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Modern Western Modes Spectral Analysis using Dynamic Time Warping Method

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Abstract

Modes are melody forming tone arrangement derived from the progression of natural basic tone (major scale) and grouped based on patterns and produced nuances. This paper emphasizes on to similarity analysis of seven types of modes, i.e Ionian, Dorian, Phyrgian, Lydian, Mixolydian, Aeolian, and Locrian. Each modes has been recorded in C major scale and analyzed by spectral analysis with Dynamic Time Warping (DTW) method to determine the similarity to one another. The results showed the similarity between modes based on the value of minimum cumulative distance or similarity cost. There are high resemblances to each other between Ionian, Dorian, Phyrgian, and Lydian mode. High similarities between Mixolydian and Locrian modes. Aeolian mode stand on its own because it has large similarity cost value. ©

1. Introduction

In musical theory, the definition of music modes are melody forming tone arrangement derived from the progression of natural basic tone (major scale) and grouped based on patterns and produced nuances. The modes origin comes from the ancient Greek developed by Pythagoras and Aristoxenus. At that time the modes system were used in tuning of seven stringed lyres [1]. It gained prominence in vocal compositions during the golden age of Gregorian chant around the 900 AD. In the baroque and prebaroque era, some people used the major and minor scales exclusively on modes they played. After the era of baroque, classical and almost all romantic era, the modes have been abandoned. It returns to gave an important role again when jazz musicians started using modes in improvise and compose modes into something useful on music curriculum [2].

There are seven well known scales in modern western modes as presented in table (1) i.e, Ionian, Dorian, Phyrgian, Lydian, Mexolydian, Aeolian, and Locrian. The pattern is a unique result of an inversion rearrangement of the major scale [3]. When a major scale is played with a certain technique, it was able to provide different nuances for every single mode. Nuance is out due to a tone emphasis on the reference modes from the melody progression that played out.

In table (1), Ionian mode is the first mode (1st degree of major scale) with tone intervals T - T - S - T - T - T - S (T = tone/ whole tone, S = semi tone/ half tone) or it has intervals tone values 1 - 1 - 1/2 - 1 - 1 - 1 - 1/2 (whole tone value = 1, half tone value = 1/2). When Ionian mode is played out, it means the nuance (bright and upbeat sounds) come from the tone emphasis of its first note of major scale. Compatible chord types represent what chords types should uses when someone play modes scale and the compatible chords for Ionian are major and major seventh.

Table 1. Characteristics of Modern Western Modes [5]

Major scale degree	Mode	Intervals	Compatible chord types	Sound
1	Ionian	T-T-S-T-T-T-S	Major, major seventh	Bright, upbeat
2	Dorian	T-S-T-T-T-S-T	Minor, minor seventh, minor ninth	Minor quality suited to jazz
3	Phyrgian	S-T-T-T-S-T-T	Minor, minor seventh	Spanish Sounding
4	Lydian	T-T-T-S-T-T-S	Major, major seventh, major ninth, sharp 11th	Ethereal, light sound
5	Mixolydian	T-T-S-T-T-S-T	Major, dominant chords, dominant seventh	Blues character
6	Aeolian	T-S-T-T-S-T-T	Minor chords, minor seventh	Sad, somber
7	Locrian	S-T-T-S-T-T-T	Diminished, minor seventh flat five (m7b5)	Dark and brooding

Eventhough the theoretical base of modes are actually quite easy to understand, but it hard to practice and also very difficult to play. Apart from the problem, studying modes also encountered difficulties in distinguishing of one to another modes. When all it plays as one part of solo melody it would brings impression that may confuse to audience. This occurs because the nuance is given so quickly changes and makes each kind of modes is not enough to achieve in harmony. Although there are several modes that have a dominant character, but it is still very difficult for peoples to calssify what kind of modes is he or she listen to.

Research on music classification and recognition has been conducted in several methods. Mel frequency cepstral coefficient (MFCC), hidden markov, and dynamic time warping (DTW) have been widely applied. But it still very limited literature that related to the music modes analysis. Most of previous publications are focused the analysis on the music genre, chord recoginitons, and scales that are common as major and minor. Li and Chan (2011) have been doing research on music genre classification using MFCC method that focused on music chord. They used a sample from 1000 songs which consist of 10 genres is Blues, Classical, Country, Disco, Hip-Hop, Jazz, Metal, Pop, Reggae, and Rock. Each song has been cut to 30 seconds with a sampling rate of 22050 Hz in 16 bits [4]. In this work, the more fundamental study is on the musical modes, which is the base of forming harmony of musics genre and it was investigated by using DTW approach to calculate and visualize the similarity.

2. The object of the study

Keyboard Roland bk-5 and standard recording studio tools has been used in this study. Each modes was recorded as many as five times in the same tempo in C major scale (C = do) and stored with *wav digital extension format with the sampling rate of 44100.

Table 2. Details of recorded modes

No.	Modes	Note Progression	Used chord
1	Ionian	C - D - E - F - G - A - B - C	Cmaj7
2	Dorian	D - E - F - G - A - B - C - D	Dm7
3	Phyrgian	E - F - G - A - B - C - D - E	Em7
4	Lydian	F - G - A - B - C - D - E - F	Fmaj7 (sharp 4)
5	Mixolydian	G - A - B - C - D - E - F - G	G7
6	Aeolian	A - B - C - D - E - F - G - A	Em (flat 7)
7	Locrian	B - C - D - E - F - G - A - B	Bm7 (flat 4)

Ionian modes were recorded using its compatible chord types (Cmay7) with melody progression start from C acording to it's intervals. And for the other modes were recorded as represent in table (2) above.

3. Methods

The entire recorded data was digitally processed by using Wavepad Sound Editor. A MATLAB codes has been developed for analysing the raw data. In this case the short time fourier transform (STFT) and DTW algorithm has been implemented to obtain