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Developing an audio analyzer for instantaneous stroke position identification on table tennis racket to assist technical training

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ABSTRACT

This study has successfully developed an audio analyzer system to identify the stroke position on table tennis racket instantaneously, which can effectively help the technical training. It's well known, a good stroke is often determined by the exact stroke position on table tennis racket during the play. Therefore, instantaneous identification of the stroke position on table tennis racket during play can provide good adjusting reference of action and effectively help the technical training. In this research, this developed audio analyzer consists of a microphone and the analysing program with fast Fourier transform (FFT) using LabVIEW software. The face of table tennis racket is divided into four blocks which are the center, the left-of-center, the right-of-center, and the trail. The stroke sound generated between table tennis racket and ball during play is captured by the microphone and synchronously analyzed through FFT to determine the principal frequency, where the different stroke position on the table tennis racket yields different principal frequency. The results of calibration show that every table tennis racket has three characteristic principal frequencies on the four blocks, which can distinguish center, right/left, and trail respectively. The positional verification rate of the center position identification is all higher than 90% even up to 100% which can assist technical training.

1. Introduction

It is essential to emphasize the importance of sports due to the awareness of health consciousness. Among all kinds of sports, table tennis is popular because of the less sports injuries, less demand for space requirement, and simple sports equipment. It is not only a physical exercise for fun, but also a significant sport competition in the world. To promote the skillful technique for players, training could be seen as the most advanced learning, which provides high density, high strength, and large number of drills. A professional coach often plays a key role in athlete's training, However, the coach needs to repeatedly serve the balls to player during the training process and it's physical strength costly. Effective training can efficiently reduce the expense and time for both player and coach. This is the reason to develop such an audio analyzer system to identify the stroke position scientifically which can help coach to correct the player's strike and posture. Even without the guidance of coach, the player can use this system to do independent practice.

Table tennis racket is usually made from wood covered with rubber on one or two sides. According to International Table Tennis Federation (ITTF) regulations [1], at least 85% of the racket blade by thickness shall be of natural wood and the other 15% can be composite material. The sweet spot is the area of the blade that gives you the best performance during playing the stroke type sport [2]. When the sweet spot is hit, it's easy for the player to hit a strong and powerful ball. For typical table tennis sport, the sweet spot is usually located at the center position of the racket. Other than the sweet spot, different stroke position also affects stroke techniques such as slice and smash in table tennis [3]. The speed and spin of the ball are strongly dependent on the slice angle which is the angle between the direction of the ball and the racket. Also, the rubber deformation on the racket at the stroke position is also important.

Therefore, the stroke position provides a good reference during table tennis training. In recent research, there are lots of studies related to the stroke position detection using high-tech tools [4–7]. Among these tools, vibration is one of the most common ways used to detect the sweet spot of racket in tennis and badminton because different part of the racket has different vibration frequency.The material of the

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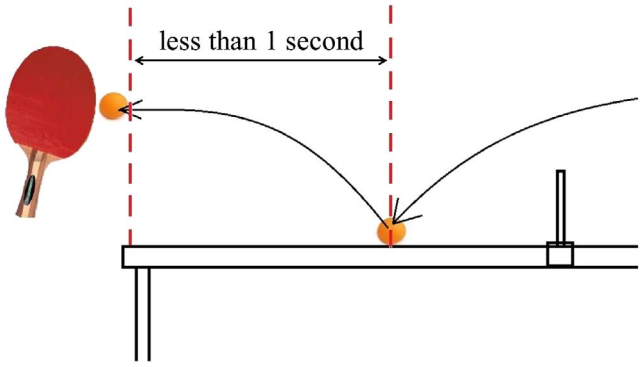


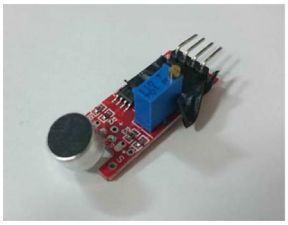
Fig. 1. The schematics of the ball bouncing path.

racket affects the vibration frequency, and the vibration is related to the sounds caused from the racket [8,9]. One of the major features different from the table tennis to badminton and tennis is that table tennis racket is with no string but solid surface covered. Instead of using vibration, the sound signal frequency is used in this research to identify the stroke position. Sound signals can be converted from the time domain to the frequency domain by the fast Fourier transform (FFT), a discrete Fourier transform algorithm.

This study has successfully developed a “stroke position identification system” which is based on the frequency analysis of audio signals of ball-racket impact. Morever, a set of experiments to measure the system accuracy were also carried out. This stroke position identification system can provide players useful information to adjust the way of stroke and can be employed during the training.

2. Basic theory

To develop an audio analyzer for the instantaneous stroke position identification system and execute a set of experiments to check the measurement accuracy, the Fast Fourier transform is used. Signals can be analyzed from two sides: the time domain and the frequency domain [10,11]. However, any signals that can be represented as an amplitude that varies in time has a corresponding frequency spectrum. In the time domain, signal is continuous and changes with fluctuations over time. In the frequency domain, signal is discrete and lies on each frequency band, and it is independent on time. Through a sound wave, acoustic pressure is the local pressure deviation from the ambient atmospheric pressure. In the time domain, the sound density is captured at each time point, however, the scale of the sound can not be distinguished. In the frequency domain, any scale of the sound has its own unique frequency. Even with a severe change of sound intensity, the frequency of the sound would not be interfered. By using this characteristic, the difference of the sound can be distinguished.



(a) The photo of the sound sensor

(b) The photo of the webcamera

Fig. 3. The images of sensors used in this system.

During the real experiments, it is possible that the identified results would be interfered by the surrounding sounds. These noises could make the system unable to analyze the sound sample. To reduce this issue, a trigger is applied here to control the system. Fig. 1 is the schematics of the table tennis ball bouncing path. The ball strikes the table from the opposite side then bounces and strikes the racket. The whole process usually only takes less than 1 s. The sound made by the ball striking the table from the opposite side is set as a trigger. It could be triggered easily by microphone since the sound transmission not only through the air but also the table. When the trigger is on, the system will analyze the detected sound within this 1 s. Within this 1 s, the most obvious sound is made by the ball hit on the racket, and most of the surrounding sound would be filtered. At the end, the clear sound samples are received. Also, another trigger is needed to be used for the result comparison. Once the sensor detects the sound made by the ball and racket, the system would execute the webcamera to snap a picture in which the ball hits the racket. This picture is used to compare with the identified result.

3. Experimental details

This audio analyzer system for instantaneous stroke position identification on table tennis racket mainly consists of a microphone, a webcamera, and the analyzer. The webcamera is applied here for the measurement calibration. Fig. 2 shows the schematics of the experimental setup. During the process of experiments, a table tennis machine (model:CRACKV-989E) is installed to serve the balls for players. The microphone captures the stroke sound signals yielded between the table tennis racket and the ball during the play. The signal is instantaneously transferred to the analyzer with FFT analysis for stroke position identification and also set as the trigger point to start the image capturing at the same time.

Fig. 2 shows that the microphone installed on the table border of the player side and the webcamera is set on the table facing the player. The microphone is driven by a 5 V DC and its output voltage can be adjusted by using variable resistors. Fig. 3 is the image of sensors used in the

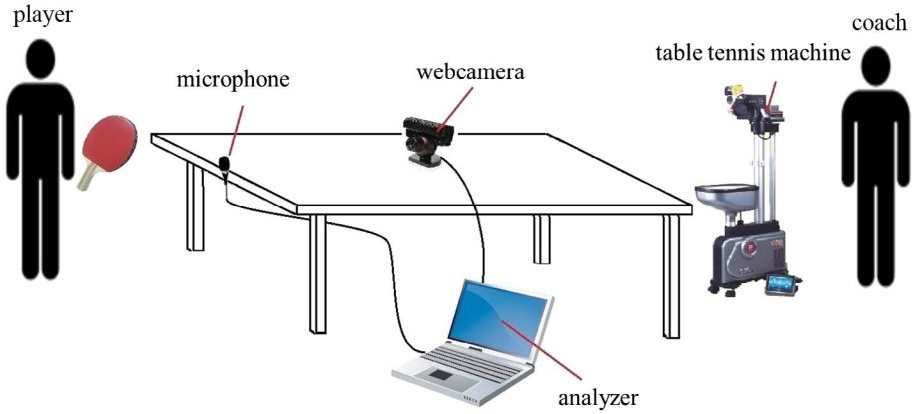


Fig. 2. The schematics of the experimental setup includes: microphone, webcamera, table tennis machine, and audio signal analyzer.