Performing Easley Blackwood's *Twelve Microtonal Etudes*: An Open-Source Software Development Project

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Abstract. This paper outlines an open-source development project dedicated to the performance of microtonal music, specifically Easley Blackwood's *Twelve Microtonal Etudes* (1980). Despite the piece's fixed format, Blackwood stated a specific desire to have the work performed live. This project incorporates multiple elements to this effect, including a standalone software synthesizer and a web application. The paper details prior efforts for microtonal performance on traditional keyboard instruments by Joel Mandelbum and Robert Hasegawa, describes the emergent issues inherent in such endeavors to translate between standard performance practices and microtonal tunings, and proposes methods that will allow for the accurate and easily replicable performance of Blackwood's etudes. The software synthesizer, proposed as a pedagogical design project for computer science students at the University of Central Florida, is currently under active development. The web application, available at the project website, includes source code and documentation for the use of future development teams.

Keywords: Microtonal · Equal temperament · Easley Blackwood · Performance · Keyboard · Gesture

1 Introduction

Easley Blackwood's *Twelve Microtonal Etudes* (1980) [1] are a unique case in the world of electronic music. The pieces, each in a different equal-tempered tuning, were created as a fixed-format collection, performed and recorded by Blackwood on the Polyfusion Series 2000 Synthesizer between March 1979 and July 1980, but unlike most works in this genre, the pieces also subsist in a printed score published in 1982 [2], offering analysts an opportunity to investigate with relative confidence the novel harmonic structures that Blackwood composed. Upon the rerelease of the recordings for a 1994 album, Blackwood noted his desire to hear new interpretations of the work by other performers [3]; his prefatory notes to the score indicate the same sentiment but also warn of the difficulties of the task since the pieces are not performable on standard instruments. While occasional arrangements of the collection have appeared over the years, the full work has seemingly never received a live performance despite having a complete score dedicated

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to this task. Blackwood provides a roadmap for the performance of these works, but he does not include a detailed set of directions or instructions that can lead us to a satisfying destination.

This situation creates a remarkable circumstance for Blackwood's work since it is, at once, a static entity in its original fixed form and a potential space for dynamic interpretation. The problems with such an enterprise are well known. The musical score itself is not easily performable due to a lack of available microtonal instruments; neither is the music simple to arrange with its unorthodox set of accidentals (see Fig. 1). Additionally, finding an adequate number of performers who are willing and able to learn such complex notation schemes is a significant undertaking. The current project sets out to resolve the performance issues of this work through a multifaceted strategy involving musical analysis, gestural interpretation, and software development. The aim is to create a procedure for the performance of these works that is not only functional but also able to be easily replicated. To this goal, the project is completely open-source from the outset.

Fig. 1. Easley Blackwood, *Twelve Microtonal Etudes*, "21 Notes," mm. 1–6

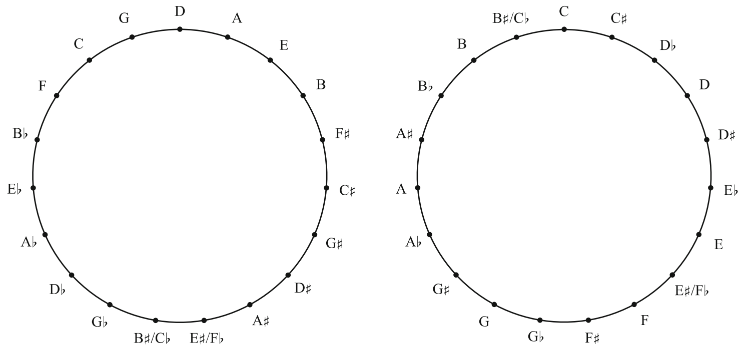
This paper offers a set of first steps toward this goal. We will first outline some other microtonal performance practices that align with Blackwood's vision. These methods can serve as inspiration for the project's efforts. We will then detail the parts of the current project that are required to achieve a full performance of Blackwood's etudes, focusing on two applications: a software synthesizer that provides native support for equal-tempered microtonal playback and MIDI keyboard mapping and a web application that replicates some of this functionality for a general audience. Through these development elements, we intend to produce a full performance of Blackwood's etudes, living up to his stated aspirations for the work.

2 Examining Some Keyboard Mappings for Microtonal Music

While keyboards with hexagonal layouts (such as the MicroZone from Starr Labs or the novel Lumatone devised by Siemen Terpstra) have received a great deal of support in recent years due to their accommodation of microtonal scales and tunings, the cost and unconventionality of these instruments leaves little opportunity for their widespread use among performing keyboardists. Notably, the Polyfusion synthesizer used for Blackwood's etude recordings is not a dedicated instrument for microtonal performance—it uses a four-octave keyboard with a traditional twelve-tone organization—but its size, complicated design, and rarity make it an uncommon instrument for most keyboard players to have on hand. The traditional keyboard allowed Blackwood to use standard gestures that would have been natural to him as a concert pianist, but it also required a translation of the non-twelve-tone tunings into the common twelve-tone layout. The etudes, composed in equal temperaments using between thirteen and twenty-four notes per octave, necessitate a keyboard mapping that either (a) denies gestural octave equivalence by using a one-to-one correspondence of notes to keys or (b) leaves out certain notes of a tuning to maintain a sense of commonality with standard twelve-tone orientations. The choice is between having an unfamiliar note layout (and therefore unfamiliar gestures) or not having all the notes immediately available without changing the mapping. While the first of these options may seem to be a reasonable compromise since it would allow performance of fully "chromatic" music in any of the equal temperaments under consideration, the latter option, leaving out some notes to preserve gestural practices (and some basic intervallic relationships) has a rich tradition in the performance practice of microtonal music. To examine this practice more closely, I'd like to consider two pieces written for traditional keyboards tuned in nineteen-tone equal temperament.

Arranging nineteen tones with roughly even distribution within a single octave has been practiced at least since Guillaume Costeley's experiments in the sixteenth century [4]. Figure 2 provides the most common notation scheme for this tuning, represented as a circle of perfect fifths and as a nineteen-tone chromatic pitch-class circle. Note that the perfect fifth in this tuning is roughly 695 cents and the chromatic step interval roughly 63 cents. These constructive intervals cause a number of notes to lie "between the cracks" of pitch perception when attempting to perform in a given key or a traditional scale. Additionally, as discussed by Julian Hook [5], among others, the notation of nineteen-tone equal temperament does not follow the canonical enharmonic equivalence relation of twelve-tone equal temperament. For instance, the note names "C-sharp" and "D-flat" refer to different pitch classes in this system while still having functions similar to their counterparts in twelve-tone tuning. Table 1 provides basic tuning information (given in approximate cent values rounded to the nearest whole number) for a single octave of nineteen-tone equal temperament.

A number of modern compositions make use of this notation scheme, adapting the tuning for use on traditional keyboard layouts. Joel Mandelbaum's 1961 collection of *Nine Preludes for Two Pianos in 19-Tone Equal Temperament* [6] uses retuned twelve-note keyboards that share the set of frequencies assigned to the black keys, the F-sharp major pentatonic collection, but the pianos utilize different tunings for the white keys. Figure 3 provides Mandelbaum's mapping and notation scheme for two pianos in nineteen-tone equal temperament, displaying the notes on the nineteen-tone pitch-class circle and how they are oriented on the two keyboards. Notably, both pianos use a maximally even distribution of twelve notes in the nineteen-tone space, ensuring the closest possible approximation to twelve-tone equal temperament. This circumstance



(a) (b)

Fig. 2. The circle of fifths and the chromatic pitch-class circle for nineteen-tone tuning

Table 1. Notation and tuning of nineteen-tone equal temperament

Pitch class	Note name	Cents from C (approximate)
0	C-natural	0
1	C-sharp/D-double-flat	63
2	C-double-sharp/D-flat	126
3	D-natural	189
4	D-sharp/E-double-flat	253
5	D-double-sharp/E-flat	316
6	E-natural	379
7	E-sharp/F-flat	442
8	F-natural	505
9	F-sharp/G-double-flat	568
10	F-double-sharp/G-flat	632
11	G-natural	695
12	G-sharp/A-double-flat	758
13	G-double-sharp/A-flat	821
14	A-natural	884
15	A-sharp/B-double-flat	947
16	A-double-sharp/B-flat	1011
17	B-natural	1074
18	B-sharp/C-flat	1137

suits Mandelbaum's compositional choices quite well, especially for his sixth prelude which explores twelve-tone serialism in the nineteen-tone tuning. However, the unusual note names for the white keys of Piano II may cause some unwanted performance issues as a pianist would have to retrain certain associations when reading the music. The gestural motions of the pianist using this mapping are likely to be similar to those of traditional performance practice due to the maximally even distribution, but the process of learning the piece with such an unfamiliar notation scheme could prove laborious (or could at least cause an unnecessary difficulty).

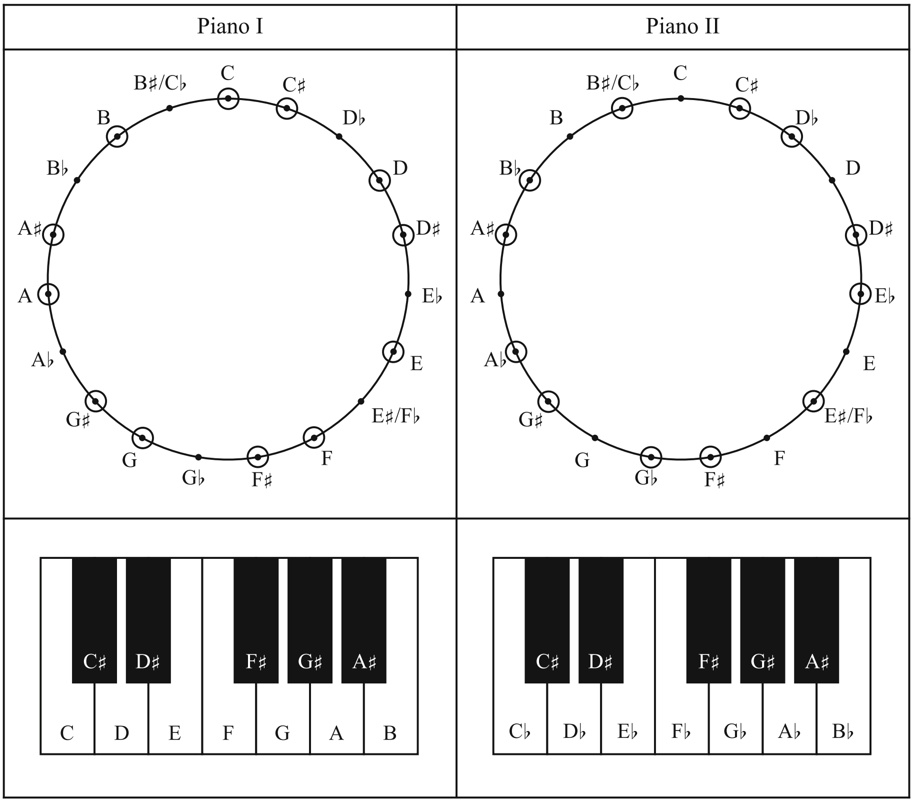


Fig. 3. Mandelbaum's mapping for two pianos in nineteen-tone equal temperament

The mapping used in Robert Hasegawa's *Due Corde* [7], while quite similar, rectifies the atypical note-name-to-key associations from Mandelbaum. Figure 4 provides Hasegawa's mapping for two pianos in nineteen-tone equal temperament, introduced to him by Jon Wild. This piece not only uses a maximally even distribution of notes for both pianos but also maintains traditional associations between notes and keys for both pianos. The notes of Piano I are the same chosen by Mandelbaum, but Piano II aligns the flat note names with their traditionally corresponding keys. The pianos share the notes of the F major pentatonic. This mapping allows for both easy readability and familiar gestures when offering the work to a performer, alleviating many of the performance issues that arise when dealing with microtonal music.

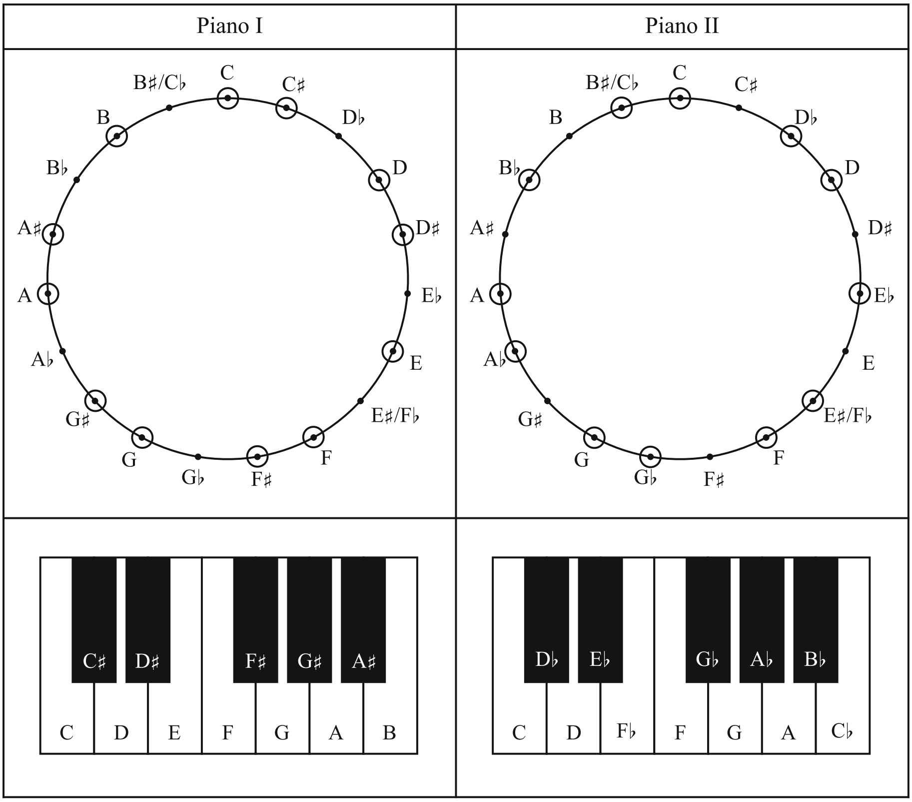


Fig. 4. Hasegawa's (and Wild's) mapping for two pianos in nineteen-tone equal temperament

From this brief examination of tuning practices for nineteen-tone microtonal music, it seems that a successful mapping requires both readability and gestural familiarity to promote easy performance. Applying this concept to Blackwood's etudes is slightly more involved due to the number of different tunings, the complications of his notation, and the sheer scope of the work, but these mappings by Mandelbaum and Hasegawa highlight some of the steps that need to be taken in order to achieve this feat.

3 An Open-Source Project for Microtonal Music Software

The current development project takes a multifaceted approach to resolving these issues of performing Blackwood's works. The project will ultimately include three novel elements: (1) an open-source, cross-platform softsynth that allows for front-end remapping of MIDI keyboard input, (2) a score that translates chosen mappings to traditional notation for ease of reading and reproduction, and (3) an online application for practice and demonstration during the rehearsal and development process. This section briefly outlines the first two elements before detailing completed work on the final element.

The first of these elements, a software synthesizer capable of microtonal output and MIDI keyboard remapping, will be the first point of contact for performers, so the main concerns for its development are ease of use and functionality. The program itself was proposed as a pedagogical design project for senior Computer Science majors at the University of Central Florida. The program (see Fig. 5) requests a base frequency (in Hz) and the cardinality of the tuning (the number of notes per octave) to generate a single octave of frequencies, which can then be mapped to a keyboard representation. Mappings and parameters are fully adjustable in a popup window. The program includes multiple oscillators to generate instrument sounds that replicate Blackwood's timbres (which are also fully adjustable for fine tuning), allowing the program to bypass compatibility issues with virtual studio technologies and digital audio workstations. The key mappings can be customized through nodes and lines drawn between frequencies and keys and can also be saved for future use. While these remapping, tuning, and generation abilities exist in prior efforts, they are often split between programs. This open-source endeavor combines and simplifies these functionalities for an easily replicable performance practice.

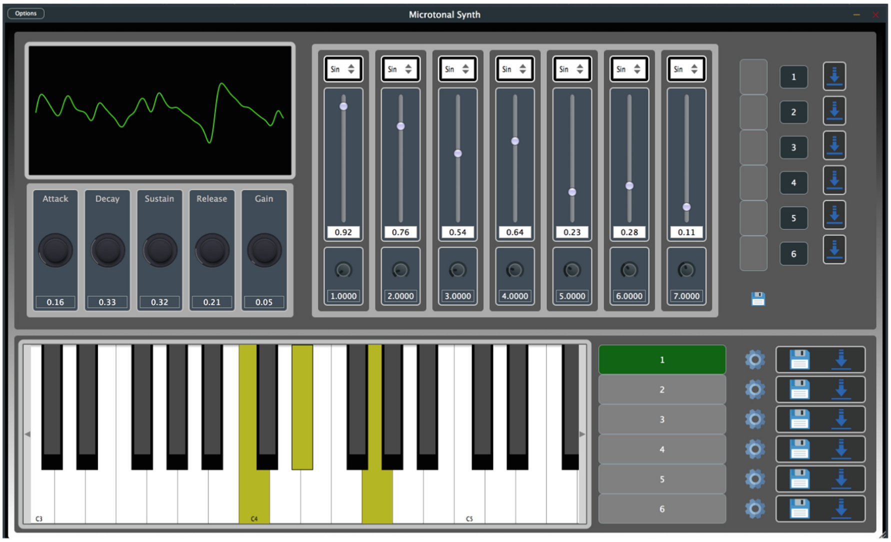


Fig. 5. User interface for a software synthesizer capable of microtonal output and MIDI keyboard remapping

The second element of this project, a reworked score that provides traditional notation and instructions for performers, introduces some interesting difficulties that are worth mentioning here. The purpose of this element is to offer an easy method for trained pianists to recreate the musical output while avoiding the difficulties of learning a completely new system of musical notation. Since Blackwood's general attitude toward composition with microtonal tunings is to incorporate elements of tonal structure [8], his score allows for preset mappings of the synthesizer program that utilize maximally even distributions of notes in most cases, much like Mandelbaum's and Hasegawa's mappings, which would provide (at least nominally) a sense of gestural simplicity or familiarity. Therefore, the only choices to be made are how to organize Blackwood's voices, only a single musical line each, into performable keyboard parts that contain associated material fitting into a single mapping. There are moments, as in the second theme of the etude "19 Notes," where distributions are far more chromatic in nature, as mentioned by Hook [5] in his examination of the piece. From the density of notes in the score, the piece is conceivably performable by only four keyboard players, but moments of dense chromaticism problematize the organization of players and potentially require adjustments to this number.

The final element of this project is crucial to early stage demonstration and for the purposes of executing and testing mapping possibilities and gestural ideas for score and part production. The novel online application for this project replicates basic design elements of the softsynth, including microtonal mapping (see Fig. 6), but allows anyone with a web browser to test out microtonal keyboard mappings and their effect on gestural performance. The browser application allows users to set a reference frequency, the number of notes within one octave of the chosen tuning, and the basic wave type (sine, square, triangle, or some other synthesized options). While the application removes some levels of flexibility due to the web format, specifically the adjustable instrument sounds, it provides plug-and-play ability with a MIDI keyboard through the Web MIDI API [9], meaning that anyone who loads the page with a keyboard plugged into their computer can control the output exactly as the standalone program would. Without a MIDI device, users can still type on the computer keyboard or click on the screen to activate notes and test sound combinations. The ultimate goal of this application is to test arrangement options for Blackwood's piece and to offer an introduction to interested performers and organizers. Further information about the application, including all source code and documentation, is available at the project website [10].

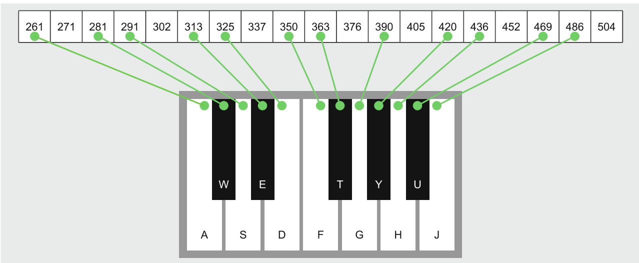


Fig. 6. Portion of the user interface for a web application capable of microtonal output and MIDI keyboard remapping

4 Conclusion

This project is in the first year of a three-year development schedule, including time for score/part production, fine tuning/debugging, and rehearsal/implementation. Progress thus far has produced a functional standalone program, a web application, and extensive documentation for potential adaptations by future teams. Notably, many sections of Blackwood's score (including the opening of the etude in nineteen-tone equal temperament) can be reproduced reliably by the web application in its current state, allowing effective demonstrations of the project's potential. Our goal is to produce a full performance of the work that can be reproduced with minimal effort, using a single cross-platform application with an associated score that requires little in terms of preparation beyond rehearsal. The hope is to live up to Blackwood's stated desire to replicate his music in a live format.

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