THE ROSEGARDEN CODICIL: REHEARSING MUSIC IN NINETEEN-TONE EQUAL TEMPERAMENT

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ABSTRACT

The subject of this paper is microtonal tuning and a project which has developed several technologically-assisted methods of rehearsing live performance of music based on one particular microtonal scale (19-tone equal temperament). The open-source Rosegarden sequencer is enhanced with performance metrical capabilities which are designed to be able to cope with pitch classes of arbitrary scales. A rehearsal session and performance of three original one-minute songs written in 19-ET is incorporated in the demonstration.

1. INTRODUCTION

The composer's wish to explore the expressive possibilities of such alternative tuning systems in live performance situations not involving instruments of mechanically determined intonation (keyboards, fretted instruments etc.) presents new challenges to singers and wind players who, even at the highest level, may have limited experience with microtonality. Through the extension of a powerful piece of existing open-source software, the Rosegarden sequencer, a rehearsal aid has been developed which is highly accessible to expert musicians and sufficiently flexible to handle many different microtonal scales. We call it the Rosegarden Codicil : a mildly tongue-in-cheek adoption of the legal term for an addition or supplement that explains, modifies, or revokes a will or part of one (from the Latin *codicillus*, 'little book'). The software modifies standard MIDI-based sequencer code, so as to overcome the tuning limitations of most such programmes, imposed by their adoption of MIDI as an internal structural template (which means that they are able only to deal with standard 12–ET notation, and that badly). Using this software, we attempt to explain how singers might approach microtonal scales in a way which links up with their existing musical skills and to revoke the idea that microtonality is accessible only to specialists or those obsessed with microtonal theory.

2. MUSICAL BACKGROUND

The following quote from critic Meirion Bowen, writing nearly 40 years ago about Harry Partch's settings of texts from the Chinese and the Hebrew, suggests some aesthetic and expressive reasons for his interest in microtonal tuning. Although Partch deploys microtonal accompanying instruments, it is above all the voice, the vocal line and the declamation of the text which is the centre of attention.

> In his musical treatment of the *Seventeen Lyrics by Li-Po* (1931-33), Partch brought new life to the words in ways that do not unhinge them from their ancient origin. So, too, with his setting of *Psalm 137, By the rivers of Babylon* (1931): the wailing voice-intonation lends an age-old, timeless quality to the lament, enhanced by comparable sounds from the instrumental accompaniment of chromelodeon, kithara, and adapted viola. [1]

These are by no means the only possible aesthetic and technical reasons for adopting microtonal tuning, but certainly something of the same general intentions drove the compositional aspect this project: a search for the technical means of enabling texts from remote times, places, languages or modes of utterance to find expression through the musical language of the twenty-first century and contemporary vocal performance practice. The specific intentions were however quite different from the restraint and austerity of Partch: a search for a musical language to reflect something of the ecstatic Islamic mysticism of various couplets from the celebrated fourteenth-century Turkish sufi poet Yunus Emre in the English translations of Süha Faiz [3].

Three of these couplets provided the text for Hair's composition Three Microtonal Songs: *Wine, Ash and Dance* – for soprano, clarinet and harmonium – the 'test piece' performed by Amanda Morrison and clarinettist Ingrid Pearson. The technical intentions were different too, as we used equal temperament, not just intonation.

3. TECHNOLOGICAL SUPPORT

Rosegarden is a sophisticated sequencer with high quality music typesetting available as a bonus. It is written for the GNU/Linux operating system and is therefore portable across a large number of hardware platforms. It comprises some quarter of a million lines of source code. The main developers are active and, more importantly, available, which is rarely, if ever, the case with proprietary software. The possibility of communicating with the developer directly is particularly important when changes are being considered to such an extensive and complex application.

Three rehearsal devices based on Rosegarden were implemented for this project in the first instance:

1. the capacity to play 19–ET sing-along recordings from a computer;
2. 19–ET *scordatura* keyboard which enables the singer to check her intonation of a melody drawn from the 19–ET scale on a USB MIDI keyboard designed to play 12–ET melodies, and which also enables an accompaniment containing 19-ET harmonies supporting the musicians' intonation to be played; and
3. a pitch-tracker (the Rosegarden Codicil), which 'listens' to the musicains' performances, and provides on-screen feedback on how they're doing, either in real time or as a post hoc comparison of a recorded audio track with the score.

Additional devices are being added at the suggestions of the performers.

Like most MIDI sequencers, Rosegarden's internal representation is highly dependent on the MIDI standard. MIDI pitch is encoded as an integer in the range 0–127 representing performance pitch, with no information regarding the enharmonic spelling of a note. To support notation within Rosegarden, MIDI pitch is augmented by an optional accidental, which allows the user to specify how a note should be notated on a conventional staff. Real-time performance is a *sine qua non* for a sequencer program, so one of the basic design principles set out by the Rosegarden development team is that information should be represented in a way that makes the music near trivial for the sequencer to play. Consequently, any changes had to be made within the existing representation, especially if they were to be adopted by the development team into the mainstream release of the Rosegarden package. Within this framework, it was indeed possible to extend Rosegarden to accommodate microtonal accidentals, and modify the graphical classes to display these notes accordingly on the staff. During playback, the MIDI pitch and accidental of the current note are translated into an enharmonic spelling. The tuning system indicates which pitch this spelling represents and calculates the target frequency. The concept of a tuning system has been added to facilitate the translation of the standardised enharmonic representation into the target frequency. Commands to change tuning systems can be embedded within the score, so that the flexibility of microtonal representation is sufficient to accommodate any future extension.

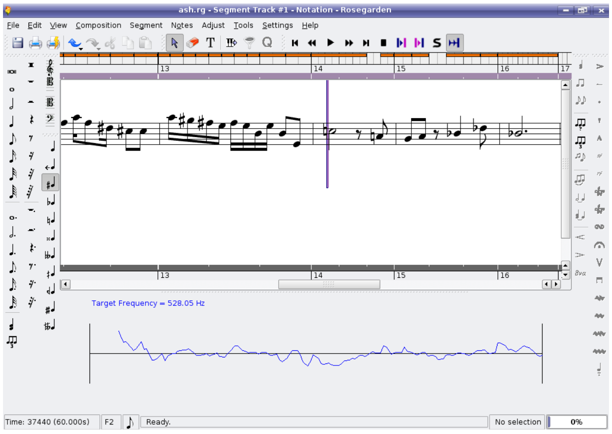
The process by which the performer maintains pitch is analogous to a closed control loop. The musician adjusts the performed frequency according to instantaneous feedback. In a normal situation the musician's auditory system provides this feedback with perceptually no latency. In the rehearsal situation, the musician is relying on the feedback provided by the pitch tracker since she is not trained to recognise 19–ET intervals. Unlike a recording situation where it is essential to capture every sample of data, this is a hard realtime application dependent on the currency of the data it processes. Loss of samples is preferable to the introduction of latency. A data capture thread copies samples into a ring-buffer which holds sufficient to provide a complete frame for the pitch tracker. Each new sample is written over the oldest sample, so when the pitch tracker requires data, the capture process can immediately provide a window stretching backwards from the current instant. To achieve this, the pitch tracker uses the Jack Audio Connection Kit (JACK). This is a high-performance, low latency audio server for Linux/Macintosh OS X which is also used for audio routing by Rosegarden.

4. VOCAL PITCH TRACKING

The pitch-tracking class uses a choice of algorithms to provide a high-resolution estimate of the fundamental frequency of harmonic complex tones. It comprises two stages: a low-resolution search for the fundamental frequency followed by a high resolution localisation of the fundamental component.

Alternative methods have been implemented in the first stage. The first, autocorrelation, is one of the most widely used methods of fundamental frequency estimation. It provides a measure of the periodicity of the signal by comparing the signal with a time-shifted copy of itself. It is capable of detecting the fundamental frequency even if that particular frequency component is missing from the signal. The alternative Harmonic Product Spectrum or HPS (Schroeder 1968) method searches for a harmonic pattern within the spectrum of the signal. When the frequency axis of the power spectrum is downsampled by an integer factor n, the nth harmonic aligns with the position of the fundamental. The product of these spectra provides the HPS. Repeated multiplication has the effect of exaggerating the fundamental while at the same time attenuating other partials.

A common error made by pitch trackers[4] is to misjudge the fundamental frequency by an octave. In the case where both algorithms are making octave errors, an option exists to make the comparison between target and performed frequency independent of octave differences.



User interface screen-shot of the Rosegarden Codicil microtonal rehearsal tool. The line represents deviation from "expected pitch" and vertical lines on the pitch-time graph denote note onsets in the score.

Once an estimation for the fundamental frequency has been obtained through one of the above methods, a high-resolution estimate is obtained using phase vocoding[2] coupled with a phase-unwrapping technique. This uses the phase difference between the same bin in two successive FFT frames to detect the frequency of the partial contained in the bin with greater accuracy, based on the assumption that no more than one partial occupies each analysis bin using Portnoff's algorithm[6].

Because all of these methods are obtained using the Fourier transform, the data from the first stage of processing can be reused in the second.

5. REHEARSING

As the Codicil is intended for real-time use, the user interface required that the score and feedback be displayed simultaneously. Also, the feedback should be clear and obvious so that it can be analysed while reading the score. To achieve this, the pitch view is positioned in a resizable panel beneath the score view. The feedback is displayed as a moving graph plotting the deviation from the target frequency in cents. Markers traverse the graph when a note on/off occurs to assist in following the score and to mark the transient effects which occur at these points. By scrolling backwards and forwards through the score, it is possible to review pitch accuracy after the practice session.

The 19–ET keyboard part is realised by re-mapping the MIDI pitch values from a normal controller. Performers play from *scordatura* notation, so that what they see on the page indicates where to place their fingers rather than the sounds which would normally emerge if the keyboard retained its normal 12–ET tuning. Performing on such an 'ill-tempered' keyboard might be thought to be somewhat confusing, but clearly better than expecting players to work out where the 19–ET note lies on the modified 12–ET instrument from notation which indicates the desired sound.

This demo will conclude with a performance of the 3 songs.

6. REFERENCES

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