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Musical Concept and System Design of "Chaotic Grains"

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ABSTRACT

Musical automata and automatic composition are interesting themes in computer music. This report is about one approach called "PEGASUS Project", to research musical environment for composition or perfomance, and about experimental composing one piece.
The piece "Chaotic Grains" is composed in 1992-1993, and performed Feb. 11th in Tokyo (Jujiya Hall). One special software is produced with the concept of "Chaos" in this composition, and some special hardware is produced/arranged for the piece.
All parameters are controlled individually by conductor or sequence data in real time, and the results of the generation of chaos are different from each other in every performances. The characters of "Chaos" are changing and metamorphosing every time in this piece, thus there is one kind of "real-time composing".

コンピュータ音楽作品 "Chaotic Grains" における音楽的コンセプトとシステム構築について

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概要

音楽情報科学研究会主催、日本現代音楽協会共催のコンサート「電楽 II」(1993年2月11日・銀座十字屋ホール) で初演された、コンピュータ音楽の実験的作品 "Chaotic Grains" について、その音楽的コンセプトとシステム構築について詳細に報告する。
この作品は、昨年の「リアルタイムの Granular Synthesis 制御」システムに続くステップとして、音楽に関する作曲・演奏・即興・対話などを統合的に実現するための "PEGASUS Project" という研究の一環として作曲された。
演奏は、ピアニストと、センサ制御も行う指揮者の2人によって行われ、作品の一部であるオリジナルソフトウェア ("Chaos Generator") によって、リアルタイムに演算されるカオス状態が音楽の個々の要素を生成する。このパラメータは、演奏者のコントロールやシーケンス情報によって刻々と変化することにより、コンピュータ音楽の重要な研究テーマの一つである「リアルタイム作曲」の実験的形態を実現した。

1 Background

1.1 Computer Music

There are many field to research in "Computer Music". For example, "musical automata" and "automatic composition" are interesting themes for composers. Many theories and models are discussed, many systems and softwares are researched or developed by many researchers and composers in the world [1] [2].

Today, software engineering and computer technology are growing powerful, so we have good environment for computing musical information in real time, and the concept of "real-time composing" can be used easily in compact system [3].

1.2 PEGASUS Project

The research called PEGASUS Project (Performing Environment of Granulation, Automata, Succession, and Unified-Synchronism) has produced one compact system of real-time Granular Synthesis [4] [5], and the second step of this project is aimed at "automata and unified-synchronism".

This project aims at not only producing any systems or the softwares, but also trying experimental composition for application with the concept in every developing steps.

This paper presents the "MAKING" of the piece called "Chaotic Grains", which is composed in 1992-1993, and performed Feb. 11th in Tokyo ("DENGAKU" at Jujiya Hall) [1]. This piece is one result of the PEGASUS Project at current level, and one special software is produced with the concept of "Chaos".

1.3 Chaos in Music

1.3.1 Logistic Function

There are many reports of "Chaos" applications for wide fields. Chaos is easily generated with simple equation :

$$X_n = \mu \cdot X_{n-1} \cdot (1 - X_{n-1})$$

and this equation is called "Logistic Function".

With the area $1 < \mu \leq 3$, the value of X_n is only one, but with increasing in the area $3 < \mu$, the value of X_n is separated into two, four, eight, ... and is going into "chaos" zone [6].

In this area, some kind of randomness is generated, but there is special different from other "noisy" randomness. The parameter μ is very important to control the random character, and it is possible to control the "chaos" with the selecting the value of μ.

1.3.2 CIM

It is very interesting that the result state of chaos cannot be determined in spite of its deterministic definition. With experiment of chaos simulation, there is more interesting character as if "it lives". There are many points with finite values of X_n in "chaos zone" of μ (normally with infinite values), and called "Windows".

The interesting interaction is occured on the edge of this Window. The finite chaos vibration falls into perfect random state with wide shift of the value of μ, but if the value is slight shifted, the chaos vibration may be pushed back in some case. This reaction is very critical and nervous, but interesting.

I called this "Chaotic Interaction Model (CIM)", and using this value range (interaction range) of μ, the CIM simulator is produced and experimented [7].

This edge area of chaos is considered for somewhat "intelligent system" application [8] [9] [10], and chaos system may be useful for composition [11].

[1] Pianist : Ayano Fujiwara, Conductor : Yoichi Nagashima.

2 Musical Concept

2.1 Scale and Tonality

The notes in "Chaotic Grains" are selected by some scales with 12–equal temperament. "Chaos Generator" software generates MIDI note messages, and these notes are easily generated by MIDI synthesizer modules.

There are three scenes, and each scene has each tonality with scales : Diatonic, Whole Tone, and Pentatonic [2].

2.2 Chaos Event

With "Chaos Generator" software, many chaotic MIDI events are generated. In this piece, all chaotic notes are selected as "Percussive Sound", because this software manages only the "rising edge event" of notes. This simplification is no problem in this piece, and the contrast between chaotic notes and back-grounded notes is emphasized.

"Chaos Generator" ganerates each MIDI note event with short duration, and every synthesizers are tuned up for frequently sound generation.

The main theme of this piece is "metamorphosing chaotic character". With changing the chaotic parameters, each scales/renges/tonalities are changed with the "scene". And there is somewhat "musical conversation" of chaotic notes, synthesizer sounds, granulation sound, and acoustic piano sound.

2.3 Pianist

Pianist part is independent with electronic systems. Pianist generates "natural" acoustic sounds as an antithesis of digital/electronic/synthesized sounds.

Pianist plays some cluster notes and the reaction of chaotic notes with improvisation. Only some rules are defined for selecting enabled scales, and pianist may play every White Keys in "Diatonic Scene", may play every Black Keys in "Pentatnic Scene", must play only 6 notes in "Whole Tone Scene".

2.4 Performer/Conductor

Besides the pianist, there is another performer on stage. He/she conducts some cues, and performs real-time granulation synthesizers. In some scene he/she performs to send triggers for chaotic parts.

Almost part of "Chaotic Grains" are played with pre-recorded MIDI sequences, but sometimes the sequencer stops for waiting the conductor at some point, thus the duration of this piece is not fixed exactly.

3 System

3.1 Software

3.1.1 Chaos Generator

As the part of this composition, one original software is produced. The software, called "Chaos Generator" is programmed with C language, compiled by MS-C (ver5.1), and runs on MS-DOS (NEC PC9801NS/T).

System clock cycle is about 16msec with VSYNC interrupt, and there are 8 channel parallel-running musical tasks and MIDI/Mouse/Console tasks.

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[2] See [Appendix] Score Notes.

Each channel contains : Channel, Volume, Panpot, Program, Timing, Duration, Down, Note Ranges, Note Filters, and "Myu" parameters. Parameters of "Channel, Volume, Panpot, Program" mean MIDI messages. "Timing" is the interval between MIDI trigger and starting point of generating chaos. "Duration" is the interval between each chaotic events. "Down" is the rate of decreasing velocity, and chaotic events continue eternally with this value ZERO. "Note Ranges" are highest and lowest edge of enabled note number in generating chaotic note events. "Note Filters" are enabled 12-tones probability in generating chaotic note events, and these parameters can be controlled for any tonalities in real time. "Myu parameters" are the Logistic function parameter μ, and the value is represented with 6 mantissa data.

Except only MIDI channel, all parameters can be controlled in real time, not only with mouse/console but also MIDI special messages. For example, the "Note filters" parameters are frequently changed with sequenced MIDI data, so selected chaotic note events are changed little by little.

The sample of this software will be uploaded into Data Library of AI Forum in Nifty-Serve as "Freeware".

3.1.2 System Control

Performing control parameters are all included as special MIDI messages. I defined MIDI 16 channel only for "Control Channel" in this piece, and all control parameters are specially/irregularly/systematically defined.

For example, Joy-Stick X-axis value is sent with [DF 00]–[DF 7F], and Y-axis value is sent with [CF 00]–[CF 7F]. For real-time granular synthesizer, "grain compression" parameter is sent with [AF 19 00]–[AF 19 1F], and "average density" parameter is sent with [AF 1A 00]–[AF 1A 7F]. For Bar Counter machine, current bar number is sent with [AF 5F nn].

The start/stop command and MIDI external clocks are generated by the Chaos Generator, and another simple sequencer is controlled by it as the "slave" machine.

3.2 Hardware

3.2.1 Synthesizers

Because of the policy for "Simple and Compact System", there is only one 8U–Rack on stage. Normal Synthesizers are two [K4r] modules (2U + 2U), but they are arranged for containing original synthesizers. Other materials in this rack are 8 channel stereo mixer [MX8SR] (2U), double half-rack Effectors [SE50][EMP100] (1U), and original MIDI message display (1U).

[K4r] is set for "mutli mode", and all sounds are not specially synthesized. Because there are many good sound as default, only "factory" sounds are used. Specially synthesized sound of [K4r] is not important in this piece.

3.2.2 Granular Synthesizer

Original two granular synthesizers are built into one [K4r] [3].

In this piece, two control mode are both used : one is direct MIDI controlled parameter from sequencer, the other is Joy-Stick assigned parameter control. This assigned parameters are real-time changed, so "X = pitch, Y = panpot" is set in some scene, and "X = volume, Y = density" can be set in other scene.

3.2.3 Sinusoid Synthesizer

Original two sinusoid synthesizers are built into another [K4r]. These synthesizers can generate some strange and interesting sounds only by sinusoid waveshapes.

[3] The detail of this system is already reported [4].

Using PCM sampling and wave-table looping technique, each wave data are not read out constant rate. Thus, the sound does not have constant pitch or constant timble. These sounds are used only as "spice" in the piece.

3.2.4 Joy-Stick Controller

Original Joy-Stick Controller is already produced [5], and re-arranged for this piece.

There are three modules in it : Joy-Stick (X-axis and Y-axis) sensor and A/D conversion, MIDI stream input buffering, and MIDI output merger of input data and Joy-Stick data.

3.2.5 Monitor Display

Original two Monitor Display for performance are produced. One is 7-segment LED display box on the piano for pianist, the other is LCD Panel with EL back-light display box for conductor.

These monitors display "measure number", because this piece is very long, and it is important to follow "where is this?". The measure information is sent as special MIDI message from sequencer, and performers can easily detect the point.

4 Composition

4.1 Part and Scene

There are 12 parts for synthesizers, and 6 parts are double-defined for "sequenced" and "chaotic generated". Each part is assigned to MIDI channels with sequencer. All data are set as input by console, not by MIDI real-time recording.

4.2 Timbre and Sound

Timbles for chaotic part are selected as "instrumental sound", and back-grounded sounds are selected as "artificial sound", because I hoped the audience to listen to the scales and notes.

4.3 Rehearsal

Some rehearsals of pianist and composer (another performer) was held. At first, free discussion of images for this piece and common definition for perfornmance was approached.

After pianist's experiment/training, studio rehearsal was held only once. The computer/synthesizer part was tape-recorded with uncontrollable style as KARAOKE, so the main theme was "how to feel and play the piano".

At final rehearsal in the hall, both performers and computer systems had their first ensemble.

5 Discussion and Conclusion

I have discussions with some audiences about the performance. Unfortunately most of them told me that they could not distinguish chaotic (real-time composed) notes from sequenced (pre-recorded) notes.

There are some reasons and problems, my low-level composition of couese, but I think it is important to synchronize visual information with music. For example, graphical media diaplaying chaotic generation will give some impact or message to audience, and it may be easily understood the structure of the music. This theme will be researched.

This is start of the second step of PEGASUS project, and next target is CIM application for real-time compositional system and next experimental composition.

Next chance for presentation and demonstration or performance is scheduled at IAKTA Workshop in Osaka, September 16th 1993.

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Appendix (from the Score)

Chaotic Grains

Computer Music for Piano and Live Electronics

by Yoichi Nagashima
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Performers

"Chaotic Grains" is played by two members : the pianist, and the conductor who is also the player of live electronics. Conductor may operate the computer system with only start command.

Pianist

Pianist plays the piano with the score, and the piano sound may be amplified with necessity.

In this piece, the pianist has much freedom of playing/selecting phrases with improvisation, because this piece is composed with some kind of random (chaos) under the concept of **real-time Composing**.

There are some rules for selecting notes in the score, so the pianist must not play the prohibited notes. The rules are changing with the score, and some part is written by confused scales in order to metamorphose the scene.

Conductor

Conductor stands at the opposite side from the pianist on the stage, and plays "joy-stick controller" with conducting. The computer system may be placed beside the conductor, and the screen of computer display is watched for detecting the sign of the sequence.

Conductor sends some cue to the pianist, sends the start signal for the next scene to the computer, and plays some phrases with the cue of Chaos Generator.

Media

"Chaotic Grains" is played with four types of sounds : acoustic piano, granular synthesis, chaotic-controlled synthesizers, and sequence-controlled synthesizers. The piano part is already described.

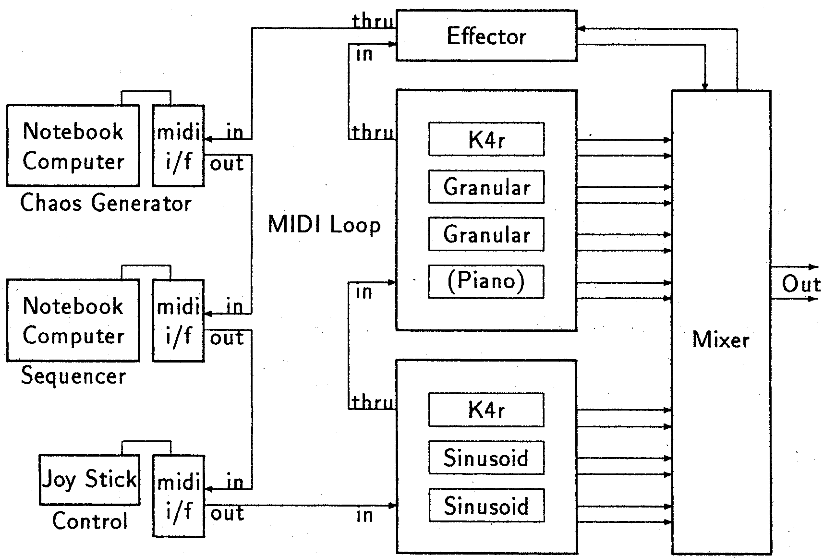
System Block Diagram

There are two notebook computer, three intelligent MIDI interface box, two synthesizer modules including built-in some special synthesizers, and joy-stick controller for conducting the system.

All audio outputs of synthesizers are connected to the stereo mixer, and the final stereo output is sent to the P.A. system. Some effectors may be connected with the mixer.

See the System Block Diagram below :

System Block Diagram of "Chaotic Grains"



Computer and Software

One notebook computer is NEC PC9801N with intelligent MIDI interface. The software is simple MIDI sequencer [Micro Musician 2] of MS-DOS, containing 16 tracks, using external MIDI clock, and software THRU. The file size of "Chaotic Grains" data is about 110Kbytes.

Another notebook computer is NEC PC9801NS/T with specialized intelligent MIDI interface. The "Chaos Generator" software is originally produced by the composer, and this software is one part of this piece. There are 8 parallel running musical tasks, each managing independent chaotic operation. With conductor control, this software also manages the MIDI system clock and real-time messages, and send cues to many musical processes. The detail of this software will be presented in some conferences : ISPJ 1993 spring, JMACS, etc.

Synthesizers and Joy-Stick Controller

For producing chaos-generated and back-grounded sound, two Kawai [K4r] modules are used. Both synthesizers are set multi-timbre mode, and used as individual 4 channel MIDI sound modules.

Original two granular synthesizer modules are built into one K4r. The parameters of granular synthesis are real-time controlled by specialized MIDI commands : width of grain, average density of grains, shape of grain, compress/expand modulation of grain, panpot, volume, joy-stick control, etc.

Original two sinusoid synthesizer modules are built into another K4r. The parameters of synthesis are real-time controlled by specialized MIDI commands : looping points, pitch, panpot, volume, etc.

The Joy-Stick Controller is produced arranging the intelligent MIDI interface applied with A/D converter. This machine ganerates 2-D(X-axis,Y-axis) continuous control parameters with specialized MIDI commands. Conductor can send the control parameter for granular synthesis, and can send cue to the system software with moving the stick.

The piano sound and the performance of pianist is somewhat Antithesis of Live Electronics. Thus, pianist may play with free feeling and may fight a battle against the synthesized sounds or pre-recorded musical sequences.

Score

The score of "Chaotic Grains" consists of 12 parts : conductor(1), piano(2), MIDI/chaos synthesizers(7), granular synthesizers(1), and sinusoid synthesizers(1).

"Beat" and "Tempo" is not important in this piece, but to adjust each part and to make somewhat ensemble, this score is written with [12/2] beat notation with tempo [150]. This means about "1 bar = 10 seconds", and total duration of this piece will be about 15 minutes (total 90 bars), but conductor can expand the duration with delaying the cue of the next scene.

Scene

There are three main blocks in this piece with each scale : Diatonic, Whole tone, and Pentatonic, called "scene". All sounds/notes are selected with these scales, so pianist must not play inhibitive notes, but may play freely within the scale.

The Diatonic scene is constructed by C, D, E, F, G, A, B notes, thus pianist can play **everything** with white keys. The Whole tone scene is constructed by C, D, E, F#, G#, A# notes. Pianist must be nervous to select these notes, but this feeling is important in the scene. The Pentatonic scene is constructed by C#, D#, F#, G#, A# notes, thus pianist can play **everything** with black keys.

Performance

For the pianist, there are only three points to fix the attention on the conductor for adjusting the Tutti timing. Then, pianist can listen to the whole sounds with relaxed feeling in other everywhere.

It is important for pianist to imporvise every phrases triggered with other parts. Because other electronic parts are not played just same style precisely, and this random character is one of the concept of this piece. Pianist must not play the piano part score of "Chaotic Grains" : these notation means not "to be played this note", but "to be played **like this**".

Nevertheless the score shows one note, pianist may play chords. Nevertheless the score shows low range notes, pianist may play highest notes. Nevertheless the score shows long duration notes, pianist may play very short notes when the musical feeling is commanded.