MODELING PROCESSES OF MUSICAL INVENTION

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1.0 ABSTRACT AND INTRODUCTION

Unlike the other arts, music is self-modelled, for--except by analogy--its sounds cannot be seen or touched, nor can they be consistently understood as symbols representing anything other than the intangible experiences they evoke. The intangible, its models clear, existing in our minds’ gyali real and valued. Music’s models are its own vast array of musical compositions. The form of a composition is, in fact, fashioned in its own image—it is self-similar—both when the composer works to model an original form and when it is an extrapolation, variation, or equation of pre-existent forms, the composer’s own or other composers. What composers do to invest material for a new piece, then, is to create that piece's modeling process, the working strategy of its creation. In effect, the composer asks, "How will I piece be like itself?" In the present paper, computer-assisted processes are explored and illustrated with musical examples from finished as well as in-progress works, concentrating on those used to model the composer’s intuitive skills in creating, elaborating, and transforming musical material.

1.0 MODELING MELODIC SEQUENCES

2.1 Assumptions and Methods

To create, with a composing algorithm, a melodic sequence derived from an intuitively composed model, we begin with two assumptions:

1) Intuitively composed melodic sequences are good, because they are modeled on the composer’s considerable powers of freely creating, amalgamating and organizing musical materials;

2) Melodic sequences created with a composing algorithm which can create a credible variation of the original, intuitively composed model, are good as well, relative to their believable resemblance to the original sequence.

Based on these assumptions, a method can evolve for writing a program to compute a credible, artificial melody from an original model. The method derives from several approaches:

1) Analysis of intuitive, compositional process;

2) Musical/theoretical analysis of pre-compositional procedures;

3) Empirical experimentation with modeling the analysis of intuitively composed melodies on scientific and/or arbitrary methods just to see what would happen if…

4) Determination, generally, of how melodies behave and applying these characteristics in creating good artificial melodies.

2.2 Testing for Credibility

Assumptions accepted, methods chosen, the program written and running, the test for the credibility of an artificial melody created with a composing algorithm is simple: compare the artificial melody with the original, and see how closely it is derived. Of course, if we know or have even composed—the original melody, chances are that we will want to believe, easy on, that our artificial melody bears reasonable resemblance to the non-artificial original. Our program is deemed successful, but our test is flawed.

If, on the other hand, other hand, we present the original model somewhere in the midst of a series of artificial versions of it, and if the person making the choices is not the composer of the original sequence, our test is considerably more reliable. It follows, of course, that an artificial melody is in the test, the less likely the subject of the test will choose the original by chance, thus, each time the subject of the test derives that a particular artificial melody is, indeed, the authored model, the validity of the composing algorithm is affirmed and strengthened.

206
1987 ICRC Proceedings
In figure 1, six melodic sequences are presented. They are original, intuitively composed model sequences; five are artificial sequences derived by a composing algorithm from the original model. There are three ways to test for and choose the original figure among the artificial: 1) by studying with the eyes the printed notation of the sequences; 2) by actually hearing all six in succession; or 3) by comparing at the same time following thenotated music of the sequences. Slightly different results obtain from all the methods. It is easier, for instance, to fool the subject, it seems, with the aural-only test, since the ears seem to accept, even welcome as natural, subtle rhythmic and intervalic variation. The eyes, in contrast, seem to look for and welcome prominent ordered relationships. We find it difficult to believe, in studying a sequence with our eyes, that a melody would be intuitively composed, if it contained an apparently jumbled succession of irrational times, pitched or silent. Our ears, by comparison, are more apt to accept such a succession quite attractively, even normal. In combination, the eyes and/or the ears prevail in the choice, depending on the subject's methods of cognitive and perceptive analysis.

2.3 An Algorithm for Analysis and Derivation

Of course, in our test here for credibility, the original model sequence was relatively complex, rhythmically. That—along with the method used to derive artificial derivatives—makes it easier to recognize, if you believe in and accept the original model as well as the first place! When the composer of both the original sequence and the process that created the derivative, artificial sequences are one of the same person, the composer/programmer can certainly be expected to be influenced in composing further sequences by what that composer sequence is created artificially by the program. But we can an experienced user of the program be less influenced. That's not only predictable but desirable.

In the present case, the composer/programmer wanted a continuous stream of self-similar melodic sequences, derived from the original model, not developed beyond its elemental properties. A program was written which could be used to generate the original and silent questions in credible succession. Each subsequent artificial sequence would resemble the original model, would limit its properties by the original "character set," determined simply by the number and incidence of individual, successive pairs of pitched and/or silent duration; i.e., notes and rests. Each different note or rest was designated as a distinct member of this melodic/rhythmic character set. In turn, the incidence of each successive pair of notes and rests was tabulated in a "frequency table." This analysis of the sequence yielded a simple table of probabilities; the program would select pair of note/ rests in the sequence. From this frequency table—using only the original melodic/rhythmic character set and only the same number of notes and/or rest pairings—artificial sequences were created based on first-order probability distribution of the elements in the original melodic sequence.
The original, intuitively composed melodic sequence, in Figure 1, is "A". It had a total of 29 pairs of notes/rests, of which 14 were unique members of its character set. 4 of which were repeated once. The repeated character pairs were, of course, twice as probable to occur in the artificial sequence (9% probability), as the singly iterated pairs (4.5% probability).

3) Redundancy through successive iterations of the artificial sequences will create self-similar properties in the continuous, lowering the degree of entropy, provided the original sequence is carefully composed, fairly short, and somewhat redundant itself. The tape part in Austin's Montage typifies this characteristic use (Figure 2).

2.4 Composing Applications

In working with this modeling process, using a large number and variety of intuitively composed models to create generations of artificial offspring, certain aspects are revealed about human processes of musical invention:

1) The original sequence, with its resultant character set and frequency table, serves as a kind of input for improvisation with the computer;

2) Functionally important features of the original can and will be sustained by repetition in the artificial versions;

4) With a much longer and more varied original sequence, the degree of entropy, contrast, and complexity is heightened. The violin part of Montage illustrates this characteristic (Figure 2).

In Figure 2, an excerpt from a segment of violin and tape music from Montage illustrates both high and low degrees of entropy in combination in the musical texture.
3.0 PARSING, TREES, AND SET MANIPULATION

3.1 Text Parsing

Intuitively composed melodies rely on the composer's experience, taste, judgement, frame of mind, and countless other factors and processes, both conscious and unconscious. We will examine the processes that naturally occur during the making of a melody. The initial idea for a melody can spring from any number of sources. The traditional source is 'inspiration', but any other source can be just as meaningful. An example of the latter is a piece of music, in this instance, has been popular in composition. These objects can come from many sources such as other pieces, or natural phenomena. The use of text as a generator of melody has interested composers for centuries. Ugozeph and Josquin were among the earliest practitioners of 'soggetti cavati delle parole', a technique which was reused in different forms by several composers from Bach and Schumann to Reger, Shostakovich and Harris.

To be able to manipulate text is a fundamental operation of computers. Text parsing gives us new ways to practice an old art. The objective would be to convert each character of a given text to its ASCII representation. Further refinements may be the exclusion or conversion of non-alphabetical characters, or the substitution of upper for lower case (and vice versa). Characters can be classified into vowels, consonants, diptongs, phonemes etc.

In the following example (figure 3) the ASCII representation of a sonnet by ducento Sicilian poet Cecco Anghiari is mapped onto both pitch and rhythm.

Figure 3. Mapping the ASCII representation of a sonnet.

Because the original sonnet is structured and organized, each word and it's relation to each other, the resulting melody reflects the same structuring.

3.2 Melodic Variation Modeled on Sorting Trees

Now we have our inspiration. Call it a centus infrata. We want to vary the melody. We shall learn to sort the pitches contained in the melody. There have been many sorting algorithms developed, each achieving the same goal by different means. A melody 'in progress' could be created by observing each section into the ordered structure. The following steps process illustrates how our centus infrata can be varied by insertion into a binary tree.

Subtree of E3

G82
A82
B2
C3
E3
G83
A3
C84
D4

// current pitch tree */
// inserting E3 */
F81
E3

// current pitch tree */
// inserting C83 */
F81
C83
E3

// current pitch tree */
// inserting A83 */
F81
C83
E3
A83

A binary tree is a fortunate data structure for use in creating melodies. Given a centus infrata tree, we can obtain three variations in the ordering of the data. The following process yields preorder, postorder, and inorder traversals of the final tree:

// Final pitch tree */
// inserting A3 */
F81
G82
A82
B2
C3
E3
G83
A3
C84
D4

// Tree preorder */
F81 G82 A82 B2 C3 E3 G83 A3 A83 C84 D4
// tree postorder */
F81 A83 C84 C83 G83 B2 A82 G82 E3 F81

In addition, the tree can be broken into subtrees, the sorting criteria changed, and the tree re-balanced:

1987 ICMC Proceedings 209
3.3 Analysis-based Modelling

Computer algorithms usually produce large amounts of data which must then be interpreted by the composer. The composer compares the output with a database of previous works and variations, and our hypotheses are determined by the composer and may change from piece to piece or even phrase to phrase. Programs can learn these rules and make suggestions that the composer may use or discard.

For instance, we can use set theory as our rule database. The following example is an analysis of a group of 5 pitches extracted from our database. The choice of the number 5 is arbitrary and could be any other set size. The pitches are ordered for comparison with standard sets. After the group is identified as a common subset, other sets are created that are related to the original group. An extension might be to find sets that are related to these sets. Any of the suggested sets may be used as a new database from which variations may be selected. Another program may reorder a set chosen from this database and suggest other orderings after comparison with the original group. For example, as follows:

File: "...I'm not..."
Original pitches: G3$ G#3$ A3$ A2$ B2$ Ordered pitch array: 7 8 9 10 11
As pitches: G0$ G2$ A0 A8 B6$ Ordered interval array: 1 1 1 1 8
Set info:
Set array: 1 1 1 1 8
Inversion: No Inversion
Trans: 4 3 2 1 0 0
Is a subset of: 6-2 1 1 1 1 1 1 C0 C0# D0 D0# E0 F0 G0 C0
No Inversion
Is similar to: 5-2 1 1 1 C0 C0# D0 D0# E0 F0 G0 C0
Contains: 4-1 0 0 0 0
No inversion
4-1 0 0 0 0
No inversion
4-0 0 0 0 0
No inversion

4.0 CONCLUSION

These approaches have increased our understanding of our intuitive composing powers and of what constitutes workable processes for melodic invention using a computer. As composers, what we are really interested in is a process--mental or mechanical--in finding ways to make Music that are musically predicatable, even musically promising, and--the big advantage with computers--extremely easy to reproduce. We are, in this way, modeling our resulting artificial melodic sequences.
on intuitive compositional processes. In a complementary way, if we seek new paths, unusual results, the unexpected, which our composer's imagination disposes of assimilates. The material is desirable, the composer completes the cycle. This highly useful, symbiotic relationship between composer and computer is the give and take, the yin and yang of real and artificial invention.

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...COMPOSERS AND THE COMPUTER.


1987 ICCM Proceedings 211