Dynamical Systems in Two Music Compositions

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ABSTRACT

The utilization of dynamical systems and the resulting fractals in the area of music composition has produced a number of notable works. Musical uses of two dynamical systems, the "chaotic gingerbreadman" (see [3]), in which

$$X_{n+1} = 1 - Y_n + |X_n|$$
$$Y_{n+1} = X_n.$$

and the Henon Map as defined in [6] by

$$X_{(n+1)} = 1 + Y_n - 1.4(X_n)^2$$

$$Y_{(n+1)} = 0.3(X_n).$$

are described. In particular, two musical compositions, *A Noite, Porém, Rangeu E Quebrou* and *Help Me Remember*, (both by Waschka) which employ these systems, are analyzed. Similarities and differences in the musical utilization of these systems are described.

BACKGROUND

Dynamical systems and related fractal processes have been used to organize various aspects of musical compositions. Examples include the use of Verhulst dynamics, 1/f-noise (see [10]), the von Koch snowflake, and the pieces discussed below use the Henon Map and the Chaotic Gingerbreadman. Often these uses were involved creating the melodic structures and sometimes the rhythmic structures of pieces. Pieces composed using these kind of techniques include works by Bruno Degazio ([2]) using dynamical systems, Charles Dodge ([4]) and Dodge and Curtis Bahn ([5]) using the von Koch snowflake and 1/f noise, Larry Austin ([1]) mapping the coastlines of Canada, Gary Lee Nelson ([9]) using a "fractal mountain", George Lewis ([8]) using 1/f noise, and Waschka ([11]-[17]) using 1/f noise, and dynamical systems. Typically, but not always, different processes or intuition were used to control parameters other than the melodic structure of the composition.

The following discussion and analysis considers the dynamical systems used to make the pieces *A Noite, Porém, Rangeu E Quebrou* and *Help Me Remember*, both composed by Waschka.

A NOITE, PORÉM, RANGEU E QUEBROU

A Noite, Porém, Rangeu E Quebrou (At Night, However, It Creaks and Breaks) composed by Waschka (see [12]) is a work for unspecified instrument of low pitch range and tape, with optional computer. It has been performed by instrumentalists playing the cello, string bass, and trombone with the premiere performance given by J. Cason at the Del Mar College Contemporary Music Festival, Corpus Christi, Texas in November of 1989. It has received numerous performances both in the United States and abroad including performances in Mexico, the then Czechoslovakia, and at the SEAMUS festival. It is recorded on a Centaur compact disc as part of the Consortium to Distribute Computer Music (CDCM) Series. The title is taken from a line from the poem *Campo de Batalha* by Tomaz Kim (Joaquim Fernandas Tomaz Monteiro-Grillo).

The score for the performer may be generated by a computer and read from a monitor or it may be printed out and read in the traditional manner. The method of score production and the performer's role in the piece are discussed in [13].

The tape part for *A Noite, Porém, Rangeu E Quebrou* was generated using the chaotic dynamical system known as "the chaotic gingerbreadman". This chaotic set is in two dimensions and when plotted resembles a gingerbreadman with its head oriented towards the intersection of the x and y axes. The dynamical system is given by

$$X_{n+1} = 1 - Y_n + |X_n|$$
$$Y_{n+1} = X_n.$$

The mapping of the plane is stable in certain regions and chaotic in others. *A Noite, Porém, Rangeu E Quebrou* uses a particular set of

several hundred iterations of the chaotic gingerbreadman that results from an initial point of (-0.01, 0.0). The mapped iterations have a starting point several hundred iterations into the sequence and include a critical section in which the results move away from a "near stability" -- in this case the range of the mapped results expands dramatically. These iterations were mapped to frequency to produce a long melodic construct, which continues throughout most of the piece.

This use of the dynamical system to produce a relatively slow-moving linear structure is typical of many of the pieces made by composers using these techniques.

A similar, but more interesting, melodic construct is found in *Help Me Remember* generated by the Henon Map. The greater complexity and interest is created by the application of the Henon Map to both pitch material and timbre.

HELP ME REMEMBER

Help Me Remember is scored for performer, real-time interactive computer music system, tape, shaker, and slides. The first performance took place at the Center for Experimental Music and Intermedia at the University of North Texas in February of 1990. Subsequent performances have taken place at the International Computer Music Conference (Scotland), in New York, North Carolina, and elsewhere. The work has been recorded on a Centaur compact disc as part of the CDCM series (1993). The performer is required to speak, to play the shaker, and to control various aspects of the computer synthesis system. *Help Me Remember* contains three distinct movements: Listening, Looking, and Dancing.

In the first movement, pitch and amplitude information derived from the performer's speaking are taken in by the computer program via a Digigram MIDI-Mic. The computer program then creates a real-time accompaniment based on the incoming information.

A compositional algorithm in use in the second movement of the piece is based on the Henon Map, which is defined as:

$$X_{(n+1)} = 1 + Y_n - 1.4(X_n)^2$$

$$Y_{(n+1)} = 0.3(X_n).$$

This system features a "strange attractor". In the case of *Help Me Remember*, the "x" values were mapped to pitch, while the "y" values were mapped to timbre. In particular the percentage of real-time effects present were determined by the "y" value. This mapping resulted in a lively and wide-ranging melodic structure which begins near the start of that movement and develops throughout most of the second section.

In the second and third movements, the "chaotic gingerbreadman" is used in conjunction with a granular synthesis technique known as "rapid event deployment" (see [11]). This combination of techniques creates comparatively dense granular synthesis gestures which are the aural analog of putting hundreds or thousands of points before the audience simultaneously or in a short time period. As noted in [7] by the authors:

Clearly, applying fractals to music is different from applying them to a static visual. In the visual realm, the general structure of the entire work is perceived at a glance; whereas in music, the listener may not know, or be able to guess, the general structure until an entire work is complete. Even the smaller, localized structures may require several seconds or even minutes to be assimilated.

The authors previous work described exploratory work in this area which was eventually brought to fruition in the making of *Help Me Remember*.

The use of granular synthesis techniques in combination with a chaotic dynamical system produces much more successful sonic objects. More successful in that a listener can actually hear the changing structure of the dynamical system. Periods of relative stability sound stable. They reiterate very similar frequencies and other aspects such as dynamic levels that make it possible for the audience to recognize near, but not exact repetition. Likewise, periods of instability are also obvious with rapid and irregular changes in frequency and other parameters of the music.

CONCLUSION

The use of dynamical systems in these two pieces shows a clear development in the handling of the technique. In the earlier piece, *A Noite, Porém,*

Rangeu E Quebrou, the dynamical system is used to create a rather straight-forward linear structure. In the later piece, *Help Me Remember,* a dynamical system is used first to create a similar, but more interesting and complex linear, melodic structure. In the other parts of the piece it is used in combination with rapid event deployment techniques in a MIDI environment to achieve interesting structures not on the melodic, but timbral level.

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