RoughNote: A Single-Tone-Note-Like Visual Representation of Classical Music

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ABSTRACT

Classical music works have temporal variations, such as change in volume or tempo. We think very useful for studying the classical music if we can look over the variations in a single display space. Also, such display is also convenient and fun for listening to the classical music. This paper presents "RoughNote", which visualizes the variation of features of the classical music in a single display space. "RoughNote" represents feature values of intervals of tunes as colored spheres, and horizontally arranges them onto a display space. We name this visualization technique "RoughNote", because its visualization results look like roughly created single-tone notes. We think "RoughNote" is useful and enjoyable for understanding the variation of the classical music while listening to them.

Keywords: Visualization, Classical Music

1. Overview

Classical music works have temporal variations, such as change in volume or tempo. It is usually difficult to understand such variation until we listen to the whole music. Music visualization is an active research topic to assist the understanding of music. Visual techniques have been already bundled with music playing techniques; for example, several music player software (e.g. Microsoft Media Player) bundle visual effects during playing music. However, it is generally difficult to understand the whole musical structures or variations of playing tunes just by looking at the visual effects. On the other hand, visualization techniques which represent whole works in one display space will help the variation and structure of music.

Many works on music visualization techniques have been already presented. Several works displays detailed musical information by analyzing MIDI data. Early works on MIDI-based music visualization techniques [1][2] simply displayed note information. Recent techniques [3][4] analyzed melodic or harmonic information to simply display overall structures of tunes in a single display space. On the other hand, MIDI data is not very common for general listeners. MIDI data is mainly used by composers, arrangers, and players, not general listeners; most of them collect only acoustic data (e.g. WAVE and MP3 files) to listen to the music. Therefore, music visualization based on acoustic data is an active research topic. It is difficult to visualize musical structures and variations just from acoustic data, comparing with MIDI-based visualization techniques, since it is still a difficult problem to exactly retrieve note information from acoustic data. Early acoustic-based music visualization techniques just briefly represented variations of volumes or dominant frequencies; it was not always sufficient representations to understand the variations of tunes. Recent musical information retrieval techniques realize extraction of brief musical features such as tempo and chords, and they are useful information for music visualization based on acoustic data.

This paper presents RoughNote, a music visualization technique based on acoustic data. RoughNote represents variation and structures of musical features including volume, tone, chord, inharmonicity, and tempo, in one display space. It provides friendly representation of musical variation and structures like a single-tone-note, so that general listeners can enjoy looking at the visualization results while listening to the music. We name this visualization technique "RoughNote", because its visualization results look like roughly created single-tone notes.

2. Related Work

There have been many visualization techniques displaying note information along time sequence. Such visualization techniques are categorized into MIDI-based and acoustic-based techniques.

MIDI-based techniques are preferable if users are interested in looking at note-by-note information, or semantics, structures, and variations of melodies and harmonies. We think MIDI-based visualization techniques are mainly useful for expert-level use to assist to play, compose, and arrange. Early MIDI-based music visualization techniques [1][2] simply displayed note information, but it may be sometimes difficult to understand high-level knowledge of the music from the visualization results. Recent MIDI-based techniques including Colorscore [3] and ScoreIlluminator [4] focus on representation of more abstract musical structures based on similarity and roles of note blocks. While the above techniques focused on note-like representation of tunes in a single display space, there have been several other MIDI-based visualization techniques. For example, Fujisawa et al. presented a harmony-based music coloring technique [5].

On the other hand, MIDI data is not very common for general listeners; most of them collect only acoustic data (e.g. WAVE and MP3 files) to listen to the music. Therefore, music visualization based on acoustic data is an active research topic. There have been many works on visualization of transition of music from acoustic data. One of the early works represents the transition of tones applying a piano-role-like representation [6]. Another work named SmartMusicKIOSK [7] displays blocks of pop music. These works do not display note-by-note information, because it has been a difficult problem to retrieve low-level musical information from acoustic data. Recent musical information retrieval techniques realize extraction of brief musical features such as tempo and chords, and they are useful information for music visualization based on acoustic data. Our technique presented in this paper focuses on representation of brief transition of classical music applying such musical features retrieved from acoustic data.

3. Visualization by RoughNote

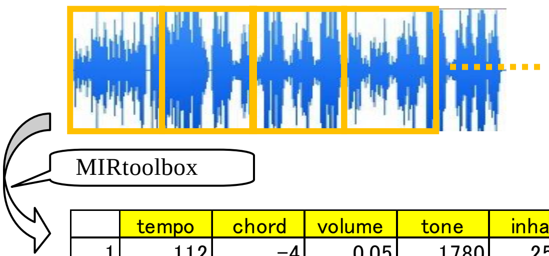
Processing flow of RoughNote consists of the following two steps:

1. Divide a give tunes into unit-time interval tunes, and calculate the feature values for each interval tune.
2. Display spheres representing the feature values of the interval tunes.

The below sections describe the detailed implementation of the processing steps.

3.1 Musical Feature Extraction

As a preprocessing, RoughNote divides given acoustic data into short pieces per several seconds, and calculates musical features by applying music information software MIRtoolbox [8]. Our current implementation calculates five dimensional feature values as shown in Figure 1.



	tempo	chord	volume	tone	inhar.
1	112	−4	0.05	1780	2500
2	112	2	0.06	3000	10247
3	112	−4	0.03	1200	11000
4	112	−4	0.02	4300	1399
5	30	5	0.06	4200	10000

Figure 1: Musical feature extraction from acoustic data.

The feature values are calculated as follows:

[Tempo] Estimate the tempo of a tune from a frequency of power peak of the acoustic data.

[Chord] Estimate whether the chord is major or minor, from the ratio of frequency between the root (=lowest) tune and other dominant tunes, for each time step. Calculate the ratio between major and minor chords from the estimation results.

[Volume] Calculate the RMS (Root-Mean-Square) of the powers of each time step.

[Tone] Integrate the powers of each frequency from the lowest tunes. Calculate the frequency that integral of the power archives at 85% of the total power.

[Inharmonicity] Extract inharmonic tunes from the ratio of frequency between the root (=lowest) tune and other tunes, for each time step. Calculate the ratio between the power of inharmonic tunes against the total power.

3.2 Feature-to-Ball Mapping

RoughNote assigns a ball for each piece of the acoustic data. It calculates radius of a ball from volume, position from tone, hue from chord, intensity from inharmonicity, and animation from tempo, as shown in Figure 2.

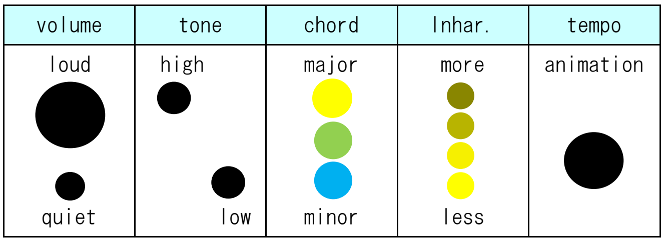


Figure 2: Balls represented from musical features.

RoughNote displays a sequence of the balls onto a display space, assigning time to the X-axis, and tone to the Y-axis. Consequently, RoughNote realizes a single-tone-note-like representation of music, as shown in Figure 3.

	tempo	chord	volume	tone	inhar.
1	112	−4	0.05	1780	2500
2	112	2	0.06	3000	10247
3	112	−4	0.03	1200	11000
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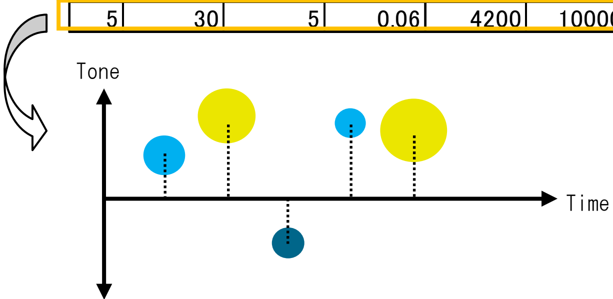

Figure 3: Location of balls.

Figure 4 shows an example of the location of balls. The ball 1 denotes loud volume, high tone, major chord, and less inharmonicity at this moment. On the other hand, the ball 2 in Figure 4 denotes small volume, low tone, minor chord, and more inharmonicity.

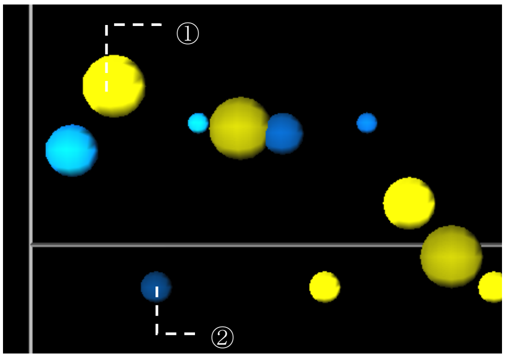

Figure 4: Example of balls.

4. Examples

This section introduces results visualized by RoughNote.

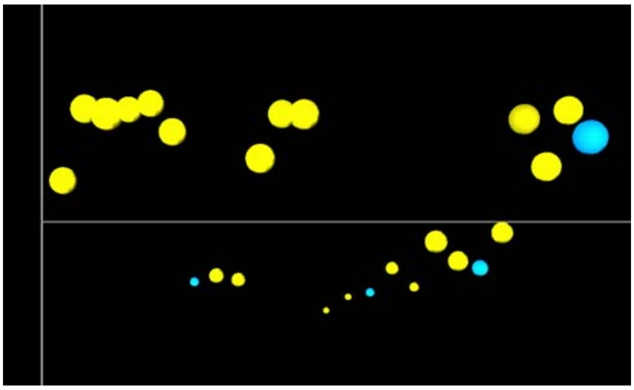

Figure 5: Visualization result of Prelude in the first suite of "Carmen" composed by Bizet.

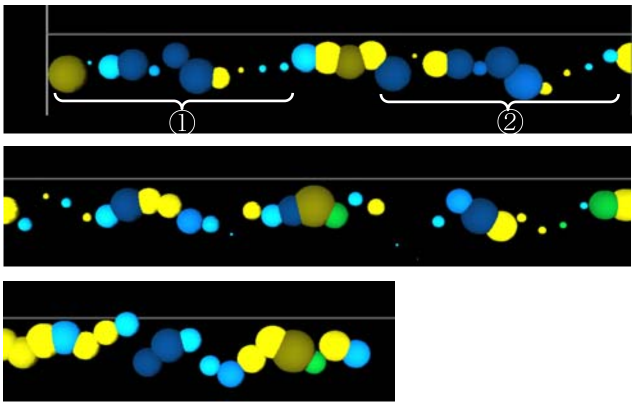

Figure 6: Visualization result of the first movement in the fifth symphony composed by Beethoven.

Figure 5 shows a visualization result of Prelude in the first suite of "Carmen" composed by Bizet. We divided the acoustic data per 5 minutes to obtain this result. This result clearly represents times when tone or volume drastically vary, or crescendo towards the finale.

Figure 6 shows a visualization result of the first movement in the fifth symphony composed by Beethoven. Comparing with Figure 5, more minor or inharmonic chords are observed. This result also denotes that similar progress is observed at 1 and 2 in Figure 6.

5. User Experience

We had user experiences with subjects including 15 female students. We applied L'apprenti sorcier, scherzo symphonique, composed by Paul Abraham Dukas.

As the first test, we asked the subjects to draw lines on the visualization result where they would like to start to play. We did not let them know the name of the tune. Here, this tune consists of 8 scenes, and therefore we treated 7 points at the border of the scenes as the correct answers of the test.

Figure 7 shows the visualization result of the tune with correct answers drawn by dotted pink lines. The figure also shows the statistics of answers of subjects. This result denotes that many of subjects adequately selected correct positions. We think the result demonstrates that RoughNote is somewhat effective to visually represent the musical structures and borders of the musical progresses. On the other hand, their answers included non-border positions. Especially, the position indicated by a dotted yellow line in Figure 7 was selected by 6 subjects.

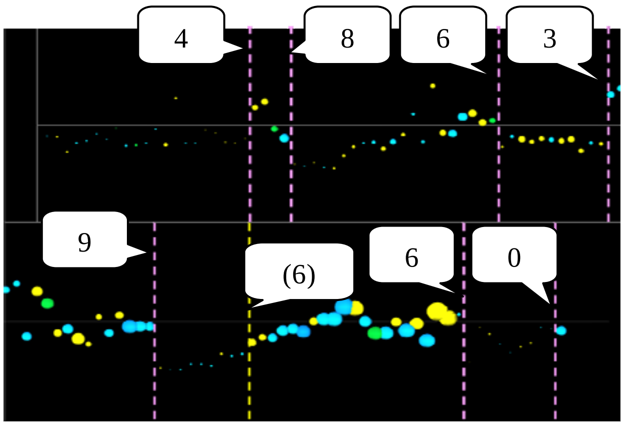

Fig. 7 User experience applying L'apprenti sorcier, scherzo symphonique, composed by Dukas. (1)

As the second test, we explained the scenario of the tune, and asked to watch the Disney movie of "Fantasia" using this tune as background music, without any sound. After that, we asked subjects to specify the starting positions of following 5 scenes on the visualization result

1. A disciple casts a spell to a broom.
2. The broom laves the water.

3. More brooms appear and start working.
4. An old master solves the problem.
5. The master admonishes the disciple.

Figure 8 shows the number of subjects who adequately selected the positions of the above scenes on the visualization result. We think the result demonstrates that RoughNote adequately represents the variation and progresses of the tune.

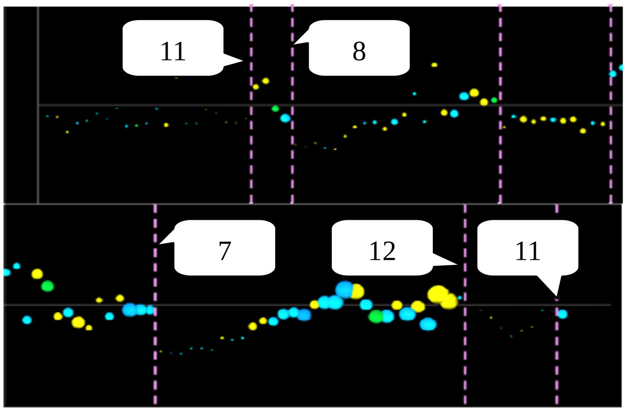

Fig. 8 User experience applying L'apprenti sorcier, scherzo symphonique, composed by Dukas. (2)

5. Conclusion

This paper presented RoughNote, a visualization for transition of classical music based on features of acoustic data. The paper also introduced the visualization examples and user experience results.

As a future work, we would like to develop more sophisticated music playing functions and more effective representations. Also, we would like to discuss how to improve RoughNote to effectively represent more variety of classical music. We do not think current implementation of RoughNote is very effective for tunes which tones or volumes do not vary (e.g. solo music). Also, we do not think it is very effective for tunes whose harmony cannot be explained as major or minor chords (e.g. middle age music or contemporary mucis). We would like to discuss how RoughNote can be adjusted to such kinds of music.

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