Automatic generation of musical score in vertical line notation from MIDI file

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Current mainstream music notation uses a 5-line staff. Staff notation is used for many types of instruments, and contains a great deal of information. However, to understand staff notation is difficult for beginner players who are not used to reading it because of its complexity. Vertical line notation is a new type of notation that is easy to understand because of its simple and intuitive design. It was created by Suguru Agata who is one of the authors of this research. In this study, we examine a method for creating a musical score in vertical line notation from a MIDI file.

1. Introduction

Generally, instrumental players use staff notation. There are some other types of notation such as tablature notation for guitar, one line notation for percussion, graphic notation, numeral notation, Japanese traditional notation, and so on[1)].

In ancient Greece, character notation was used. The characters show the pitch of notes, and were written above the lyrics. The oldest Christian chant in existence, which is said to have been created in A.D. 280, is written using this notation. In the ninth century, neumatic notation was introduced for use in Gregorian chant. At first, the neumatic notation included just a curve and straight lines which indicated a pitch and length of note. Next, the notation introduced a horizontal line as a reference pitch, and the line went increased gradually four and then five, finally it is same as a contemporary staff notation. Around 1025, Guido d'Arezzo, who was an Italian music theorist and monk devised a notation which is considered a prototype of current staff notation. The notation used square notes on four lines. The number of horizontal lines of music notation was settled at five in the early 17th century.

Current mainstream music uses staff notation, and is not limit to the piano. In fact, staff notation is used for many types of instruments. It contains a large amount of information such as pitch, length, dynamics, tempo marks, expression marks, articulation, repeat signs, ornamentation, abbreviations, accidentals, key signatures, and so on. Therefore, to understand staff notation is difficult for beginner players, especially older persons, who are not used to reading it because of its complexity, even though they grasp only the pitch information.

With this background in mind, vertical line notation was devised in 1985 for keyboard education purposes by Suguru Agata, who is one of the authors of this study. Agata made a textbook in vertical line notation in English[2)] and German while he was in Germany between 1982 to 1985. At that time, he worked for an instrument manufacturer. Unfortunately, his superiors did not see the value in vertical line notation. However, he has frequently demonstrated the effectiveness of this approach in open lectures of keyboard class for older persons at Showa University of Music since August 2010.

Vertical line notation is a new type of music notation, and even the beginner can understand it very easily. Currently, musical score in vertical line notation is made by using Microsoft Excel manually.

In this study, we present an automatic conversion system from a MIDI file to a musical score in vertical line notation.

2. Vertical line notation

Fig.1 shows an example of musical score in staff notation of Japanese children's song "Tulip". And Fig.2 is in the vertical line notation which corresponds to Fig.1. This musical score is made for a little child or an older person, so title is written on the top of the musical score in hiragana-character. The lyric is also described on the left side in hiragana-character.

In the vertical line notation, horizontal direction means the pitch of note: the left side is lower pitch and right

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Fig.1 Example of staff notation (Japanese children's song "Tulip")

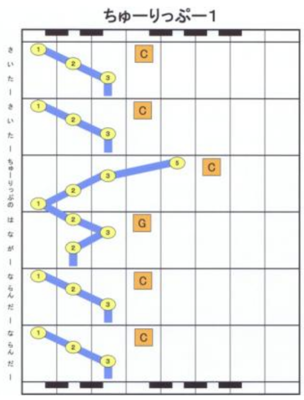


Fig.2 Example of vertical line notation ("Tulip")

side is higher pitch. The vertical direction signifies time; going in the downward direction moves forward.

Each circle is a note located on a corresponded pitch. The circle includes numeric figure which shows which finger to use. In this way, the piano player can perform correct fingering very easily. The correct fingering is important to play smoothly and without wasted motion.

The blue beam does not have a special meaning; however, it is useful for seeing whether the pitch of the next note is up or down compared with the current pitch.

Moreover, musical score in vertical line notation can contain chord names. In Fig.2, they are expressed in squares with orange background color. Therefore, the accompanist or a senior player can perform the chord with the left hand.

Fig.3 shows another example of staff notation. This is called "I Stepped on a Cat" in Japan, and the name of this song exists about 28 versions in the world. For example, this song is called "Circus Song" in USA, UK, and Canada. This music is G flat major, which has six flats. Therefore, this song looks very difficult. On the other hand, a musical score in vertical line notation shown in Fig.4 can be read easily. In this case, notes which are colored with orange background on the left side indicate to play with left hand, and each note which is connected a dotted line is performed at the same time as a chord.

3. Musical Instrument Digital Interface

In digital music area, Musical Instrument Digital Interface (MIDI) has been most often used. It was formulated by the Japan MIDI Standard Committee (JMSC; in 1996, this organization was incorporated into

Fig.3 Example of staff notation ("I Stepped on a Cat")

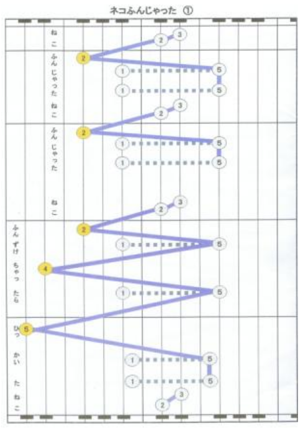


Fig.4 Example of vertical line notation ("I Stepped on a Cat")

the Association of Musical Electronics Industry, AMEI) and the MIDI Manufacturers Association which is an international organization[3)]. MIDI is a universal standard for the digital transmitting of performance data between electronic musical instruments. It consists of some regulations, such as physical transceiver circuit and interface, communication protocol, file format, et cetera.

Transmission and reception of data on the MIDI standard are all carried out on MIDI messages. Plural bytes (8 bits per one byte) construct a MIDI message. To transmit MIDI messages efficiently, the bytes which express MIDI messages are divided into two types: "status byte" and "data byte". The status byte has "1" at the most significant bit (MSB); namely, it contains 128 data types from 80H to FFH in hexadecimal. In contrast, the data byte includes "0" at the least significant bit (LSB). Thus the range of the data is from 00H to 7FH.

There are three types of formats of standard MIDI files. The format 0 has only one track which includes all note information. It is, so to speak, mixed down music data. Therefore, this format is for the purpose of playback only. The format 1 can contain many independent tracks. This format easily deals with decomposed data on a MIDI sequencer. The Format 2 seems to have been originally developed and intended for use in, for example karaoke. However, it is little used in practice.

The standard MIDI file is composed of several parts. One is the "header chunk," which includes information of the whole standard MIDI file. The other is "track chunk," which contains real performance data.

4. Transformation method from MIDI file to vertical line notation

The header chunk and the track chunk begin with a magic number as “MThd” and “MTrk”. First, it is necessary to find these bytes in a MIDI file. In the header chunk, a time resolution, which is called “delta time”, is defined. This shows a capacity to decompose a quarter note. For example, in case that the delta time is 480, it is possible to express the quarter note to 480 divided lengths.

The delta time is also described together in all events the MIDI file is represented. In this case, the delta time represents the time until the next event is performed. To represent the note by MIDI events, use two types of delta time of the above, and both of “note-on” (a command of turning on the sound) and “note-off” (turning off the sound). In case that the time length from note-on to note-off is equal to delta time, it means a quarter note. Let S show a time of note-on, E be a time of note-off, D mean a delta time for whole MIDI file, the meter be four-four time, and the music has no Auftakt. In these conditions, the note length l is calculated by Equation (1).

$$l = (E - S) / (D * 4). \quad (1)$$

A note position P from the beginning in a measure is obtained by Equation (2), and a measure number N of a note is calculated by Equation (3).

$$P = S \bmod (D * 4), \quad (2)$$

$$N = [\, S / (D * 4) \,] + 1, \quad (3)$$

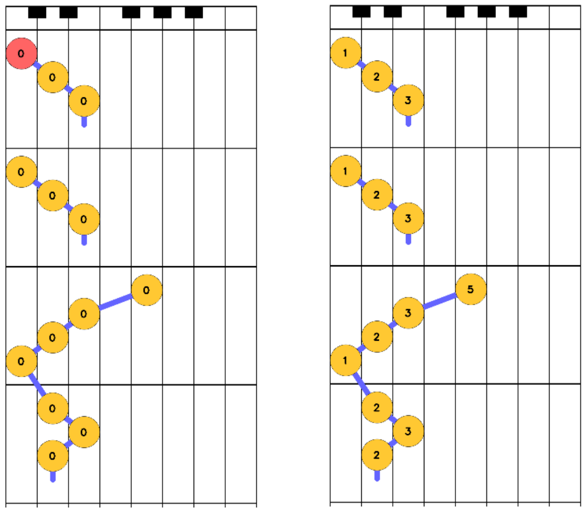
where “mod” means the remainder operation, “[ ]” indicates the floor function, and 4 is the denominator of the musical time. By using these three equations, performance data of a MIDI file are converted to data sequences which have only note length, note position, and measure number.

5. Implementation

We have developed software which inputs a MIDI file and converts it into a musical score in vertical line notation. The software creates the musical score as a graphics data by using OpenCV[4)].

OpenCV is a very useful computer vision library. This is developed and released by Intel, and is an open source. Currently, development of OpenCV has been taken over by Willow Garage.

We use C++ and introduce Qt for GUI programming[5)]. Qt provides a cross platform environment such as Windows, Mac OS, Android, and so on. It contains integrated development environment (IDE) which is called “Qt Creator”. Using the Qt Creator, we can perform the debug process easily, and design a window interface which includes a push button, radio button, slider bar, table, menu bar, and so on.



(a) (b)

Fig.5 Experimental results. (a) initial result of transformation from MIDI file into vertical line notation, (b) final result with suitable finger number

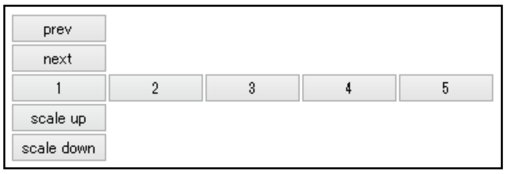


Fig.6 Control panel to input finger numbers

6. Experimental results

Fig.5 (a) shows the result of the conversion from a MIDI file into in vertical line notation immediately after reading the MIDI file. At this time, the finger numbers are all zeros. Fig.5 (b) shows the final result which includes suitable finger numbers. Fig.6 presents a control panel to input finger numbers. To push each button from “1” to “5”, the finger number is placed into the circle in the musical score in vertical line notation. A notice circle is expressed in red. The “prev” and “next” button changes the notice node. The “scale up” button magnifies the score and “scale down” button reduces respectively.

7. Discussion

7.1 Improvement of software and vertical line notation itself

This developed software can make the fundamental musical score in vertical line notation. However, several issues are left and are included to improve the vertical line notation itself.

First, it is necessary to introduce an automatic fingering determination method. To make the musical score in vertical line notation, the finger numbers is set manually both in conventional way and even in this study.

Fig.7 Example of staff notation ("For Elise")

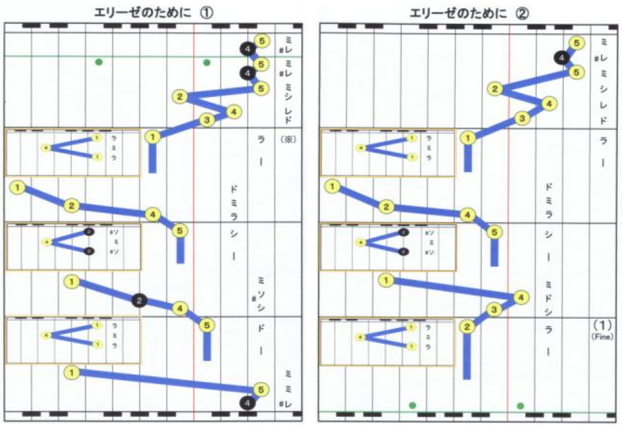


Fig.8 Example of expanded vertical line notation ("For Elise")

However, it takes a great deal of time and effort. We will refer to some prior studies[6-8].

Second, it is necessary to establish an arrangement method. Although the vertical line notation can show music faithfully, for beginner and older player, it is difficult to play a complex chord and phrase, a range of very short notes, or a large jump of pitch. We will try to solve these problems by implementing reducing note or measure, simplifying rhythm, and adjusting pitch.

Third, it is important to express a length of each note. Currently, the vertical line notation shows the length of the note by the vertical distance between nodes. Although it is simple, the player may not understand the length of the note immediately. Therefore, for example, we consider showing each node by a rectangle instead of a circle, and the height of the rectangle means the length of the note.

Finally, we will try to expand the vertical line notation. A characteristic of the vertical line notation is simplicity compared with the staff notation. On the other hand, we have considered giving it a more functional representation. Fig.7 and Fig.8 show examples of musical scores ("For Elise" by Beethoven) in staff and expanded vertical line notation. Fig.8 contains left hand part, which is arranged, and repeat marks shown as green line and dots on upper in the left score and on lower in the right score respectively. The software will be able to deal with these kinds of information.

7.2 Potential of vertical line notation

The vertical line notation is designed for education of keyboard performance. In addition to this purpose, vertical line notation has a very big potential.

Agata has used musical scores in vertical line notation at a facility covered by public aid providing long-term care to the elderly. One of the residents of the facility suffers from Parkinson's disease. This person's body usually leaned to one side. However, since the start of the keyboard performance using musical scores in vertical line notation, his posture has improved. In addition, his speech ability has also changed for the better, and he has been able to evaluate the performance of others. It is considered that muscle and brain are activated by playing the keyboard. If Agata used a complex musical score, the person might lost interest. The vertical line notation is suggested to be fully utilized in the welfare field.

8. Conclusions

In this study, we developed software which converts from a MIDI file into in vertical line notation. The vertical line notation is a new notation for piano beginners and older persons. Its horizontal direction indicates the pitch of note and its vertical direction presents time sequence. The software, which is constructed by using OpenCV based on C++ on Qt Creator, works properly to read MIDI file and processes finger numbers input from control panel.

We have examined the effectiveness of vertical line notation on the field of keyboard education and welfare. For our future work, we will solve several issues described in section 7.

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