Interactive musical editing system to support human errors and offer personal preferences for an automatic piano
- Information system regarding a musical sign -

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Abstract

We have developed an automatic piano that can accurately control the motion of both the keys and the pedal based on performance data that a user has inputted for a particular piece of music. However, this system cannot sight read a new piece of music, as in the simulation of a human being's expressive performance. Therefore, we developed a program that can memorize and use knowledge databases and user preferences concerning the interpretation of a piece of music.

We analyzed performance data of performances of highly skilled pianists in order to observe performance tendencies, and found that phrases of similar patterns existing in the same composition were performed with similar expression by the same pianist. Moreover, it was found that the pattern of notes in the score sometimes influence how the expression emerges.

Therefore, we developed a system for inferring phrase expression from the patterns of the notes. We evaluated the system by comparing performance information inferred from the databases with the pianist's actual performance.

Key words: *automatic piano, knowledge database, music interface, user's preference, computer music, inference system*

1. Introduction

We developed a performance system for an automatic piano. In this system, 90 actuators are installed in the 88 keys and 2 pedals of a grand piano. Those actuators operate key strokes and pedaling to be executed on the piano. (See Figure 1)

Reproducing music with the piano is similar in some ways to reproducing music on the computer. Essentially, variations in tempo, dynamics, and so on are needed to arrange the respective tones in the desired way. However, in the case of piano music, there are 1000 or more notes in a score of even a short piece of music, and the editor must spent enormous amounts of time working with the arrangement in order to simulate the expressions of an actual performance.

Even for a skilled computer user, it becomes prohibitively burdensome to reproduce a score and add expression simultaneously using the automatic piano and a computer music system. The reason is because the musical data cannot be rewritten all at once. By contrast, highly skilled pianists can sight-read an unfamiliar piece of music, even if the performance is not completely in accord with a specific musical interpretation. The computer system cannot sight-read a new piece of music, and cannot simulate a human pianist's expressive performance.

Therefore, in this research, we have developed an interactive musical editing system to edit music more efficiently[1]~[4].

We devised a method for inferring a performance from information on the score and a particular user's editing characteristics for similar phrases. We evaluated the system by comparing performance information inferred from individualized databases with the pianist's actual performance.

In this paper, we describe the method of inference based on analytical results, and its result in an actual simulated performance.

Figure1. View of the automatic piano

2. Musical Editing Support System

2.1 System Architecture

The structure of the system is shown in Figure 2. The user edits music via the user's interface on the computer display. The user can also access a database that has musical grammar, the user's preferences, and so on. As a result, editorial work is reduced and efficient editing becomes possible.

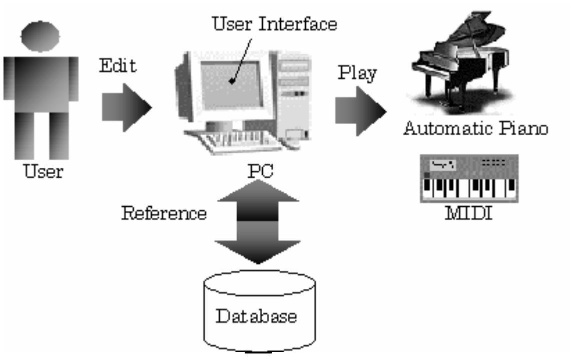

Figure 2.1 Structure of the editing system

2.2 Format of Performance Information

The parameters of performance information are shown in Tables 1 and 2.

The automatic piano that we have developed uses a music data structure that is similar to MIDI. We defined performance information, dividing it into two categories, the notes and the pedals.

The note information is comprised of the six parameters involved in producing a tone: "Key (note)", "Velo (velocity)", "Gate", "Step", "Bar", and "Time". "Velo" is the] dynamics, given by the value of 1～127. "Gate" is the duration of the note in milliseconds. "Step" is the interval of time until the next note, and it also exhibits tempo. "Bar" is the vertical line placed on the staff to divide the music into measures.

The pedal information is comprised of four parameters: "Key (indicating the kind of pedal, "Damper" or "Shifting")", "Velo (the pedaling quantity)", "Time (the duration for which the pedal is applied)", and "Bar".

Table 1. The parameters of note information

Parameter	Key	Velo	Gate	Step	Time	Bar
Unit	-	-	m sec	m sec	m sec	-
Reference	21～108	1～127	-	-	-	-

Table 2. The parameters of pedal information

Parameter	Key	Velo	Time	Bar
Unit	-	-	m sec	
Reference	Damper or Shift	0～127	-	-

2.3 Editing Support Process with Database

The procedure for editing by the system is shown in Figure 3.

Temporary music data (TMD) is the data of a piece of music without expression. Because expression has not been added, the necessary editing of the TMD is extensive.

Therefore, if the user chooses, the TMD is automatically translated by the system into original music data (OMD), similar in structure to TMD; after that, the user can start to edit it. The automatic translation program uses a Score Database, Musical Rules Database, and Preference Database, the details of which are described later in the paper. The user adds editing to the OMD and makes slight adjustments. When editing, the system watches over the data the user enters and music knowledge is provided. Concurrently, phrases in the music are discovered. When a phrase with the same pattern as one already edited occurs in the music, it is automatically translated. After editing, the system extracts the expressions and preferences that are peculiar to the user from the OMD. These expressions are stored in the Preference Database, which is then used when editing other music, resulting in improved editorial efficiency.

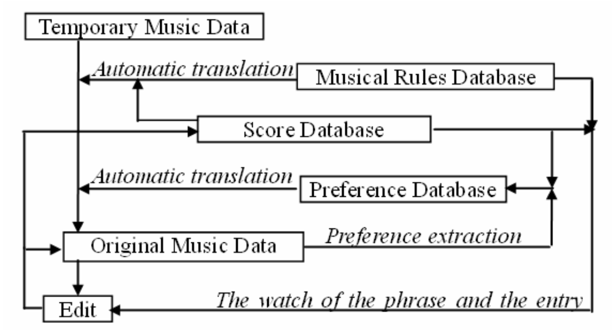

Figure2.2. Structure of the editing system

2.4 Details of the Databases

2.4.1 Score Database

This database has symbols including notes, time signature rests, and other standard musical notations. Symbols were pulled together in order of bars, and bar symbols are arranged in time series.

This database is composed of three tables, the

"Element table" (showing the position of the note and composition of the chord), the "Symbol table" (showing the position of the music symbol), and the "Same table" (showing the position of the repetition of the phrase).

2.4.2 Musical Rules Database

This database contains the architecture of musical grammar necessary to interpret symbols in musical notation. This database is composed of five tables containing "Dynamics marks", "Articulation marks", "Symbol of Changing Dynamics or Changing Tempo (symbol that affects the speed of a note or the increase or decrease of the volume)", "Time signature", and "Tempo marks".

Analyzing a music symbol according to its usage allows efficient information processing by the system.

2.4.3 Preference Database

This database contains the expressions of the user's characteristic performance. The expressions show the relationship between tempo and dynamics.

The "Edit" selection in the user's interface gives the user access to the parameters for expression. A user can edit his or her parameters, and the respective databases will automatically change at least one of their parameters.

3. Construction of the Preference Database

We analyzed a tendency to editing (a characteristic of a performance) based on a performance of a pianist and built a Preference Database. Among a lot of existing music symbols, we focused on the musical notation indicating Staccato.

We used the Pathetique sonata by Beethoven as the object music for our analysis.

We used "Gate (length of a sound)"," Step (an interval of a sound)" and "Gate ratio (the ratio of gate for step)" for the performance information that we analyzed.

3.1 Analytical Results

3.1.1 About a Sforzando

We analyzed a sound-added Sforzando sign and sounds that were not added.

Figure 3.1 shows the score of bars 11 to 14 of Beethoven's sonata Pathetique. This phrase appears in the score of bars 19 to 22 and 121 to 124.There are no Sforzando signs in the score of bars 121 to 124. In addition, there is repeat sign at the top of the score. Therefore, this phrase is played six times total. We analyzed these data. The general Gate ratio is 0.7 to 0.8.

Figure 3.1 The score of bars 11 to 14 of Beethoven's sonata Pathetique

Table 3.1 Analytical Result[s]

Bar number	Gate ratio
11-14 (1st)	0.130
11-14 (2nd)	0.125
19-22 (1st)	0.144
19-22 (2nd)	0.148
121-124 (1st)	0.881
121-124 (2nd)	0.905

Table 3.1 shows the analytical result. It also shows that the Gate ratio tends to become small by addition of the Sforzando sign. In addition, the Gate ratio thereby becomes approximately constant.

3.1.2 About a Staccato

Figure 3.2 shows the score of bars 35 to 36 of Beethoven's sonata Pathetique. This phrase appears in the score of bars 39 to 40 and 43 to 44. In addition, there is a repeat sign at the top of the score. Therefore, this phrase is played six times total. We analyzed these data.

Figure 3.2 The score of bars 35 to 36 of Beethoven's sonata Pathetique

Table 3.2 Analysis of Result

Bar number	Gate ratio
35-36 (1st)	0.356
35-36 (2nd)	0.277
39-40 (1st)	0.350
39-40 (2nd)	0.388
43-44 (1st)	0.419
43-44 (2nd)	0.394

Table 3.2 shows the analytical result. It shows that the Gate ratio tends to become small by addition of the Staccato sign. In addition, the Gate ratio thereby

becomes approximately constant

Furthermore, we analyzed the case of a half-note. The result showed that a half-tone has a smaller Gate ratio than a quarter-note.

We also analyzed the case of a Staccato that did not continue. As a result, the Gate ratio tends to become big.

3.1.3 Summary of An Analytical Result

We understood that the Gate ratio changed by the presence of musical signs from these analysis results. When the Sforzando sign is added, the Gate ratio tends to become small. The case of a Staccato sign being added is special. When a staccato continues in a phrase, the Gate ratio tends to become approximately constant. However, when the Staccato sign does not continue, the Gate ratio tends to become big

3.2 Making of GateratioData

We understood that the Gate ratio changed by the presence of musical signs from these analysis results. Therefore, we used GateratioData in the Preference Database to automatically convert user's editing characteristics. GateratioData consists of the Gate ratio, role (right or left hand), a kind of note, and a kind of musical sign.

4. Automatic conversion by musical sign

We converted the note with a Staccato sign (Figure4.1) automatically by using Gateratio Data in the Preference Database. Figure 4.2-(a) shows TMD. Figure 4.2-(b) shows OMD that was converted to TMD automatically by using the Musical Database and Score Database. Therefore, Figure 4.2-(c) shows the OMD that was converted to Figure 4.2-(b) automatically by using Gateratio Data. The process from (a) to (b) is converted musical process. The process from (b) to (c) is converted in consideration of the user's editing character.

Therefore, we are able to offer playing-information that took in user's editing character to user ,and we efficiency of work rose.

Figure 4.1 The score of bars 3 of Beethoven's sonata Pathetique

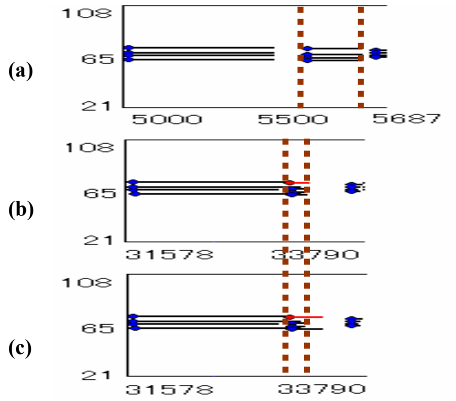

Figure 4.2 Automatic Changing Result

5. Summary

On an interactive musical editing system to support human errors and offer personal preferences for an automatic piano, we focused on [he user's editing character by the addition of a musical sign, and worked to store the Gate ratio in the Preference Database.

We were able to develop an automatic conversion processing function that based on Step. This function can offer playing information that took in user's editing character to user.

In the future, we plan to analyze other musical signs besides Staccato and Sforzando, improve the Preference Database, and develop a system that is able to convert plural musical signs.

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