

An Acoustic Artificial Life System Using the Game of Life and its Application for Performing Arts

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Abstract

Sound and vibration are forms of energy propagation. We have constructed an artificial life form that takes sound as energy and produces energy. The system converts sound into a two-dimensional pattern and uses it as input to the Game of Life. After n steps, the Game of Life is re-transformed into sound, and the sound is output. The sound allows the artificial life in the PC to interact with the outside world. We used this system to create an artwork that interacts with a dancer interactively through sound.

Keywords: Butoh, The Game of Life, Sound, Deep Micro Vibrotactile, DMV

1. Introduction

Tactile sense is the common language of Nature, so the tactile language should allow us to integrate the PC with Nature. We are trying to integrate the PC with Nature through haptic interaction.

If we want to integrate the PC with Nature, what do we need to "transmit"? Unlike the Internet, the natural system is not the PC, and the Internet cannot directly connect the PC and the natural system. PCs, in general, do not have a sense of touch, so tactile interaction requires tactile sensors and output devices.

One way to connect the PC to Nature is through sound: the PC has a microphone and a speaker, and through the microphone, the PC can convert sound into electrical

signals, process the information, and output the sound through the speaker.

What is sound? A sound is a form of energy. Energy is converted into waves, which travel through a medium. The propagation of the waves depends on the Nature of the catalyst. If we can sense the waves as they travel through the medium, we can convert them back into energy. In other words, by connecting a natural system to a PC via waves, energy can be exchanged between the natural system and the PC.

In the natural system, the energy is converted into waves, which travel through space and reach the PC's microphone. The energy is converted into an electrical signal in the microphone, processed in the PC and converted back into an audio signal. The audio signal is

then sent out through the speakers, allowing the PC to transmit energy in waves to the natural world.

2. The Sound Creature

To connect Nature and PC via waves, we created the **Sound creature, SC**. This creature obtains energy from outside via waves and metabolizes them, and generate another wave. In other words, this artificial creature is an energy transformer. SC consists of a transformation from sound to two-dimensional patterns and vice versa and the game of life.

John Conway, who proposed the Life Game, strongly rejected the deterministic position in an invited talk at ALife conference, the international conference on artificial life in 2014. He emphasized contingency is much more critical than determinism; he said that "*there is full of contingencies in the world.*"

The universe of the Game of Life ¹⁾ is an infinite, two-dimensional orthogonal grid of square cells, each of which is in one of two possible states, alive or dead (or populated and unpopulated, respectively). Every cell interacts with its eight neighbours, which are the cells that are horizontally, vertically, or diagonally adjacent. At each step in time, the following transitions occur:

- i) Any live cell with two or three live neighbours survives,
- ii) Any dead cell with three live neighbours becomes a live cell,
- iii) All other live cells die in the next generation. Similarly, all other dead cells stay dead.

The initial pattern constitutes the seed of the system. The first generation is created by applying the above rules simultaneously to every cell in the seed, live or dead; births and deaths coincide, and the discrete moment at which this happens is sometimes called a tick. Each generation is a pure function of the preceding one. The rules continue to be applied repeatedly to create further generations ¹⁾.

The game of life is entirely deterministic; there is no room for "contingency," So we integrate the game of life and the sound surrounding a PC, where the game of life is working.

The sound of volume (amplitude) converts the ambient sound of the PC into a two-dimensional pattern. Since the amplitude of the input sound is between -1 and 1, we divide this into N equal parts, where N is the sensitivity

of the SC. The average amplitude of the input sound during Δt (about 0.01 seconds) is measured and converted into a Tactile score. Then, the input speech is converted into a two-dimensional pattern based on the Tactile Score at time t and $t + \Delta t$

This two-dimensional pattern is the volume change pattern of the input speech, and the game of life converts the two-dimensional pattern into other patterns. Recall the episode of the introduction of the Tactile Score. What was the difference between a cheerful good morning and a cheerless good morning? The difference was the way they said it, that is, the pattern of the volume change.

To change the pattern of the volume change is to change the way we say things. In other words, when the game of life converts a volume change into a two-dimensional pattern into a different volume change, it is equivalent to changing the wording.

The SC outputs the input environmental sound differently. In order to output sound, we need vocal cords. So Life game converted the 2 dimensional, 2D pattern into a Musical Instrument Digital Interface, MIDI code. This MIDI code was then used as input to a Digital Audio Workstation, DAW. We used Ableton Live as the DAW. We then generated "musical noise" from the continuous MIDI input.

2.1. Garandoh no Niwa (empty garden)

We worked with *Butoh* dancer *Norihito Ishii* (*Sankai jyuku* company) to create a dance piece using SC. *Butoh* is a form of Japanese dance theatre that encompasses a diverse range of activities, techniques and motivations for dance, performance, or movement ²⁾.

A founder of *Butoh*, *Tatsumi Hijikata* explored the transmutation of the human body into other forms, such as those of animals. He also developed a poetic and surreal choreographic language, *butoh-fu* (*fu* means "score" in *Japanese*), to help the dancer transform into other states of being.

Butoh Score is a choreographic pair of counts and poetic statements. For example, it can be described as follows;

*"A body lies in a heap of flesh, 40 counts.
The corpse comes to life. 20 counts.
....."*

2.2. A fusion of Butoh Score and Tactile Score

We read and recorded the Butoh Score according to the count. The recorded sound was then subjected to a low-pass filter to extract very low-frequency sounds below 20Hz. We created a sound art by layering nature sounds recorded in the forest-based on the very low-frequency sound.

The length of this work follows the count of Butoh Score, so it is almost the same as the dance length. This sound art piece was played at the beginning of the dance. The Butoh Score was transformed into the Tactile Score via voice and fed into the Sound creature, thus creating a fusion of Butoh Score and Tactile Score. sound generated by vibrations of 20 times or less per second.

3. Method

We used two microphones, two PCs, loudspeakers and a projector. One microphone was placed on the floor to collect sound from the floor and output to the PC. Another one was on the floor to collect sound from the space and production to the PC (Fig.1).

Each PC runs the Sound creature; they chat with each other through sound. One PC outputs the audio of their

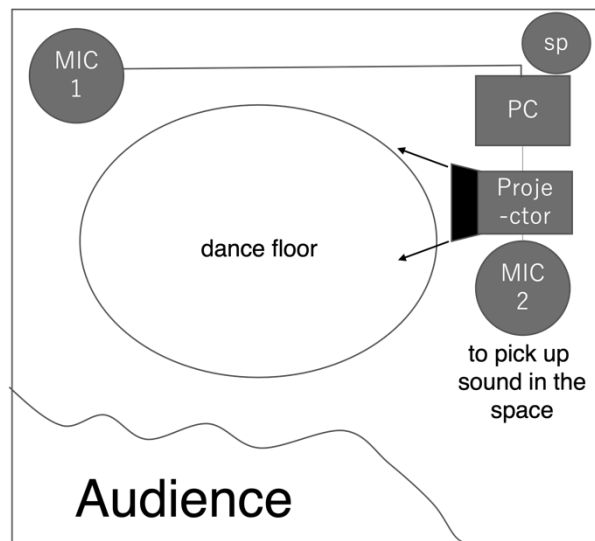


Fig. 1. Floor map of the performance

conversation to the audience, while the other PC outputs the process of creating sounds in the SCs. The process is a pattern of the game of life (Fig.2).

4. Result

We had a live performance with Norihito Ishii, Sound



Fig. 2. from live performance, left) patterns of process of sound creating / transforming of SC1 and SC2 right) Norihito Ishii (Butoh dancer).

creatures and the audience. Sound creatures run as autonomous computer programs with no operator in the performance (Fig 2).

References

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Authors Introduction

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He is an Associate Professor of Graduate School of Informatics, Nagoya University Japan. graduated from Japan Advanced Institute of Science and Technology in 1995, received D. Informatics from Kyoto University in 2001.