The research about editing system of performance information for player piano. -Inference in the same phrase including ostinato-

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Abstract

We have developed a system to reproduce human-like piano performance with an automatic performance device. In order to perform on a par with a human, it is necessary to express the intensity of the notes and other aspects of the performance. Therefore, using F. Chopin's music as a subject, we studied the changes in performance expression when similar phrases such as ostinato are repeated. Then, we developed an interactive music editing system to realize efficient music editing.

Keywords: Player Piano, DP Matching, Knowledge Database, Computer Music, Music Interface

1. Introduction

The purpose of this research is to reproduce human-like piano performance with an automatic performance system. The automatic musical performance system developed by Hayashi et al. in 1996 has the same performance capability as a human, but it does not have the ability to infer musical expressions such as the strength of notes[1]. Therefore, we inferred the musical expression of the same performer in an unperformed piece of music using the performer's existing performance information and score information. In this paper, we study the changes in performance expression when similar phrases such as ostinato are repeated in a piece by F. Chopin, and describe the inference method.

2. Editing Support System

2.1 Performance Information

The songs listed in Table 1 of CrestMusePEDB, which were created from the actual performance of Vladimir Davidovich Ashkenazy (Russia), were used as performance information. From now on, the names of the songs are A to F in Table 1.

Table.1 Song information

Character	Song Title	Tonality
A	Prelude Op.28 No.7	A-Dur
B	Prelude Op.28 No.4	E-Moll
C	Prelude Op.28 No.15	Des-Dur
D	Prelude Op.28 No.20	c-Moll
E	Etude Op.10 No.4	Cis-Moll
F	Nocturnes Op.9 No.2	b-Moll

In this study, song A was inferred. Therefore, we also used the data of the eight performers who played the song A in Table 2. Hereafter, the names of the performers will be referred to as ① through ⑧.

Table.2 Pianists who played song A

Number	Pianist Name	Nationality
①	Maria Martha Argerich	Argentina
②	Claudio Arrau León	Chile
③	Jorge Bolet	Cuba
④	Rafał Blechacz	Poland
⑤	Alfred Denis Cortot	Switzerland
⑥	Dang Thai Son	Viet Nam
⑦	Maria João Pires	Brazil
⑧	Ivo Pogorelich	Croatia

2.2 Score information

Table 3 shows the variables used for musical notation information in the MIDI (Musical Instrument Digital Interface) standard, where Key is the position of the keyboard, Velo is the strength of the note, Gate is the length of the note, Step is the interval to the next note, and Time is the playing time.

Table.3 Note Information

Para meter	Key	Velo	Gate	Step	Time	Bar
Unit	—	—	ms	ms	ms	—
Refer ence	21～ 108	1～ 127	—	—	—	—

2.3 Performance Reproduction Flow

Figure 1 shows the flow of reproducing a piece of music that has not been played by the performer. The features of the performer extracted from the performance and score information are applied to the score information of the unplayed piece to infer and reproduce the performance expression.

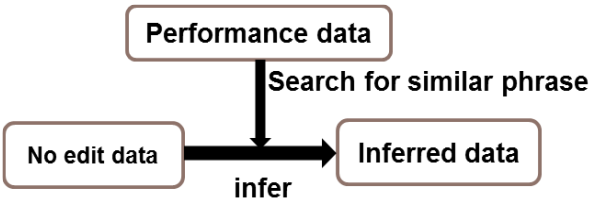

Fig.1 Flow of performance reproduction

2.4 Search systems

From previous research, it was found that phrases with the same note value sequence are similar in performance expression. Based on this theorem, we have developed a search system that uses DP(Dynamic Programming) matching to find phrases (similar phrases) that have a similar sequence of note values to the phrase of a song that we want to reproduce (search phrase)[2]. This method calculates the shortest distance and path between two patterns, and expresses the similarity between them in terms of distance. The range of the search phrase was set arbitrarily. However, phrases that are considered to be musically coherent, such as phrases connected by "slurs," are set as articulations, but since these phrases were not found in this study, the search was divided into three phrases as shown in Figure 2.

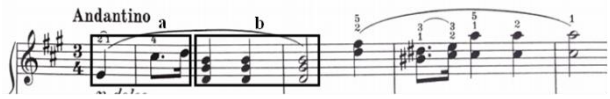

Fig2. Examples of search phrases

2.5 Selection system

When multiple similar phrases with the same DP matching score are found, the selection system selects the phrase that is most suitable for inference (the optimal phrase) using the following five selection indices.

(1) Selection based on dynamics symbols and Velo
(2) Selection by StepRate
(3) Selection by staccato removal
(4) Selection by similarity of pitch change
(5) Selection by Gate

2.5.1 Selection based on dynamics symbols and Velo

Dynamics symbols are thought to affect performance expression, We selected the ones with matching dynamics symbols. Then, those with too large or too small Velo were subsequently excluded.

2.5.2 Selection by StepRate

The StepRate is the ratio of the theoretical time in the score to the Step. The performance data of the performers in Table 2 is used to select phrases with high SR correlation from similar phrases. StepRate will be abbreviated as SR from now on.

2.5.3 Selection by staccato removal

Compare the length of the notes before and after the staccato part of the B~F song. Exclude any search phrase that exceeds the average of its results.

2.5.4 Selection by similarity of pitch change

Phrases with similar pitch changes are considered to have similar performance expressions, and phrases with higher similarity in pitch changes are selected.

2.5.5 Selection by Gate

From the average of 8 pianists as well as SR The phrase with the highest correlation of Gate was selected.

2.6 Inference system

The inference system performs Step and Velo inference.

2.6.1 Inference of Step

The Step inference uses n_SR, where the nth n_SR is as in "Eq. (1)".

$$\text{n\_SR} = \text{SR}(n+1) \ / \ \text{SR}(n) \qquad (1)$$

This way, once the SR for the first note is determined, the SR for the following notes can be determined. n_SR is used from the optimal phrase selected in 2.5. Since the previous inference method gave the same inference results for all eight phrases, we used the data of the performers in Table 2 to infer each phrase. First, to determine the SR of the first note of each phrase, we calculated the BPM (Beats Per Minute) of songs B~F and the performers in Table 2. Since the BPMs of songs A~F are different, it is necessary to match the BPM of song A. The average BPM of the performers of song A in Table 2 is 37. Using this, the ratio to Ashkenazy's BPM of songs B~F is calculated and listed in Table 4. Using the BPM ratios in Table 5, the inferred SR from the average SR of songs B~F is obtained from "Eq. (2)" and is shown in Table 4.

$$\text{Inference SR} = \text{SR average} \ / \ \text{BPMratio} \qquad (2)$$

From the data of the performers in Table 2, calculate the average SR for each phrase using only the values whose average SR is between 3.4 and 4.2 as calculated by inferred SR. This value is used as the SR of the first note of each phrase, and the SR of the second and subsequent notes is calculated using n_SR to obtain the inferred value of Step.

Table.4 BPM ratio and SR average

	B	C	D	E	F
BPM ratio	0.66	0.52	1.06	0.21	0.55
SR average	2.49	1.83	3.63	0.72	2.31
Inference SR	3.77	3.51	3.44	3.39	4.19

2.6.1 Inference of Velo

For song A, the dynamics symbol is p only. The range of p is from pp to f. As in the Step inference, we determine the inferred value of Velo by calculating the average per phrase and average per note from the performers in Table 2. n_Velo for the nth note is Eq (3).

$$\text{n\_Velo} = \text{Velo}(n) \ / \ \text{Velo}(n-1) \qquad (3)$$

The first note of each phrase is assigned the average value of the phrases that fall within the range of p of the performers in Table 2; from the second note onward, the inferred value of Velo is calculated by calculating n_Velo from the average value of each note of the performers in Table 2.

3. Inference experiment

3.1 Experimental Method

We conducted an experiment to compare the actual performance data of song A with the inference results of the system.

3.2 Results of experiment

The right-hand graph comparing Step's inferred values, the actual performance, and the data before editing is shown in Figure 3. Similarly, the right-hand graph of Velo is shown in Figure 4.

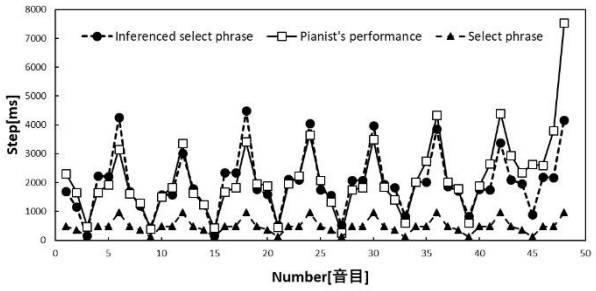

Fig.3 Comparison of the right-hand Step

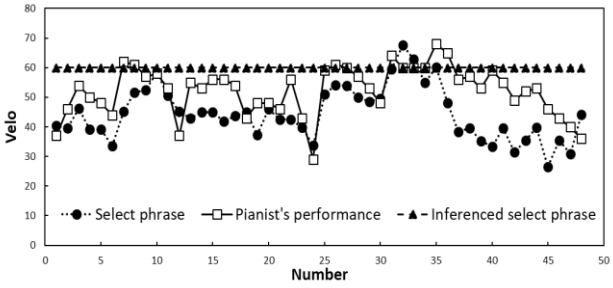

Fig.4 Comparison of the right-hand Velo

4. Consideration

The selection system and inference system used data from other pianists as well, resulting in more accurate results than before. From this, we believe that we were able to demonstrate the effectiveness of this system. However, we have not yet been able to reliably mimic the loudness of the notes or the way the notes are extended.
We believe that this is due to the search system that judges similar phrases based only on the length of the sound, although the connection before and after is also important in musical expression.

5. Conclusion

This year, we introduced an inference system that combines the performance data of other performers with the performance information editing support system. The problem was that when the same phrase was repeated twice, the inference results were exactly the same, but in this year's experiment, we were able to infer each phrase by combining the performance data of the performer we wanted to infer with that of other performers. However, since this method relies on the performance data of other performers, it cannot be used for music with only a few performers or for music for which there is no data to begin with, which is an issue for the future.
We would also like to study the development of an alternative search system to DP matching that takes into account the connections before and after.
Therefore, we will consider developing a more versatile system with the addition of another method.

6. References

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Authors Introduction

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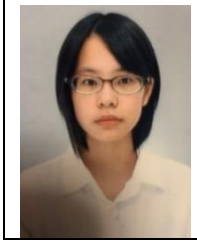

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