# Feature exaggeration in scale performance on the piano

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This paper proposes a set of parameters for describing features of scale-playing on the piano. The parameter set consists of 15 parameters, among which 12 are three sets of four parameters $p_{i1}$ through $p_{i4}$ where $i =\{$t, v, d$\}$ distinguishes three basic features; onset time, velocity, and duration. Each of these basic features is modeled as the sum of a global curve and the deviation from it, where the spline interpolation is employed using locally averaged points, or representative points, as the points to be passed. The local average is calculated for each sequence of notes played without finger crossing. The suffix $j$ in $p_{ij}$ distinguishes the standard deviations ($j=0$), the rms deviation from the spline curve ($j=1$), the range of the curve ($j=2$), the rms difference between successive notes ($j=3$), and the rms of the spline curve from the metronomic line ($j=4$). All parameters are made controllable with slider bars from 0% to 200% for synthesizing suppressed performance or exaggerated performance, where 100% represents the original performance. Proposed parameter set is expected to be useful in self-training of piano, as it can indicate the features and undesirable habits of the player by setting values above 100% in exaggerated form.

# 1    Introduction

Recently, piano has been one of the popular musical instruments. Almost all the experts on playing the piano have been practicing the piano from early childhood. In recent years, low price commercially-sold pianos such as a MIDI keyboard has been available among people, so they can easily obtain an environment of practicing the piano. However, some people cannot obtain instructions by experts for several reasons, so most of them often give up practicing the piano. Examples of the reasons are: they cannot obtain neither instructions nor objective evaluations by experts for his/her performance. Moreover, they cannot design their practice schedule of playing the piano by themselves. In order to improve such situation, many systems for supporting pianists and/or beginners have been developed [1-3]. However, even though these systems record and employ much data of his/her performance, these systems cannot appropriately evaluate a performance in terms of artistic aspects. In order to improve this issue, we have been proposed a method of an automatic evaluation of the skill level and the appropriateness for scale performance within one octave [4].

# 2    Background

In our previous study, an evaluation method by using "onset time", "velocity", and "duration" in the MIDI representation was proposed for scale-performance on the piano [4], where several parameters to analyze the given performance were introduced. The proposed parameter was concerning tendencies of given performance using the three basic features. A set of parameter consists of 15 parameters, among which 12 are three sets of four parameters. In our previous study, actual performance is modeled as sum of a global curve and the deviation from it, where the spline interpolation is employed using locally averaged points, or representative points, as the points to be passed. An automatic evaluation of the skill level and the appropriateness for a scale performance on the piano is examined by using these 15 parameters. The musical score shown in Fig.1 represents a task of scale performance and numbers below each note represents fingerings for right hand.



Fig.1 An example of musical score for scale performance within one octave (key of C Major)

# 3    Outline of this paper

This paper aims at exaggerating a feature for scale playing on the piano with the performance parameters modified from the originals or extracted from the input performance. A feature of a performance is exaggerated by controlling each parameter continuously which is proposed in previous paper. Concretely, the difference between calculated global curve and the performance is controlled by controlling the performance parameters. A feature of performance is exaggerated as a manner of morphing techniques. Proposed in this paper is a system that synthesizes from "suppressed" to "exaggerated" performance by manipulating slider bar on the screen. Therefore, proposed system can be expected to support practice in the piano from a beginner to expert, because players are able to easily find own feature and own weak point.

# 4    Method

## 4.1    Details of each parameter

A simulated performance is generated by controlling 12 parameters which distinguishes three basic features; onset time, velocity, and duration. Those parameters are defined as $p_{ij}$. The suffix $i$ in $p_{ij}$ distinguishes onset time ($i=$t), velocity ($i=$v), and duration ($i=$d). The suffix $j$ in $p_{ij}$ distinguishes the standard deviations ($j=0$), the rms deviation from the spline curve ($j=1$), the range of the curve ($j=2$), the rms difference between successive notes ($j=3$), and the rms of the spline curve from the metronomic line ($j=4$). Details of the parameter used to generate a simulated performance about onset time are shown in Fig.2 and below, where $t$ means ideal onset time, $t'$ means onset time, $\hat{t}'$ means parameter of spline curve, and $t''$ means difference between actual performance and the spline curve.

$$t'' = t' - \hat{t}'$$                    (1)

1. A parameter $p_{t1}$ is defined as the rms deviation from the spline curve, shown as;

$$p_{t1} = \frac{1}{n}\sum_{k=1}^{n}|t_k''| \qquad (2)$$

2. A parameter $p_{t2}$ is defined as the range of the spline curve, shown as;

$$p_{t2} = \max(\hat{t}') - \min(\hat{t}') \qquad (3)$$

3. A parameter $p_{t3}$ is defined as the rms difference between successive notes, shown as;

$$p_{t3} = \frac{1}{n-1}\sum_{k=2}^{n}\sqrt{(\hat{t}_k' - \hat{t}_{k-1}')^2} \qquad (4)$$

4. A parameter $p_{t4}$ is defined as the rms of the spline curve from the metronomic line, shown as;

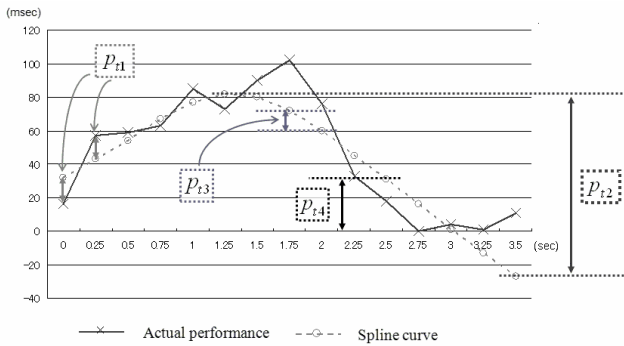$$p_{t4} = \frac{1}{n}\sum_{k=1}^{n}\hat{t}_k' \qquad (5)$$



Fig.2 The parameters for onset time

## 4.2 Controlling $p_{t1}$

A parameter $p_{t1}$ is defined as the rms deviation from the spline curve. Therefore, $p_{t1}$ is controlled by manipulating the difference between the spline curve and the recorded performance of each note. A parameter $\tilde{t}$ is defined as controlled parameter of onset time. A parameter $C_{t1}$ represents a rate for changing $p_{ij}$ ($0 \le C_{t1} \le 2$).

$$\tilde{t} = \hat{t}' + C_{t1}(t' - \hat{t}') \qquad (6)$$

## 4.3 Controlling $p_{t2}$

A parameter $p_{t2}$ is defined as the range of the spline curve. Therefore, $p_{t2}$ is controlled by manipulating the middle of the range which calculated in the spline curve. $M$ is the middle of the range in spline curve. A parameter $C_{t2}$ represents a rate for changing $p_{ij}$ ($0 \le C_{t2} \le 2$).

$$M = \frac{\max(\hat{t}') + \min(\hat{t}')}{2} \qquad (7)$$

$$\tilde{t} = \begin{cases} M + C_{t2}(\hat{t}' - M) & (\hat{t}' > M) \\ M - C_{t2}(M - \hat{t}') & (\hat{t}' < M) \end{cases} \qquad (8)$$

## 4.4 Controlling $p_{t3}$

A parameter $p_{t3}$ is defined as the rms difference between successive notes. Therefore, $p_{t3}$ is controlled by manipulating the difference between the spline curve and a standard straight line. The straight line employed passes max and min. A simply increasing straight line is defined as $S_U$ and that for decreasing is defined as $S_L$. The straight line in which the sum of the difference between the spline curve is assumed as the standard, which means 0% (see (9), (10), and Fig.3). In Fig.3, the standard straight line assumed here is $S_L$. A parameter $C_{t3}$ represents a rate for changing $p_{ij}$ ($0 \le C_{t3} \le 2$).

$$S_U = (\max(\hat{t}') - \min(\hat{t}'))/k(n-1) + \min(\hat{t}') \qquad (9)$$

$$S_L = (\min(\hat{t}') - \max(\hat{t}'))/k(n-1) + \max(\hat{t}') \qquad (10)$$

$$\tilde{t} = \begin{cases} \hat{t}' + C_{t3}(S_L - \hat{t}') & (\sum|S_U - \hat{t}'| < \sum|S_L - \hat{t}'|) \\ \hat{t}' + C_{t3}(S_U - \hat{t}') & (\sum|S_U - \hat{t}'| > \sum|S_L - \hat{t}'|) \end{cases} \qquad (11)$$
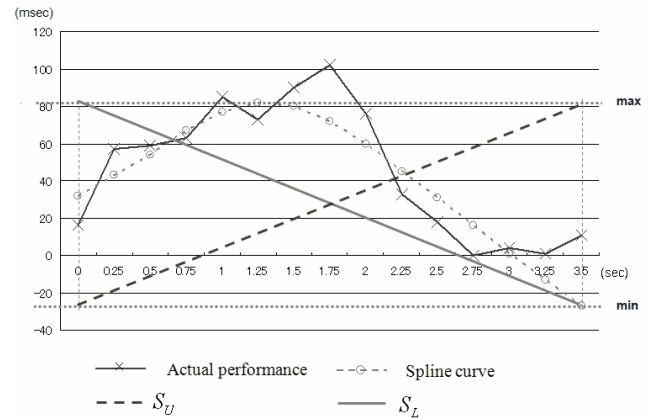


Fig.3 A standard straight line

## 4.5 Controlling $p_{t4}$

A parameter $p_{t4}$ is defined as the rms of the spline curve from the metronomic line. Therefore, $p_{t4}$ is controlled by manipulating average of the difference between the spline curve and the metronomic line. A parameter $C_{t4}$ represents a rate for changing $p_{ij}$ ($0 \le C_{t4} \le 2$).

$$\tilde{t} = \frac{C_{t4}}{n}\sum \hat{t}' \qquad (12)$$

## 5 Proposed system

An overview of a proposed system is shown in Fig.4. Proposed system analyzes performances recorded as MIDI data, and gives parameter for onset time, velocity, and duration, therefore 15 parameters are calculated. Users can control his/her performance by changing the calculated parameter by manipulating corresponding slider bar. The proposed system generates a simulated performance based on the changed parameter controlled by the user, and

presents it to the user. Therefore, the player can listen to the exaggerated performance, and can easily find his/her feature and/or weak points. An example of screen capture of the proposed system is shown in Fig.5 and Fig.6. Proposed system has two window, main window and slider bar window. In Fig.5, main window has several facilities such as virtual metronome, recording MIDI data, automatic evaluation for a performance, and producing simulated performance. In Fig.6, slider bar window realizes a facility of controlling the 12 parameters. The range of slider bar that can be operated is from 0 to 200%, where 100% represents the original performance. In case a rate of each slider bar is defined as $C_{ij}$, Table 1 shows the initialization of each slider bar. The use of the proposed system is as follows;.

1. The user clicks "start" button in the main window. Therefore, the visual metronome starts.

2. The user plays the piano according to metronome. In case the user finished playing, the system automatically analyses the recorded performance information, and calculates values of parameters.

3. The player can control the amount of the value for each parameter by manipulating slider bars in the slider bar window.

4. After manipulating the slider bars, the player should click the "simulate" button in the main window. Then, simulated performance is generated.

5. The player can listen to simulated performance by clicking the "play" button.

A proposed system can visually present the player the result of exaggerating the feature. Therefore, the player is able not only to listen to the performance to simulated performance but also to visually confirm weak points of him/herself.

| $j$ \ $i$ | t | v | d |
|---|---|---|---|
| 1 | 0% | 0% | 0% |
| 2 | 100% | 100% | 100% |
| 3 | 100% | 100% | 100% |
| 4 | 100% | 100% | 100% |

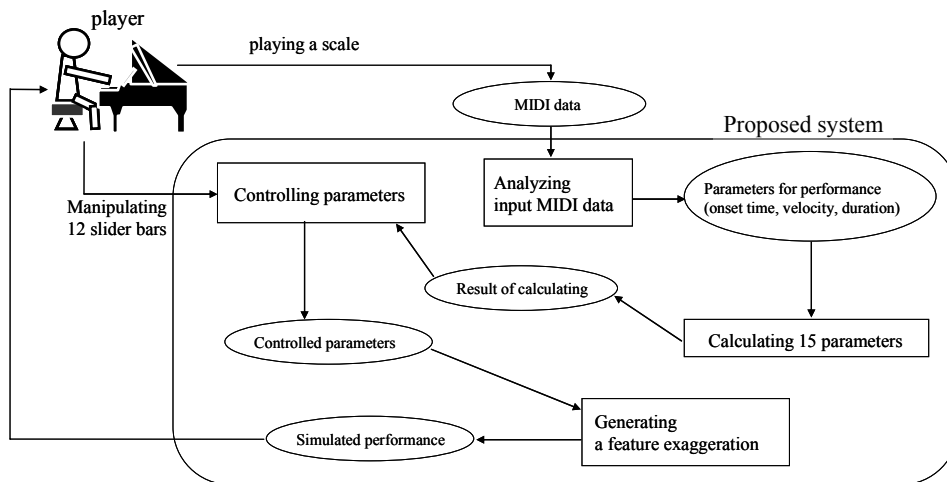Table1 Initialized situation of each slider bar
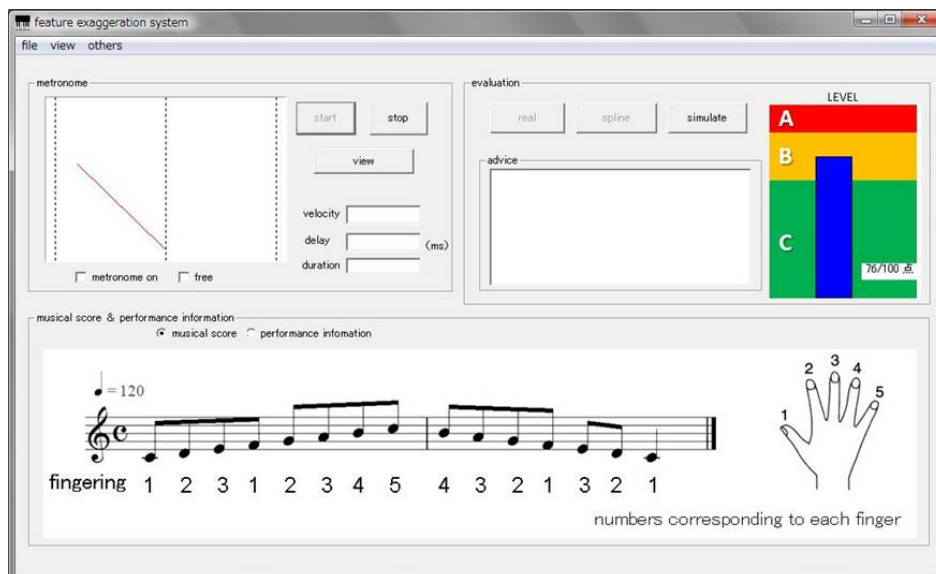


Fig.4 An overview of the proposed procedure



Fig.5 An example of screen capture of main window

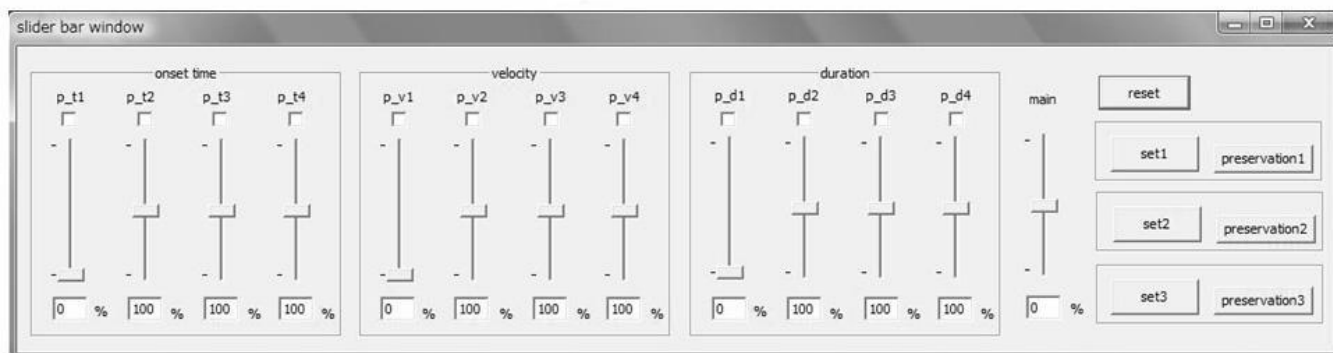Fig.6 An example of screen capture of slider bar window

# 6 Example of feature exaggeration

## 6.1 Condition of exaggerating a feature

In this paper, exaggerated performances are generated under the condition of each parameter which was assumed to be $C_{i1}$=200%, $C_{i2}$=100%, $C_{i3}$=100%, and $C_{i4}$=100%. Two analyzed performances here are those evaluated as high or low by a piano teacher. The example of exaggerating the feature by using the proposed technique for the skilled performance is shown in Fig.7. The example of exaggerating the feature by using the proposed technique for the unskilled performance is shown in Fig.8.

## 6.2 Result

It is difficult to confirm the errors before exaggerating them for the skilled performance. However, it is expected to stand out them by using exaggerating techniques. In addition, the tendency of the skilled players in terms of intonation and/or artistic duration was able to be clarified. In the result of exaggerating the feature of the unskilled performance, players can easily confirm his/her weak point by listening to them by beginners even though users have no expertise for the piano. Therefore, it is thought that his/her own habit of the performance and the weak point or tendency of skilled person can be analyzed easily by exaggerating the feature of the skilled performance and unskilled performance.
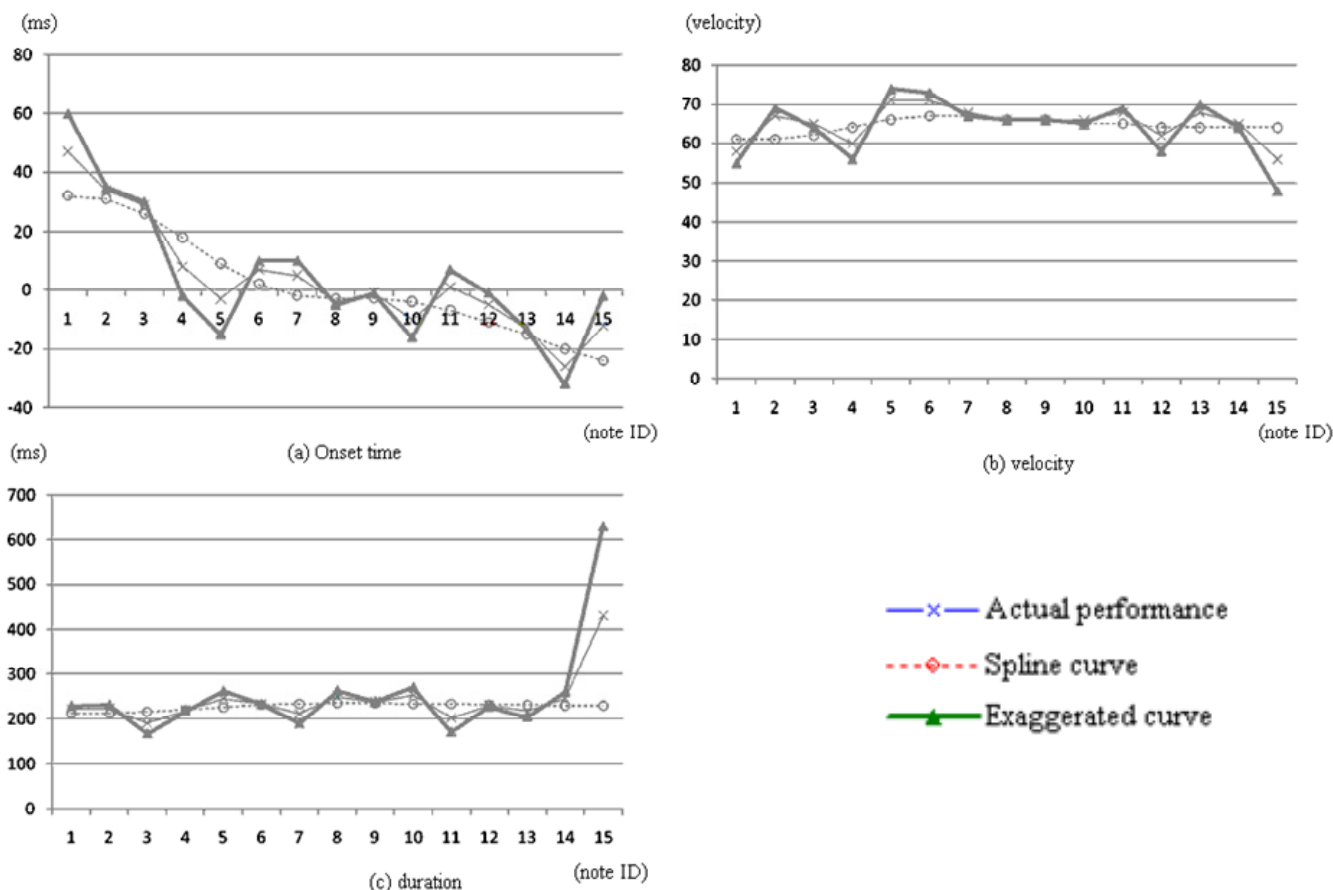


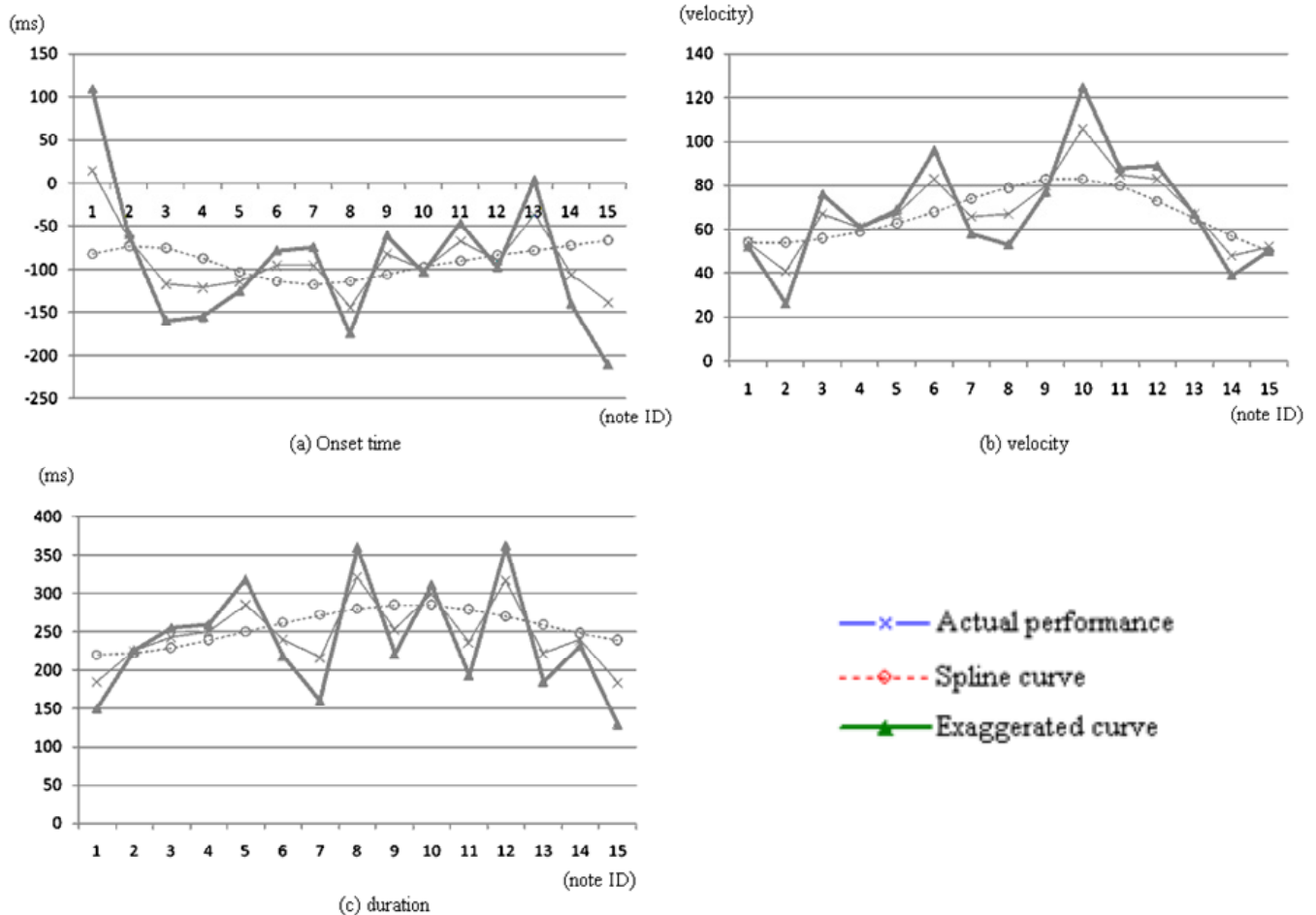Fig.7 The result of exaggerating the feature for the skilled performance

(a) Onset time

(b) velocity

(c) duration

Fig.8 The result of exaggerating the feature for the unskilled performance

# 7    Conclusion

This paper proposes exaggerating a feature for scale playing on the piano by controlling the parameters, and the system that generates a simulated performance. The parameter can be controlled by manipulating the slider bar corresponding to each parameter between 0% and 200%. As a result, proposed system generates the piano performance that continuously changes the tendencies with keeping the original aspects. Moreover, the feature of the performance is exaggerated by controlling the parameter to 100% or more, and an own weak points can be discovered. Proposed system can support practice in the piano from a beginner to expert, because players can analyze own performance by using this system. Combinations of values for each parameter are allowed because 12 parameters are controlled independently at the same time. This paper operated $C_{m1}$ from 0% to 200%, and the simulated performance was analyzed.  In the future, it will be necessary to compare the simulated performance in other patterns when several parameters such as two or more parameters are simultaneously controlled. Moreover, it is expected that the proposed system can be applied to the analysis of the piano performance because user's individuality and tendency are shown by exaggerating the feature of the given performance.

# Acknowledgments

# References

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