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Procedure for arranging backing phrases for ensemble music by evaluating ease of playing on instrumentalists

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ABSTRACT

Since arrangement of sheet music for orchestral ensemble requires a certain musical knowledge and expertise, amateur orchestral musicians often have difficulties when they arrange the sheet. An automatic arrangement method was proposed by employing Eigenmusic which is a set of eigenvector for many music excerpts, in order to evaluate the similarity among phrases. The difficulty in playing the arranged sheet music, however, was not evaluated so whether players feel difficulties on playing was out of discussion. This study proposes procedure for evaluating the degree how easy to play the phrases on sheet music. This procedure generates phrases for woodwind instruments using a MIDI database of backing phrases. Each musical phrases selected from the database are allocated to instrumentalists. Next, the ease of playing each phrases is evaluated based on fingering that is important in performance. Finally, phrases evaluated as the easiest are conjoined in each instrumentalist. We conducted an experiment to investigate the ease of playing for generated sheet music by musician's rating. Experimental results showed that the procedure for evaluating ease of playing is effective so that proposed procedure can generate easier phrases to play than our previous method.

Keywords: Arrangement, backing phrase, ease of playing

1. INTRODUCTION

Orchestral performance involves four instrumental families; string, woodwind, brass, and percussion. It may contain approximately 50 to 80 instrumentalists. A small number of instrumentalists often play together as an ensemble, so they need sheet music appropriate for their needs. In order to obtain a sheet music for limited number of instrumentalists, arrangement of a sheet music for orchestra is necessary. However, the arrangement requires musical expertise and takes a long time to complete. Thus, automatic arrangement is preferred to solve this problem.

Several studies of automatic arrangement have been reported, some of which are for arrangement based on melody extraction or instruments (1) and others are for arrangement of specific sheet music of wind orchestra into sheet music for a few musicians (2). However, previous studies didn't focus on the naturalness of the arranged excerpts. Another method for automatic production of the base part of popular music from many MIDI excerpts by using principal component analysis (PCA) (3) was reported. Abe's method extracts tracks of the base guitar part from many MIDI excerpts and constructs a database of the part's Eigenmusic which is a set of eigenvector for many music excerpts. The database is used to extract the global average of patterns, which is used to generate the natural pattern of the base part.

We proposed a method for automatic arrangement of orchestral performances, employed Abe's method in order to take into account the naturalness of arranged sheet music(4). This method arranges backing phrases. In our previous study, naturalness of music is defined as the extent one can listen without feeling uncomfortable. We conducted the following steps: i) database construction, ii) Eigenmusic calculation, iii) automatic arrangement, and iv) performance evaluation. For i), we constructed a database by using the extracted backing patterns from thousands of MIDI excerpts. For ii), we calculated the Eigenphrase of backing, which is a part of Eigenmusic, where the Eigenphrase of backing shows the average backing feature. For iii), we chopped the tracks of the MIDI excerpts into

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phrases on which we applied a previously proposed method (5) to obtain the phrases. When labelling the phrases as melody, base, or backing, we used the Eigenphrase of backing. The labelled tracks are then composed into the arranged sheet music. For iv), we confirmed the naturalness of the arranged music through an evaluation experiment. Experimental results showed that the proposed method satisfied the naturalness of the music for listeners. The difficulty in playing the arranged sheet music, however, was not evaluated so whether players feel difficulties on playing was out of discussion.

Therefore, this study proposes procedure for evaluating the degree how easy to play the phrases on sheet music. This procedure generates phrases for woodwind instruments using a MIDI database of backing phrases.

2. METHOD FOR ARRANGING BACKING PHRASES

The proposed method for arranging backing phrases is outlined in Fig.1. This method was proposed based on our previous method(4). The procedure for evaluating the ease of playing the phrases on sheet music is involved in this study.

First, the tracks of MIDI excerpt inputted in the system are chopped into phrases on which we applied a previously proposed method. Then, the extent of similarity between those phrases and Eigenphrase of backing are calculated to label those phrases as melody, base, or backing. Next, each musical phrases labelled as backing are selected phrases that instrumentalist can be played in terms of pitch and allocated to instrumentalists. The ease of playing each phrases is evaluated based on fingering that is important in performance. Those phrases evaluated as the easiest are conjoined in each instrumentalist. Finally, the arranged sheet music is obtained by allocating rests and exchanging phrase.

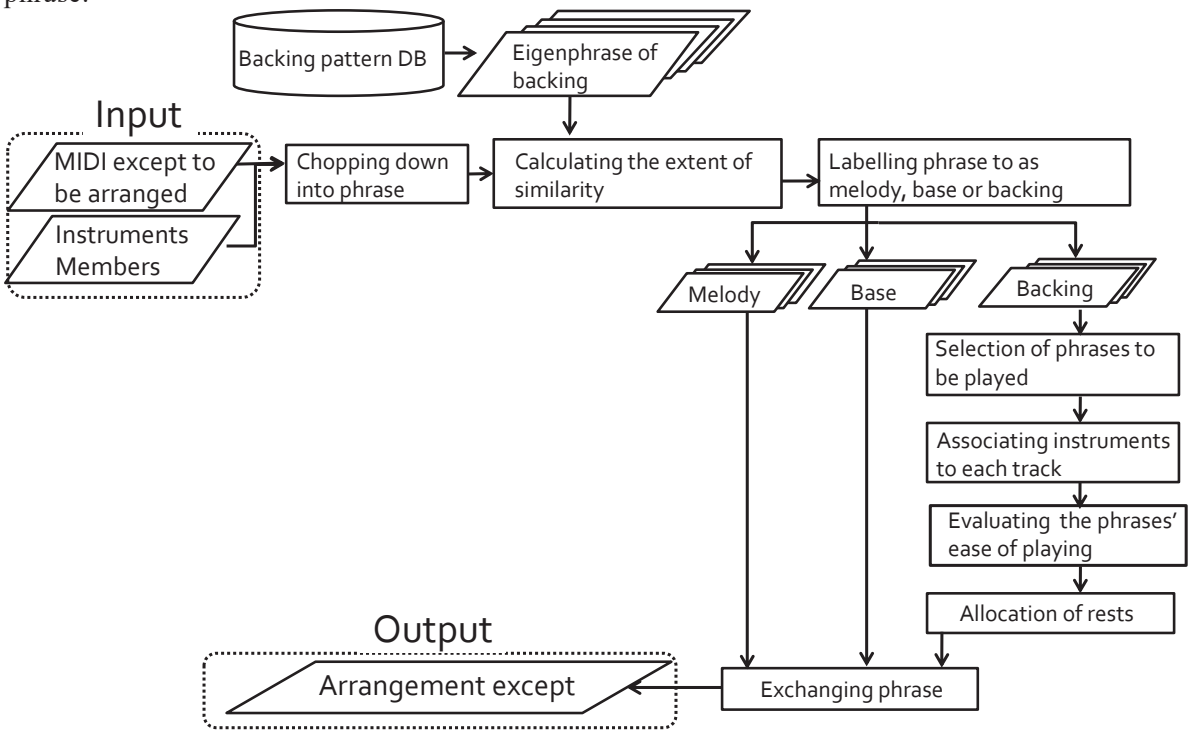


Figure 1 – Proposed method for arranging backing phrases

3. FEATURES OF EASE OF PLAYING

We investigated features of ease of playing by questionnaire. 35 instrumentalists were asked to answer features of phrase that players don't feel difficulties on playing.

Figure 2 shows the results of questionnaire. As a result, ease of playing depends on range of pitch, disjunct motion, tempo, key and so forth. Moreover, those features are divided into two categories: pitch and time. So, we propose procedure for evaluating the ease of playing phrases based on those categories.

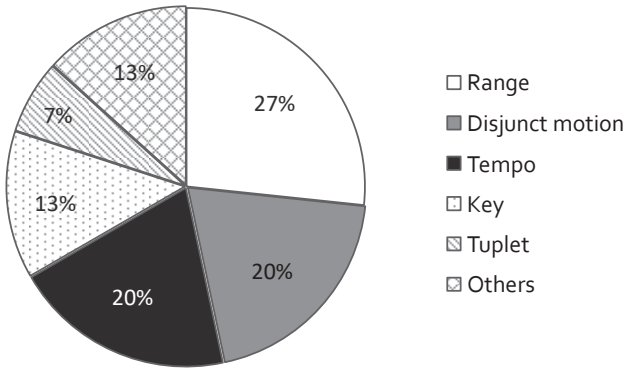


Figure 2 – Result of questionnaire

4. INVESTIGATION OF RHYTHM PATTERN EASY TO PLAY

4.1 Method of investigation of Rhythm Pattern

Specific pitch features of ease of playing were obtained from the questionnaire, whereas specific time features weren't clarified. So, we investigated rhythm pattern of ease of playing by another questionnaire. 14 instrumentalists were asked to rate ease of playing on a scale of one to three.

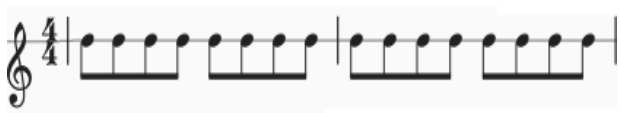
The stimuli were 20 rhythm sheet music obtained from backing pattern DB. 10 of those stimuli were phrases $P_i(i{:}1{\sim}10)$ that occurrence rate is high, the others were phrases $P_i(i{:}11{\sim}20)$ that occurrence rate is low. Those phrases were comprised from 2 bars.

4.2 Result of Investigation of Rhythm Pattern

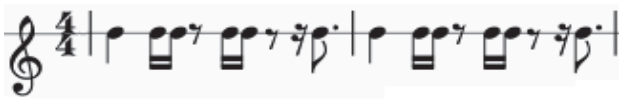
Table 1 shows the result of rating. As can be seen in table 1, it was found that rhythm phrases with high occurrence rate are evaluated as easy to play. Figure 3 shows an examples of rhythm sheet music. We investigated the relation between ease to playing and features of those rhythm. As a result, it was found that variation in type of note and number of 16th-rest in a phrase affect ease of playing. Figure 4 shows the relation between ease to playing and number of 16th-rest in each phrase. As can be seen in Fig. 4, it was found that phrases evaluated as easy to play don't have 16th-rest. There was a strong negative correlation with a number of 16th-rest and ease of playing (r = - .83 (n=20)).

Table 1 – Result of investigation of the rhythm pattern

Ease of playing	Phrase ID
Easy	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{13}, P_{14}, P_{15}, P_{17}, P_{18}
Neither	P_{19}
Difficult	P_{11}, P_{12}, P_{16}, P_{20},



(a) Easy to play



(b) Difficult to play

Figure 3 – Example of rhythm sheet music

5. PROCEDURE FOR EVALUATING EASE OF PLAYING

As described in chapter 3, pitch features of ease of playing were obtained from the questionnaire. Moreover, time features of ease of playing were obtained from the investigation as described in chapter 4. In this study, selected backing phrases are evaluated ease of playing depend on those feature.

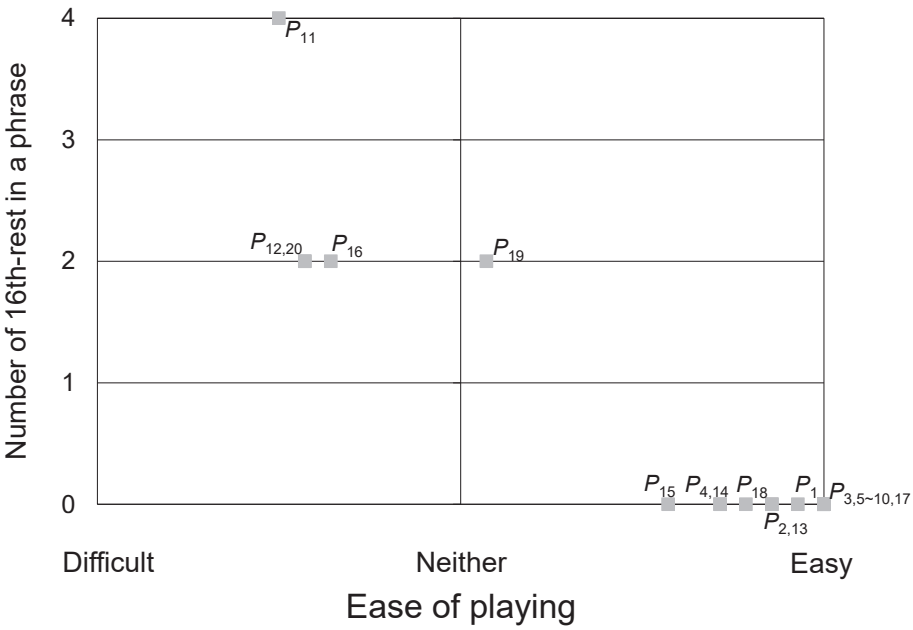


Figure 4 – Result of investigation of the relation

First, over an octave disjunct motion was extracted from each phrase as pitch feature. Specifically, pitch difference *pd* between two notes in each phrase is calculated as follows.

$$pd = H_i - H_{i\text{-}1} \tag{1}$$

Here, H_i represents pitch of *i*th note in each phrase. If the difference *pd* is not more than an octave, the phrase is evaluated as easy to play.

Next, similarity between rhythm of those phrases and the rhythm evaluated as easy to play in chapter 4 is calculated. If the similarity score of a phrase is high, the phrase is evaluated as easy to play and selected as a candidate for phrase in arranged sheet music. If the phrase is evaluated as difficult to play, the phrase is exchanged for other phrases back to selection of phrases to be played. Figure 5 shows an example of the arranged sheet music generated using the proposed procedure.

6. EVALUTION EXPERIMENT

6.1 Method

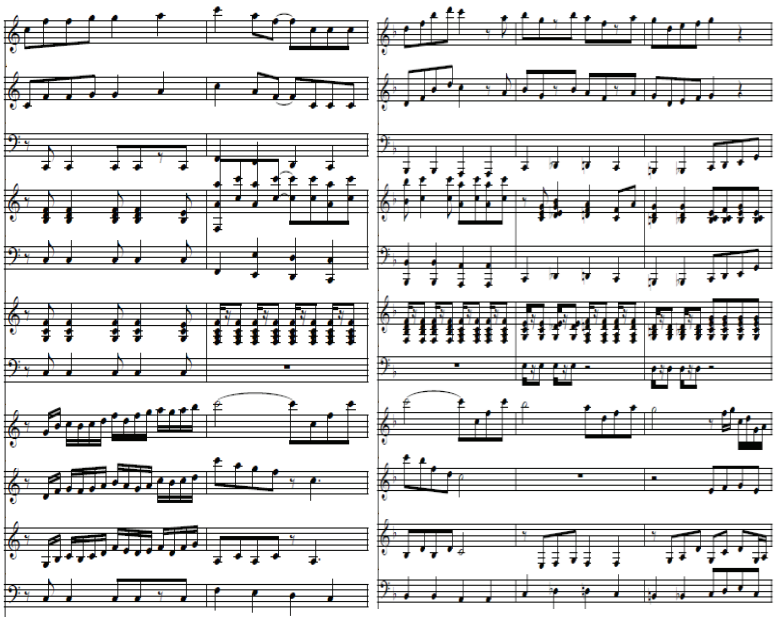
We conducted an experiment to investigated the effectiveness of automatically arranged sheet music generated using the proposed procedure in terms of instrumentalist impression. We selected 4 sheet music from 5650 MIDI excerpts and arranged those music comprising from 15 to 24 bars by using the following methods.

- Method B: Arrangement from the previous method (4)
- Method P: Arrangement from the method using evaluating ease of playing based on pitch
- Method V: Arrangement from the method using evaluating ease of playing based on time value
- Method A: Arrangement from the proposed method in this study

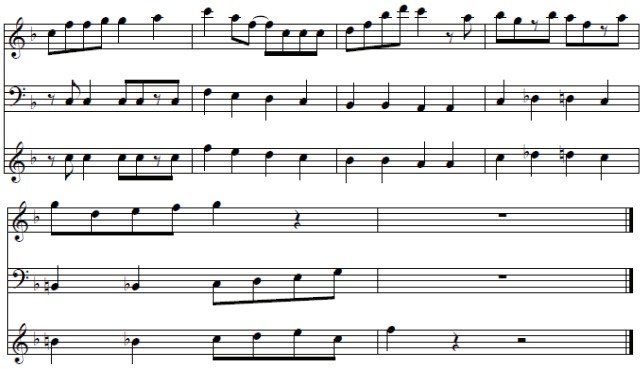
Six players who are playing woodwind instruments participated in our experiment. The players were asked to play those original and arranged sheet music in random order and then rate their impression in terms of naturalness and easiness.

6.2 Results

Figure 6 (a) shows the average and 95% Confidence Interval (CI) of easiness scores, and Figure 6 (b) shows the average and 95% CI of naturalness scores. Figure 6 (a) shows that Method A was rated the highest in all method for easiness. Moreover, it's found that Method P, V and A were rated higher than Method B ($p < .05$). Figure 6 (b) shows that Method B was rated the lowest in all method for naturalness. In addition, there was no significant difference ($p<.05$) found among all Methods.

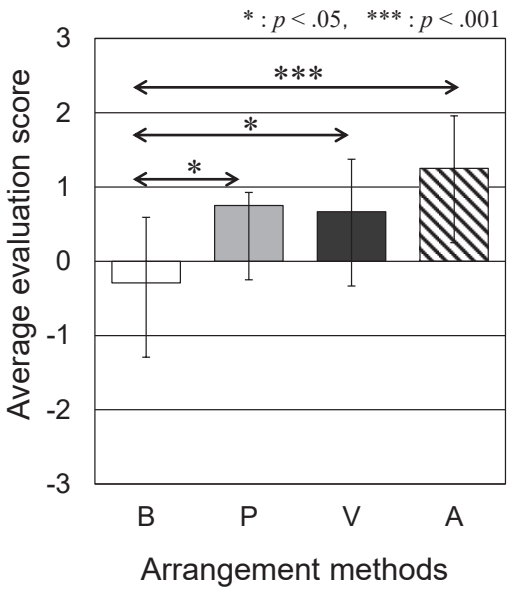


(a) Original sheet music

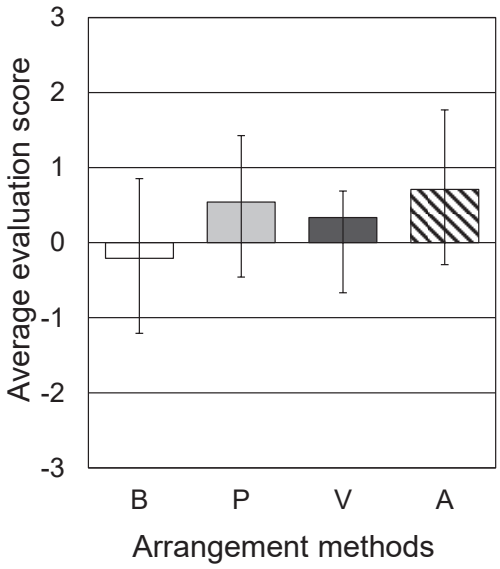


(b) Arranged sheet music for 3 instrumentalists

Figure 5 – Example of arrangement generated using proposed procedure.



(a) Average easiness scores



(b) Average naturalness scores

Figure 6 – Results of evaluation experiment

7. DISCUSSION

From the results of easiness scores, Method P, V, and A generated sheet music to play more easily than Method B. So, the analysis of variance (ANOVA) was conducted for the result. This ANOVA revealed an effect of type of Method ($p < .001$). To further examining the effect, post hoc analysis were made using either Tukey's multiple comparisons test. Tukey's post hoc analysis showed that average score of Method A is higher than that of Method B ($p < .001$). Moreover, it's shoed that average score of Method P and V are higher than that of Method B ($p < .05$). Therefore, the proposed method is effective for generating sheet music that is easier to play than the method proposed in our previous study.

From the results of naturalness scores, Method P, V, and A generated more natural sheet music than Method B. However, there were no significant difference between each methods. So, we need to investigate feature that affect naturalness of music.

8. CONCLUSIONS

We proposed a procedure for arranging backing phrases for ensemble music by evaluating ease of playing on instrumentalists. In subjective evaluation experiment of arranged sheet music, we asked instrumentalists to evaluate arrangement excerpts with our previous method and the proposed method in terms of naturalness and easiness. Experimental results showed that the procedure for evaluating ease of playing is effective so that proposed procedure can generate easier phrases to play than our previous method. Moreover, the proposed method maintained naturalness better than our previous method. However, no significant difference among those methods was confirmed.

For future work, we will discuss aspects that affect naturalness of music. Moreover, we plan to propose a new arrangement method that can evaluate the ease of playing other instruments, for example string or brass instrument.

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