



AN ALGORITHM TO EVALUATE THE APPROPRIATENESS FOR PLAYING SCALES ON THE PIANO

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ABSTRACT

This study aims at realizing automatic evaluation of appropriateness on playing scales within one octave using a MIDI piano, and it also aims at designing a support system for practicing the piano which can point out defects of the user in his/her playing scales. Records of playing scales together with corresponding subjective scores are collected using five experts of piano in order to construct the evaluation criteria. Performances using a MIDI piano were recorded on a MIDI sequencer. Onset intervals, velocities, and durations for each note are obtained and a set of three (IOI, velocities and durations) regression curves for each performance are obtained by using the spline interpolation, using the average value of each parameter calculated for each wrist position on the keyboard. The subjective scores obtained are employed as both test data or training data in turn to achieve open tests. KL expansion and k -NN algorithm are tried to be used to predict subjective scores of new scale-performance data. It is confirmed that outputs by the proposed system are relatively similar to subjective evaluation scores and the appropriateness of values for description parameters is discussed.

INTRODUCTION

There are a lot of junior colleges for educating young children of about a couple of years old in Japan. Piano performance is one of the main subjects for them to learn, so as to accompany singing children with the piano. Students majoring it are usually required to master playing the piano as the level as to play several simple excerpts of piano without difficulties. Students majoring education for young children have a variety of experiences of playing the piano, some of them are skilful as the same level of students majoring playing the piano at musical colleges, whereas others have almost no experiences of playing the piano. One of the serious problems for students and/or teachers is that it is hard for students without the ability of playing the piano to master it within a couple of years. So, kind of a support system which can assist their lessons of piano is desirable. In this study a support system for mastering playing the piano is proposed to help the beginners, and a subsystem of the proposed system which evaluates appropriateness of playing the piano at a basic level is tried to construct. In this study, scale performances for 12 major keys are focused on as objectives for beginners to study.

Several systems for supporting playing the piano have been developed[1,2], and we proposed a prototype system for beginners of piano as a basic stage combined with a procedure of learning[3]. These systems are designed as an expert system, on which users can learn the piano performance interacting with computer systems. These systems, however, deal with only the performance situations, such as missing note, performance errors, and so forth. So, except for Jabusch's study[4], there are few studies of evaluating the appropriateness of piano performances objectively. So, this study aims at realizing a automatic evaluation system for simple piano performance (a scale performance within one octave). A support system for practicing playing the piano is proposed to help beginners of piano, and a subsystem of the proposed system which evaluates appropriateness of playing the piano at a basic level is tried to construct. Performances of major scales for 12 keys within one octave are assumed as an important task for beginners in this study. It has been known that it is not necessary for piano players to play mechanically on realizing a good performance from a musical viewpoint. Scale performances by experts using MIDI piano sometimes show some deviations from the exact performance as well as those by novice players. The criteria of evaluating the performance are

not easy but complex. Though past researches have trying to evaluate automatically the scale performances, discussing the difficulties of evaluating appropriateness of scale performance for recorded MIDI data is thought to be useful.

DIFFICULTIES OF EVALUATION FROM RECORDED MIDI DATA

Appropriateness for scale performance is thought to be complex. Figure 1 shows an example of musical score for scale performance of C-Major within one octave. On playing the scale synchronizing a click sound generated by a metronome, players should play the scale correctly on timing, volume, and duration for each note. In this task an ideal performance is assumed to be a perfect performance. The features of ideal performance are:

- timing is exactly same time to metronome,
- volume for each note are common to all notes, and
- duration of each note are same of all notes and equal to the eighth note.

But, we found in a preliminary study that it is not necessary to be exact to realize a good performance. We recorded scale performance by experts using MIDI piano and found that recorded data by experts shows some deviations from the exact performance as well as those by novice players. So discussions for the difficulties of evaluating appropriateness of scale performance from recorded MIDI data should be conducted.



Figure 1.- An example of musical score for scale performance within one octave

PROPOSED METHOD

Outline

Here explains proposed method for evaluating appropriateness of scale performance using piano. When a scale performance is recorded using MIDI piano and a MIDI sequencer, onset time, velocity and duration for each note are obtained. Using these obtained data, a set of three regression curves for each performance is calculated by using spline interpolation for the average value of each data calculated for each wrist position on the keyboard. The graph in Fig.2 shows recorded data of a scale performance where a beginner plays the one octave scale at 120bpm, where ordinate represents deviation from ideal onset time and abscissa represents time. Dotted line represents a regression curve calculated by spline interpolation. It is assumed that characteristics of scale performances are squeezed up in the obtained curve so you can extract some features concerning subjective evaluation of it from this regression curve.

Description of recorded data

Recorded data of scale performance using MIDI piano is represented as follows;

$$v_{ij} = [v_{ij1}, v_{ij2}, \dots, v_{ijn}]^t \quad (1)$$

$$t_{ij} = [t_{ij1}, t_{ij2}, \dots, t_{ijn}]^t \quad (2)$$

$$d_{ij} = [d_{ij1}, d_{ij2}, \dots, d_{ijn}]^t \quad (3)$$

$$i = 0(\text{left hand}) \text{ or } 1(\text{right hand}) \quad (4)$$

$$1 \leq j \leq J \quad (5)$$

$$1 \leq k \leq K \quad (6)$$

where t_{ij} represents a vector of onset time on playing a scale performance (degree of the key is j) using hand i , v_{ij} represents a vector of MIDI velocity, d_{ij} represents a vector of duration, i represents left or right hand, j represents degree of the key from C, and k represent ID of scale performance. In this study, the maximum of j is represented as J (12, in this paper) and that of k is K (15, in this paper). The unit of velocity is same as the MIDI velocity (from 0 to 127). The variable n represents number of played notes on a scale performance (15, in this paper). t_{ij} , v_{ij} , and d_{ij} are also represented as follows;

$$t_{ijk} = m_k + t'_{ijk} \quad (\text{msec}) \quad (7)$$

$$m_1=0 \quad (\text{msec}) \quad (8)$$

$$m_k=m_{k-1}+250 \quad (\text{msec}) \quad (9)$$

$$v_{ijk} = \bar{v}_i + v'_{ijk} \quad (10)$$

$$\bar{v}_i = \frac{1}{JK} \sum_j \sum_k v_{ijk} \quad (11)$$

$$d_{ijk} = l + d'_{ijk} \quad (12)$$

$$l=250 \quad (\text{msec}) \quad (13)$$

where m_k represents an ideal onset time generated by a metronome, \bar{v}_i represents an average velocity on playing hand i , and l represents length of ideal duration (250msec in this paper). t'_{ijk} represents a deviation from an ideal onset time, v'_{ijk} represents a deviation from average velocity, and d'_{ijk} represents a deviation from ideal duration. Regression curves for t'_{ij} , v'_{ij} and d'_{ij} is obtained by spline interpolation and represented as \hat{t}'_{ij} , \hat{v}'_{ij} , and \hat{d}'_{ij} ;

$$t'_{ij} = \hat{t}'_{ij} + t''_{ij} \quad (t'_{ijk} = \hat{t}'_{ijk} + t''_{ijk}) \quad (14)$$

$$v'_{ij} = \hat{v}'_{ij} + v''_{ij} \quad (v'_{ijk} = \hat{v}'_{ijk} + v''_{ijk}) \quad (15)$$

$$d'_{ij} = \hat{d}'_{ij} + d''_{ij} \quad (d'_{ijk} = \hat{d}'_{ijk} + d''_{ijk}) \quad (16)$$

Four features

Four features for obtained regression curves are defined as follows:

A parameter p_1 is defined as a sum of differences between a deviation value and corresponding regression value for each note, shown as;

$$p_1 = \sum_{k=1}^n x''_{ijk}{}^2, \quad x = t, v, \text{ or } d. \quad (17)$$

A parameter p_2 is defined as difference between maximum and minimum for x , shown as

$$p_2 = x'_{ijk_1} - x'_{ijk_2}, \quad x'_{ijk_1} = \max_k(\hat{x}'_{ijk}), \quad x'_{ijk_2} = \min_k(\hat{x}'_{ijk}) \quad (18)$$

A parameter p_3 is defined as a sum of squares between \hat{x}'_{ijk} and \hat{x}'_{ijk-1} , shown as

$$p_3 = \sum_{k=2}^n (\hat{x}'_{ijk} - \hat{x}'_{ijk-1})^2 \quad (19)$$

A parameter p_4 is defined as averages of \hat{x}'_{ijk} , such as

$$p_4 = \frac{1}{n} \sum_{k=1}^n \hat{x}'_{ijk} \quad (20)$$

Figure 1 shows methods of obtaining four parameters from a recorded MIDI data for a scale performance concerning onset timing.

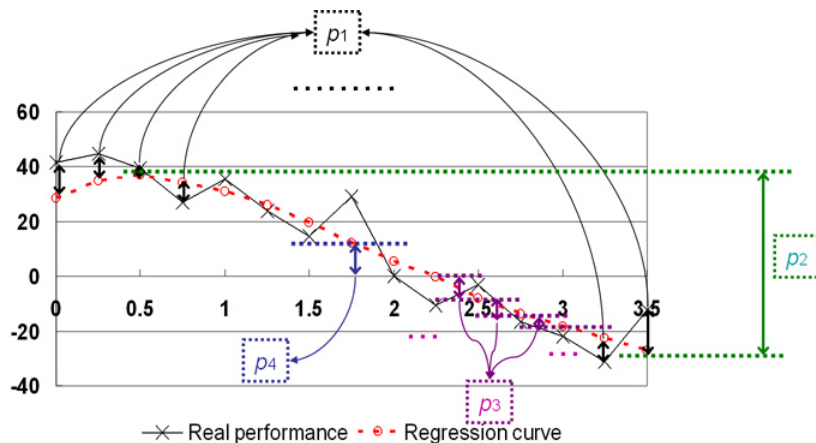


Figure 2.- Method of obtaining four parameters for onset time.

EVALUATION EXPERIMENT

Fourteen students (from S1 to S14) majoring education for young children participated in this test. They are asked to play scale performances for twelve key using left or right hand. All performances are recorded using MIDI piano (YAMAHA C3) and a PC-based MIDI sequencer (Steinberg, Cubase SX). Five experts of education for young children participated in this test. They are asked to evaluate recorded scale performances by scoring from one (as bad) to seven (as good)

The k -NN algorithm is employed for predicting the evaluation scores by an expert. Each principle component extracted by the principle component analysis represents an axis of fourth order space. In case a new data is put in this space, a predicted score will be calculated by referring other samples of nearest neighbourhoods. It is found that the average of the results of correlations to scores by an expert is 0.502. So, it is confirmed that in this study performance of k -NN algorithm is somewhat same level as those among experts(0.55-0.75).

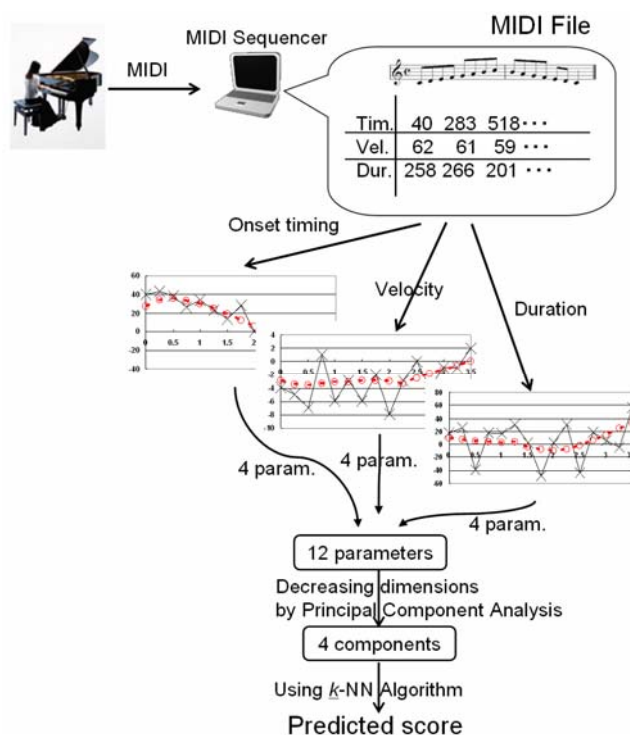


Figure 3.- Overview of automatic analysis for appropriateness of scale performance

Conclusions

Proposed here is a method for evaluating appropriateness of a simple style of scale performance based on regression curve of deviations by spline interpolation. Future work is to improve this scheme so as to predict better than this scheme and to implement this scheme so that a subsystem of self-learning system of playing the piano will be realized.

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