

PIANO ARRANGEMENT SYSTEM BASED ON COMPOSERS' ARRANGEMENT PROCESSES

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ABSTRACT

Our goal is to construct an automatic musical arrangement system by applying analysis results of composers' arrangement processes. We arranged an orchestral score for a solo pianist to evaluate our system. Usually, an orchestral score has several instrumental parts, which is difficult for a soloist to play. Therefore, an orchestral score needs to be arranged with several instrumental parts into both hands parts, which enables a solo pianist to play with both hands. However, there is a problem with an arrangement of more than five notes for each hand, since one hand has only five fingers. To solve this problem, we introduce a protocol analysis for analyzing the process of arranging music. We applied this protocol analysis to a musical arrangement, and analyzed the arrangement process. By using the analysis results, we constructed a piano arrangement system for warning the composer of problems in the score that need to be arranged.

1. INTRODUCTION

We propose an automated method for arranging an orchestral for piano, which enables a solo pianist to comfortably play an orchestral score.

Musical arrangements have several variations. For example, a folk song arranged in a jazz style or rock song arranged with a heavy use of strings. There are also arrangements for soloists. For example, there are musical arrangements originally for multiple-instruments for solo pianists.

Musical arrangements are divided into two types, those with many notes and those with fewer notes. Although previous research has mostly focused on the former [1] [2], we investigated musical arrangements with fewer notes. We used an original orchestral score, and arranged it for a solo pianist. This type of arrangement is called a "piano-arrange score", which is widely available. However, a piano-arrange score is usually written for professional or semi-professional soloists. Therefore, a musical novice may have difficulty in playing it.

We used a think-aloud protocol analysis to examine five composers' arrangement processes [3]. Originally, a think-aloud protocol analysis a usability testing technique used to analyze composers' thinking-aloud process. Based on

this analysis, we can determine what the problems are in an arrangement and how to solve them.

In this protocol analysis, we recorded the five composers' thought process for arranging an orchestral score for piano by using an eye mark camera. After the music was arranged, we queried the composers on how or why they arranged their music they way they did. The data from eye mark camera enabled us to perform detailed protocol analysis using not only their thinking-aloud processes but also visual points. Using results of the think-aloud protocol analysis, we constructed a piano arrangement system. There were exactly the same points that a musician arranged and the system warned, and musical novices were able to choose from several arrangement processes.

We described our protocol analysis in Section 2, a system implementation in Section 3, an example of analysis using the system in Section 4, and we making concluding remarks in Section 5.

2. ANALYZING MUSICAL ARRANGEMENT PROCESSES

In arranging an orchestral score for piano, we have to pay attention to several problems concerning the use of a musician's fingers. For example, it is difficult to play two notes that are more than one octave distant with one hand because the fingers cannot stretch that far. Also, the number of notes that can be played at the same time is limited due to the number of fingers. In addition, it is difficult to cross the hands while playing. Furthermore, it is important to maintain an original piece of music and considered melody repetition because there are repetitions of similar melodies in an orchestral score. For example, there are two similar orchestral melodies, "p" and "q", and only "q" has a flute part. When "p" and "q" are arranged without the flute part, the arranged melodies "p" and "q" are exactly the same. The arrangement cannot be reproduced from an original piece because there is essentially no difference between "p" and "q" in the arrangement. Repetition and maintenance are complicated problems because of recognized the entire score and in a musical arrangement. However, composers are able to arrange music that has these problems. Therefore, we analyzed a composer's arrangement process.

2.1. RECORDING COMPOSERS' ARRANGEMENTS

We recorded five composers' arrangement process. In **Figure 1**, a piano arrangement of an orchestral score. To record a video of a composer's visual points, we used an eye mark camera. We also recorded each composer's voice when he/she is thinking-aloud by using microphones.

After the music arranging process, we queried the composers on the details of their arrangement processes using the video from the eye mark camera. For example, we asked composers questions such as. Why did you focus on this section for a long time? What is troubling you now about your arrangement? Please tell me if you have any good ideas for the arrangement.

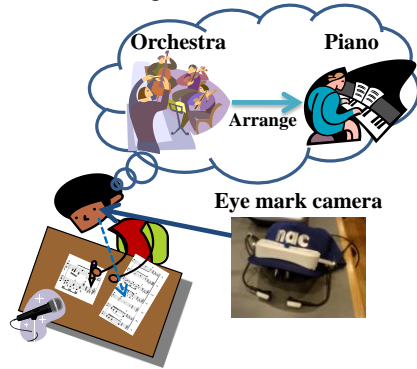


Figure 1: Recording of Musical Arrangement Process

2.2. PROTOCOL ANALYSIS

We analyzed the arrangement process by using a think-aloud protocol analysis. **Table 1** list the details of protocol analysis of a composer arrangement processes. "Time" denotes the time it took to arrange the music. "Events" denotes important actions during the process, for example, playing a midi keyboard or thinking-aloud. "Arrangement work" denotes details of arrangement.

In the first example in Table 1, the Time was 1:48, the "Events" were that the composer played the viola and cello parts in midi keyboard. When the composer looked for the base line, he said, "Difficult to play". It would be difficult to play if both viola and cello parts are included. The composer solved this problem by including only the cello part and left out the composer viola part.

Time min:sec	Events	Arrangement	Problem	Operation
1:48	play: [viola + cello] [3-4 bars]	Playing viola and cello parts		
	(consider left hand)	Looking for base line (Difficult) If playing both viola and cello parts Difficult to play Use cello, remove viola	P ₀ P ₇	j ₄
4:48	Think-aloud: "It is difficult to play cornet, because of many notes." "Not using cornet."		P ₆	j ₄
	Play [1 st violin + 2 nd violin] [2 bar]	Playing 1 st violin and 2 nd violin		
7:43		Last 2 bars, there are over-lapped notes Remove note	P ₅	j ₄

Table 1: Example of Think-Aloud Protocol Analysis

In another example listed in Table 1, the Time was 4:48, the "Events" were that the composer's thought-aloud. He said, "It is difficult to play cornet because there are many notes". The composer's thinking-aloud indicates that he was having difficulty because of the "many notes", and he solved this problem by not including the cornet part.

Thus, using the results of the think-aloud protocol analysis, we labeled the problems and problem-solving operations which appear plural times and examined the relations between them. We found that certain problems and problem-solving operations occurred when composers are in trouble in arrangement process. These problems indicate that problems occurred during arrangement, and solving the problems indicated that the problems were also solved.

In the third example in Table 1, the time 7:43, and the composer is in trouble because of over-lapping notes between several parts. In Table 1, the problems are described as P₅ (Problem 5) under "Problems". Then, the composer solved the problem by "Removing a note". In Table 1, the solution is described as j₄ (problem-solving operation 4) under "Operation". Consequently, we found nine problems and six operations in the arrangement process.

2.3. MODELING PROBLEMS AND PBLEM-SOLVING OPERATIONS

In **Figure 2**, "P" indicates a problem, and "j" indicates a problem-solving operation. We used them, to construct a state-transition model. The model showed the arrangement process started in P₀ and ended in S₉ (Solution 9). P₀ involves inputting composed orchestral melodies, and S₉ involves outputting piano melodies. P₀ is actually P₁₋₈ via j₁₋₆ or transition to another problem except for S₉. Several problems are formed simultaneously, but a musical novice solved each problem one by one, enabling him/her to transition to S₉.

For example, when a pianist's fingers cannot reach (P₇) when melodies are composed, Figure 2 produces three problem-solving operations, j₄₋₆. When no problems occur, the state-transitions to S₉ and the model output the melody. Based on this model, we constructed a piano arrangement system. In the next section, we describe these various problems, and how they are transitioned.

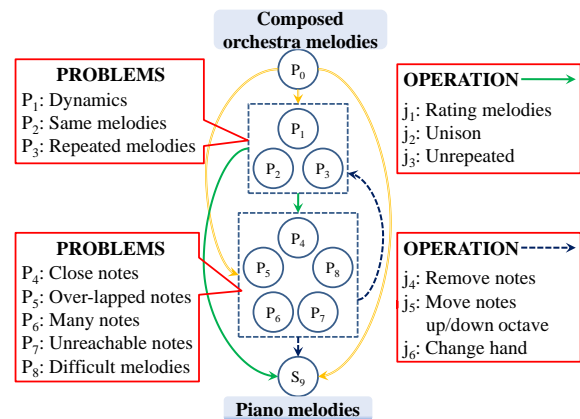


Figure 2: State-Transition Model

2.4. PROBLEMS

P_{1-3} are transitioned by j_{1-3} . P_1 is where there are noticeable dynamics. Dynamics are important in deciding a piece's ambience. The problem determines the melody's rating from forte (f) or piano (p). P_2 is where the same melodies exist several parts. When different parts with the same melodies are played together, we call this Unison. The Unison melody is important, and the melody's rate is added. P_3 is where there is a repeated melody. Our system records the melody and warns if they are the same. To implement these three problems, we need further protocol analysis because there are many solutions. We describe P_{4-8} in Section 3.

3. IMPLEMENTATION

We implemented a part of the state-transition model (Figure 2) as a system, P_{4-8} (Figure 3). Before starting the arrangement, we map the each part for the left or right hand. According to iterate problems and problem-solving operations, a musical novice is able to arrange by interactively reducing the system's warnings.

For these problems, the model shows three problem-solving operations; j_{4-6} . In this system, a musical novice is able to solve problems using these operations. For input files, we used MIDI [4] files consisting of several parts.

We transcribed variables as follows; $Pitch_X$ is the pitch of note $_X$ (MIDI note number), O_X is onset of note $_X$, L_X is the length of note $_X$, and H_X is playing hand of note $_X$.

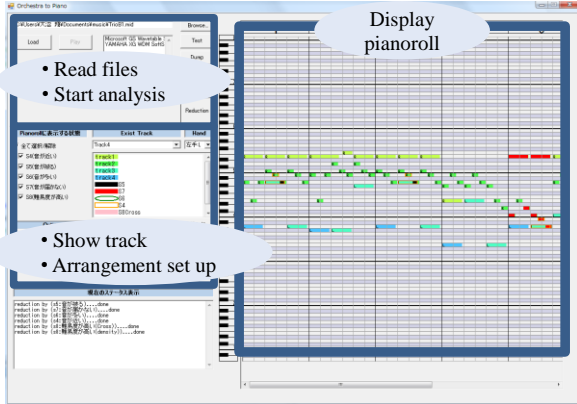


Figure 3: Overview of Piano Arrangement System

3.1. IMPLEMENTATION OF PROBLEMS

P_5 (Over-lapped notes) is formed when there are two notes of the same pitch and over-lapped pronunciation time. When notes of different parts over-lap, the system warns the musical novice because they are difficult to play. P_5 is described by the following formula. The system displays these notes in black (Figure 4 P_5).

$$O_A \leq O_B < O_A + L_A \text{ and } Pitch_A = Pitch_B \quad (1)$$

P_7 (Notes over one octave) is formed when it is difficult to play two notes that are over one octave apart together in one hand. The system warns the musical novice of these

notes because the pianist's fingers cannot reach them. P_7 is described by the following formulas. The system displays the notes in red (Figure 4 P_7).

$$\begin{cases} O_A \leq O_B < O_A + L_A \text{ and } Pitch_A + 13 \leq Pitch_B \\ H_A = H_B \end{cases} \quad (2)$$

P_6 (Many notes) is formed when there are many notes played together in one hand. It is difficult to play more than five notes with one hand. P_6 is described by the following formulas. Then, Num_x is number of note $_x$ and "Rv" is number of notes which is limitation of playing together, initial value is four. The system displays the notes as green circles (Figure 4 P_6).

$$\begin{cases} O_A \leq O_X < O_A + L_X \text{ and } Pitch_A \neq Pitch_X \\ H_A = H_X \text{ and } Num_x \geq Rv \end{cases} \quad (3)$$

P_4 (Close notes) is formed when it is difficult to play two notes that are close together with each hand. When we play the piano with both hands, it is difficult to play when our hand are too close. The system warns the musical novice if notes are too close. P_4 is described by the following formulas. The system displays the notes as orange squares (Figure 4 P_4).

$$\begin{cases} O_A \leq O_B < O_A + L_A \text{ and } H_A \neq H_B \\ Pitch_A + 4 \geq Pitch_B \text{ and } Pitch_A < Pitch_B \end{cases} \quad (4)$$

P_8 (Difficult melodies; Crossing) is formed when a melody is difficult to play. The system warns the musical novice when the arranged melodies became too difficult. For example, fingers need to move fast or too far apart. However, a melody's difficulty is different from each player. Therefore, detecting this problem is difficult.

Therefore, we implemented a version of P_8 , called Crossing. This means that the system warns the musical novice when the arrangement requires the crossing of hands. P_8 is described by the following formulas. The system displays the notes in pink (Figure 4 P_8).

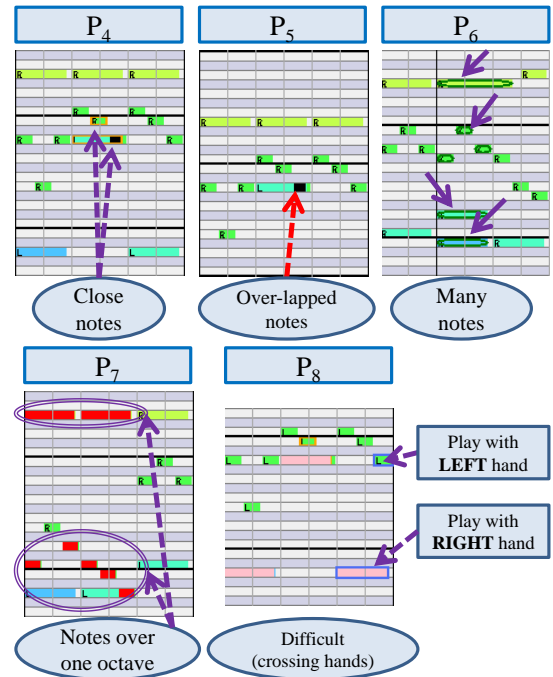


Figure 4: P_{4-8}

$$\begin{cases} O_A \leq O_B < O_A + L_A \text{ and } Pitch_A < Pitch_B \\ H_A \neq H_B \text{ and } H_A = Right \end{cases} \quad (5)$$

Thus, the system can be used to analyze music and display warnings in various colors.

3.2. PROBLEM-SOLVING OPERATION IMPLEMENTATION

When these warning appear, the musical novice needs to solve the problem. In this system, musical novice can perform the following problem-solving operations; remove notes (j_4), move notes up or down in octave (j_5), and change the playing hand (j_6). These operations produce warnings in the system so the musical novice can solve the problem.

4. EXAMPLE OF ANALYSIS

We constructed our piano arrangement system using the model. Then, we compared the arrangement produced using the system with that arranged by composer without the system using two problems; over-lapped notes (P_5) and notes over one octave (P_7). For comparison, we used SYMPHONIE No. 14 by W. A. MOZART K.114 Trio, bars one to sixteen.

Figure 5 shows the results of analyzing this original piece of music. From the composers' arrangement processes, we determined that tracks 1 and 2 are played with the right hand and tracks 3 and 4 are played with the left. **Figure 5** shows that there were many warnings, signified as arrows. Therefore, this original piece needed to be arranged.

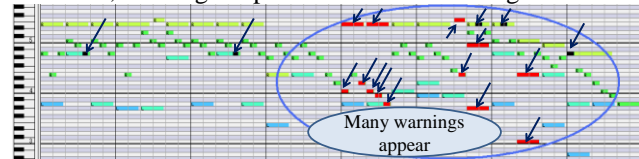


Figure 5: Results from Original Piece

4.1. ORIGINAL PIECE AND ARRANGEMENT OF COMPOSER

We then compared the original piece with one of the five composer's arrangement. **Figure 6** is a part of result that the system warned P_5 or P_7 .

First, we described P_5 . In **Figure 6** "Warning (P_5)", the system detects that there is an P_5 in the original piece. The composer solved the problem by moving a note one octave down. Applying j_5 to the original piece produced the same result as that during a composer's traditional arrangement process.

Then, we described P_7 . In **Figure 6** "Warning (P_7)", the notes enclosed in circles are played with the right hand in the original piece. The composer solved the problem by changing the playing hand to the left one. Applying j_6 to the original piece produced the same result as that during a composer's traditional arrangement process.

Therefore, this warning system and the composer arrangement process are the same. Accordingly, the problems detected by the system were correct.

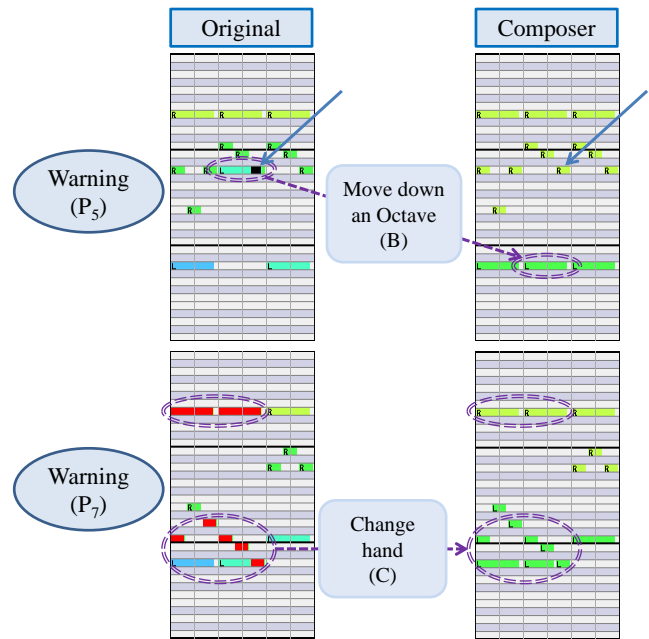


Figure 6: Comparison of Original Piece and Composer's Arrangement (Move down an Octave B-> j_5 Change hand C-> j_6)

5. CONCLUSIONS

We constructed a piano arrangement system by applying protocol analysis of composers' arrangement process. In the think-aloud protocol analysis, we recorded the composers thinking-aloud and visual points, and we determined nine problems and six operations in the arrangement process. Using the result of the analysis, we constructed a piano arrangement system. There are exactly same points that a musician arranged and system warned, and musical novice enable to choose from several arrangement processes.

We plan to implement P_{1-3} and operations j_{1-3} in our system by analyzing other composers' arrangement process. This will also be automated.

6. REFERENCES

- [1] Dan Gang, Daniel Lehmann, Naftali Wagner: "Tuning a Neural Network for Harmonizing Melodies in Real-Time," International Computer Music Conference, 1998.
- [2] Takashi K., Mitsuru N., Hiroshi S., Hideki S.: Hidden Markov Model Applied to Automatic Harmonization of Given Melodies, IEICE technical report. Speech 99(627) pp. 25-32 2000. (in Japanese)
- [3] Sho O., Masatoshi H.: Time Series Analysis of Music Arrangement Work -Reduction from orchestra's score to piano's score-, 09-IPJSJ-71-2, pp. 2.227-2.228, 2009 (in Japanese)
- [4] MIDI Manufacturers Association (Reference 12/22 2009) <http://www.midi.org/>