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Automatic Music

Tom Johnson

Abstract: Les automates finies n'occupent qu'un chapitre dans mon livre Self-Similar Melodies (1996), *mais en 1997 j'eus envie d'étudier des suites de cette sorte plus rigoureusement et de composer une collection de* Automatic Music for six percussionists. *Les sept premiers mouvements furent créés à Moscou par l'ensemble de Marc Pekarsky, et simultanement à Munich dans le cadre de Klang Aktionen, et il y a maintenant 18 mouvements. J'analyse ici trois de ces pièces, deux desquelles me paraisse "tordues."*

A finite automaton is a sequence using a finite number of symbols or letters, generated according to precise rules. In the case of my *Automatic Music*, six percussionists each have only two notes, high and low, and the alphabet is limited to *1* (the low note), *2* (the high note), and *3* (a silence). The following rules, for example:

1 -->1 1 2

2 --> 3 2

3 -->3 3

begin with 1

produce a sequence, which became "Canon," one of the 18 movements of*Automatic Music*.

1

112

11211232

11211232112112323332

11211232112112323332112112321121123233323333333332

etc.

Each transformation, each line, begins with two statements of the previous line; the rests, the repeated threes, grow longer with each transformation; and the process leads to a single sequence infinitely long. Of course, this sequence of digits does not yet determine which of the six instruments is playing what, or how many musicians are playing at once, and many other important compositional decisions remain to be made. I prefer to think of these not as compositional decisions, however, but rather as interpetative decisions. The composer is the automaton itself, and I do not wish to add subjective messages of my own, but simply to interpret, to find the arrangement and colors that allow the automaton itself to be heard as clearly and naturally as possible. Obviously, the percussionists continue this interpretative process.

In this case, I decided to interpret the sequence as a canon, an additional musician entering with each transformation. By the time the fifth instrument begins the sequence, the first has already advanced to the last line shown above, and one can also hear, simultaneously, the interceding three transformations. Everyone is basically playing in unison, but the voices entering earlier are filling in more and more self-similar details, and it is clear that the progression must end with a rather long solo for the sixth player.

Most logical sequences studied by mathematicians are similar to this one. Each transformation begins by stating the previous transformation, and the process advances toward a single limit sequence of infinite length, a "fixed point." Such sequences are relatively clear and neat, and often rather easy to understand and predict, so it was perhaps inevitable that most of the sequences I used when I began composing *Automatic Music* were of this type. Gradually, however, I began to find that the music was sometimes more interesting when it was produced by "twisted" sequences that were not so neat. Consider the following, for example:

1 --> 2

2 --> 3 1

3 --> 1

begin 2 3 1

which makes its first six transformations in this way:

2 3 1

3 1 1 2

1 2 2 3 1

2 3 1 3 1 1 2

3 1 1 2 1 2 2 3 1

1 2 2 3 1 2 3 1 3 1 1 2

2 3 1 3 1 1 2 3 1 1 2 1 2 2 3 1

In this case I call the movement "Oneline," and interpret the sequence monophonically, but with particular motifs played as solos by particular players. *2 3 1*, for example, is the motif for player VI, *1 1 2* is the motif for player I, and the longer underlined sequence, the sixth thransformation, is always played tutti.

I had a most interesting discussion with the mathematician Jean-Paul Allouche, as I was composing this music. For some years Allouche has taken an interest in my efforts to write mathematical music, and in fact, I had already decided to dedicate *Automatic Music* to him as a token of my appreciation. As he looked at some of my "twisted" sequences, he couldn't understand why I was adding what to him were unnecessary intermediate steps. In this case, for example, he felt it made more sense to view the sequence three transformations at a time:

1 -->	*2 -->*	*3 1 -->*	*1 2*
2 -->	*3 1 -->*	*1 2 -->*	*2 3 1*
3 -->	*1 -->*	*2 -->*	*3 1*

and summarize the system as:

1 --> 1 2

2 --> 2 3 1

3 --> 3 1

Now the automaton develops:

2 3 1

2 3 1 3 1 1 2

2 3 1 3 1 1 2 3 1 1 2 1 2 2 3 1

etc.

Each transformation begins by restating the previous transformation, the logic has been untwisted, we are moving toward a fixed point, and we are getting there three times faster. The only problem is that two thirds of the music has been lost, and every transformation begins in the same way. It is much more interesting when each phrase begins differently than the phrase just before, and where the earlier patterns are imbedded into the later ones in less obvious ways.

It became clear that Allouche and I had different values here, coming from the two different disciplines we had learned. Allouche was looking for a general truth, a way of paring things down to the most essential elements, a way of penetrating the complications and reducing them to general theorems. I was looking for particular situations, curious twisted sets of rules, which produced forms and sequences that one could not find in any other way.

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Another example of a twisted automaton is a movement that I called "Hocket," because the percussionists weave between one another, never playing at the same instant. Here are the rules:

1 3 --> 1 3 3 2

3 2 --> 3 2 1 3

begin 13

The development continues like this,

1 3

1 3 3 2

1 3 3 2 3 2 1 3

1 3 3 2 3 2 1 3 3 2 1 3 1 3 3 2

1 3 3 2 3 2 1 3 3 2 1 3 1 3 3 2 3 2 1 3 1 3 3 2 1 3 3 2 3 2 1 3

and the way the isntrumental parts come together, or rather, never come together, can be seen if I line up the first, fourth and fifth transformations, showing how the audible ones and twos never coincide with the silent threes:

1 3 3 2 3 2 1 3 3 2 1 3 1 3 3 2

1 3 3 2 3 2 1 3 3 2 1 3 1 3 3 2 3 2 1 3 1 3 3 2 1 3 3 2 3 2 1 3

1 3 3 2 3 2 1 3 3 2 1 3 1 3 3 2 3 2 1 3 ...

This sequence also approaches a "fixed point," and it exactly doubles its length with each transformation, but it is twisted in other ways. There is no rule for transforming *2*, one must transform pairs of letters instead of individual letters, and it is difficult to see where the sequence is going. For Allouche, I was again adding unnecessary complications, because all that is really happening here, as far as he was concerned, could be described as:

a = 1 3

b = 3 2

a --> a b

b --> b a

begin a

Viewed as a binary sequence, in this way, the progression is simply the Thue-Morse sequence, which is well studied and rather uninteresting today for a mathematician. My sequence was essentially a cliché, and not original at all. But of course, I would never have found this music, if I had been thinking about *a* and *b* in the correct logical way. By twisting the sequence into my three-digit automaton, and transforming pairs of letters instead of individual letters, I was able to find a unique hocketing pattern.

If there is a general observation to be made here, which may summarize what I have already said, it is probably simply this: Even for a composer like myself, who wishes to allow his music to be completely deterministic and predictable, a product of little mathematical machines, music remains essentially different from mathematics. If a good mathematical theorem represents something that can be found in many places, a generality, I would say that a good piece of music is something that can only be found in one place, some twisted particular case.

References

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Self-Similar Melodies (1996), 291 pp, ISBN 2-907200-01-1, Editions 75, 75 rue de la Roquette, 75011 Paris.