A Concept to Facilitate Musical Expression

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ABSTRACT

In this paper, we propose a concept for helping performers to freely demonstrate their musical expression. This approach divides all of the musical elements into non-expressive elements and expressive elements and allows the performer to directly manipulate the performance with the expressive elements. We illustrate three prototype systems based on the concept and evaluate their effectiveness through the systems' subjective experiments. The results of the experiments suggest the possibility of our concept as well as effectiveness. In addition, we discuss an essential feature of musical performance and the role of a facilitating system for musical performance.

Keywords

Musical performance, facilitating expression, expressive elements, non-expressive elements

INTRODUCTION

In this paper, we propose a concept for helping a person to freely demonstrate her/his musical expression and illustrate three example systems based on this concept. In classical music, a performer plays a musical instrument based on a score that is usually composed by another person, i.e., a composer. In most cases, the performers perform the pitches of the notes, the order of the notes, and the basic rhythm as they are indicated in the score, though performers are often permitted to improvise some grace notes, e.g., a trill, as they like. On the contrary, although many expression marks are also indicated in the score, musical "expression" of performances usually varies with the performers, even if they use the same score.

Accordingly, we think that music can be divided into two kinds of elements from the performer's perspective: non-expressive elements and expressive elements. The pitches, sequence of pitches and basic rhythm in reproductive performance are the non-expressive elements. The performers must accurately reproduce them as the composer has directed. Therefore, the performer cannot demonstrate his/her expression with them. However, each of these notes has many other attributes, e.g., *Dynamik* (Varying and contrasting degrees of intensity or loudness in musical tones) and *Agogik* (A slight deviation from the main rhythm for the purposes of accentuation). We call those attributes the expressive elements. Individual expression is reflected how to these expressive elements are controlled. For example, even if the "crescendo" *Dynamik* mark is described on the score, the process of turning up the sound is different depending on the performer. However, the difficulty of reproducing the non-expressive elements prevents the performer from concentrating on the expressive elements.

Consequently, we propose a concept for helping performers to freely demonstrate their musical expression. It is most essential for performers to perform the expressive elements, not the non-expressive elements. Therefore, allowing performers to directly perform the expressive elements without wasting the performers' musical capacities on accurate performance of the non-expressive elements could facilitate the performers' demonstration of not only their musical expression, but also their creativity.

The rest of this paper describes a prototype system based on this concept named "Coloring-in Piano (CiP)" and its applications, i.e., piano lesson support and the two-step input method. CiP can be used by a piano teacher to play a model performance of a technical piece when sufficient preparation is not possible. The two-step input method supports a composition of expressive MIDI sequence data. The effectiveness of CiP for these applications is also shown. In addition, we show a "What-You-want-to-Express-Is-What-You-Perform (WYEIWYP) instrument." WYEIWYP-instrument is a new instrument that alleviates the initial barrier to performing. Finally, we discuss the concept in detail.

PROTOTYPE MUSICAL INSTRUMENT: CiP

Figure 1 shows the set up of CiP. CiP consists of a MIDI keyboard, a music-database, a function for replacing note numbers, and a tone-generator. Before performing, it is necessary to enter the sequence of MIDI note-numbers (corresponding to pitches) of the piece to be performed into the music-database. While performing, the replacing function replaces the played note-numbers with the note-numbers registered in the music-database, based on the order in which they were entered. Accordingly, the correct note number is

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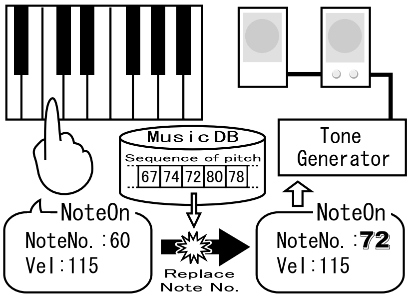

Figure 1: Structure of CiP

always output by touching any key. On the other hand, the expressive elements, i.e., note-on (key down) velocity, note-off (key up) velocity, onset/offset timing, and pedal messages, are output as the performer plays. Consequently, the replaced pitch numbers are input into the sound generator with the expressive elements preserved as they were performed.

We used a YAMAHA silent grand piano C5 professional model that outputs MIDI (Musical Instrument Digital Interface) note-on/off and pedal control messages. The piano is connected to an SGI Indy workstation in which the music-database and the replacing function of note-numbers are implemented. In the current prototype system, a key-touch that occurs within 50 ms after the preceding key-touch is ignored in order to avoid unexpected progression in the sequence of note-numbers by a mis-touch.

APPLICATIONS OF CiP

Supporting Piano Lessons

A piano lesson is an event where a teacher cultivates the pupils' musical creativity. In the lesson, the teacher attempts to convey his/her knowledge of piano performance. A model performance is a typical way to show the teacher's way of expression. However, if a pupil studies a highly technical piece that the teacher has seldom or never performed, the teacher may not be able to perform it perfectly without prior practice. However, even then the teacher has knowledge of how to perform it. In such a case, CiP would surely be useful. By using CiP, it is expected that the teacher would be able to immediately show his/her expression on the piece without being concerned about accurate control of the pitches of the notes.

Method of evaluations

Twelve experimental subjects who are experienced in piano playing, e.g., those who had finished the Bayer Manual, evaluated the performances played on a conventional piano and on CiP. They did not know the details of this experimental condition. C. Oshima, who is one of the authors, performed parts of two pieces on the conventional piano and on CiP. She played only the melody without accompaniment. In the case of CiP, three ways of performance were tried, e.g., using only one finger for one key performance (CiP-1), using only two fingers for two-key performance (CiP-2), and using five fingers for all-key

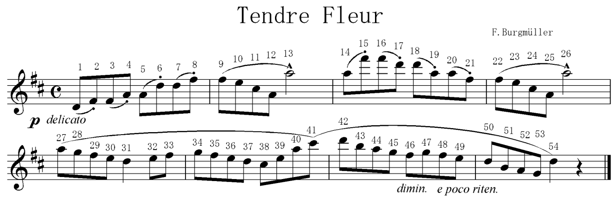

Figure 2: Bar 1st-8th of "Tendre Fleur," which is one of the 25 Leichte etuden Op. 100 by A. Burgmuller

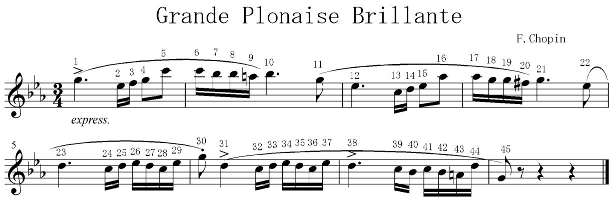

Figure 3: Bar 220th-227th of "Grande Polonaise Brillante Op. 22" by F. Chopin.

performance (CiP-5). One of the pieces was "Tendre Fleur," which is one of the 25 Leichte etuden Op. 100 by F. Burgmuller. We called this piece "Piece-A." The other piece was "Grande Polonaise Brillante Op. 22" by F. Chopin. We called this piece "Piece-B." Both of them are examples of the style known as romanticism and include various articulations. Figures 2 and 3 show eight bars selected from each piece. We asked the subjects to evaluate each of the performances from the perspective of whether it is musical (1: not musical to 5: very musical). We thought that the meaning of "musical" would be difficult to evaluate. Accordingly, we also explained to the subjects that "musical" means "interesting" or/and "comfortable." Moreover, we asked them to evaluate the degrees of resemblance between the CiP-1, 2, and 5 performances and the conventional piano performance (1: very different to 5: almost the same). We also asked them to evaluate the resemblance between a conventional piano performance and the same conventional piano performance. All of the evaluations were conducted under a blind condition, so the subjects did not know which performances they were comparing.

Analysis of performance data

Based on the performance data in MIDI format, we calculated inter-onset interval (IOI) and gap value. The IOI is obtained as follows:

$$IOI_i = t_{Non(i+1)} - t_{Non(i)}, \quad (1)$$

where IOI_i is the i-th IOI, $t_{Non(i)}$ is emitted time of the i-th note-on message $Non(i)$, and $t_{Non(i+1)}$ is emitted time of the (i+1)-th note-on message $Non(i+1)$. The gap value is obtained as follows:

$$gap_i = t_{Non(i+1)} - t_{Noff(i)}, \quad (2)$$

where gap_i is the i-th gap time, $t_{Noff(i)}$ is emitted time of the i-th note-off message $Noff(i)$, and $t_{Non(i+1)}$ is emitted time of the (i+1)-th note-on message $Non(i+1)$. Hence, if gap_i is positive, the performer shortened the i-th note. Additionally, we extracted the velocity values included in the MIDI note-on message. The velocity of a note-on message shows the velocity of going down a key and nearly corresponds to the sound level of the note.

Method of trial performance

C. Oshima additionally tried to perform two other technical pieces on CiP-2, CiP-5 and the conventional piano. One was “Piano Concerto No. 1” by F. Chopin, which she had not performed yet. We called this piece “Piece-C.” The other was “Piano Concerto No. 2” by F. Chopin, which she had not performed for a long time. We call this piece “Piece-D.”

Results of evaluation by the subjects

Table 1 shows the average evaluation values for musicality by twelve experimental subjects. The results of a t-test indicate that the musicality of CiP-1 performance is significantly worse than that of the conventional piano performance for both pieces.

Table 2 shows the average values for resemblance between the CiP performances and a conventional piano performance or between a conventional piano performance and the same conventional piano performance. Additionally, it shows t-values that are obtained by comparing the average value of “CiP-n: conventional piano” pair to that of the “conventional piano: conventional piano” pair. The results of the t-test indicate that no significant difference in resemblance can be found between CiP-5 and the conventional piano performance for Piece-A.

Table 1: Average values of evaluations of musicality. An asterisk (*) indicates a significant difference at 1%.

	Piece A				Piece B		
	conventional	CiP-1	t-value		conventional	CiP-1	t-value
1	3.17	2.00	5.63*	1	2.92	1.92	3.63*
	conventional	CiP-2	t-value		conventional	CiP-2	t-value
2	3.50	3.67	0.46	2	2.67	3.00	0.84
	conventional	CiP-5	t-value		conventional	CiP-5	t-value
3	3.58	3.41	0.62	3	3.25	3.50	1.00
	conventional	conventional	t-value		conventional	conventional	t-value
4	3.50	3.33	1.00	4	3.58	3.58	0.00

Table 2: Average values of resemblance between CiP performances and a conventional piano performance or between a conventional piano performance and the same conventional piano performance. An asterisk (*) indicates a significant difference at 1%.

Piece A	CiP-1:conventional	conventional:conventional 3.67	t-value
	2.17		3.1*
	CiP-2:conventional		t-value
	2.58		3.77*
	CiP-5:conventional		t-value
	3.42		0.64
Piece B	CiP-1:conventional	conventional:conventional 4.00	t-value
	1.5		10.85*
	CiP-2:conventional		t-value
	2.5		5.74*
	CiP-5:conventional		t-value
	2.75		5.74*

Results of performance data

The IOIs of the four ways of performance with CiP-1, CiP-2, CiP-5 and conventional piano are very similar for both pieces. Figure 4 shows the transition of the average gap values of the four ways of performance for Piece-B. The x-axis corresponds to the sequence number of notes of each piece indicated in Figs. 3. It is clear that the transition of the CiP-2 performance achieves positive values at the 8th and 19th notes, although CiP-5 and conventional piano performances have positive values at the 7th and 18th notes. Generally, a performer changes fingers when repeatedly performing the same note. However, this performer played the same notes with the same finger as with CiP-2.

Figure 5 shows the transition of the average note-on velocity values of the four ways of performances for Piece-A. It is clear that the velocity of the CiP-2 performance decreases at the 14th note. This velocity value is 36 points smaller than that of the normal performance.

Results of trial performance

C. Oshima could perform Piece-C perfectly with CiP-5 even though it was her first trial. Concerning Piece-D, although she sometimes confused some fingering with CiP-5, she

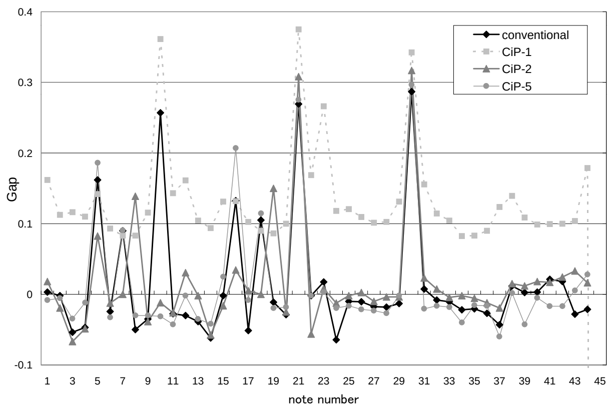

Figure 4: Transition of average gap values of the four ways of performances of Piece-B.

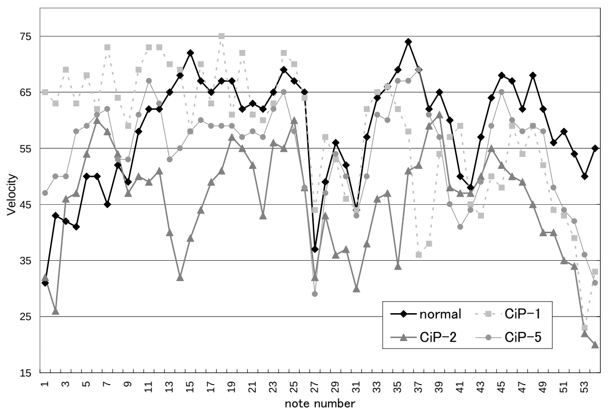

Figure 5: Transition of average note-on velocity values of the four ways of performance of Piece-A.

could perform it basically good enough. On the other hand, she made many mistakes with the conventional piano in playing both pieces. She felt that CiP-2 was very useful when she played technical passages, and she could perform them more smoothly. However, she could not express expression marks, e.g., staccato and articulation, as much as she would have liked with CiP-2.

Discussions on support to the teacher by CiP

These results demonstrate that CiP, except for CiP-1, allows the performer to express his/her preferences. Moreover, CiP-2 helps the performer to play technical passages more smoothly. However, we found that the pieces were expressed differently between CiP-2 performances and the conventional piano performances. This must derive from the difference in fingering between two-finger use and five-finger use. Therefore, it would seem that the teacher couldn't fully express his/her images with CiP-2. Each way of playing has advantages and disadvantages. Accordingly, it is desirable that CiP provide all keys, as with CiP-5, and that it allows the teacher to select the way of playing, i.e., CiP-2 or CiP-5.

In this application, CiP is used as a supporting system for piano teachers, not novices, to convey the their musical knowledge to pupils. On the other hand, CiP could also be used as a supporting system (or a mere "Toy") for novices. We do not yet know whether CiP has negative effects on novices who cannot manipulate the various elemental pieces of knowledge for expressing desired timbre, articulation, and so on. However, if novices desire to learn how to perform the conventional piano, we think it is better to practice with the conventional piano, not with CiP. It is important for a novice at piano playing to first make the effort to reproduce the pitches from a score.

Supporting Composition of MIDI Sequence Data

It has recently become possible for people to perform any musical piece by using a computer. When MIDI sequence data are input, the computer can perform even a symphony by a full orchestra. This method benefits those who want to perform music but are not good at playing any musical instrument.

Currently, there are two ways of composing MIDI sequence data, i.e., a real-time input method and a step-by-step input method. In the real-time input method, the sequence data are basically composed by performing on a musical instrument that outputs MIDI data in the usual manner. Therefore, it is impossible for people who cannot play any musical instrument to compose MIDI sequence data by the real-time input method. In the step-by-step input method, people compose MIDI sequence data by separately inputting the pitch, velocity, onset time, and offset time of each note as numerical values. Therefore, anyone can compose MIDI sequence data by the step-by-step input method even if he/she cannot play any musical instrument. However, it is difficult to control the balance among the expressive elements, i.e., velocity, onset/offset time, as well as to provide "nuance" to each element. Therefore, it is usually a very troublesome task to achieve rich musical expressions by the step-by-step input method.

As a solution to the problems mentioned above, we propose a "two-step" input method. In this method, the process of composing MIDI sequence data is divided into two steps. In the first step, only the sequence of pitches is input without giving consideration to any expressive elements; it can be done in a similar manner to the step-by-step input method. Then, in the second step, the expressive elements for the piece, i.e., the velocity and the onset/offset time data, are input with CiP by using the sequence of pitches input in the first step. Finally, the performance obtained by integrating the expressions input by CiP with the sequence of the pitches is recorded by using XGworks 4.0. Differing from the step-by-step input method, the velocity and the onset/offset time data are concurrently input in a real-time manner. This is important, we think, for achieving a good balance among the expressive elements.

Experiments on composing MIDI data by three methods

We conducted experiments using subjects as performers to compare the two-step input method with the two conventional input methods. We employed eighteen subjects who are students at an undergraduate institution as well as our graduate school. The subjects were asked to input "Akatonbo," which is a very famous Japanese children's song, by the three methods.

Before the experiments on composing MIDI data, we had three basic musical tests, i.e., sight-reading, beating rhythm, and fingering. In the sight-reading test, the subjects were asked to read and play a sequence of twenty notes picked out from the score of "Akatonbo" at random. Nine subjects read and played them in about fifteen seconds, while the others read and played them over twenty seconds and made some mistakes. In the beating rhythm test, the subjects were asked to beat three patterns of rhythm that are included in "Akatonbo." Ten subjects made mistakes in one of the patterns that include dotted notes. In the fingering test, the subjects were asked to smoothly play six notes. The six notes were D, G, A, C, F, and G: the interval between the first D-note and the last G-note is the eleventh (one octave and two and a half tones). We denoted the sequence number on the corresponding keys to the six notes and asked the subjects to play the keys along with the sequence number. In order to smoothly play the six notes, the technique of the thumb passing through the other fingers is required. We evaluated whether the subjects could use this technique. Eleven subjects who have played keyboard instruments succeeded in this task.

Then, after the subjects listened to a performance of "Akatonbo" by a professional vocalist [1], they were asked to compose MIDI sequence data of "Akatonbo" by the three methods and to be as expressive as possible in emulating the professional vocalist. Before the experiments, we explained each way of inputting data and had them practice each method with another small piece. The time limit was thirty minutes for each method. If the subject was satisfied with her/his data or threw up her/his hands in despair over one of the methods, the subjects could stop composing the MIDI data within thirty minutes. Each subject provided a subjective evaluation for each method after composing the sequence MIDI data by all of the methods. The subjects evaluated the degree of satisfaction (1:non-satisfaction to 5:very high satisfaction) with each of the composed sequence data and the difficulty (1:very easy to 5:very difficult) of inputting four elements, i.e., melody, rhythm, *Agogik*, and *Dynamik*, by each method. Additionally, the subjects were asked about their experience in playing musical instruments and making MIDI data.

Results of evaluations by subjects

Table 3 shows the average evaluation values for the real-time input method and the two-step input method. The results of a

Table 3: Average evaluation values for the two-step input method and the real-time input method. Three asterisks (***) indicate a significant difference at 1%. Two asterisks (**) indicate a significant difference at 5%. A single asterisk (*) indicates a significant difference at 10%.

	melody		rhythm		agogik		dynamik		emotional burden
average	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	
two-step	1.89	3.22	2.22	3.39	2.50	3.17	2.44	3.28	2.28
real-time	3.44	2.56	3.67	2.83	3.44	2.50	3.56	2.56	3.22
t-value	3.50***	2.13**	3.71***	1.82*	2.88**	2.06*	2.60**	2.06*	2.12**

Table 4: Average evaluation values for the twp-step input method and the step-by-step input method. Two asterisks (**) indicate a significant difference at 5%. A single asterisk (*) indicates a significant difference at 10%.

	melody		rhythm		agogik		dynamik		emotional burden
average	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	
two-step	1.89	3.22	2.22	3.39	2.50	3.17	2.44	3.28	2.28
step-by-step	2.72	3.28	2.50	3.00	3.72	2.33	3.28	2.61	3.33
t-value	2.29**	0.17	0.68	1.07	3.33**	3.39**	1.87*	1.94*	2.29**

Table 5: Average evaluation values for the two-step input method and the real-time input method by the subjects who did correct fingering.

	melody		rhythm		agogik		dynamik		emotional burden
average	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	
two-step	2.63	3.13	2.63	3.25	2.63	3.13	2.75	3.13	2.38
real-time	2.75	3.13	3.63	3.00	2.75	3.00	3.25	2.75	2.75
t-value	0.22	0.00	1.87	1.53	0.31	1.00	0.88	1.00	0.60

Table 6: Average evaluation values for the two-step input method and the step-by-step input method by the subjects who did correct fingering.

	melody		rhythm		agogik		dynamik		emotional burde
average	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	
two-step	2.63	3.13	2.63	3.25	2.63	3.13	2.75	3.13	2.38
step-by-step	2.50	3.00	2.25	3.25	3.38	2.88	3.38	2.63	3.00
t-value	0.26	0.28	1.42	0	1.82	0.68	1.26	1.18	1.36

Table 7: Average evaluation values for the two-step input method and the real-time input method by the subjects who did incorrect fingering. Three asterisks (***) indicate a significant difference at 1%. Two asterisks (**) indicate a significant difference at 5%. A single asterisk (*) indicates a significant difference at 10%.

	melody		rhythm		agogik		dynamik		emotional burden
average	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	
two-step	1.30	3.30	1.90	3.50	2.40	3.20	2.20	3.40	2.20
real-time	4.00	2.10	3.70	2.70	4.00	2.10	3.80	2.40	3.60
t-value	7.36***	2.71**	3.25***	1.50	4.00***	2.01*	2.67**	1.79	2.26**

Table 8: Average evaluation values for the two-step input method and the step-by-step input method by the subjects who did incorrect fingering. Three asterisks (***) indicate a significant difference at 1%. Two asterisks (**) indicate a significant difference at 5%.

	melody		rhythm		agogik		dynamik		emotional burde
average	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	
two-step	1.30	3.30	1.90	3.50	2.40	3.20	2.20	3.40	2.20
step-by-step	2.80	3.70	2.80	3.20	3.60	2.70	3.60	2.30	3.30
t-value	3.14***	0.84	1.59	0.76	4.13***	0.96	3.28***	2.70**	2.18**

Table 9: Average evaluation values for the two-step input method and the real-time input method by the subjects who had previously composed MIDI sequence data with the step-by-step input method of some sequencing software. Three asterisks (***) indicate a significant difference at 1%. Two asterisks (**) indicate a significant difference at 5%.

	melody		rhythm		agogik		dynamik		emotional burden
average	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	
two-step	1.60	3.10	1.90	3.50	2.20	2.80	2.30	3.10	2.80
real-time	3.30	2.60	3.80	2.70	3.30	2.70	3.30	2.70	3.30
t-value	3.79***	1.17	4.67***	1.81	4.71***	0.32	2.02**	1.00	0.76

Table 10: Average evaluation values in the two-step input method and the step-by-step input method by the subjects who had previously composed MIDI sequence data with the step-by-step input method of some sequencing software. Three asterisks (***) indicate a significant difference at 1%. Two asterisks (**) indicate a significant difference at 5%.

	melody		rhythm		agogik		dynamik		emotional burde
average	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	
two-step	1.60	3.10	1.90	3.50	2.20	2.80	2.30	3.10	2.80
step-by-step	3.10	3.20	2.70	2.60	4.00	1.80	3.10	2.70	3.70
t-value	4.02***	0.22	1.35	1.96**	3.86***	3.35***	1.21	0.77	1.19

Table 11: Average evaluation values in the two-step input method and the real-time input method by the subjects who had never composed MIDI sequence data with the step-by-step input method of sequencing software. Two asterisks (**) indicate a significant difference at 5%.

	melody		rhythm		agogik		dynamik		emotional burden
average	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	
two-step	2.25	3.38	2.63	3.25	2.88	3.63	2.63	3.50	1.63
real-time	3.63	2.50	3.50	3.00	3.63	2.25	3.88	2.38	3.13
t-value	1.59	1.82	1.26	0.61	1.07	2.58**	1.62	1.84	2.64

Table 12: Average evaluation values in the two-step input method and the step-by-step input method by the subjects who had never composed MIDI sequence data with the step-by-step input method of sequencing software.

	melody		rhythm		agogik		dynamik		emotional burde
average	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	difficulty	satisfaction	
two-step	2.25	3.38	2.63	3.25	2.88	3.63	2.63	3.50	1.63
step-by-step	2.25	3.38	2.25	3.50	3.38	3.00	3.50	2.50	2.88
t-value	0.00	0.75	0.48	1.00	1.49	1.43	2.37	2.37	2.55

t-test indicate that the two-step input method is easier than the real-time input method for inputting the expressive elements and is lighter than the real-time input method in their burden. Moreover, the subjects tended to be more satisfied with the sequence data composed with the two-step input method than that composed with the real-time input method.

Table 4 shows the average evaluation values in the step-by-step input method and the two-step input method by the subjects. The results of a t-test indicate that the two-step input method is easier than the step-by-step input method in inputting the expressive elements except for rhythm and is lighter than the step-by-step input method in their burden. Moreover, the subjects tended to be more satisfied with the sequence data composed with the two-step input method than the sequence data composed with the step-by-step input method for the expressive elements of *Agogik* and *Dynamik*.

To investigate what kind of people prefer the two-step input method, the results of the evaluations were divided into two groups from the results of the fingering-test. Except for one subject, those subjects who gave correct fingering have some experience with a keyboard instrument. Tables 5-8 show the average evaluation values for the step-by-step, real-time, and two-step input methods by the subjects who did correct fingering and the subjects who did incorrect fingering. The results of a t-test indicate that the two-step input method is easier than the other two methods for the subjects who did incorrect fingering.

Additionally, the subjects who did incorrect fingering were more satisfied with the two-step input method than with the other two methods for the most part of expressive elements. On the other hand, the subjects who did correct fingering felt no significant difference between the two-step input method and the other two methods.

Subsequently, the results of evaluation by subjects are divided into two groups based on whether they have ever composed MIDI sequence data with the step-by-step input method of some sequencing software. Tables 9-12 show the average evaluation values for the step-by-step, real-time, and two-step input methods by the experienced subjects and the inexperienced subjects of the step-by-step input method. The results of a t-test indicated that the two-step input method was easier than the real-time input method for the subjects who had previously composed MIDI sequence data with the step-by-step input method.

Furthermore, the subjects who had previously composed MIDI sequence data with the step-by-step input method were more satisfied with the two-step input method than with the step-by-step input method for rhythm and *Agogik*. On the other hand, the subjects who had never composed MIDI sequence data with the step-by-step input method were more satisfied with the two-step input method than the step-by-step input method for *Dynamik*.

Discussion on the two-step input method

The results indicated an evident tendency of the two-step input method to be easier than the real-time input method and the step-by-step input method. Furthermore, most of the subjects were more satisfied with the sequence MIDI data composed with the two-step input method than that composed with the real-time input method. In particular, the results suggested that the two-step input method is not only suitable for the subjects inexperienced in using keyboard instruments but also for subjects experienced in the step-by-step input method.

The two-step input method inherits the merits of both of the conventional methods. The merit that derives from the step-by-step input method is that all of the musical elements are divided into two sets of elements: one set includes the pitch and the sequence of the pitches and the other set includes the expressive elements, i.e., *Agogik*, *Dynamik*, articulation, and so on. By this division, people can easily reconstruct the sequence of pitches without worrying about the expressions and then performers can concentrate on expressions without confusing the fingering to achieve an accurate reproduction of the sequence of pitches. The merit that derives from the real-time input method is that the all of the expressive elements can still be input simultaneously. All of the expressive elements are tightly related, and the balance among them is very important for achieving good musical expression.

WYEIWYP-INSTRUMENT: PROPOSAL OF A NEW MUSICAL INSTRUMENT

Many people hope to play a musical instrument. However, it is difficult for a performer only to operate the musical instrument to correctly replay the sequence of pitches along the score. However, essentially, it is a real pleasure for the performer to show individual expression. Accordingly, we propose a new musical instrument named "WYEIWYP-instrument" based on the concept we described in this paper. The mechanism of the WYEIWYP-instrument is the same as that of CiP. The performer can immediately concentrate on the expressive elements with the WYEIWYP-instrument. Therefore, all expressive elements can be concurrently input to achieve well-balanced expressions.

While CiP is equipped with the same eighty-eight keys as the conventional piano because of its purpose, i.e., supporting piano teachers, the WYEIWYP-instrument does not need to (or should not) be equipped with a full keyboard. The WYEIWYP-instrument is not a substitute musical instrument for the conventional musical instruments. Reasonable as well as free expression can be achieved only with two fingers as we showed in the experimental results with CiP-2. Therefore, some novel interfaces for the WYEIWYP-instrument should be designed, e.g., a keyboard with only three keys.

DISCUSSIONS

Formerly, the composer was the only performer of his/her opuses. Therefore, in the 11th or 12th century, there was only the sequence of pitches described in the score as a reminder for the composer. In the 17th century, the composers came to accurately direct phonetic values and basic rhythm as well as pitches, e.g., the scores of J. S. Bach and W. A. Mozart, although some improvisational performances even on the non-expressive elements were still allowed in baroque music. However, no evident directions of expression were described. Therefore, the performers were entirely responsible for the expressions of the opuses through this period.

Since about 1830, the composers have come to describe the expression marks minutely in scores for others, i.e., the specialists of musical performance. In this period, the composer was not always the performer. For example, the composer's pupil might play the composer's opus. Moreover, the movement of other performers playing the opuses of the late J. S. Bach had accelerated the tendency of composers to describe detailed expressions in the score for posterity [2][3]. Thus, not only the non-expressive elements but also the expressive elements came to be described in the score. However, it is still impossible for composers to perfectly describe the expressions, e.g., detailed *Dynamik*, articulation, and *Agogik*, in the score because of the vast diversity and ambiguity of musical expression. Accordingly, musical expression basically depended on the performers even in this period (and in the contemporary period). Therefore, the performers must interpret the opus and give their own expression by controlling the musical instruments based on interpretation. Eventually, it was accepted that an opus is completed only when the performer plays the opus with expression based on his/her own interpretation. Consequently, it is essential for performers to demonstrate their musical expression.

Accordingly, we proposed a concept, i.e., dividing all of the musical elements into the non-expressive elements and the expressive elements, to help performers to freely demonstrate their musical expression. We showed the effectiveness of the CiP that was implemented based on this concept, through subjective experiments. Consequently, the results indicated the possibility of the concept to facilitate the performer's own expression.

We would like to emphasize that the systems/instruments based on the concept do not enhance the performer's musical ability in musical expression or techniques for manipulating conventional musical instruments. The systems/instruments can help to externalize the musical expressions that already exist in the performer's mind. However, they can neither create nor add new musical expression for the performer. The performer is always entirely responsible for creating his/her own new musical expression even if he/she uses the systems/instruments based on our concept. However, by the alleviating the cognitive load in the performance due to non-expressive elements, the systems/instruments allow the performers to externalize more of their own musical expression.

This consideration is supported by the results that the degree of the subjects' satisfaction of the MIDI sequence data composed with the two-step input method were almost the same as those of the others, while the subjects felt that it was much easier to compose the MIDI sequence data by the two-step input method than by the other methods. These facts suggest that it became easy for the subjects to externalize their own expressions, but that their own musical expressions were originally not so rich. To achieve richer expressions, they have to study irrespective of what kind of instruments is used.

Please note that we do not recommend the systems or the instruments based on the concept described here to the novices and pupils who desire to learn a conventional musical instrument. For example, piano pupils should avoid using CiP. Although CiP seems to provide the same interface as a conventional piano, the techniques used to play them are completely different. We are afraid that the CiP might prevent novices and pupils from acquiring skill in reproducing non-expressive elements, i.e., the pitches and sequence of pitches, which is an essential skill for the performance with the conventional piano.

RELATED WORKS

Various supporting systems for musical performance have been proposed, and some of them are now commercially available. "Two Finger Piano" [4] is a toy system that allows the user to coarsely handle tempo and Dynamik for each "beat" (not for each note) by using two fingers. However, it is impossible to fully control musical expressions at the "beat" level. CASIO LK-40 Lighted Keyboard[5] is equipped with "3 Step Teaching System," which is a self-study system of the keyboard. The first step of the self-study system is quite similar to CiP in outputting available pitches by hitting any key. However, this system does not output the velocity value. Thus, such ordinary systems can only be applied for the public's amusement use, while our new musical instrument aims at facilitating pure musical expression not only by novices but also by professionals.

CONCLUSIONS

In this paper, we proposed a concept to help performers to freely demonstrate their musical expression. Our approach divides all of the musical elements into non-expressive elements and expressive elements and allows the performer to directly manipulate the performance with the expressive elements. We illustrated a prototype instrument based on the concept, i.e., CiP, as well as its applications, and the WYEIWYP-instrument. We evaluated the effectiveness of CiP for supporting a piano teacher and for the two-step input method through subjective experiments. The results of the experiments suggested the possibility as well as the effectiveness of our concept.

Currently, the prototypes can alleviate only the reproduction of the pitches as non-expressive elements, and while another non-expressive element, i.e., the basic rhythm, must still be controlled by the performer. In the future, we would like to explore a way to alleviate reproduction of the basic rhythm.

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