A NEW MUSIC DATABASE DESCRIBING DEVIATION INFORMATION OF PERFORMANCE EXPRESSIONS

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ABSTRACT

We introduce the CrestMuse Performance Expression Database (CrestMusePEDB), a music database that describes music performance expression and is available for academic research. While music databases are being provided as MIR technologies continue to progress, few databases deal with performance expression. We constructed a music expression database, CrestMusePEDB. It may be utilized in the research fields of music informatics, music perception and cognition, and musicology. It will contain music expression information on virtuosis' expressive performances, including those of 3 to 10 players at a time, on about 100 pieces of classical Western music. The latest version of the database, CrestMusePEDB Ver. 2.0, is available. The paper gives an overview of CrestMusePEDB.

1 INTRODUCTION

Constructing music databases is one of the most important themes in the field of music studies. The importance of music databases has been recognized through the progress of music information retrieval technologies and benchmarks. Since the year 2000, some large-scale music databases have been created, and they have had a strong impact on the global research area [1, 2, 3].

Corpora of scores, audio recordings, and information on books of composers and musicians have been collected and used in the analysis of music styles, structures, and performance expressions. Meta-text information, such as the names of composers and musicians, has been attached to large-scale digital databases and been used in the analysis of music styles, structures, and performance expressions from the viewpoint of social filtering. In spite of there being many active music database projects, few projects have dealt with music performance expression, such as dynamics, tempo, and the progression of pitch. The performance expression plays an important role in formulating impressions of music. Providing a performance expression database, especially describing deviation information from neutral expression, can be used as a research in MIR fields.

In musicological analysis, some researchers construct a database of the transition data of pitch and loudness and then use the database through statistical processing. Widmer *et al.* analyzed deviation of tempi and dynamics of each beat from Horowitz's piano performances [4]. Sapp *et al.*, working on the Mazurka Project [5], collected as many recordings of Chopin mazurka performances as possible in order to analyze deviations of tempo and dynamics by each beat in a similar manner to Widmer. Their researches are expected to provide the fundamental knowledge in the quantitative analysis of music style and performance expression. However, their archives are focused on the specified composer and player but ignored all other types of music. And they are not enough to be covered with the description of the deviation of duration and loudness of each note from score. Toyoda *et al.* have provided a performance expression deviation database which is aimed to describe those of individual note [6]. But their data format is limited to performances recorded by MIDI signals not audio signals. However, most of the analysis of classical Western music expression is determined by the researchers' acute musical sense; even less research has quantitatively analyzed music performance expression based on data [7, 8, 9, 10, 11]. One of the reasons for this absence of data is that this qualitative research has been based on the field methods of music performance education up until now.

MIDI files of performances are prolific on the Internet; however, very few of these are actually created by professional musicians, but rather by students and amateurs. Also, searching with the precise details on the performances is too difficult, although the information on each piece (e.g., the title, composer, genre, and the composition of the musical instruments) is rich.

A database, which describes outlines of changes in tempo, dynamics, the delicate control of each note, the deviation regarding starting time and duration to existing virtuoso performances in the form of acoustic signals as time-series data, can be used for new studies in the fields of music informatics, musicology and music education. To that end, we constructed a performance expression database, 'CrestMusePEDB,' that covers classical Western music, especially piano pieces performed by famous professionals.

2 CONSIDERATIONS IN THE DATABASE DESIGN

2.1 Ensuring the amount and quality of performances

A music database generally needs to contain high-quality performances. Goto *et al.* recorded performances by many professional musicians as part of their RWC music database [12]. Copyright restrictions pose difficulties for performance database creators. One method of avoiding such restrictions is to have the collectors record musical performances specifically for the database. Financially this is a onerous task and can compromise quality when extending a large database. For this problem, McEnnis *et al.* suggested an approach: collecting the parameters of audio features (covered in music information retrieval) in the real performances around the world and showing those reference information[3]. This approach is a rational way to avoid copyright problems and that the system can deal with raw data of the real world. We used the same approach.

2.2 Handling performance control data

The main information in a performance expression database pertains to instrument control. It has various kinds and levels of information. For keyboard instruments such as the piano, control data can be represented as the onset time, the offset time, the dynamics (velocity), and the depth of the damper pedal. The information on the instrument control deals with the feature quantity at the MIDI level. Describing them in a database requires having really useful information that can be extended in the future. Therefore, we constructed control information as XML-based data in CrestMusePEDB. We will extend and work out the details of these descriptions in accordance with the individual situations and technology.

Another problem which deals with music information is to identify the intensity of each note from acoustic signal. We especially need to be careful in describing the loudness of each note. To obtain the strict value of loudness of a note, we need to construct a sound model including the characteristics when recording the performance and architectural acoustic characteristics. However, getting that information from only the audio signal is quite difficult. Although some approaches using non-negative matrix factorization (NMF) are suggested, the problem has not been radically resolved yet in audio signal processing. In the view point of construction of a useful database, those information of the performance data should be collected as correctly by auditory as possible. Therefore, the velocity data is estimated approximately in CrestMusePEDB based on a specific digital audio source by well-trained experts using some support tools described in section 3.4.

2.3 Musical structure

A specific musical structure corresponds with a performance. CrestMusePEDB includes the data of the musical structures in an analysis of each performance, and it provides support to use the data in research on musicology, performance theories, and computational music systems.

The best solution is to interview a pianist and ask how his/her performance was achieved based on the musical structure. However, such an interview must be done immediately before and after the recording. The musical structure data should be collected by estimating the data from audio signals. Our approach involves interviewing as many players as possible to estimate the structures through discussion between a few musicologists and asking an expert pianist to play some performances with different musical structures. We aimed to get both the musical structure and the way it is expressed from the original recording

3 OVERVIEW OF CRESTMUSE PEDB

3.1 Music pieces

The focus of the database is on classical music from the Baroque period through the early twentieth century, including music by Bach, Mozart, Beethoven and Chopin. We chose around a hundred music pieces, including those referred to often by previous music studies in the past couple of decades. We also chose various existing performances by professional musicians; the database includes 3 to 10 performances for each musical score.

3.2 Contents of the database

The database consists of the following four kinds of component data. These kinds of data will sequentially be provided from SCR, DEV. The description of the database is based on XML files. CrestMusePEDB does not contain any acoustic signal data (WAV files, AIFF files, MP3 files.) except for PEDB-REC. Instead, it contains the catalogs of the performances from which expression data is extracted. The original audio sources can be purchased by the database users if necessary.

PEDB-SCR (score text information): The score data included in the database: files in MusicXML format and in SMF (standard MIDI file) format will be provided.

PEDB-IDX (audio performance credit): The catalogs of the performances from which expression data are extracted: album title, performer's name, song title, CD number, year of publication.

PEDB-DEV (performance deviation data): Tempo changes outline changes in dynamics, the delicate control of each note, deviation regarding starting time, duration, and dynamics extracted from expressive performances. Performances from 3 to 10 performers are analyzed a piece, and plural deviation data analyzed by different sound sources are provided a performance. Each data is described in Deviation-InstanceXML format (see below).

PEDB-STR (musical structure data): This contains the information on a musical structure data (hierarchical phrase structure and the top note of a phrase). The data is described in compliant MusicXML format. The structure data corresponds with a performance expression data in PEDB-DEV. But if plural adequate interpretations exist in a piece, the plural structure data is provided in the performance data.

PEDB-REC (original recordings): The audio performance data we will newly record based on PEDB-STR. The data will be useful to analyze performance expression from the view of music structure. It provides an audio signal and MIDI data that an expert pianist plays.

3.3 DeviationInstanceXML format

DeviationInstanceXML describes the deviation information from score information in a music performance as a subset of CrestMuseXML (CMX)[1] , which is the universal data format for music informatics. The latest version (0.32) deals with the control information of the piano playing, such as the onset time, offset time, and the velocity in MIDI of each note, tempo control, and damper pedal control. This control data is categorized into (1) common or multiple parts (non-partwise), (2) each part (partwise), and (3) each note (notewise) and is described as follows:

```
<deviation target="sample.xml" xmlns:
      xlink="http://www.w3.org/1999/xlink">
  <non-partwise>...</non-partwise> (1)
  <partwise>...</partwise> (2)
  <notewise>...</notewise> (3)
</deviation>
```

The details of this description are shown in the site, but here is the overview shown.

(1) <non-partwise> One of the common deviations of plural parts is tempo information. It is described as a combination of two XML tags: one is <tempo>, which describes the fundamental impression such as Andante and Allegro. It indicates the number of beats per minute (BPM). The other is <tempo-deviation>, which describes the micro tempo per beat; it is expressed as the ratio of the value of <tempo>.

(2) <partwise> The deviations of each part deal with the fundamental dynamics and damper pedal control into a <partwise> tag. The fundamental dynamics describe the global indication such as forte and piano. The pedal control is available to be described in the MusicXML format, but the control refers to the expression of the score and does not always correspond to the performance. The pedal description in DeviationInstanceXML handles the pedal control in an actual performance expression. Some people might think that the pedal control should be described as the common deviation of all the parts. For CrestMusePEDB, the pedal control is sufficient because the only instrument in all of the performances is the piano. However, the DeviationInstanceXML will be used to describe the control with plural instruments in the future. This issue is controversial, but here, the pedal control is described in <partwise>.

(3) <notewise> The deviation information of each note deals with the deviation of the onset time and offset time from the score and the deviation of individual dynamics (the velocity of each note key). The individual dynamics are for describing a micro-expression within a phrase to which the note belongs. The actual loudness of the note is computed by multiplying the individual dynamics by the fundamental dynamics at the score-time of the piece.

[1] http://www.crestmuse.jp/cmx/

3.4 Procedure for making DEV data

Transcribing an audio-signal performance into MIDI-level data is the core issue for constructing the CrestMusePEDB. Although we have improved the automation of the procedure, at present, an iterated listening process by plural experts with commercial audio editor and original alignment software possesses higher reliability. The data needs to be extracted from a recording as efficiently as possible. We now use an approach where four experts who have specialized in music including piano, composition and musicology manually identify the transcription/data in CrestMusePEDB using their ears and three support tools that we have implemented for the procedure.

Figure 1 illustrates the procedure for generating PEDB-DEV information.

Step 1: identify the attack time in the beat level of a piece while listening to the CD audio.

Step 2: estimate the approximation of the onset time, offset time, velocity of each note, and whether or not the damper pedal is used and whether or not it is fixed to the sound source.

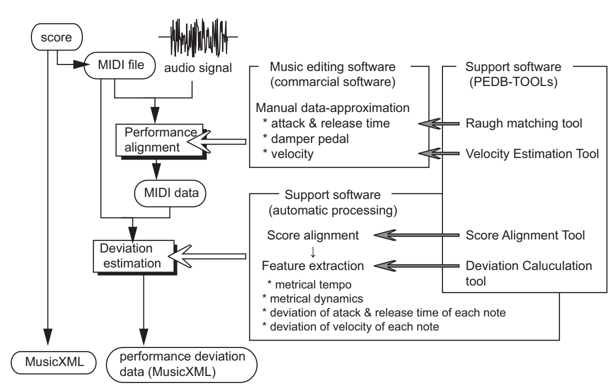

Figure 1. The procedure to make PEDB-DEV.

Step 3: refine the estimation with repeating step2 until a expert accepts and have it cross-checked by other experts. This step needs the most time of all the steps and takes at least five hours to a day a piece.

Step 4: match the expression data obtained through steps 1-3 with the normal expression data.

Step 5: calculate the time transition of tempi and dynamics, the deviation of the onset and offset time of each note, and the deviation of velocity from the fundamental dynamics (nominal expression) to the whole score.

The velocity estimation in step 2 and step 3 is necessary for resolving the problem with the loudness range when an audio signal differs because each audio CD was recorded using different musical instruments and in different environments. Here, we give priority to obtaining the value of the velocity for each note approximated to the listening data of the audio signal by experts who listen to the data of the audio signal. After justifying the range of the loudness for all of the audio signals, the experts repeat refining the approximated data with their headphones, which is always identical.

We have implemented three of support software to help with each step of the procedure.

Rough Matching Tool enables aligning the rough attack time of each note of a score corresponding with audio spectrogram, using Dynamic Programming.

Velocity Estimation Tool enables estimating the velocity of each note based on the original audio signal, the onset time of each note (which is roughly identified by the above tool), and an audio source for the sound of the MIDI data.

Score Alignment and Deviation Calculation Tool supports two procedures to extract the deviation information. The first one identifies all the notes of the score as those of the expressed performance. The second one calculates the deviation information (the onset time, the offset time, and the velocity) for each note. The deviation information is described in the DeviationInstanceXML format.

The rough matching tool and the velocity estimation tool do not have to function at a very high accuracy in order to be beneficial. The skill of experts is arguably higher than that of current systems. The former tool is used for step 1, and the latter is used when deciding the initial parameters in step 2. Meanwhile, the score alignment and deviation calculation tool seldom make errors. We determined the result data using these tools in step 4 and step 5. We will make these tools public so that a community of CrestMusePEDB users will grow.

3.5 Subset tools

The data description in the XML format has scalability and data integrity. Meanwhile, it is not so useful for researchers except for those in computer science. Therefore, we provide the following sub-tools for CrestMusePEDB so that it can be effectively utilized.

CrestMusePEDB player: a music player that inputs SCR and DEV data, then generates expressed performance data through the indicated audio source.

CrestMusePEDB time-line viewer: a deviation visualizer that inputs SCR and DEV data then shows each note and the data described in the DEV data to a piano-roll display.

CSV (Comma Separated Values) Converter: a plugin tool for the CrestMusePEDB time-line viewer that outputs selected deviation information in the CSV format.

4 PUBLISHING OF CRESTMUSE PEDB

CrestMusePEDB has been available since November 2007. The version 1.0 and 2.0 have been released on the Internet[2] and there are totally 60 performances included. Table 1 and 2 shows the list of the music pieces included in the database, and Table 3 shows a player list and a sound source corresponding with each piece.

Each DEV data is given a unique number (PerfID) and an identification ID to discriminate itself along with a form. Identification ID is given by the combination of ScoreID and DevID. For example, the database has three perfomance DEV data (Gould, Nakamura and Shimizu) of the 1st movement of Mozart's Piano Sonata K. 331. The IDs of the Gould's performance are described as "PEDB-DEV No. 22 (snt331-1-003-b)". The alphabet at the last of DevID means a sound source used for extracting deviation data from audio source; 'a' is B osendolfer PIANO/GIGA by Crypton Future Media Inc., 'b' is GPO-Concert-Steinway-ver2.sf2 (a free source from SF2midi.com) and 'c' is Yamaha's MOTIF XS. The performances using 'c' will be provided at the future version.

We have been preparing a listening contest for music performance rendering systems (Rencon) as part of another research project (`http://www.renconmusic.org/`). In the summer of 2008, the database is provided to the Rencon competition as the standard learning set for autonomous performance rendering systems that generate expressive performance. We have been already providing some sample data on CrestMusePEDB to researchers who plan to enter the Rencon contest.

5 DISCUSSION

5.1 Applied research area

CrestMusePEDB can be used in various research areas such as musicology and music education, not only MIR fields. Next, we describe some cases for application.

Musicology In musicology, many analyses of expressive performance style examine the presence of *legato*/*non-legato* phrasing [13]. Many of them depend on a subjective verdict by an analyst. As well as these verdicts, we suppose that the

[2] `http://www.crestmuse.jp/pedb/`

Table 1. CrestMusePEDB ver. 1.0 Performance Data (No. 1-39)

Composer (ComposerID) (amount of performances)						
	PerfID	ScoreID	Title			
			Player	DevID	CD index	Track.
J. S. Bach (1) (21 performances)						
	No. 1〜2	inv001	Invention No. 1 BWV 772			
			A. Schiff	001-a/b	POCL-5099	Tr.01
	No. 3	inv002	Invention No. 2 BWV 773			
			A. Schiff	001-b	POCL-5099	Tr.02
	No. 4	inv008	Invention No. 8 BWV 779			
			A. Schiff	001-b	POCL-5099	Tr.08
	No. 5	inv015	Invention No.15 BWV 786			
			A. Schiff	001-b	POCL-5099	Tr.15
	No. 6-11	wtc101-p	Das Wohltemperierte Klavier Vol. No.1 BWV 846 Prelude			
			S. Richter	002-a/b	BVCC-37139	Tr.01
			G. Gould	003-a/b	SRCR9496	Tr.02
			F. Gulda	004-a/b	416-113-2	Tr.01
	No. 12	wtc107-p	Das Wohltemperierte Klavier Vol. I No. 7 BWV 852 Prelude			
			S. Richter	002-b	BVCC-37139	Tr.13
	No. 13	wtc107-f	Das Wohltemperierte Klavier Vol. I No. 7 BWV 852 Fuga			
			S. Richter	002-b	BVCC-37139	Tr.14
	No. 14	wtc113-p	Das Wohltemperierte Klavier Vol. I No.13 BWV 858 Prelude			
			S. Richter	002-b	BVCC-37139	Tr.01
	No. 15	wtc113-f	Das Wohltemperierte Klavier Vol. I No.13 BWV 858 Fuga			
			S. Richter	002-b	BVCC-37140	Tr.02
	No. 16	wtc123-p	Das Wohltemperierte Klavier Vol. I No.23 BWV 868 Prelude			
			S. Richter	002-b	BVCC-37140	Tr.21
	No. 17	wtc123-f	Das Wohltemperierte Klavier Vol. I No.23 BWV 868 Fuga			
			S. Richter	002-b	BVCC-37140	Tr.22
	No. 18	wtc202-p	Das Wohltemperierte Klavier Vol. II No. 2 BWV 871 Prelude			
			S. Richter	002-b	BVCC-37141	Tr.03
	No. 19	wtc202-f	Das Wohltemperierte Klavier Vol. II No. 2 BWV 871 Fuga			
			S. Richter	002-b	BVCC-37141	Tr.04
	No. 20	wtc219-p	Das Wohltemperierte Klavier Vol. II No.19 BWV 888 Prelude			
			S. Richter	002-b	BVCC-37142	Tr.11
	No. 21	wtc219-f	Das Wohltemperierte Klavier Vol. II No.19 BWV 888 Fuga			
			S. Richter	002-b	BVCC-37142	Tr.12
W. A. Mozart (02) (8 performances)						
	No. 22-24	snt011-1	Piano Sonata No.11, K. 331, 1st Mov.			
			G. Gould	003-b	SRCR-9669	Tr.01
			H. Nakamura	005-b	AVCL-25130	Tr.07
			N. Shimizu	006-b	RWC-MDB-C-2001-M05	Tr.01
	No. 25	snt011-2	Piano Sonata No.11, K. 331, 2nd Mov.			
			H. Nakamura	005-b	AVCL-25130	Tr.08
	No. 26	snt011-3	Piano Sonata No.11, K. 331, 3rd Mov.			
			H. Nakamura	005-b	AVCL-25130	Tr.09
	No. 27	snt016-1	Piano Sonata No.16, K. 545, 1st Mov.			
			G. Gould	003-b	UCCG-5029	Tr.10
	No. 28	snt016-2	Piano Sonata No.16, K. 545, 2nd Mov.			
			G. Gould	003-b	UCCG-5029	Tr.11
	No. 29	snt016-3	Piano Sonata No.16, K. 545, 3rd Mov.			
			G. Gould	003-b	UCCG-5029	Tr.12
L. V. Beethoven (03) (5 performances)						
	No. 30	snt008-1	Piano Sonata No. 8, Op. 13, 1st Mov.			
			V. Ashkenazy	007-a	POCL-5005	Tr.07
	No. 31	snt014-2	Piano Sonata No.14, Op. 27-2, 2nd Mov.			
			B. Brendel	008-b	PHCP-21023	Tr.08
F. Chopin (04) (7 performances)						
	No. 32	pld001	Prelude Op. 28, No. 1			
			V. Ashkenazy	007-b	POCL-5064	Tr.01
	No. 33〜34	pld004	Prelude Op. 28, No. 4			
			V. Ashkenazy	007-b	POCL-5064	Tr.04
			M. Argerich	009-b	UCCG-5024	Tr.04
	No. 35	pld007	Prelude Op. 28, No. 7			
			V. Ashkenazy	007-b	POCL-5064	Tr.07
	No. 36	pld015	Prelude Op. 28, No. 15			
			V. Ashkenazy	007-b	POCL-5064	Tr.15
	No. 37	pld020	Prelude Op. 28, No. 20			
			V. Ashkenazy	007-b	POCL-5064	Tr.20
	No. 38	wlz007	Waltz Op. 64-2, No. 7			
			V. Ashkenazy	007-b	POCL-5024	Tr.07
R. Schuman (05) (1 performances)						
	No. 39	kdz007	Kinderszenen Op. 15, No. 7 "Träumerei"			
			V. Ashkenazy	007-b	POCL-5106	Tr.07

Table 2. CrestMusePEDB ver. 2.0 Performance Data (No. 40-60)

Composer (ComposerID) (amount of performances)						
	PerfID	ScoreID	Title			
W. A. Mozart (02) (6 performances)						
	No. 40〜42	snt011-1	Piano Sonata No. 11, K. 331, 1st Mov.			
			C. Eschenbach	010-a	UCCG-5029	Tr.07
			I. Haebler	011-a	COCQ-83691	Tr.07
			L. Kraus	012-a	SICC-487	Tr.04
	No. 43	snt001-1	Piano Sonata No. 1, K. 279, 1st Mov.			
			G. Gould	003-a	SRCR-9667	Tr.01
	No. 44	snt001-2	Piano Sonata No. 1, K. 279, 2nd Mov.			
			G. Gould	003-a	SRCR-9667	Tr.02
	No. 45	snt001-3	Piano Sonata No. 1, K. 279, 3rd Mov.			
			G. Gould	003-a	SRCR-9667	Tr.03
L. V. Beethoven (03) (6 performances)						
	No. 46	snt008-2	Piano Sonata No. 8, Op. 13, 2nd Mov.			
			V. Ashkenazy	007-a	POCL-5005	Tr.08
	No. 47	snt008-3	Piano Sonata No. 8, Op. 13, 3rd Mov.			
			V. Ashkenazy	007-a	POCL-5005	Tr.09
	No. 48	snt014-1	Piano Sonata No. 14, Op. 27-2, 1st Mov.			
			B. Brendel	008-a	438-862-2	Tr.09
	No. 49	snt014-2	Piano Sonata No. 14, Op. 27-2, 2nd Mov.			
			B. Brendel	008-b	438-862-2	Tr.10
	No. 50	snt014-3	Piano Sonata No. 14, Op. 27-2, 3rd Mov.			
			B. Brendel	008-a	438-862-2	Tr.11
	No. 51	snt017-1	Piano Sonata No. 17, Op. 31-2, 1st Mov.			
			M. Pollini	013-a	UCCG-7069	Tr.02
F. Chopin (04) (9 performances)						
	No. 52	wlz001	Waltz Op. 18, No. 1			
			V. Ashkenazy	007-a	POCL-5024	Tr.01
	No. 53	wlz003	Waltz Op. 34-2, No. 3			
			V. Ashkenazy	007-a	POCL-5024	Tr.03
	No. 54	wlz009	Waltz Op. 69-1, No. 9			
			V. Ashkenazy	007-a	POCL-5024	Tr.09
	No. 55	wlz010	Waltz Op. 69-2, No. 10			
			V. Ashkenazy	007-a	POCL-5024	Tr.10
	No. 56	etd003	Etude Op. 10, No. 3			
			V. Ashkenazy	007-a	POCL-5046	Tr.03
	No. 57	etd004	Etude Op. 10, No. 4			
			V. Ashkenazy	007-a	POCL-5046	Tr.04
	No. 58	etd023	Etude Op. 25-11, No. 23			
			V. Ashkenazy	007-a	POCL-5046	Tr.23
	No. 59	nct002	Nocturne Op. 9-2, No. 2			
			V. Ashkenazy	007-a	POCL-3880	Tr.02
	No. 60	nct010	Nocturne Op. 32-2, No. 10			
			V. Ashkenazy	007-a	POCL-3880	Tr.10

Table 3. Players' list included in ver. 1.0 and 2.0.

No.	Player's name	Included performances
001	Andras Schiff	5
002	Sviatoslav Richter	12
003	Glenn Gould	9
004	Friedrich Gulda	2
005	Hiroko Nakamura	3
006	Norio Shimizu	1
007	Vladimir Ashkenazy	19
008	Alfred Brendel	4
009	Martha Argerich	1
010	Christoph Eschenbach	1
011	Ingrid Haebler	1
012	Lili Kraus	1
013	Maurizio Pollini	1

analysts can work more objectively by referring to qualified performance expression data.

Music pedagogy in performance expression To quantify the information on performance expression clarifies its features and enables showing us the features objectively. CrestMusePEDB can be applied to a music-learning system in music education and at rehearsal sessions for players.

Supporting the performance expression design CrestMusePEDB will contain performance expression data of over 100 pieces of music. The database will likely be used as a data set for learning expressive performances in a rendering system and for referenced performances in a case-based music system. CrestMusePEDB will contain not only performance expression data but also musical structure information. Research on performance rendering and music analysis progress can be conducted by utilizing both the performance expression data and the musical structure information.

5.2 Future works

Handling damper pedal It can be impossibly difficult to extract detailed damper pedaling information, including

Table 4. A part of music pieces the future versions will include.

Composer	Titles
J. S. Bach	Sinfonia No. 3, 5, 8, 11
W. A. Mozart	Sonata No.8, K. 310
L. v. Beethoven	Sonata No. 9, 17, 19, 20, 23
F. Chopin	Mazurkas No. 5, 7, 13, 19, 23, 38
	Polonaise No. 3, 6
J. Brahms	Rhapsody Op. 79, No. 1, 2
	Rhapsody Op. 119-4
R. Schumann	Kinderszenen Op. 13, No. 1
F. Schubert	Moment Musicaux Op. 97, No. 3, 4
G. Fauré	Barcarolle No. 4, 6, 8, 12
C. Debussey	Suite Bergamasque (all)
	Deux arabesques (both)
	Préludes 1er livre VIII 'La fille aux cheveux de lin'
	Préludes1er livre X 'La cathédrale engloutie'
	Préludes2e livre X 'Canope'
	Children's Corner No. 1
E. Granados	12 danzas españolas Op. 37-5
I. Albéniz	Cantos de España Op. 232
S. Rakhmaninov	Prelude Op. 3-2
E. Satie	Trois Gymnopédies No. 1
G. Gershwin	Three Preludes No. 1
S. Prokofiev	Sonata No. 7 (1st & 3rd mov.)
	The Love for Three Oranges, 'March'
M. Ravel	Sonatine (1st mov.)
	Le Tombeau de Couperin I. Prelude

half pedaling, from audio signals. At present, we simply estimate the position as being possible if the player changes his pedaling, depending on the resonance in the audio signal and the pianist's experience for the performance method. Extracting and describing the information of pedal control should be discussed more in the future.

Handling audio (sound) sources In CrestMusePEDB, the velocity data is estimated approximately based on a certain digital audio source. In the future, we should construct an acoustic model of the physical characteristics of the piano and architectural acoustic characteristics. The database should include these description.

Formation of a research community The most meaningful purpose of constructing an open database is to enable a lot of research to be conducted using the database and for the global research area to be developed. At present, CrestMusePEDB mainly consists of the members of the CrestMuse Project. We are preparing some useful tools for writing down musical notation. We intend to create a far-reaching community for CrestMusePEDB.

6 CONCLUSION

We introduced CrestMusePEDB containing a description of the deviation of performance expression by many world virtuosos. This database is available to researchers around the world free of charge through the Internet after the submission procedure is completed. Information on obtaining the database is described at `http://www.crestmuse.jp/pedb/`. We believe that it can be useful for research in, but not limited to, music information retrieval, music appreciation, music structure analysis, music expression analysis, musical instrument analysis/identification, performance rendering systems, and music-related visualization. With this database, researchers can now use virtuosos' performances for each stage of finding problems, obtaining solutions, implementing these solutions, and for conducting evaluations and presentations.

In the future, more expressive performances and various meta-data (descriptions of contents) will need to be added to the database pieces through cooperation with several music databases on the Internet. Also, we are preparing some tools to facilitate using the database such as a data viewer and extracting the deviation data from audio signals so that world-wide users can add data to the database. Our goal for our database is for it to be widely used worldwide and to accelerate progress in this field of research.

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