Chapter 46
Study on Badminton Smash for Training Based on Sensor

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Abstract In this paper, the local sensory system has been developed in a badminton racquet. Data were collected from independent accelerometer and earthquake sensor, installed in badminton racquet. And the accelerometer and acoustic sensor, and the combination of value-added information costs can be crushing analysis, by providing the important material of shattered performance. The ANFIS is used in the fusion of acoustic emission and acceleration information to calculate the shuttle produce the ball speed, the main performance can get a fairly accurate results. However, if the training data quantity is limited, data cannot cover the scope with the sample input data, it will lead to wrong estimated output. Therefore, it is the need to get enough large amounts of data for training system, prevents data range of problems, and has obtained the good accuracy.

Keywords Badminton smash · Training · Sensor

46.1 Introduction

In a badminton match, the most common stroke is the victory over smash, it is also the most powerful attack shooting. Its effective use is the most important, a player is competitive. However, compared with other sports, such as tennis [1, 2], golf [3, 4] and baseball, [5, 6] badminton stroke received a relatively small scientific attention [7]. An understandable badminton, significant value will help break the badminton coaches trained badminton players. In addition, the application has

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several similar applications and the method of the development is expected to this work will be directly apply to other applications.

In the published literature, most of the relevant investigation is computer imaging technology through the use of high speed camera [5, 6]. However, there are some shortcomings of these techniques, such as lack of quantitative information 2 d measuring the racket speed, significant effort required to manual for each screen frame, difficult to obtain the speed of the racket of graphic information.

46.2 Similar Works

In the literature, there are many related work analysis in all kinds of strokes and hit a ball and bat racket games foundation. Jaitner and Gawin [8] analysis in the badminton crushing use accelerometer. Three 2D micro accelerometer (Biovision) used in the investigation accelerometric and kinematics of data for badminton impact is collecting. Spearman rank correlation analysis method of the calculation speed and racket correlation ball acceleration. According to the report, about 80 % of the variance of the ball speed can be explained by the racket of acceleration. However, in the work, the accelerometer is only used to predict the shuttle's ball speed.

Ahmadi et al. [9] research and the movement of the rotating speed of the swing with acceleration plan for the athlete skill evaluation. The work of CAI [10] analysis methods of muscle table electric chart (EMG) activities provide quantitative information model of master and use swinging badminton racquet. This as evidence of how much power the player needs to perform powerful shattered. Arm movements of biomechanics analysis work and Ahmadi a-ming et al. [9] analysis of knee, foot and wrist movements provide good information, the expectations of the legs, knee, arm, and wrist movement necessary to perform a strong wave racket of shattered [11].

46.3 Project Motivations

Works [3, 9, 10] present in the previous section to contribute and analyze the different parts of the body of a player for the badminton hit. These used to help athletes and other similar player's sports of monitoring and improve their skills. However, these studies are only emphasizing physical activity in people performing a variety of different sports. Little attention has been focused on remote sensing movement of the racket. This is time consuming and expensive occupation racket games using camera [1–6], and is difficult to measure the actual speed of the racket involved complex algorithms and analysis method [8]. Works of the racquet speed analysis provide good information needed a powerful racket for the shuttle ball speed. However, they only use accelerometer serve velocity and the onboard the ball, lack of information, do not know the shuttle was hit the ball, this time the racket hit the shuttlecock.

The purpose of the current work is to fill the "information gap" with acceleration sensor related alone. The fusion of accelerometer, acoustic shock sensor data also has several industrial applications which would benefit from the development of the method.

46.4 Design of Local Sensor System

In choosing different acceleration, different ranges of accelerometer 6, 18, 30, and 50 g are tested. The installation of the accelerometer is on the string of the part of the racket. A maximum of g (gravity acceleration) won about 15 g. In order to get the best search performance, puts forward two-axis accelerometer (18 g acceleration, ADXL321) installed in base take head, with sports adjacent to the racquet head. An acoustic sensors (BRT1615P-06) installed in the racket head feels hit the shuttle's voice ball, adjacent to the racquet head. Figure 46.1 shows the accelerometer and acoustic sensors racket installed at the base of the racquet head.

46.5 Experimental Methodologies

The data from the sensor system were collected using a National Instruments NI 9201 and NI 9233 data acquisition modules. The frequency requirements for the ADXL321 accelerometer and the BRT1615P-06 acoustic sensor are both 5 kHz. NI 9201 and NI 9233 met the requirements. The signals were acquired at 10 kHz. The following experiments designed to test the signals from the accelerometer and

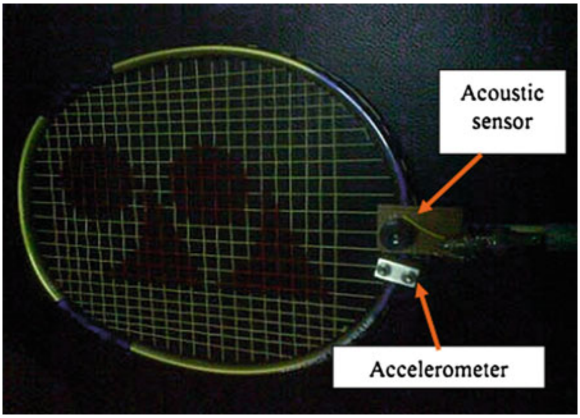

Fig. 46.1 Accelerometer and acoustic sensor mounted at base of racket head

acoustic shock sensor when swinging the racket, as well as when smashing the shuttlecock. The individual experiments are outlined below:

Exp. 1 Overhead swing movement of the racket was simulated to test the accelerometer and acoustic sensor response to the swinging action.

Exp. 2 Characterize the acoustic shock sensor when subject to surrounding sound, not produced from the racket. Done by striking two metal forks together 1 cm to the acoustic sensor to produce a loud noise.

Exp. 3 Characterize the acoustic shock sensor by striking a shuttle ball at various points on the racket strings. The racket was mounted horizontally; with shuttle ball allowed to fall freely onto the racket strings.

Exp. 4 Characterize the response of the acoustic shock sensor by striking a shuttle ball on the racket frame.

46.6 Results

To facilitate the study of each experiment, acceleration, root mean square (RMS) [12], and crest factor CF [12] was calculated as defined by the following equations:

$$\text{Acceleration} = \text{gx} \ \times \ 9.81\left(\text{m/s}^2\right) \tag{46.1}$$

$$\text{RMS} = \sqrt{\frac{\sum_{i=1}^{N} X_i^2}{N}} \tag{46.2}$$

$$\text{CF} = \text{Peak AE/RMS} \tag{46.3}$$

Where, g is the gravitational acceleration from accelerometer. X is the time series vector of the acoustic emission (AE) from the acoustic shock sensor, and $i = 1, \cdots, N$. N is the number of sample. Peak AE is the peak AE amplitude.

Exp. 1 Simulated swing movement of the racket.

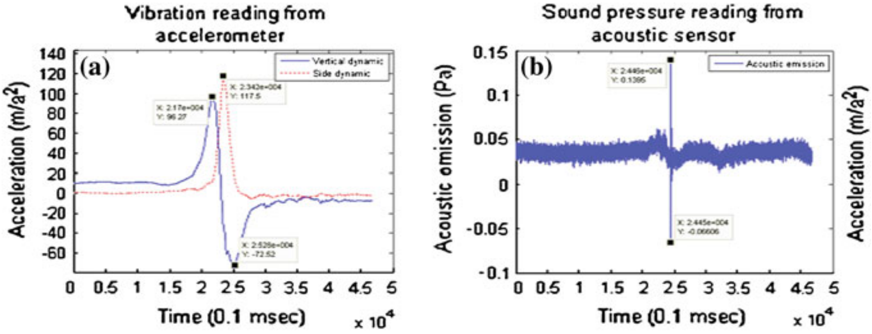

Fig. 46.2 Acceleration and AE responses during overhead swing. **a** Acceleration (forward and sideward dynamics), and **b** AE signal

Figure 46.2a shows the acceleration during the overhead swing of the racket, and Fig. 46.2b shows the AE signal obtained during the same stroke. The forward movement has peak acceleration of 96.34 m/s^2. The sideward acceleration is 117.5 m/s^2, which means the racket swinging sideway. There is a peak AE burst 0.14 Pa at the end of the swing. This was due to surrounding sound. RMS of the waveform was 0.04, and crest factor is 3.5.

Exp. 2 Metal fork striking noise acoustic shock sensor.

Figure 46.3 shows the acoustic waveform representing the noise created near the acoustic sensor. The waveform has peak AE amplitude of 1.1 Pa. RMS was 0.028, and crest factor was 4.64.

Exp. 3 Shuttle ball striking strings from a fix height.

Figure 46.4 shows the AE waveform for shuttle ball hitting string at the center of the racket head from a fix height of 1.65 m. It can be seen that the waveform diminished smoothly from peak value. The peak amplitude of AE burst was 0.93 Pa. RMS was 0.167, and crest factor was 5.58.

Exp. 4 Shuttle ball striking frame from a fix height.

Figure 46.5 shows the AE waveform for shuttle ball hitting the frame from the fix height of 1.65 m. The waveform diminished rapidly from the peak, and then a second rise of waveform which diminished slowly. The peak amplitude of AE burst was 10 Pa. RMS was 1.2, and crest factor was 8.4.

Exp. 5 Smashing a shuttlecock.

These final tests were to capture the racket's acceleration and AE signal, when smashing a shuttle ball. Figure 46.6 shows the acceleration and AE signal for the shuttle ball hitting the string of the racket. The racket hit the shuttle ball when the acceleration signal was −56.2 m/s^2 (deceleration), with the sideward acceleration at the peak.

The AE burst happened, at the same time, the shuttle ball was hit, with the peak amplitude of 85.2 Pa. RMS was 22, and the crest factor was 3.6. Figure 46.6c shows the closed up view of the waveform, which shows that the waveform diminished smoothly from peak, but forming five small waveforms. This could be because of the strong hit which caused the residue vibration to built further AE waveforms.

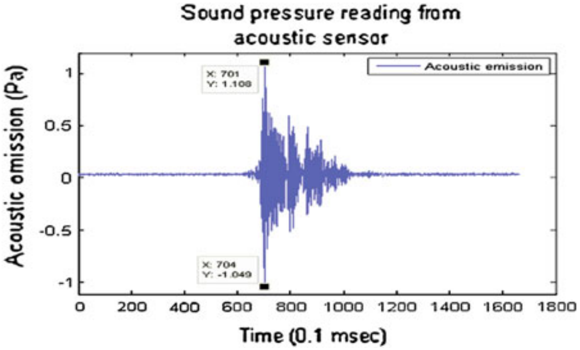

Fig. 46.3 AE waveform in response to shuttle ball hitting the ground

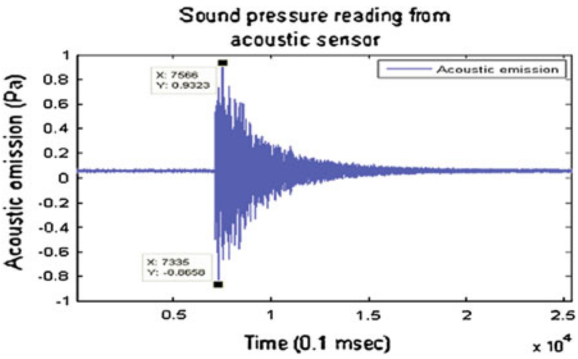

Fig. 46.4 AE waveform for shuttle ball striking the racket strings

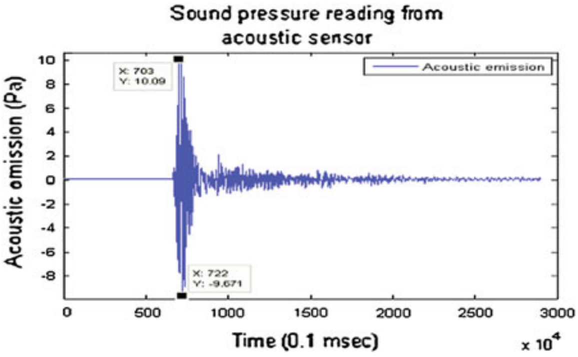

Fig. 46.5 AE waveform for shuttle ball striking the racket frame

Figure 46.7 shows the acceleration and AE signal for the shuttle ball hitting the frame of the racket. The racket hits the shuttle ball when the acceleration was $-29.48\ \mathrm{m/s^2}$. The AE burst happened, at the same time, the shuttle ball was hit, with the peak amplitude of 70.45 Pa. RMS was 10.5655, and crest factor was

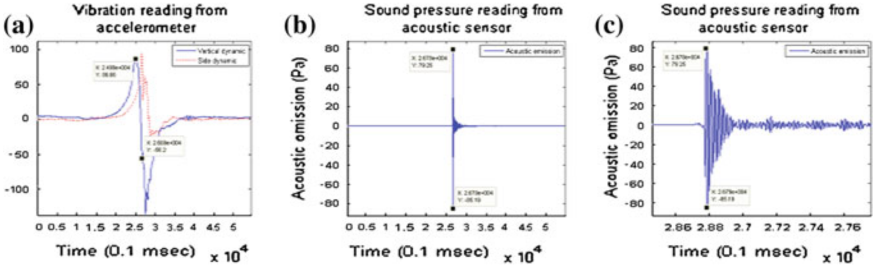

Fig. 46.6 Acceleration and AE for shuttle ball smashing on string. **a** Acceleration, **b** AE waveform, and **c** Closed up view of the AE waveform

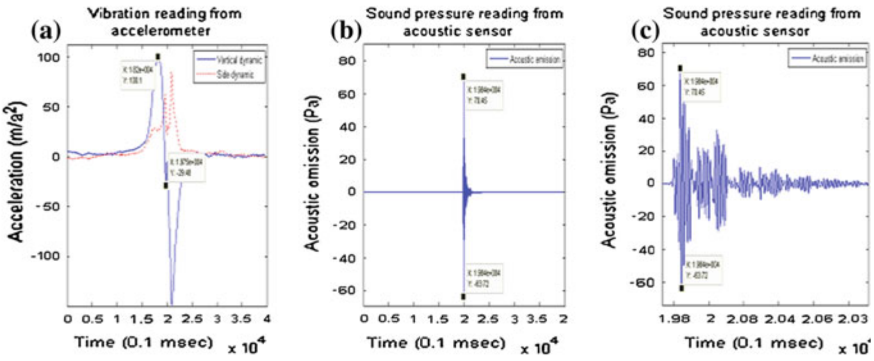

Fig. 46.7 Acceleration and AE for shuttle ball smashing the frame. **a** Acceleration, **b** AE waveform, and **c** Closed up view of the AE waveform

6.6681. Figure 46.7c shows the closed up view of the waveform, showing that the waveform diminished rapidly from the peak, but forming two big and several small waveforms.

46.7 Conclusions

The current work can be a useful contribution to the future design type of badminton rackets, can provide quantitative data and the data were shattered performance. Knowledge and estimated speed, it is possible for trained athletes to prove them crushing technology based on estimates that shuttle the ball speed. Combined with the peak amplitude, the top factor, AE racket type speed and speed, can become parameters adjustment ability.

By understanding the impact shattered by the dynamic movement and acoustic emission signal, can bring up a quantitative feedback data collected on facial muscles electric chart table (EMG) activity patterns [13] and the biomechanics of wrist, arm, knee, and leg movements [14, 15]. The three types of information combination can be a good contribution and sports training racket.

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