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A MEASUREMENT SYSTEM TO CAPTURE THE PLAYER'S CONTROL IN THE NATURAL PLAYING CONDITION OF SINGLE-REED MUSICAL INSTRUMENTS: APPLICATION TO THE PERFORMANCE LOG OF A BEGINNER PLAYER

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ABSTRACT

It is well known that the control by players (e.g. embouchure, tonguing, respiration, and so on) gives significant effects on the sound generation of wind instruments. However, it is hard to measure them in actual playing conditions due to the difficulty in putting sensors without disturbing the performance. This paper proposes new devices for measuring the control induced by players of single-reed musical instruments. These devices are capable of acquiring various aspects of the player's control including blowing pressure, biting force, acoustic pressure inside a mouthpiece, abdominal motion, and chest wall motion. The devices are designed to minimize disturbance for players in order to realize measurements in a natural playing condition. A test measurement using the devices was conducted on a person who was completely new to playing the saxophone. The player was asked to engage in daily practice for three months under the supervision of an experienced player, while consistently measuring the control information. The analysis of the performance log reveals clear improvements in certain performance indicators such as loudness, spectral centroid, and respiratory motion.

Keywords: *gesture acquisition, performance log, wind instrument, embouchure, respiration*.

1. INTRODUCTION

There have been several studies on capturing the player's oral control when playing single-reed instruments. One of the pioneer works in this context is the study on the effect of vocal tract resonance by the measurement of the pressure in a player's mouth and the pressure in a mouthpiece [1]. This concept has been further explored in subsequent studies [2-4] and extended to the investigations on the role of player's control during the transient phase of the sound generation [5-6]. A completely different approach involved morphological analysis of vocal tract images obtained through MRI measurements for saxophone players [7].

On the other hand, there have been some studies on the measurement of respiratory motion while playing wind instruments [8-10]. These studies involve time series analysis of videos capturing the motion of optical markers placed on a player's body.

This paper proposes a measurement system to capture both oral control and respiratory motion, simultaneously. The system is expected to be utilized for pedagogical purposes, such as learning how to play musical instruments and understanding the advanced technique by skilled players. To achieve this goal, the measurement system is designed following the concept:

- minimize the disturbance to performance
- easy handling (easy setup, less special equipment)

2. MEASUREMENT SYSTEM

Fig. 1 illustrates a special mouthpiece designed to capture oral control. The mouthpiece is designed to measure similar information as [2][5-6] with introducing the concept of the tunnel employed by [1][3-4]. The tunnel enables a pressure sensor within the mouthpiece to measure the pressure inside

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the mouth cavity (Pcav). In addition to Pcav, the mouthpiece is also able to capture reed strain (Sreed) corresponding to the biting force and acoustic pressure inside the mouthpiece (Pmp).
The respiratory motions at abdomen (Abdominal) and chest (Chest) are captured by the belts that wrap around the player's body (Fig. 2). The belts are equipped with CNT sensors to capture the elongation of the belts induced by respiratory motion.

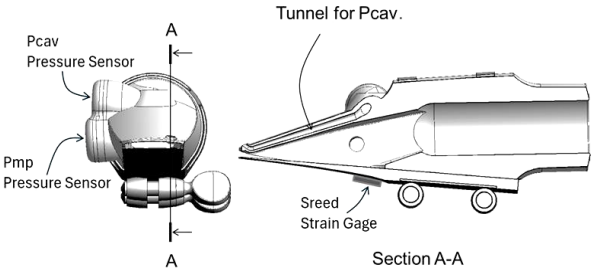

Figure 1. mouthpiece with sensors to capture the oral control.

Figure 2. belts with elongation sensors to measure the abdominal motion and chest motion.

3. EXPERIMENT

A long-term measurement test is conducted on a person who is completely new to playing the saxophone. The player is asked to engage in alto saxophone training under the supervision of an experienced amateur player. The signals from the 5 sensors are recorded throughout the training session, which typically lasts 30-60minnutes. The training is repeated every working day for three months. The player is obliged to play long tone (at Eb3, Eb4, and Eb5) and scale in Eb at least once in a daily training session.

4. RESULT

4.1 Analysis on acoustic pressure at mouthpiece

Fig. 3 and Fig. 4 are the results of the analysis on the Pmp signals (corresponding to acoustic pressure at mouthpiece). A long tone phrase in Eb4 is picked from each daily session and feature extraction is performed for the stable portion of the signal. Fig. 3 shows the median for rms amplitude of the waveform in linear scale. Fig. 4 shows the results on spectral centroid. The Comparison between the beginning (around the left end) and ending (around the right end) indicates that both the amplitude and spectral centroid gets approximately double. The result suggests that the player has improved one's playing skill through the daily training session. Note that there were no long tones in Eb4 observed on 0130 and 0202.

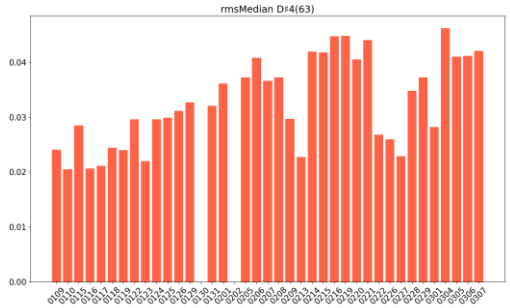

Figure 3. median for rms amplitude (in linear scale) on a Eb4 long tone over daily sessions.

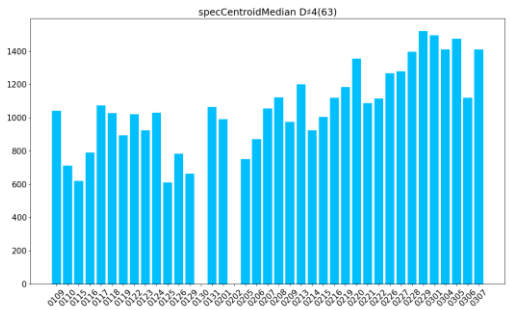

Figure 4. spectral centroid on a Eb4 long tone over daily sessions.

4.2 Analysis on the respiratory motion

From Fig. 5-a to Fig. 5-d show the analyses results of the respiratory sensors attached to the player's chest and abdomen. From the entire training period, data from distinctive four days were picked, and the figures depict the expansion and contraction of the respiratory sensors during the daily sessions. Throughout each daily session, the vertical axis plots the expansion and contraction of the band attached to the chest, and the horizontal axis plots that of the band attached to the abdomen. Comparing the plots, it is noticeable that at the very start of the training, the range of the sensor's expansion and contraction is small (Fig. 5-a). This indicates that breathing is not deep. However, in two weeks, the range of expansion and contraction for the chest sensor becomes larger, suggesting that the player is attempting to breathe more deeply using one's chest (Fig. 5-b). With further repetition of daily training, the range of expansion and contraction for the chest sensor gradually decreases (Fig. 5-c and Fig. 5-d). This suggests that the player has acquired more efficient control through training.

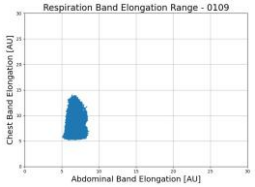

Figure 5-a. 01/09

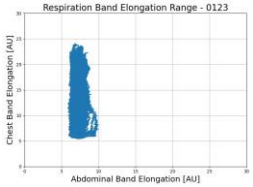

Figure 5-b. 01/23

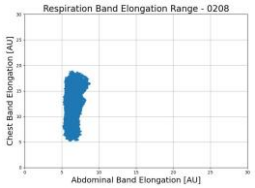

Figure 5-c. 02/08

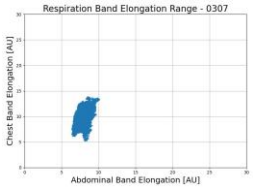

Figure 5-d. 03/07

Figure. 5 respiratory sensor elongations at four different daily sessions. Vertical and horizontal axes correspond to chest and abdomen motions, respectively.

5. FUTURE WORK

The preliminary results indicate that the measurement system has enough potential to assess the player's ability. However, the capability of the measurement system needs to be evaluated through the experiment involving players of different skill levels, from beginners to professionals. Additionally, intensive analysis of sensor signals also needs to be done in order to correlate the player's control and the resulting sound.

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