A Study on Taiwanese Bei Guan Automated Composition Based on Rhythm Complexity and Markov Chain Analysis

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Abstract

In traditional Taiwanese music, not much information is recorded for percussion instruments. There is a very small amount of research for gongs and drums in Taiwanese music. This research tries to analyze rhythm of Bei Guan music by using rhythm complexity measure, to find out its attributes and similarities, and then to perform the similar and automated composition of Bei Guan music. The result of the research shows the possibility to preserve and promote Taiwanese Bei Guan Music with automated composition techniques.

Keywords: Bei Guan music, Rhythm Complexity, Algorithm Composition.

1. Literature Review

The main difference between the two rules for automated composition is whether or not training data is used. The explicit rule needs experience or music theory to compose music; the implicit rule needs training data to find the common feature, and then music is composed with the common feature. In this research we use explicit rule and Markov Chains [8] to build up certain rule to compose music.

1.1 Bei Guan Music

Bei Guan (北管) music is one kind of traditional music in Taiwan. Bei Guan was the most popular music and drama in Taiwan [3]. From the middle of the Qing Dynasty to Taiwan Retrocession Day, Bei Guan drama was the most popular traditional drama; it showed up in weddings, funerals, religious ceremonies and festival celebrations. It is very important in the musical history of Taiwan [4].
The name of "Bei Guan"is compared to "Nan Guan" (南管) with their controversial meanings. With the immigration from China, traditional drama and music came to Taiwan in different periods and were formed in different areas. By localization, Bei Guan came to have enormous variation and multiple music systems [3]. Bei Guan music can be divided into four categories including pai zi (牌子), sian pu (絃譜), si cyu (戲曲) and si cyu (細曲) [2] . In this research, we focus on pai zi. Pai zi is mainly performed with a percussion instrument and souna horn. It is also performed in other kinds of drama. For example, Taiwanese Opera (歌仔戲), Glove Puppet Show (布袋戲), Marionette Show (傀儡戲), Shadow Play (皮影戲), and Taoism ceremony. It is the most vigorous performing art among the four categories of Bei Guan music.
There is some preliminary research for Bei Guan music, but most of them are about drama or melody [1]. After reviewing the research literature on Bei Guan music, we found out that there is not much study about gong and drum, and the related research is mostly just a brief introduction. A possible reason: the previous research includes algorithm composition, Bei Guan music, and rhythm complexity, as shown in the following paragraphs.

1.2 Research of Algorithm Composition

Automated composition or algorithmic composition goes through an algorithmic way to compose music, and it makes the composers to write music with minimum influence and intervention by humans [6]. According to the research of algorithmic composition in the past, we define two kinds of rules as follows:

I. Explicit Rule: Generate rules according to music theory or experience.

II. Implicit Rule: Generate rules according to machine learning with training data.

The reason for the lack of research concerning gong and drum is that, traditionally, there is no detailed score about gong and drum; people were taught and inherited the knowledge of the gong and drum by reciting pithy formulae. Traditional handwritten copies did not describe the details about how to play gong and drum, therefore, reciting "luo gu jing" (鑼鼓經) became the most important thing of learning gong and drum [1].

1.3 Rhythm Complexity

I. Toussaint's Off-Beatness
The Off-Beatness Measure was proposed by Toussaint [9]. It measures how an irregular rhythm is formed by counting the number of onsets which does not align with the vertices of regular polygons when placing the rhythm on a circle [11].

II. Keith's Complexity
Keith's Complexity Measure was proposed by Michael Keith [9]. Keith introduced a measure for rhythmic syncopation based on three rhythmic events: hesistation, anticipation, and syncopation. A hesitation event can be defined as a note

beginning on the beat, with the ending off the beat. The beginning of a note is the onset, and the end of a note is the offset. For percussive instruments without sustained notes, as in this study, we assume that offsets fall on the same pulse as the onsets. An anticipation event is when a note begins off the beat, but ends on the beat. A syncopation event is the combination of a hesitation and anticipation [11].

III. Weighted Note-to-Beat Distance (WNBD)
WNBD focuses on the relationship between onsets and strong beats. Given a rhythm with n pulses and k onsets, the distance of each onset to the nearest beat is measured. The beat is determined by a parameter p, which evenly distributes n/p onsets in a rhythm of n pulses. For our purposes, we calculated the measure for all values which evenly divide n, aside from 1 and n, and then averaged these results. The distance is weighted [5] by a rule which depends on where the onset lies between the beats and the distance of the next onset [5, 6]. This is calculated for each onset and scaled by k to yield the WNBD Measure [11].

1.4 Markov Chain

The basic idea is to create a completely specific representation of example data sequences and generalize the model to predict/generate new instances[8]. These can be used to describe one dimension of the musical style of a composer. However, other aspects of music could also be learned using this method: pitch, duration, tempo, dynamics, melody, phrasing, and rhythm[8].

2. Research Method

Rhythm Complexity Analyze

I. Toussaint's Off-Beatness
First, let a rhythm with n pulses and k onsets, place n pulses evenly around the circumference of the circle, and mark each pulse from 0 to n-1. Second, find the value r that is greater than 1, less than n, which evenly divides n. Third, take 0 as vertex, r as side length, and inscribe all possible polygons on the circle (Figure 1). Fourth, find out the pulses that do not correspond to a vertex of any inscribed polygon, and defined those vertexes as off-beat. Last, sum up the number of onsets which occur on off-beat. The higher numeral means the higher rhythm complexity degree.

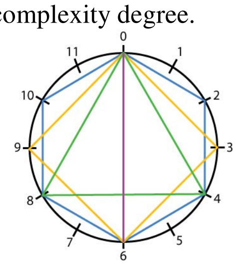

Figure 1. 12-unit Circle with Its Divisor Polygons

II. Keith's Complexity
First, let r be a rhythm with n pulses and k onsets. Second, let an onset to be i, and the following onset to be j. Compute duration A = j – i, and define Â to be A rounded down to the nearest power of 2. Third, calculate the answer of i mod Â and j mod Â. If the answer is 0 we define i or j as on beat, if the answer is not 0 we define i or j as off beat. Fourth, compare i and j to Figure 2, find out the value of s. Last, repeat step two to step four until all onsets have been picked, then sum up all s. A higher numeral means a higher rhythm complexity degree.

$$s = \begin{cases} 0 & \text{if } i \text{ is on beat and } j \text{ is on beat} \\ 1 & \text{if } i \text{ is on beat and } j \text{ is off beat} \\ 2 & \text{if } i \text{ is off beat and } j \text{ is on beat} \\ 3 & \text{if } i \text{ is off beat and } j \text{ is off beat} \end{cases}$$

Figure 2. Keith's Measure Reference Equation

III. Weighted Note-to-Beat Distance(WNBD)
First, let r be a rhythm with n pulses, k onsets, and m be the number of beats in the meter. Strong beats defined in terms of the meter defined. Let e_i, e_{i+1}, e_{i+2}, … be strong beats. Second, let x be an onset in r, calculate the distance of (x, e_i) and (x, e_{i+1}), then pick the smaller distance and divided by m, let this result be T(x). Third, assign D(x) as Figure 3. Last, go through all the onsets, sum up all D(x), and then divided by the number of k onsets. A higher numeral means a higher rhythm complexity degree.

$$D(x) = \begin{cases} \frac{1}{T(x)} & \text{if } x \text{ ends before or on } e_{i+1} \\ \frac{2}{T(x)} & \text{if } x \text{ ends after } e_{i+1} \text{ but before or on } e_{i+2} \\ \frac{1}{T(x)} & \text{if } x \text{ ends after } e_{i+2} \\ 0 & \text{if } T(x) = 0 \end{cases}$$

Figure 3. WNBD Reference Equation

$$WNBD(R) = \frac{1}{k} \sum_{i=0}^{m-1} D(x_i) = 14/5$$

Figure 4. Calculation of WNBD Example

Research Process

This research selects two instruments as the data. One of these two is the traditional small drum called “ban gu” (板鼓), and the other one is the traditional small gong called “siang jhan” (響盞). The reason why we choose these two instruments is because that ban gu plays the most important role in the band, and it conducts the way the music goes. Ban gu and siang jhan require more skill than the other percussion instruments, and they perform more variation beats. After collecting the data of gong and drum, we analyzed their rhythm complexity, and found out attributions, similarities and differences. Then we use the Markov Chain model to build up system rules. Lastly, the system automatically generates Bei Guan music, as shown in Figure 5.

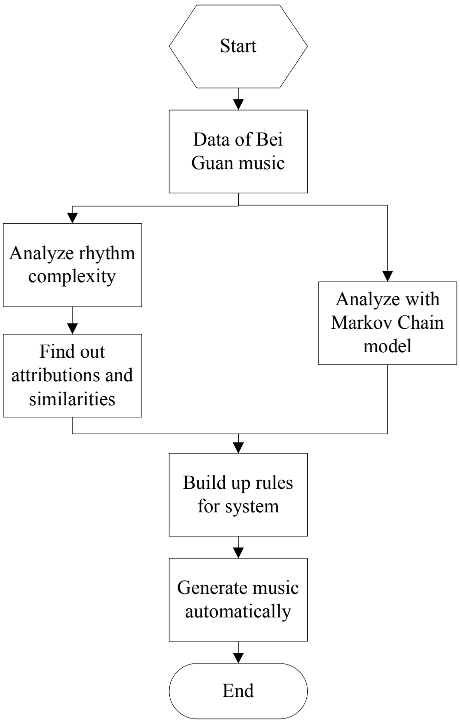

Figure 5. Research Process

3. Result of Research

This research emphasizes one category of Bei Guan music-"pai zi". But due to the fact that the data of gong and drum is not much, we analyze with the limited data that which we have. In Keith's Complexity Measure (Figure 6), most numerals of ban gu fall on 0 or 2, and most numerals of siang jhan fall on 6. In WNBD Complexity Measure (Figure 7), most numerals of ban gu and siang jhan fall between 1.6 to 2. In Off-Beatness Measure (Figure 8), most numerals of ban gu fall on 0 or 1 and most numerals of siang jhan are all 0. Except "cing jiang yin", most of pai zi reveal the same value or a small range of values.

However in Off-Beatness Measure, all numerals of siang jhan are 0. It cannot be determined as to whether these values are useful or not to be able to support this research.

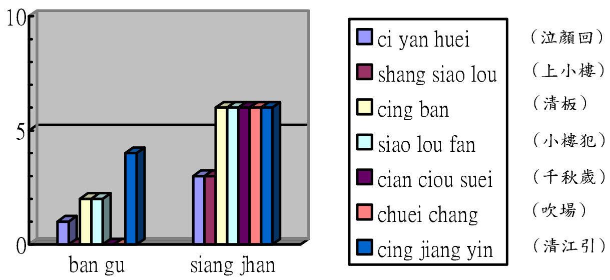

Figure 6. Keith's Measure Chart

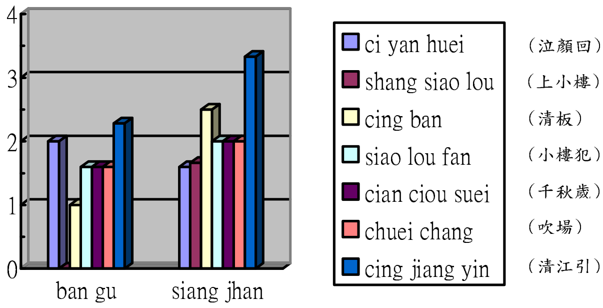

Figure 7. WNBD Measure Chart

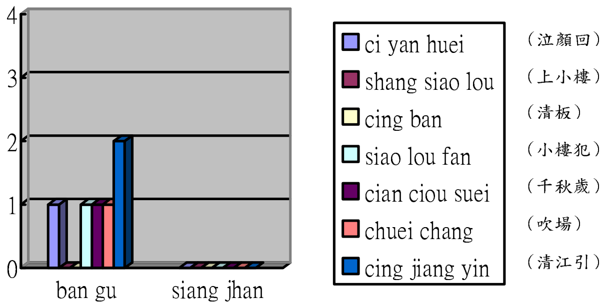

Figure 8. Off-Beatness Measure Chart

4. System Implement

This system is developed on Eclipse with java language, and use JMusic as the resource to generate MIDI music. Because MIDI doesn't support several timbres of traditional instruments, we search other timbres that are similar to the original one. Therefore the music can be generated from the system and sound, as possible as we can manage, like the acoustic instruments.

5. Experiment Result

The final product of this research generates MIDI files of Bei Guan music. In order to visualize the result of the music we generated, we use JMusic to create a diagram comparing the music that the system generated. This diagram marks different instruments with pitch and rhythm (Figure 9).

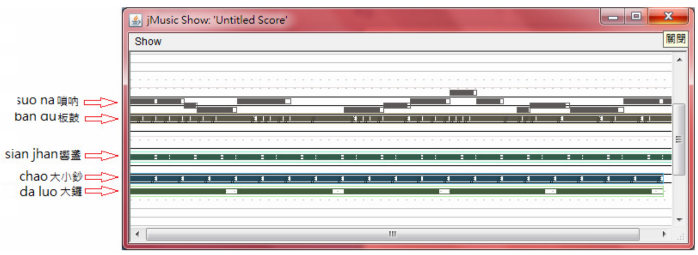

Figure 9. Diagram of MIDI Music

The generated MIDI file can be transferred to a music score form as in Figure 10.

Figure 10. The Notation of the Automated Composed Music for Bei Guan

6. Conclusion and Future Work

This research analyzes Bei Huan music with rhythm complexity, and tries to generate similar and automated compositions. With data limited to Bei Guan music, it produces results that are the same or within a small range. In the future, other rhythm complexity methods will be used to analyze other types of music. This will provide more specific results for us to study, in order to build up rhythm complexity of any kind music, and to provide not only styles, but a flexible range to control its complexity. Finally this research creates an automated, random rhythm with a manageable range control; we hope that it provides a contribution to algorithm composition for traditional Taiwanese music.

7. Acknowledgement

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