An Algorithmic Approach to Composing for Flexible Intonation Ensembles

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Abstract

The paper details a compositional approach intended to create music that facilitates the 'natural' intonation practices of ensembles with flexible-intonation capabilities. The approach is based on the representation of tetrachords as objects that are sequenced to create a homophonic sub-structure, or harmonic rhythm, for the piece. In terms of aesthetic concerns this paper examines the flexible intonation potential facilitated by these ensembles and explores this approach in the context of historical and contemporary tuning theory.

1 Introduction

This compositional process is based on an object-oriented representation of tetrachords and its object-oriented algorithm is implemented for the purpose of tonal organization. This object-oriented representation was realised in a program entitled *SoundObjects*. *SoundObjects* generates a sequence of tetrachords through the implementation of its Tetrachord class. The member variables of the objects store the information that governs the construction of the tetrachord by defining the pitch-class set, fine-tuning, and rhythmic durations. The fine-tuning variable holds the amount of the deviation in cents between the equal-tempered version of each interval and the tuning of the ratios found in the harmonic series.

The rules governing the sequencing of the tetrachords are determined, in part, in the methods of these objects. These methods, or functions, combine with additional logic in the *SoundObjects* program to determine how the tetrachord objects interact to produce a series of pitches and their durations, which in turn provides the basic homophonic sub-structure of the piece. While the character and pacing of the harmonic rhythm is determined, the rules for the realisation of the tetrachord sequence into a piece are not stipulated, thus pitch and rhythmic material remain freely composed.

2 Temperament

So entrenched is equal temperament in our musical culture that many people, musicians and otherwise, are ignorant of the vast number of historic temperaments – not to mention unique contemporary microtonal systems.[1] In particular, the Renaissance and early Baroque periods offer a rich array of temperaments. The dominance of equal temperament subsequent to these periods has all but obliterated the understanding of these systems in contemporary musical culture. The popularity of the piano in the past few hundred years has been perhaps the major factor in cultivating this situation. The success of equal temperament can be attributed to the fact that it is a compromise that allows modulation to all keys while also allowing the piano to play "in tune" in all keys. The irony here is that vocalist and instrumentalists on non-fixed intonation instruments spend as much of their time, at least when not playing with fixed intonation instruments, playing in some form of pure intonation as they did hundreds of years ago. In this age of computer music, musicians are finally able to work with non-fixed temperament comfortably and effectively.[2] Despite the current dominance of Equal Temperament, vocalists and instrumentalists on instruments with flexible intonation revert to playing in some form of 'natural' intonation when not playing with fixed intonation instruments.

In an attempt to avoid the undue complications that would arise from writing the precise tunings into the score the performers are requested to focus on attaining pure sonorities and re-orienting their sense of tonal centre during the sustained sonorities of the instances of the prescribed tetrachord sequence. Although this is not an exact implementation of Pythagorean or five-limit Just Intonation the resulting tunings do adhere quite closely to a non-tempered system on account of the tendency of

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[1] See Barbour's *Tuning and Temperament: A Historical Survey.* and Lloyd and Boyle's *Intervals, Scales and Temperaments.*for a more detailed discussion.

[2] For a detailed survey of recreations with synthesizers see Wilkinson's *Tuning In: Microtonality in Electronic Music*.

vocalists/instrumentalists to perform the interval with 'natural' intonation.[3]

3 Compositional Algorithm

Tetrachord Class Definition

```
class Tetrachord{
private:
        int notes[4];
        int retune[4];
        char rhythmic_dur[4];
public:
        bool used = FALSE;
public:

        Tetrachord(int num);
        populate_notes(int num);
        populate_retune(int num);
        populate_rhythm(int num);
        ret_values(int *note);
        mark_used();
}
```

Each instance of the Tetrachord class represents a potential tetrachord for use in the composition through the specification of its pitch-classes, durations, and fine-tuning properties. All possible tetrachords containing only those pitch-classes found in the scale chosen for use in the composition were identified; each of these tetrachords was then represented by one and only one instance of the Tetrachord class. The Tetrachord class member variables include the 'notes' array, the values in which are determined by the included pitch-classes of the tetrachord while the order of the elements is determined by the order in which the included pitch-classes occur in the tetrachord, e.g. the first, and lowest, pitch-class is 'notes[0]', the second pitch-class is 'notes[1]', etc. To the extent that the voice/instrument to which the pitch-class is assigned limits it, the order of the elements assigns the registral order of the pitch-classes in the first tetrachord of the piece, the order in the remaining tetrachords is determined by either the continuation of a common pitches or by movement to the closest available pitch. The fine-tuning[4] is determined in relation to the bass-note of the tetrachord ('notes[0]') using five-limit ratios.

The tuning of each instance of a pitch-class is dependant on the bass-note of the tetrachord in which it occurs. Thus the tuning of a pitch-class is only consistent when it occurs in tetrachords with the same bass-note or when the intervallic difference between the pitch-class and bass-note is one that maintains a level of consistency between ratios.[5]

The deviations, in cents, from the equal-tempered tuning of the note are stored in the 'retune' array. Ultimately, the 'retune' array became superfluous as it was decided during the compositional process that the specification of tunings in terms of cents for each tetrachord pitch-class was likely to cause the players undue confusion. Instead the players are instructed tune on the fly to the bass-note, with the hope that the 'natural' tendencies of the players to gravitate towards pure ratio tunings will prevail.

The rhythmic durations were selected, in order, from a numerological sequence containing sets of numbers representing the length in sixteenth notes of each note in the tetrachord. In this process, sets of four durations were determined by selecting those occurring in prime number locations from a series of the first twelve primes. This data is stored in the 'rhythmic_dur' array. The rhythmic durations are based on prime numbers in order to obscure any sense of regular meter. The length of each tetrachord section is determined by the longest duration, a process that subverts any uniform bar divisions the ear may try to impose.

The freely composed material between instances of the tetrachords was composed with no preconceived rules governing its creation. The only consistent overriding consideration was the function of the material to move from the starting pitch-class given by the previous tetrachord to the pitch-class prescribed by the next one. The voice/instrument assigned the tetrachord pitch-class with the shortest duration carries a melody line through to the next tetrachord. The other two voices/instruments play either counter-melodies or rests, depending on the amount of time between the end of their tetrachord pitch-classes and the beginning of the next tetrachord.

A Boolean member variable, 'used', was included in the class to flag whether the particular instance had been used or not. The rules for the sequence require two common pitch-classes between instances, but a pitch-class cannot occur in more than two instances in a row. In an implementation of this sequence the piece ends when there are no unused instances of the class left to progress to.

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[3] Which form of 'natural' intonation the players revert to is subject to some debate. The theory that instrumentalists gravitate towards Just thirds was first purported by Helmholtz (*On the Sensation of Tone* p. 324-5) however acoustic analysis done during the 1960s (Barber, J. *Acoustical Foundations of Music* p. 131-2) indicated that instrumentalists tend towards Pythagorean thirds. Ultimately this is something of a non-issue as the intended aim is to create a piece in which the instrumentalists tend towards a 'natural' tuning, whichever one that may be.

[4] This fine-tuning array was not actually used in the creation of the acoustic pieces, rather, as discussed below, the exact intonation was left to the player.

[5] For instance there would be consistency between the G a perfect fifth above C and the G a perfect fourth above D this consistency can be explained by nature of the fact that all of these ratios (3:2 between G and C, 4:3 between G and D, and 9:8 between D and C) are three-limit but if you were to take the pitch-class E when it is calculated as a 5/4 above C rather than as a 9/8 ratio above D the latter is twenty-two cents sharper.

3   *deMusica*

The choral work *deMusica* was composed within this system and is based on the pitch-classes contained in the eight-note scale C-D-E-F sharp-G-A-B flat-B; this scale contains all the pitch-classes that occur in the first sixteen partials of the harmonic series.

The aesthetic effect of the compositions is defined by a number of factors: First, the object-oriented approach produces compositions without an overriding identifiable tonal centre. Second, the pitch-classes available in the eight-note scale provides impressions of both the Lydian and 'acoustic' modal scales. Third, combined effect of the homophonic texture created by the occurrences of the tetrachords and the melodic, often contrapuntal, nature of the freely composed material produces a texture in which the sustained tetrachords, ostensibly the occurrences of pure sonorities, are emphasized.

The twelve-part choir was divided in four groups; soprano, alto, tenor, and bass, with three voices assigned to each grouping. The division of the choir into four allowed equal assignment of pitches from the Tetrachord class. In order to exploit the greater textural potential offered through the existence of multiple voices while still maintaining the integrity of the homophonic substructure there were, within each group, offsets of either an eighth or a quarter note.

The text is from the chapter titles of *De institutione musica, liber I,* Boethius' treatise summarising Greek musical thought and philosophy, particularly the link between music and nature. The text intentionally becomes obscured through the placement of the syllables, serving only to provide a syllable for the singer to articulate rather than to create a sense of meaning, the possibility of which is made more remote by the use of a Latin text, a language aurally unfamiliar to many people.

Conclusions and Future Work

The algorithm developed for this composition process succeeded in producing works that allowed the performers the opportunity to reflect closely on intonation issues. The main challenge that arose during the process was in attempting to produce intonationally accurate digital re-creations of the works. The re-creations required extensive analysis, calculation, and data entry of the tuning deviations from the equal tempered intervals for each note instance. This problem is not specific to these compositions but common to all works for ensembles made up of instruments with flexible intonation capabilities. It speaks to the need for a more detailed understanding of the intonation practices of these ensembles and an examination of the ways in which these practices could be modeled for digital re-creation purposes.

References

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