2014 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE)
July 6-11, 2014, Beijing, China

Melody Oriented Interactive Chaotic Sound Generation System Using Music Conductor Gesture

Shuai Chen, Yoichiro Maeda and Yasutake Takahashi

***Abstract*— In the research of interactive music generation, we propose a music generation method, that the computer generates the music, under the recognition of human music conductor's gestures. In this research, the generated music is tuned by the recognized gestures for the parameters of the network of chaotic elements in realtime. To make outcomes more closer to music, a different method is proposed to make melody specifiable. Music theories are embedded in the algorithm, as a result, the generated music will be richer. Furthermore, we reconstructed the music generation system and performed the experiment for generating the music composed by human.**

I. INTRODUCTION

TRADITIONAL music has thousands of years of history. But playing a musical instrument is not a simple matter for every person. Only musicians that have undergone a process of intensive training can produce music through an instrument effectively. The people who only have interest but know nothing about the instruments, can only play the role of the listeners. However, interactive music, that typically involves human interaction, has become a new way to create the music.

There are already existing interactive systems controlling music or sound based on human body movements, for example, Sound Sculpting[1]. It proposed a new approach to mapping hand movements to sound through shapes of a virtual input device controlled by both hands. The attributes of the virtual object are translated into parameters for real-time sound editing within MAX/MSP. And a vision-based system, Body-Brush, has been proposed, that captures the entire human body motions and gestures for 3D painting synthesis and musical sound generation[2]. And also, instead of the virtual acquisition of body movements, Cyber Composer, introduced as a music generation system, that melody flow and musical expressions can be controlled and generated by wearing motion-sensing gloves[3].

In order to arouse the interest from everyone, it is necessary to make the users' control more in the way to generate their music. In addition, in order to ensure that the generated music makes every user feel easy to understand and easy to control, music conductor gestures must be applied in this research.

In this research, the proposed method is designed, not only following the requirements of people but also generating the music automatically by using Interactive Chaotic Amusement System (ICAS)[4]. In our former researches, music conductor gestures and basic music theories are embedded in the algorithm, so that, after the music has been generated, it will be arranged by the human's hand conducting gestures[5]. Users use their hand gestures to interact with the computer for generating the music. Human intention and chaotic calculation generate sounds with mutual multiplier effects. We attempt to improve the output more approximate with real music, we let the melody specifiable in our system. By iterating the specified melody with network of chaotic elements, a capable range of the parameters is discussed.

Shuai Chen and Yasutake Takahashi are with the Graduate School of Engineering, University of Fukui, 3-9-1, Bunkyo, Fukui, 910-8507 Japan, Yoichiro Maeda is with the Faculty of Engineering, Osaka Institute of Technology, 5-16-1 Omiya, Asahi-ku, Osaka, 535-8585 Japan (email: {schen,yasutake}@ir.his.u-fukui.ac.jp, maeda@bme.oit.ac.jp).

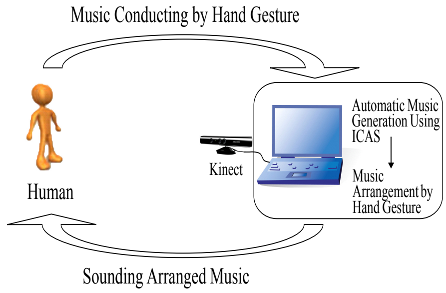


Fig. 1. Overview of Chaotic Music Generation System

II. OVERVIEW OF CHAOTIC MUSIC GENERATION SYSTEM

Network of chaotic elements has the connected elements of chaos which are coupled to mainly network-like. And these chaotic elements are given in the form of differential equation. It is also known as large-scale coupled map, proposed by K.Kaneko[6]. By using this theory, it is possible to control the state of synchronous and asynchronous of chaos. In addition, the combination structure of network of chaotic elements can be divided into Coupled Map Lattice (CML), and Globally Coupled Map (GCM). In this research, the Globally Coupled Map has been used in ICAS. The former music generation system generates sound by ICAS, and combined with the generation of rhythm patterns, chord progression and synchronization process, and then arrange the music beat, tempo, and dynamics by using hand gesture.

A. Globally Coupled Map

Globally Coupled Map(GCM) is a model of non-linear system with a global connected chaotic network, that changed by all other elements interacting with the same degree of intensity. The equation of GCM is shown as follows:

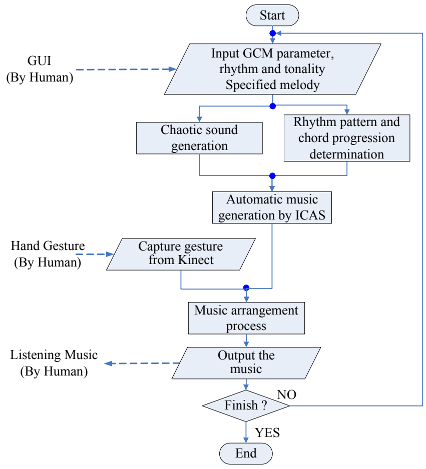


Fig. 2. Algorithm of Chaotic Music Generation System

$$f(x_j(t)) = 1 - ax_i^2(t) \qquad [i = 1, 2, ..., n], \tag{1}$$

$$x_i(t+1) = [1-e]f(x_i(t)) + \frac{e}{N}\sum_{j=1}^{N} f(x_j(t)), \tag{2}$$

where $x_i(t)$ shows the state of element i at a discrete time t, $f(x)$ shows logistic map, a parameter e shows the strength of the entire combination, and N shows the total number of elements.

B. About ICAS

In this research, we propose some further works of Interactive Chaotic Amusement System (ICAS)[4]. By using ICAS which united the chaotic elements to generate various sounds by GCM, favorite sounds for an operator appear as a whole adjusting the parameter of GCM. Its control is enabled by the human operator, and the sound is tuned by a visual information.

C. Proposed Music Generation System

We propose a method to generate the music that changes according to the hand gesture of operator in real-time, and not simply mapping the gestures directly into music. Through the application and extension of ICAS, we make it possible to combine the diversity and the randomness of computer-generated music with the human requirements for the music. The overview of our system is shown in Fig. 1. Fig. 2 is the flow chart of hand gesture-based ICAS.

In this research, first we get the GCM parameters from the Graphic User Interface(GUI) with these data, and we can generate the pitch and length of sound. And then, with the selected rhythm type in the GUI, we adjusted the accompanied sound with the rhythm and chord progression, and we achieved to make our output sounds more like music. We capture the operator's hand gesture by Kinect, and find out the hand position from the input data, then figure out the center point of hand and wrist as the characteristic point of hand gesture. With the coordinates of those points of both hands in several serial frames, we can calculate the amplitude, speed and acceleration of the motion of hand. Finally, we arranged the automatic generated music with the data of recognized hand gesture.

III. Music Generation Method

In our former works, the system united the chaotic elements to generate sound by the Network of Chaotic Elements, and its control is enable by the operator. In our music generation system, we use ICAS to generate the basic sound according to the operator's setting of rhythm and tonality, and we proposed a method to select the chord progression automatically. After this, we obtain the basic sound, generated by ICAS, the rhythm and chord progression, generated by our automatic selection method.

In this paper, we proposed several methods to improve the generated music of our system. First we add a main melody into our system, using the iteration of network of chaotic elements to relating with other chaotic variables. Next, we introduced a parameter to regulating the influence of main melody. Finally, we discussed the feasible range of the parameter, and generated sound with those data.

A. Addition of Main Melody

The melodies existing in most European music written before the 20th century, and popular music throughout the 20th century[7]. But in our former generation method, all the pitch and length of each note are generated by ICAS, user can do nothing on what melody will be generated, every note is determined under the iteration calculation. The original intention of using this is to generate brand new music depended on the unpredictability of chaos. But after our evaluation experiment, we found that without main melody, our output music do not have any vitality, each sound channel sounds like background accompaniment. Hence, we try to add main melody into our system as the foreground sound.

Since it is difficult for our system to generate main melody automatically, we make the melody specifiable by our system users. In order to accompany with main melody, the network of chaotic elements has been restructured. Fig. 3 shows the idea of iterating the main melody notes in network of chaotic elements. In the former networks, all the state variables are calculated by Eq. (1) and Eq. (2), but in Fig. 3, we set up a special state, which use the data of specified main melody after preprocessing and normalization. Here the state for main melody makes influences on other chaotic state by taking average calculation.

We have divided the range of GCM output into 30 segments, as Table 1 shows, for tonics, dominants and subdominants, there are two segments corresponding to them, and we also increased the number of other scales, in order to make each scale has a roughly equal probability. Through this process, the pitch of main melody can be transfer into normalize range of GCM state variables.

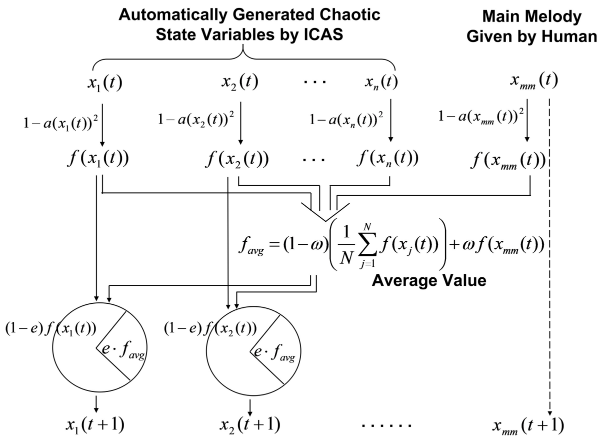


Fig. 3. Addtion of Main Melody

Table 1 GCM Outputs and Corresponding Pitches

GCM output	Corresponding pitch						
[-1.5, -0.6]	C-	D-	E-	F- F-	G-	A- A-	B- B-
[-0.5, +0.4]	C C	D	E E	F	G G	A	B
[+0.5, +1.4]	C+ C+	D+ D+	E+	F+	G+ G+	A+	B+

B. *Weights Setting of Melody*

The average computing in Eq. (2) and Fig. 3 cause all the state share the same weights, in this research, we make the weights of main melody controllable, and rewrite the average of all elements as Eq. (3), thus Eq. (2) can be rewrite as Eq. (4):

$$f_{avg} = (1-\omega)(\frac{1}{N}\sum_{j=1}^{N} f(x_j(t))) + \omega f(x_{mm}(t)), \quad (3)$$

$$x_i(t+1) = (1-e)f(x_i(t)) + ef_{avg}, \quad (4)$$

where ω in Eq. (3) is the weights of main melody, N in Eq. (3) is the number of chaotic elements, and e in Eq. (4) indicates the degree of synchronicity among the chaotic elements in GCM.

IV. Experiment

We have implemented the system described in this paper to evaluate the effect of the system. We designed two experiments, to find out the difference of the output sound, when the parameter e and ω have difference.

The system we have simulated, is programmed under Microsoft Visual C++ and Cycling74 company's MAX/MSP. The GUI of hand conducting gesture recognition is shown in Fig. 4. We get the operator's music command gesture using a Kinect. The red cross shows the center point of hand and wrist. In this GUI, we calculate the hand speed and amplitude in realtime, and we can get hand direction data easily by using Kinect, all these data will be send to the music generation and music arrangement program. We divided the gesture recognition view into four areas, when left hand is out of view, the right hand position decides the part play instruments. When both hands can be detected by our system, for example in the case shown in Fig. 4, the system will play the music in ensemble.

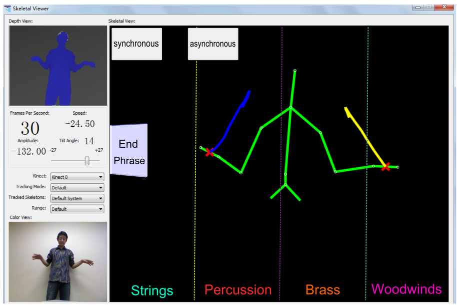


Fig. 4. GUI of Hand Conducting Gesture Recognition

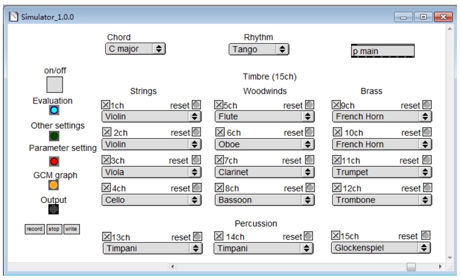


Fig. 5. GUI of ICAS Simulator

The GUI of improved ICAS simulator is shown in Fig. 5. This GUI mainly shows about the music generation, we can set the sound tonality and length here. All 15 orchestra instruments by MIDI are listed in group, and we can set them on or off respectively. And before our conducting, we can listen to the automatical generated music first adjusting the parameters. When we think it has become interesting enough, we start our conducting, and will let the music richer, more diverse.

A. *Experimental Results*

We performed an experiment aiming to verify the reasonable range of parameter e and ω . First, we try to figure out without adding main melody, how chaotic statement changes when we take different parameter a and e. As we want to know how well will the chaotic state accompaniment with main melody, we first figure out the maximum standard deviation among chaotic states when a and e changes.

Fig. 6 is a result of the GCM phrase diagram without melody, and in Fig. 7 shows the GCM phrase diagram when ω takes the value from 0.5 to 0.8. From Fig. 7 we can find out that when ω <0.6, we can hardly get the deviation below 1.0 covering the full range of a(indicated by the red area in Fig. 7), this will make it impossible to synchronous the chaotic sound with melody. On the other hand, while changing the value of e with constant a and ω, and expecting to let the results containing greater range of variation, as a result, we have to choose ω $\geq$0.7, and 1.8$\leq$ a $\geq$2.0.

Fig. 8(a) gives the main melody line used in this experiment, which is from one of the most popular pieces of Lee Ru-ma, Korean. Fig. 8(b) to (h) show one of the

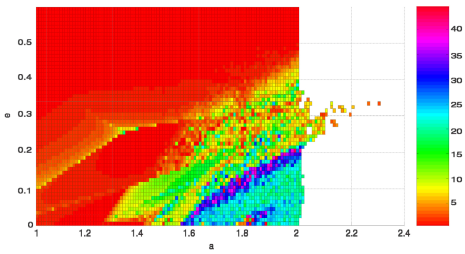
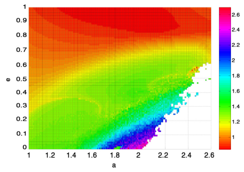
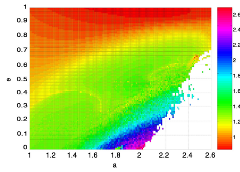


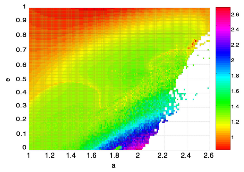
Fig. 6. GCM Phase Diagram (Without Melody)



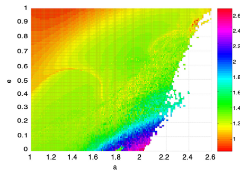
(a) ω=0.8



(b) ω=0.7



(c) ω=0.6



(d) ω=0.5

Fig. 7. GCM Phase Diagram (With Melody)

chaotic element's state accompanying with main melody, while parameter e ranging from 0.1 to 0.9. When e=0.9 and e=0.7, the chaotic element follows the main melody well, while e=0.5 chaotic state begins to distribute on two orbits, and there are four orbits at the peaks in e=0.3. As the e decreasing the chaotic element spread to more orbits. Chaotic state back to chaos after e=0.1. Therefore, we think it can be considered that we can get a main melody oriented outcome when $e \geq 0.7$. While the rest range of e is also interesting. From e=0.7 to e=0.2, we can see some intermittency chaos. And if we want to get an totally chaotic outcome, as we did before, we can set $e \leq$0.2.

In Fig. 9, we apply parameter to generate the music, while setting the ω=0.7 and e=0.7. The Former ICAS notes show significant irregularity, on contrary, the chaotic elements accompany with main melody well.

As a result of the simulation, we confirmed that the generated music has more orderly than the simple ICAS system and we can get the desired sound along with the specified melody.

V. Conclusions

In this paper, we proposed the music conductor gesture arranged music generation system. We generated the chaotic sounds first, the conducting hand gestures have been used to arranging the output music. We took the main melody of music into consideration. For the further research, we will perform the emotion evaluation experiment and enrich the musical expressions and the conducting gestures to achieve a better output sound and a higher level of interaction.

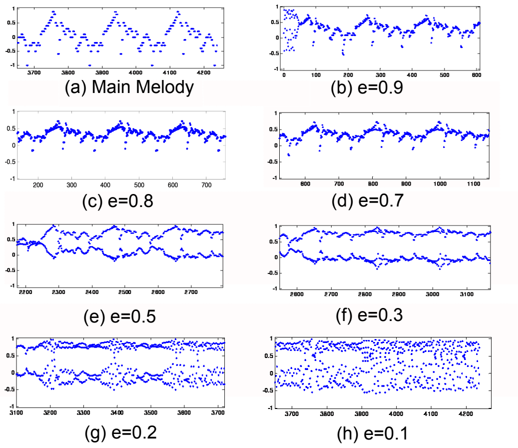


Fig. 8. GCM output while e from 0.1 to 0.9

(a) Former ICAS

(b) Melody Oriented ICAS (ω=0.7, e=0.7)

Fig. 9. Score of Output Music

References

[1] A. Mulder, S. Fels, "Sound Sculpting: Manipulating Sound through Virtual Sculpting," *Western Computer Graphics Symposium*, pp. 15-23, 1998.

[2] H. S. Ip, H. Young, C. C. Tang, "Body-Brush: A Bodydriven Interface for Visual Aesthetics," *ACM International Conference on Multimedia 2002*, pp. 664-665, 2002.

[3] H. S. Ip, C. K. Law, B. Kwong, "Cyber Composer: Hand Gesture-Driven Intelligent Music Composition and Generation," *Proceedings of the 11th International Multimedia Modelling Conference (MMM '05)*, Vol. 1550, pp. 5502-5505, 2005.

[4] M. Yamamoto, Y. Maeda, "Interactive Kansei System for Sound Generation Based on Network of Chaotic Elements ", *Proc. of the Fourth International Symposium on Human and Artificial Intelligence Systems: From Control to Autonomy (HART 2004)*, pp. 315-320, 2004.

[5] S. Chen, Y. Maeda, Y. Takahashi, "Chaotic Music Generation System Using Music Conductor Gesture," *Journal of Advanced Computational Intelligence and Intelligent Informatics (JACIII 2013)*, pp. 194-200, 2013.

[6] K. Kaneko, "Partition complexity in a network of chaotic elements", *Jonal of Physics A*, pp. 2107-2119, 1991.

[7] V. Kliewer, "Melody: Linear Aspects of Twentieth-Century Music," *Aspects of Twentieth-Century Music*, pp. 270-301, 1975.