Chord Progression Similarity of Recent Chinese Pop Music Based on the Markov Model

Jiaying Li
jli3269@gatech.edu

***Abstract*—In this paper, we present a new method to measure the similarity between chord progressions: the chord progression similarity index algorithm based on the Markov Model. The algorithm fits the similarity conclusion based on music theory perfectly and shows high compatibility types and numbers of chords in chord progressions. The algorithm also allows for modifying the weight of each chord in a chord progression to adapt real-human music similarity perception. Through the test and evaluation of the 200-song-database, which consists of the twenty most popular Chinese songs in the past ten years, we get the conclusion that Chinese pop music tends to become more and more similar in recent years.**

***Index Terms*—Music similarity, Markov Model, Chinese pop music**

I. Introduction

After the development of digital music technology, the strengthening of copyright awareness, and the popularization of short video platforms, Chinese pop music has undergone huge and obvious changes in the past ten years. Music has penetrated people's lives in more ways, and it is easier to gain exposure and attention than ten years ago. However, at the same time, it seems to be a widely acknowledged fact that popular music in China is becoming more and more similar. In 2021, cases involving music plagiarism reached more than 64.2% among the plagiarism cases and caused widespread discussion on social media [1]. At a time when the media is wailing that "creation is dead" [2], more and more professional musicians have also expressed concern and a negative attitude towards the future of China's music market. Therefore, in the current environment where original musicians generally have higher positions, how to identify similar music has gradually become an important but particularly difficult thing. For music lovers without professional musical training, chords are less likely to compare similarities than melodies [3], and that leads to more urgent market demand for the chord progression similarity. This paper aims at studying and exploring the similarity of chord progressions, and provides a new method to measure chord progression similarity based on the hidden Markov Model.

The measurement of music similarity has been a widely researched field [4], and has great significance for music searching and classification, copyright maintenance, and so on [5]. As a part of music similarity measurement, the most common method of chord progression similarity measuring is the chord alignment method [6]. However, there are quite a few limitations of the chord alignment method. Although convex optimization enables the calculation between chord progressions consisting of different numbers of chords, the chord alignment method cannot deal with inversion chords or mixing chord types [7]. Also, the chord alignment method cannot take into account the similarity between the chord progression loop and the non-cyclic state. Conversely, our algorithm based on the Markov Model has wider compatibility.

Constructing Markov chain between speech segments after framing and windowing and calculating similarity index using transition matrix is a common technique in NLP [8]. We apply a similar idea to the calculation of the chord progression similarity index. By splitting the chords into notes and calculating the Euclidean distance between the transition matrices constructed by the transition probability from the notes, and finally appropriately adjusting the weight of chord in different locations in a chord progression based on real-human perception, we can get a convincing chord progression similarity index.

We set up a Chinese Pop music database with 200 Chinese pop songs. The database includes twenty most popular songs in each year from 2012 to 2021 with chord progression information. Based on this database, we tested our new algorithm and obtained the conclusions that meet our expectations.

This paper mainly has four sections: Section 1 introduces the sampling method of the Chinese Pop music database, Section 2 describes the chord progression similarity measuring algorithm based on the Markov Model, Section 3 shows the analysis and conclusions on the foundation of Chinese Pop music database, and finally, Section 4 is related to a summary and improvement directions.

II. Construction of the Chinese Pop music database

A. Sampling Method

With the development of all kinds of media platforms, although the sources for obtaining music vary a lot, Mobile music software is still the most mainstream music platform. According to the market survey, users of music APPs under Tencent Music and Entertainment (TME) account for 94% in China [9]. TME's annual financial report shows that QQ Music, Kugou Music, and Kuwo Music include 72.8% of users, and the user groups among these music APPs have quite a few overlapping [10]. Based on the tracking data of these music APPs, the top 100 music list calculated by the clickthrough rate and the searching rate is provided by TME every year.

Suppose that in year i and $i \in \{2012, 2013, ..., 2021\}$, song j on music APP k and $k \in \{1, 2, 3\}$, where $k = 1$ represents QQ Music, $k = 2$ represents Kugou Music, $k = 3$ represents Kuwo Music. We recalculate its average ranking as:

$$r_{ij} = \frac{1}{3} \sum_{k=1}^{3} r_{ij}(k) \tag{1}$$

Among the three music APPs, since Kugou Music was renamed in 2017, its list from 2012 to 2016 is not included in the ranking of songs. In the recalculated list, the top 20 songs of each year were selected to record their chord progressions and completed the construction of the Chinese Pop Music database.

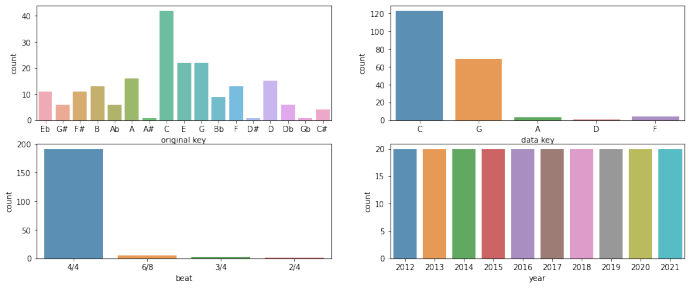

Fig. 1. Data Information of the Chinese Pop music database

B. Chord Progression Notations

In order to simplify the structure of the songs, we only divide the database into verse chord progressions and chorus chord progressions. Some complex structures such as bridges, are recorded as chorus parts.

A distinctive feature of Chinese pop music is that we can always consider chord progressions corresponding to a full lyric sentence as basic units because chord progressions in such units always have regular repetitions. Based on this feature, we use the length of complete lyric sentences as the units to record the chord corresponding to each complete lyric. After statistics, we found that in Chinese pop music, there are always at most four different group units, and we name them "chord progression groups". Thus, our database records chords in the form of chord progression groups. The chords are separated by "->", for example, "F->G->Am->C".

Besides the chord progression information, the database also contains the name, ranking year, singer, beat, original key, and the data key of a song. To keep the consistency of the data information, we use major keys uniformly.

III. Chord Progression Similarity Measuring Algorithm Based on the Markov Model

This section mainly focuses on introducing the transition matrix construction algorithm of the chord progression from the more specific to the more general cases. Starting from the simplest model based on the roots of the chords in chord progressions, and ranging to all types of chords, including seventh chords, ninth chords, and even more complicated chords.

Before starting to explain the algorithm, we map the notes with numbers to facilitate mathematical model calculation: Although from the perspective of music theory Db and C# have different definitions, they display the same pitches and frequencies from the perspective of digital signal processing [11]. Therefore, we use the same number to represent the sharps and the flats.

TABLE I
The Relationship between Notes and Numbers

	1	2	3	4	5	6	7	8	9	10	11	12
	C	C#	D	D#	E	F	F#	G	G#	A	A#	B
or	C	Db	D	Eb	E	F	Gb	G	Ab	A	Bb	B

A. Root-based Measuring Model

Before moving on to more complex situations, we start with the construction of the simplest root-based chord progression transition matrix [12].

Every chord has a fixed root, which largely determines the feature of the corresponding chord. For a chord progression K with chords $\{C_i\}$, where i represents its location index in K, we simplify it as a directed Markov chain based on its roots $\{R_i\}$. There are twelve notes in total, so each chord progression forms a 12×12 transition matrix. Assuming that each chord has the same weight in the chord progression. If chords are repeated in a chord progression, the original probability of 1 will be divided by the number of occurrences. Denote the transition probability from root R_i to R_j as P_{ij}.

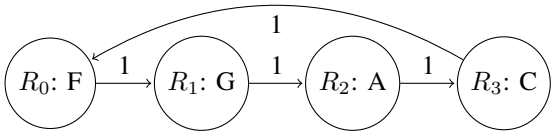

Fig. 2. Example of chord progression "F->G->Am->C"

Fig. 2 shows an example of a directed Markov chain of a chord progression. Generally, chord progressions are presented in loops in a song, so the last chord is connected to the first chord in our model.

B. Construction of Chord Progression Transition Matrix

We split every chord in a chord progression into notes. For notes N_{ij} in chord Ci, their transition probabilities to the notes N_{i+1j} in the next chord C_{i+1} are the same. Based on the previous root-based measuring model, the transition probability p_{ij} from note N_{ij} to N_{i+1k} can be defined as:

$$p_{ij} = \frac{P_{ij}}{\max j} \tag{2}$$

Fig. 3 shows the transition graph between notes in a chord progression. Consider that each chord in a chord progression

has the same weight, then every arrow represents the same transition probability.

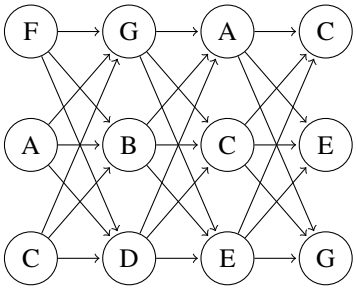

Fig. 3. Example of transition graph between notes in the chord progression "F->G->Am->C"

C. Chord progression similarity index

For chord progression K_1 and chord progression K_2, define their similarity index as the Euclidean distance of their note transition matrix Π_1 and Π_2:

$$\rho_{1,2} = \sqrt{\sum_{i,j}[\Pi_1(i,j) - \Pi_2(i,j)]^2} \tag{3}$$

D. Real-human Perception Adapted by Weighted Chords

During the cycling of a chord progression, the effects of chords in different positions are different, which leads to great differences in the perception of the human ear. For example, the first chord in a chord progression is often played heavily for emphasis in a lot of music. Our similarity measuring method based on Markov model allows to add weights to chords on different location linearly. The main idea of weighting is to adjust the parameters on the root-based model to achieve the purpose of changing the weight.

Play a chord progression with different chords as the starting position, record the difference between the real-human perception and the original chord progression, and calculate the chord weight of each position according to the data. Assume that the real-human perception weights w_i for chord C_i, modify the root-based chord progression transition matrix P:

$$P_{ijmodified} = \frac{w_i P_{ij}}{\sum_{i,j} w_i P_{ij}} \tag{4}$$

IV. Similarity Analysis of the Chinese Pop Music Database

Based on the Chinese Pop music database, we analyze the chord progression similarity relationship in the following twelve versions:

- Version 1.x.x: No weight for chords;
- Version 2.x.x: Add weight to leading chord;
- Version x.1.x: Non-simplified chords;
- Version x.2.x: Simplified chords into triads;
- Version x.3.x: Root-based model;
- Version x.x.1: Progression group as basic analysis unit;
- Version x.x.2: Combining all chord progressions together as basic analysis unit.

In each version, we calculated its verse similarity, chorus similarity, and total similarity which is measured by adding up verse similarity and chorus similarity.

A. Similarity Tendency of the Exactly Chord Progressions in Each Year

1) Non-simplified version: We can clearly see that Chinese pop music uses the exact same chord progressions more and more, especially in recent years.

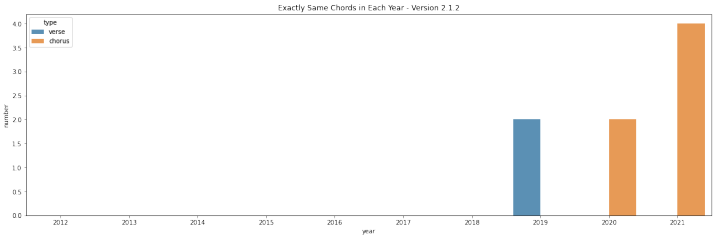

Fig. 4. Exactly same chord progression numbers in non-simplified version

2) Simplified version: If we simplify the chords in chord progressions to triads, we can find that in the past years, people still use the same chord progressions. However, there is still a significant trend that people tend to use exactly the same chord progressions.

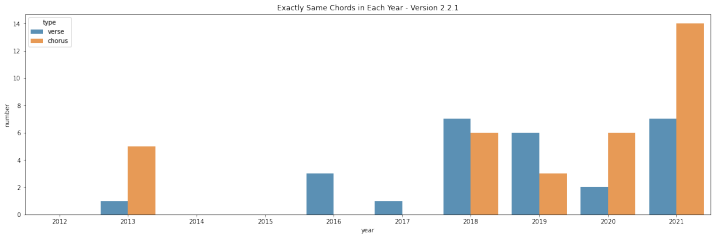

Fig. 5. Exactly same chord progression numbers in non-simplified version

B. Evaluation of Chord Progression Similarity

Since the chord progression similarity index is defined as the Euclidean distance between the transition matrices of two chord progressions as we mentioned in the previous sections, then the smaller the similarity index is, the more similar the chord progressions are.

An overview of a data analysis of top 10 songs in each year is shown in Fig. 6, and Fig. 7 shows the data analysis of top 20 songs in the past ten years. Top 10 songs are small sampling, so we used the smallest similarity index during data analysis for each song. However, top 20 songs are larger sampling, so we chose to use an average similarity index during data analysis for each song. Summarized results are listed as follows:

- Among the top 10 songs sampling, from 2016 clearly show gradually decreasing chord progression similarity index, which means increasingly similar use of chord progressions;

- The tendency of the top 20 songs is not as clear as the top 10 songs, but the corresponding trend can still be observed;
- After chord simplification (to triads), the similarity index becomes obviously smaller, and trend of similarity is harder to identify.

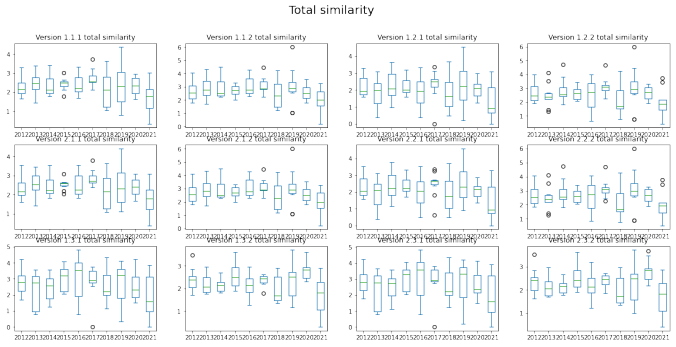

Fig. 6. An overview of similarity analysis of top 10 songs in past 10 years

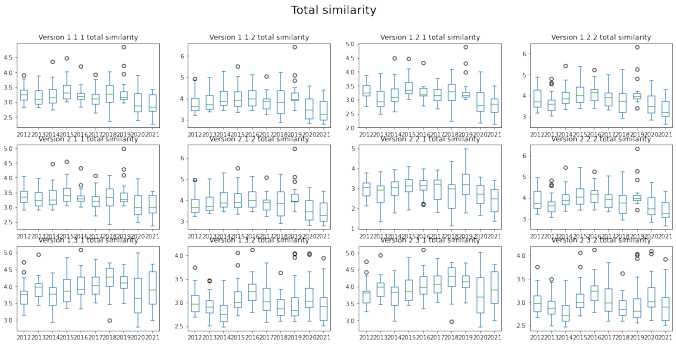

Fig. 7. An overview of similarity analysis of top 20 songs in past 10 years

C. Weight Parameter Based on Real-human Perception

V. Conclusions

This paper presents a new chord progression similarity measuring method, analyzes the similarity of the Chinese pop music database with the proposed method, and obtains the conclusion that Chinese pop music is using more and more similar chord progressions. The chord progression similarity index based on the Markov model shows encouraging results in its accuracy and adaptability, and also brings more possibilities for future related work.

There is still a lot to explore about chord progression similarity. Due to the limited time and space, we did not discuss the relationship between chord progression similarity and chord rhythms in detail, nor did we complete the verification of more musical styles and other cross-cultural music. More relative exploration will be considered in the future.

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