, AND EDUCATION

Mingfei Mike Gao
University of California
San Diego
Computer Music

ABSTRACT

A real-time, multi-touch mobile, variable pitch space application for music composition, improvisation and education is presented, allowing the player or group to graphically explore the play of notes in traditional equal temperament as well as other N-fold equal tempered tuning systems for microtonal investigation. This paper focuses on novel features implemented, special considerations to latency and limitations, as well as successes and failures in performance and educational settings. I have utilized this software for performance and education both telematically and in person, teaching music to producers who have then also used the software to perform laptop music, successfully supplementing traditional DJ performances with improvised chords and melodies despite lack of formal music education.

1. INTRODUCTION

We will begin with a brief survey of prior works including existing pitch space literature and software, followed by a description of the system, discussion of both the successes and failures of its use, considerations to tunings, and finally future directions and improvements. Uses include education and performance in both live and telematic settings, as well as research in the group theoretic aspects of N-fold tonal systems and auditioning of theoretically discovered pentatonic and diatonic scales that lie within them.

2. PRIOR WORKS

2.1. Pitch-Spaces

"And what is a diagram? A representation of a musical system. And we use a diagram so that, for students of the subject, matters which are hard to grasp with the hearing may appear before their eyes" [3]. As shown by this Bacchius quote, there has been a long tradition of utilizing geometric models and visual aids beyond the score to understand the usage of notes in music.

The idea of a geometric representation of tonal hierarchy dates back to the Baroque period, when David Heinichen (1728) created a regional circle that was very similar to the circle of fifth that music students are familiar with today. This circle involved our current circle of fifths, but with the minors alternating with the majors rather than the relative minors presented in a second circle as proposed by David Kellner (1737) [4]. These early diagrams were utilized as a device to teach smooth modulation [1]. The coloring scheme suggested by Gerald Balzano for this software is based on this circle of fifths, as will be discussed later.

One of the earliest documented examples of a grid-like pitch space is Leonhard Euler’s 7 by 4 space (1739), proposed with perfect fifths along the horizontal axis and major third along the vertical. This space dealt with just intonation, gave insight into the ratios needed to calculate the different pitches, and was rediscovered by Arthur von Oettingen (1866) and later Riemann, publishing it as the Tonnetz. This same structure was used by Renate Imig (1970) and Longuet-Higgins (1962). Gerald Balzano (1980,1982) proposes a space represented by 4 by 3 (major third by minor third). In this space, the fifths go along one diagonal axis while the chromatic notes go along another, major and minor thirds accessible horizontally and vertically.

2.2. Existing Software and Hardware

One commercially available pitch-space controller is the C-Thru Axis MIDI controller, based on the Tonnetz. It uses a pitch space based on hexagons, with fifths going up the vertical axis, major thirds going up the 60 degree diagonal, minor third going up the 150 degree diagonal. In this way, chromatic notes are laid out in a horizontal way, albeit that they are not directly adjacent.

In 2009, Craig Hanson and I proposed a controller with single touch touch-screen and eight by four button array, which was published in NIME [8]. This interface featured not only velocity sensitivity in the Axis MIDI controller, but also pressure sensitivity for each button, allowing for polyphonic after-touch. Many pitch spaces were explored, and a system was devised allowing the user to select a scale on the one-touch touch-screen to reconfigure the pitch space with pitches from the scale in one row, other notes in the next row, and so on for two octaves in four rows. This allowed for easy horizontal navigation of the scale with corresponding octaves two rows above.

Countless other pitch space instruments exist, including the LinnStrument, many Max/MSP [5] patches designed for Monome like grids and other pitch space multi-touch mobile applications such as Hex Keys. It would be too exhausting to list and discuss all of them and the differences. A description of the Cyclic-N system is much more productive for delineating the
3. THE SYSTEM

3.1. Operating Systems and Basics

The system was designed for Apple iOS, more specifically iPad, with a limited iPhone version. Apple iOS 4.2 adds Core MIDI and allows for directly sending MIDI to an interface via the iPad Camera Kit, improving latency from wireless methods. The main interface page includes a grid for the actual pitch space and button switches for accessing a menu, transposing the space, and setting the horizontal and vertical intervals of the pitch space.

The design eschews regular push buttons to prevent accidental presses: the user must slide the switch in order to access the corresponding function. At a lecture at CNM, Bill Buxton suggested the very useful marking menu, which is proposed in the Cyclic-N design for transposition and interval changing by different values and directions. To access the marking menu, one presses down on a button, revealing images for functions assigned to sliding the finger in various directions from the originally pressed location.

3.2. The Default 3:4 Pitch Space

The default pitch space when the application starts up is 3:4, rather than Balzano’s originally proposed 4:3. This is because ergonomically, it is easier to access adjacent horizontal notes with two hands. The diminished interval placed horizontally makes more sense because it takes four spaces to get back to the octave, whereas the augmented interval takes three. Placing the diminished interval on the wider, horizontal axis is therefore advantageous.

As can be seen in Figure 1, one diagonal ascends in 5ths while the other by semi-tones. Contrapuntal motion is more difficult, but can be expressed as a far diagonal, and is primarily limited by the size of the multi-touch pad. Major and minor triad can be expressed as triangles while the diminished chord can be expressed as three horizontal notes in a row. The diatonic scale can be seen in a diagonal and formed by these chords [2].

3.3. Visual Feedback and Network Features

In twelve-note equal temperament mode, the pitch space is represented in a grid with twelve colours for each of the pitch classes. As proposed by Gerald Balzano, the colours are assigned in a spectrum along the circle of fifth. Modulating along this circle ensured that only one new note would be introduced, with an added bonus that the note would only differ by a semi-tone. Seven adjacent notes in a circle of fifths form a diatonic scale, and one can remember their diatonic region simply by remembering where the spectrum of colours begin and end. Octaves can also easily be identified in the grid by having the same colour.

The application is designed so when one plays a note, it flashes the note underneath the finger, but also if the same note occurs at other locations in the pitch space. Notes are also received via MIDI in and Open Sound Control via network, allowing notes to be visualized in the pitch space via MIDI cable and telematically. This has been successfully used to telematically learn music theory from composers across the continent. While previous telematic video and audio systems can be used for education, the addition of a pitch space representation allows chords and their voicing’s to be taught and memorized once and then used in any key, due to the isomorphic properties of the space. Intervals are also geometrically consistent in each key, making understanding much easier than a piano representation. The variability of the pitch space allows the student to vary how the notes are visualized. A 5:1 representation (perfect fourths by chromatic) may be suitable for bass guitarists, while 7:1 (perfect fifths by chromatic) may be suitable for those familiar with cello. Played notes are displayed as an unfilled square, still allowing the colour of the original note to show through.

Figure 1. Major thirds go vertically, Minor thirds horizontally, Fifths up one diagonal, semitones up another

Figure 2. The diatonic scale, major and minor triads
This visual system can be utilized for live jamming, with notes sent via OSC or MIDI from different players across the stage. For multiple players, different colours as well as angle of rotation for the squares can be set so that information from various players can be displayed at once.

Twitter support with JSON has been integrated into the application for the designed usage of discovering jam partners via the web. The application discovers its own IP address and can broadcast this via Twitter in plaintext. For security reasons, simple encryption of this IP address has also been proposed.

3.4. Polyphonic Pitch Bend and Microtonal Tuning

By default, horizontal movement within each button in the grid is mapped to pitch bend. This can be disabled in the menu. The tuning system is 12-fold equal temperament by default, but can be adjusted to other N-fold equal temperament systems. The simple equation for expressing frequency is expressed as Equation 1. In the menu, the variable N can be changed for microtonal experimentation, such as auditioning Gerald Balzano’s diatonic scales in an equal tempered 20-note scale (C20) based on group theory [2].

3.5. Other Gestures and Mappings

The accelerometer and vertical movement within each button has also been tested with mappings to velocity, filter frequency, pink noise, and other simple effects. Visual feedback for accelerometer effects is provided with an animated background that slides around based on the tilting.

The multi-touch gesture of pulling and pinching together chords horizontally has also been mapped to invert the chord up and down. This allows for chords to be formed in root position, followed by inversion into other voicings without lifting one’s fingers. The current design is simple and simply takes the lowest note and moves it up to the next octave for inverting up, and the highest note and moving it to the lower octave for inverting down. Future algorithms have been planned involving more logic and counterpoint considerations.

4. PRACTICAL USAGE AND OBSERVATIONS

4.1 Teaching Jazz II-V-I and Tritone Substitution

One of the first steps taken after completing the basic application was learning a simple jazz II-V-I progression in root position and in the default space. This could be done much faster with the application and learning three shapes (see Figure 3), than learning the chords in all keys on the keyboard. Coltrane-like progressions of transposing by major thirds can be easily accomplished by sliding the same chord vertically.

![Figure 3. II-V-I progression, Major 7th chord, Minor 7th chord and Dominant 7th chord](image3)

Tritone substitution can also be very easily taught, as the user can graphically see the shared notes, as well as recognize the tritone as two notes away horizontally. In Figure 3, one can take the V chord, a dominant 7th, and transpose it a tritone away (two minor thirds to the right), forming a dominant 7th with C, E, G and A#. One can graphically see that this chord shares the same notes as the previous: A# and E, a tritone away.

Inversions can be found by using the colours to find the same notes in other octaves across the space. The multi-touch gesture of pulling the notes outward or pushing them inward has also been designed to invert the chord for auditioning inversions.

![Figure 4. Harmonic minor as minor triad with row of diminished notes](image4)

Harmonic minor can be elegantly and easily remembered and expressed in the 3:4 pitch-space as a minor triad with a row of diminished intervals above and below it.

4.2 Latency

Prior to iOS 4.2, external instruments were driven by OSC with a Max MSP script to route the OSC to MIDI supported synthesizers. This caused an amount of latency that made the playing of notes over beat music difficult. The internal synthesizer was then designed to minimize latency with a simple band limited saw-tooth wave followed by a low-pass filter with saturation and enveloping. This allowed for a small 256-size buffer
with no drop-outs at ten voices. Another reason for poor rhythmic performance other than latency was theorized to be due to the lack of haptic feedback [7]. Studies have shown that touch-screen based instruments with no haptic feedback can be disadvantageous to rhythmic performance. Solutions were sought such as a VST plug-in for live quantization to any division of the bar, which has been released to the beat production community for rhythm manipulation.

With iOS 4.2, MIDI could be sent through a Camera Kit and USB interface, improving the latency of triggering external instruments greatly. Despite lack of haptic feedback, the improvement in latency allowed rhythmic performance over beat music with heavy swing to be accomplished. It was determined that wires are not so bad after all, especially compared to wireless, a technological principle in Perry Cook’s Principles for Designing Computer Music Controllers [6].

4.3 Use for Supplementing DJ Performances
MIDI notes of chords from pre-existing tracks were exported and positioned to run along the audio in the author’s DJ and beat performance. This allowed for the harmonic content of each track to be visually displayed in the pitch space, allowing for improvisation with an awareness of harmony, similar to that of a score, but easier to understand with consistent isomorphic distances. Due to the difficulty of contrapuntal motion in the 3:4 pitch-space, improvising melodies was very difficult, but recognizing the far diagonal as major seconds was very helpful. The user can dynamically switch into other spaces such as 2:5, which makes pentatonic scale notes adjacent and easily accessible, or 1:5 for those familiar with bass guitar.

5. CONCLUSION
The design and playing of this application has been very rewarding for the author, allowing for rapid understanding of concepts in music theory. Untrained musicians and DJs have also been successfully taught to play much more complex progressions and modulate more freely. The 3:4 pitch-space with colouring scheme along the circle of fifths described in this paper is very suitable for education of tonal music. This application can be useful as not only an instrument, but as a supplementary visualization device for keyboards.

6. ACKNOWLEDGEMENTS
The author would like to acknowledge Gerald Balzano for his work in pitch spaces and C12, Tom Erbe for help in optimizing code, David Wexler for help with graphics and Steve Ellison for suggestions on visual feedback and testing.

7. REFERENCES