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Seed-turbulence-iteration

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Recommended Citation

https://doi.org/10.17077/etd.5v65-pgdf

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SEED-TURBULENCE-ITERATION

by

Joseph Norman

A thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Music in the Graduate College of The University of Iowa

May 2019

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For Glinda Wessel and Alexander Norman
ACKNOWLEDGMENTS

I am forever thankful to the following professors for their support and contributions throughout my education in the University of Iowa: David Gompper, for his knowledgeability, his critical analyses, his sharp ear, and his poignant advice; Lawrence Fritts, for showing me how to project uncompromising aesthetic values; Jean-François Charles, for opening up the world of improvised music and live electronic processing to me, and for his friendship; Matthew Arndt, for expanding my knowledge of Schoenberg, Schenker, Music Theory and Pedagogy, for providing me with thoughtful challenges, and for putting up with me in so many of his classes; Zachary Stanton, for his conversations, observations, and improving my approach to orchestration; and Nathan Platte, for providing me with a plethora of information on film music and film composition.
ABSTRACT

Seed-Turbulence-Iteration explores the aesthetic application of chaos and fractal geometry onto the musical parameters of a work constructed for chamber orchestra. Verhulst's Logistic Map and Devaney's Gingerbreadman Map are the dynamic systems from which melodic contour and temporal duration are derived. These algorithms are used to produce heterophonic and polyphonic results that iterate for a set duration before restarting. Each new beginning involves a change in density (of individual lines, as well as points of articulation in time), orchestration, register, and the pitch reservoir. All pitches are derived from a quantized spectrum that interpolates from a state of harmonicity to inharmonicity across a series of changing fundamentals. Each stage of interpolation coincides with the resetting of algorithmic iterations. Self-similarity and self-affinity are represented vertically, in the family resemblances of the lines produced within each algorithm that occur inside of a given segment, as well as horizontally, in the reiterations that occur over time. Each algorithmic reiteration and each copy within a set of iterations has varied starting or “seed” conditions that produce differentiated results of greater or lesser degrees which are presented in non-linear, strategic arrangement. Turbulence is implemented in the form of probabilistic distortions inserted into algorithmic processes that are meant to vary to some degree the amount of unpredictability of an output parameter (pitch or duration) as well as in intuitive manipulations of algorithmically generated material.
PUBLIC ABSTRACT

Seed-Turbulence-Iteration is a piece composed for chamber orchestration that involved a selective application of algorithmic processes which were coupled with human intuitive creative intervention over the course of its creation. The algorithms applied were Pierre François Verhulst's Logistic Map and Robert Devaney's Gingerbreadman Map. Verhulst's map demonstrates chaotic behavior (in terms of chaos theory) and Devaney's Map demonstrates fractal geometric behavior. The plot points of these different systems formed an inspirational basis for the control of melodic contour and durational values within the confines of individual lines. Aesthetic selections and alterations of the algorithmically generated data caused me to assign lines to individual instruments and sometimes splitting those lines across groups of instruments, conceive of a form in which to frame material, and select the pitch material. The piece's title describes the mechanism of action for Verhulst's Logistic Map. Initial, or “seed,” conditions are established, “turbulence,” is applied in order to generate variable results, and the result of the algorithm is then fed into its starting conditions, causing the process to iterate repeatedly. This sequence of actions is built into the structural fabric of the piece, as sequences of events are started and stopped in succession.
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FOREWORD

Seed-Turbulence-Iteration explores the application of chaos and fractal geometry onto the musical parameters of a work constructed for chamber orchestra. Verhulst's Logistic Map and Devaney's Gingerbreadman Map are the two dynamic systems which are used to organize material throughout the piece. Specifically, pitch organization and duration are, in part, derived from the data mapping of these two systems.

The Verhulst Logistic Map and the Gingerbreadman Map form the basis for polyphony throughout the work, as each one's characteristic contour forms a distinctive melodic shape. (See Examples 1 and 2 for differences in plotting between two maps). Simultaneously, slight variances are input into the starting arguments of each algorithm several times over. This results in a kind of family variation within each algorithm, wherein heterophony and eventually polyphony will occur within one algorithm.

The piece can be divided into two large parts; Part A (mm. 1-176), and Part B (mm. 177-255). The first 15 measures of Part A was composed intuitively, though it is based strongly on augmentations of materials presented in mm. 16-23.

Part A is arranged into twenty-one sections of that begin roughly every thirty beats, or seven and one half measures in 4/4 time, with the exception of the opening section which lasts fifteen measures. (See Example 3 for a complete table of section divisions). Some sections feature temporal distortion in the form of prolongation/expansion via insertion of additional measures of 4/4 and 2/4. Also, section conclusions sometime crossfade with the beginnings of new sections due to variations in their durations. This feature produces a degree of ambiguity in the delineation of aural structure.

Starting at m. 177, the process of generating material changes. The use of the Gingerbreadman map as a tool for organizing pitch and duration is ceased, while the Verhulst Logistic Map continues. There are five sections that span from mm. 177-255 (the conclusion), and each section is extended in

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length to roughly fifteen measures, once again allowing for some temporal distortion regarding section length. Due to the removal of the Gingerbreadman map, the texture from mm. 177-255 is decidedly more homophonic than the previous segment. Each of these five sections also feature a linear process of durational increase.

Pitch material used throughout the work is derived from approximated spectra, beginning with harmonic spectrum that is interpolated towards a new fundamental. The process of interpolation is also gradually distorted through the use of frequency modulation. Due to this, there is gradual increase of implied inharmonicity as the piece progresses. The stages of interpolation are unfolded through part A with a non-linear organization. At the start of part B the final stage of interpolation is reached, and the interpolation is ceased. Sectional pitch variance is effected through octave displacement of partials and registral restrictions. Spectra were chosen as the basis for pitch material due to their receptivity to mapping. Scales or smaller collections are limited in their mapping possibilities, and the aggregate has no possibility for interpolation. The various spectra provide unique characteristics and variety that were not available with other possibilities. (See Examples 4 and 5 for examples of starting and finished spectra).

Density of lines and dynamic range were made to loosely correspond to the relative positions of plot points of a Verhulst Map laid out on a grid. The choice of long notes against short notes followed by rests were made strategically, in order to foment coloristic development or contrast. In sections containing lower line density, individual lines were split across groups of instruments in order to expand orchestrational timbre.

The piano and percussion instruments serve a different function from the other instrument groups. The piano articulates the section divisions by playing clusters of notes culled from the new spectra as well as sometimes outlining the spectrum itself in various figurations (single notes or chords). The unpitched percussion instruments provide reduced rotational patterns derived from
algorithmically generated durations.

The raw material of pitch and duration was generated through the use of a program called OpenMusic. It was in OpenMusic that the algorithms were patched together in order to produce sketch material that was then manipulated over the course of the piece's composition. (See Examples 6 and 7 for patching layouts).

The processes involved in using two central algorithms produce to create sectional material allows for the presentation of similar or related sound objects that are framed in a variety of different musical contexts. The individual lines within sections are often self-affine, in that they will possess varying degrees of contour resemblance, however not at 1:1 ratios as self-similarity (e.g. treatments of intervallic expansion and contraction, and augmentation or diminution of duration based on multiples) would imply. Instead variances are not applied the same across an entire line (e.g. a duration of one pitch may be longer or shorter, some pitches will be higher or lower, or remain unchanged).
EX. 1 Verhulst's Logistic Map

Equation from Mikahil Malt's OMChaos Library for OpenMusic

\[ y_n = x_{n-1} + x_{n-1} \cdot \lambda \cdot (1 - x_{n-1}) \]

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Ex. 2 Gingerbreadman Map

Equation from Mikahil Malt's OMChaos Library for OpenMusic

\[ x_{n+1} = 1 - y_n - c \cdot r \cdot (\text{abs } x) \]
\[ y_{n+1} = x_n \]
Ex. 3 Structural Layout

Part A – mm. 1 – 176

Part B – mm. 177 – 255

Sections (Part A)

Section A1 – mm. 1 – 15
Section A2 – mm. 16 – 22
Section A3 – mm. 23 – 30
Section A4 – mm. 31 – 36
Section A5 – mm. 37 – 46
Section A6 – mm. 47 – 53
Section A7 – mm. 54 – 62
Section A8 – mm. 63 – 69
Section A9 – mm. 70 – 79
Section A10 – mm. 80 – 86
Section A11 – mm. 87 – 96
Section A12 – mm. 97 – 103
Section A13 – mm. 104 – 111
Section A14 – mm. 112 – 118
Section A15 – mm. 119 – 130
Section A16 – mm. 131 – 137
Section A17 – mm. 138 – 145
Section A18 – mm. 146 – 152
Section A19 – mm. 153 – 161
Section A20 – mm. 162 – 168
Section A21 – mm. 169 – 176

Sections (Part B)

Section B1 – mm. 177 – 191
Section B2 – mm. 192 – 205
Section B3 – mm. 206 – 220
Section B4 – mm. 221 – 236
Section B5 – mm. 237 – 255
Ex. 4 Pitch Reservoir for Introduction and Section A1-A5

Ex. 5 Pitch Reservoir for Section B1-B5
Ex. 6 Sample Patch for Pitch and Rhythm (Verhulst)
Ex. 7 Sample Patch for Pitch and Rhythm (Gingerbreadman)
INSTRUMENTATION

Flute/Piccolo
Oboe
Bb Clarinet/Bass Clarinet
Bassoon/Contrabassoon

Horn in F
Bb Trumpet
Trombone
Tuba

Percussion I (Glockenspiel, Snare Drum, Triangle, Marimba, Temple Blocks)
Percussion II (Vibraphone, Wood Block, Bass Drum, Snare Drum, 4 Tom-toms, Suspended Cymbal, Triangle)

Piano

Violin I
Violin II
Viola
Cello
Double Bass

String Preface

s.p. = sul pont.
s.t. = sul tasto
a.s.p. = alto sul pont.
a.s.t. = alto sul tasto
→ = gradually change bowing position (i.e. from sul tasto to sul pont.)

All tremolo is unmeasured (as fast as possible)

All glissandi are steady interpolations from one pitch to another