Development of a Self Learning System for the Shakuhachi using Information Technology

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Abstract

In this paper, the development of a self learning system of a Japanese traditional musical instrument "the Shakuhachi" is described. This system encourage the young to learn and acquire the skill of this instrument using information technology.

1. Introduction

The practice of traditional art world wide is gradually vanishing. This is also true in Japan where the number of people taking over traditional art is gradually diminishing. Usually in Japan, the technique of playing traditional music is not recorded in a document but handed over by oral communication. Consequently, it's very difficult to learn and practice it alone. That causes beginners to quit practicing on the way.

The author thought that a self learning system might be a very effective way to teach musical instruments. "Shakuhachi" is a very difficult instrument to learn and perfect. Much practice is needed to achieve a perfect sound. Using IT(Informatuon Technology), the sound of an expert and a beginner class player is captured and some characteristic parameters are extracted from each sound and processed, and finally the difference of the sound quality between an expert and a beginner is visualized in 2 dimensional space, so that the beginners can assess their own progress.

2. Aim

Shakuhachi is a kind of an air reed instrument made of natural bamboo, and it has a very simple structure, and the sound of Shakuhachi is very sophisticated. The difference of the sound quality between an expert and a beginner is very large. If the parameters which are supposed to express the quality of Shakuhachi sound are extracted and visualized on the computer, people practicing can realize whether they are making progress. So in this system, several parameters are extracted from "long tone" data captured in a computer. "Long tone" is described as the stable sound produced by blowing into a woodwind instrument for a period of more than 10 seconds. FFT(Fast Fourier Transform) can be applied once such stable sounds are achieved. Since Shakuhachi has only 5 notes in one scale(C,D,F,G,A), 10 notes in 2 scales are captured and analyzed.

In this system, we are concerned only with the difference between the sound quality of an expert and a beginner. The aim is to achieve a small difference and to encourage the continuation of practicing of this very traditional Japanese musical instrument.

3. Analysis Procedure

As mentioned above, the long tone 10 notes data in 2 scales of an expert and a beginner is captured for several seconds as a wave format file into a personal computer, and 8192 samples * 5 blocks (total 40960 samples, about 930ms) are extracted. Then 8192 FFT is applied 5 times and several data are extracted.

Fig1. shows the spectrum of the lowest note and Fig.2 shows the time transition of the spectrum of the lowest note. From the spectra it can be concluded that:

(1) An expert's spectrum of the lowest sound includes many harmonics compared to the beginner's spectrum.
(2) An expert's spectrum is very stable along the timeline.
(3) An expert's spectrum doesn't change so much between the two successive notes of the scale.

The lowest note of Shakuhachi is called "Tsutsuoto" in Japanese and is a very characteristic sound of this instrument, so this sound has to be handled specially.

The spectrum structure is expressed as a vector shown in expression(4.1), and 5 parameters are calculated from these vectors. "i" of $b_{ij}$ means pitch of the note and "j" means block number, and $b_1,b_2$ mean the power of each spectrum($b_1$ is the power of the basic frequency, $b_2$ is the second harmonic etc). When "$c_{ij}$" is used, that means the data of another player.
"fbij" is a scalar value, in which "f" means the basic frequency of the note, "i,j" is the same as above. When "fcij" is used, that means the data of another player.

\[ Bij = (b1, b2, ..., bn) \]  \hspace{1cm} (4.1)

[parameter-1] spectrum structure transition of each note vs time
\[ p1_i = \text{mean}(|b_{ij} - b_{ij-1}|) \]  \hspace{1cm} (4.2)

[parameter-2] spectrum structure transition between two successive notes
\[ p2_i = \text{mean}(b_{ij} - b_{ij-1}) \]  \hspace{1cm} (4.3)

[parameter-3] spectrum structure difference between an expert player and beginner class player
\[ p3_i = \text{mean}(b_{ij} - c_{ij}) \]  \hspace{1cm} (4.4)

[parameter-4] basic frequency transition
\[ p4_i = \text{mean}(|fb_{ij} - fb_{ij-1}|) \]  \hspace{1cm} (4.5)

[parameter-5] basic frequency difference between an expert player and beginner class player
\[ p5_i = \text{mean}(fb_{ij}) - \text{mean}(fc_{ij}) \]  \hspace{1cm} (4.6)

In case of parameter-2 and 3, the lowest note is handled as more significant data than the other 4 notes of the scale. The mean values are calculated for all the 5 parameters in regard to suffix "i" in 10 notes, finally 5 data (p1,p2,p3,p4,p5) for each player is obtained.

4. Results

Data was collected using one expert and one beginner. Each subject was assessed 6 times once every 2 or 3 months. According to the result of principal component analysis, since the cumulative contribution ratio of the first and the second principal component is already 0.875, these 2 principal components are supposed to express the total data.

Fig.3 shows the 2-dimentional vector of the first and the second principal components of the expert's data and the beginner's data. Especially during the early stage of learning, the vector of the beginner's data is far from the origin. However, with practice the beginner's vector approaches the origin and resembles that of the expert player. This is regarded as proof of progress. The beginner could know with certainty that he was progressing.

5. Conclusion

Information technology is applied to practice the very traditional Japanese musical instrument. The difference of the sound quality of each level is clearly displayed and it becomes very understandable whether or not practice achieves progress. Further studies to identify more significant parameters may be necessary.