# Interactive Musical Editing System to Support Human Errors and Offer Personal Preference for an Automatic Piano

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**Abstract**

We have developed a system that allows a piano to perform automatically. In order to play music in the manner of a live pianist, we must add expression to the piano's performance. In the case of music, there are often 1,000 or more notes in the score, requiring that an editor spend a huge amount of time to edit. Therefore, we have developed an interactive musical editing system that utilizes a database to edit music more efficiently.

*Keywords*: Automatic Piano, Knowledge Database, Computer Music, Music Interface

## 1. Introduction

We have developed a system that allows a piano to perform automatically. In this system, 90 actuators have been installed on the keys and pedals of a grand piano. These actuators execute key strokes and pedal movements to govern the piano's performance. (See Fig.1)

In order to develop an automatic piano that plays music in the manner of a live pianist, we have to add expression to the piano's performance. Essentially, variations in tempo, dynamics, and so on are needed in order to arrange the respective tones in a desired way. Moreover, in the case of piano music, there will often be 1000 or more notes in the score of even a short piece of music, and the editor must spend a huge amount of time to accurately simulate an actual emotionally expressive performance that a highly skilled pianist could give.

Moreover, a highly skilled pianist is able to play an unfamiliar piece of music by sight, even if the performance is not completely in accord with an intended specific musical interpretation. Current computing systems cannot perform a new piece of music by sight, and thus they cannot simulate a human pianist's musical expression. Therefore, we have developed an interactive musical editing system that utilizes a database in order to edit music more efficiently [1].

In a current research, MIDI data regarding the performances of highly skilled pianists has been analyzed in order to observe the stylistic tendencies of their performances. The results showed that phrases having similar patterns in the same composition were performed in the similar style.

We developed a system that searches for similar phrases throughout a musical score and infers the style of the performance. Here, we proposed a method using Dynamic Programming (DP) matching as a way to search for similar phrases. In our interactive musical editing system, we have created the Score Database which contains information regarding a musical score. This database contains a field called “Note Value,” in which data indicates the type of note--e.g., a quarter note, a triplet, and so on. This system converts notes into character strings using the “Note Value” data.

In addition, the system computes DP matching using the character strings and calculates the degree of disagreement between these strings. It uses an index to judge the resemblance between the strings. For its method of inferring performance expression, it uses the best alignment for DP matching, which enables it to express the best correspondence between notes. In order to edit music more efficiently, we must consider dynamic marking, beat and so on and we created database contains them. We developed an inferring process with regards to similar phrases using the best alignment and database.

In this paper, we describe the results of searching for similar phrases using DP matching and inferring for them using DP matching and database.

## 2. Searching for Similar Phrases

As a result of the analysis, it was found that phrases of the same pattern existing in the same tune are performed in a similar expression [2]. This time, we used DP matching to search for similar phrases.

DP matching is a technique used widely in the field of speech recognition, bioinformatics and so on. It has a feature that can calculate the similarity between two words that are different in a number of characters from each other.

In Fig.2, the route of minimum cost in each point is taken, and the route with the lowest cost is assumed finally to be the optimal path. The cost at that time is

Fig.1. The automatic piano.

$$g(i,j) = \min\begin{Bmatrix} g(i-1,j) \\ g(i,j) \\ g(i,j-1) \end{Bmatrix} + d(i,j)$$

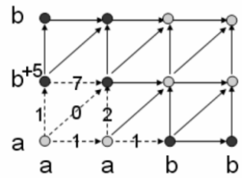



Fig.2. DP Matching

defined as the distance between patterns. In this system, this distance is handled as a threshold to judge whether the phrases are similar to each other.

For example, if the cost moves up or to the right, then it is increased by 1. If it moves to the upper right, then it does not increase. Also, if the characters do not correspond in each point, then the cost is increased by 5.

## 3. Musical Editing Support System

### 3.1. *System Architecture*

The structure of the system is shown in Fig.3, The

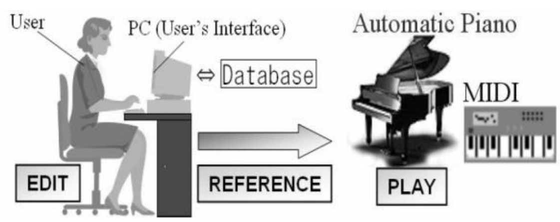



Fig.3. Structure of the editing system

user edits music via the user's interface on a computer display. The user can also access a database that has musical grammar, the user's preferences, and so on. As a result, edition work is reduced and efficient editing becomes possible.

### 3.2. *Format of Performance Information*

The parameters of performance 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 between notes, 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".

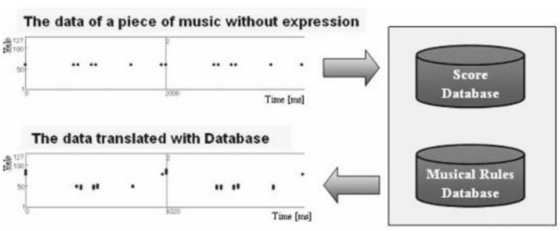



Fig.4. Automatic translation with database

### 3.3. *Editing Support Process with Database*

Our system can automatically apply a rough performance expression using Musical Rules Database and Score Database. (See Fig.4)

In addition, the system has Preference Database, which sores the editing characteristic of the user.

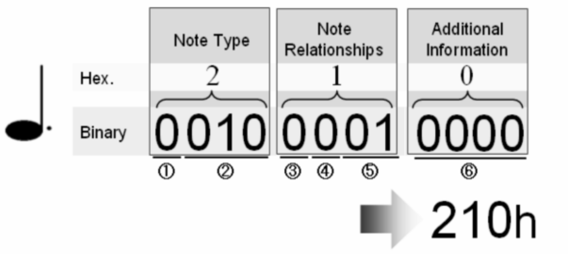
#### *3.3.1 Musical Rules Database*

This database contains the architecture of musical grammar necessary to interpret symbols in musical notation. It 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.

#### *3.3.2 Score Database*

This database has symbols including time signatures, notes, rests and so on in standard musical notation. Symbols were pulled together in order of bars, and bar symbols were arranged in a time series. Performance expression in itself is only information such as pitch, strength, and length and concerns only the enumeration of a sound. Because the identification of each sound is difficult, editing of the performance expression is difficult. By adding the Score Database's information to performance expression, we can connect each note to its enumeration. In doing so, it becomes easy to edit each phrase.

This database consists of three tables, the "Element




① Note or Rest (0: Note, 1: Rest)
② Note Value (000: A whole note, 001: A half note …etc)
③ Tie (If the note has a tie then this number is 1.)
④ Ornament
(If the note has an ornament then this number is 1.)
⑤ The number of dots
(Exceptionally, if it is "11" then the note is tuplet.)
⑥ Additional Information
The number of tuplets. (Triplets: 0011)
The type of an ornament. (Trill:010) etc…

Fig.5. Note Value

table" (showing the position of the note and the 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). The Element table contains the field "Note Value". Data in this field indicates the type of note, e.g., a quarter note, a triplet, and so on. "Note Value" is expressed by three hexadecimal numbers, which are shown in Fig.5.

### 3.4. *Beat Database*

We created Beat Database to edit music more efficiently. Beat Database is stored data which is Gerhard Oppitz's performance of beat expression. Using it, only step is inferred to change tempo.

## 4. Inferring Result

In Fig.6a is an input phrase used to search similar phrase for comparative experiments. Fig.6b is searched similar phrase. It is inferred two methods and results are outputted. First method, similar phrase is inferred, not to use Beat Database. The second method, Beat Database is used. The two results and data that performed by pianist in the similar phrase are compared to confirm improvement of the result.

The results of the experiment are shown Table1 and Fig.7. The results provide three values: the "Existing result" which don't use Beat Database, the "New result" which use Beat Database and the "Oppiz data" which is the actual emotional expression in a performance by a Oppitz in the similar phrase. "No." means note number. "No.1" means the first note in the phrases.

We have consistently found that the emotional expression represented by the "New result" resembles the "Oppitz Data" more than it resembles the "Existing result"

(a) Input phrase (b) Similar phrase

Fig.6. Phrases for inferring

Table 1. Results of inference

| | StepRate | | |
|---|---|---|---|
| No. | Existing result | New result | Oppitz data |
| 1 | 1.0000 | 0.8962 | 0.7596 |
| 2 | 1.2115 | 1.2115 | 1.2981 |
| 3 | 1.1648 | 0.9184 | 0.8240 |
| 4 | 1.0440 | 0.9144 | 0.6992 |
| 5 | 1.1500 | 0.9712 | 0.6923 |

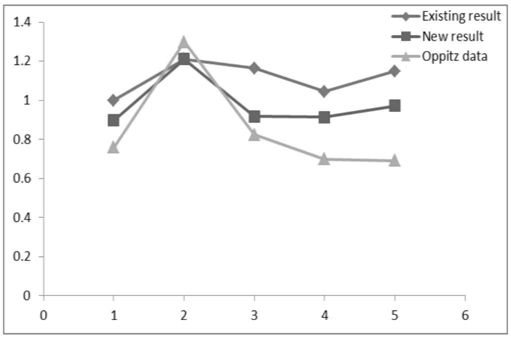



Fig.7. Results of inference

## 5. Conclusion

We developed an interactive musical editing system to edit music more efficiently. This system is composed of a "Searching system of similar-patterned phrases" and an "Inferring system of emotional expression in a performance. The Inferring system infers the emotional expression in a performance of similar phrases by referring to the databases automatically, greatly reducing the time needed for editing. Moreover, the interactive musical editing system provides edited phrases that resemble the "Pianist Data," which are the actual emotional expressions in a performance by a skilled human pianist.

## References

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