A review on badminton motion analysis

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A Review on Badminton Motion Analysis

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Abstract— **Badminton is one of the most popular racket sports in Malaysia. In the past, badminton player movement analyses such as smashing, service, racket swing and shuttle trajectory etc. were mainly carried out qualitatively with substantial human involvement. In recent time, there is increasing assimilation of computer technology in badminton movement analysis as revealed by our review of the state-of-the-art researches. This paper aims to lay a solid foundation for the exploration of further research on badminton movement analysis. Three key areas reviewed were badminton smashing analysis, badminton service recognition, and badminton swing and shuttle trajectory analysis.**

Keywords—Badminton, Motion, Analysis

I. INTRODUCTION

Badminton, the racquet sport starts its origins in ancient civilisation of Asia and Europe more than 2000 years ago. The sport, was also known as battledore and shuttlecock in ancient time, where a paddle was used to hit the shuttlecock back and forth, already gained its popularity in several regions, such as India, China, Japan, and Greece [2]. In the 1800s, British military officers revolutionised the game (a contemporary form of badminton), namely Poona where the players hit the shuttlecock across the net. Later, the sport became popular when the British officers took the game back to England [3]. Today, badminton is one of the most popular racquet sports in Malaysia, as well as in countries such as China, Indonesia, Korea and Denmark, among others. The game is generally played by two opposing players in singles match or opposing pairs in doubles match within a centre netted rectangular court. Moreover, badminton is the fastest racquet sport in accordance with shuttlecock speed along with tennis and squash [4]. As compared with other racquet sports such as tennis, there is still a lack of scientific research on badminton sport [5].

Analysis of sports motions was mostly qualitative in nature in the last two decades. However, computerised motion recognition and analysis for athlete are becoming more mature with the recent advancement of technology which is related to input acquisition sensor and computer hardware. There have been excellent reviews [6-13] on general human motion analysis. Human motion analysis, which is a study of methods and applications in which two or more successive images or frames that are produced by a camera or sensor, are processed digitally to produce information. Basically, human motion analysis can be divided into three categories, such as human activity recognition, human motion tracking, and analysis of body movement (see Fig. 1) [1]. Computerised human motion analysis from video sequences is one of the most important tasks in computer vision since it leads the machine to be furnished with ability to identify, recognise, and understand human motion in order to monitor human activities, interact with human, and control some devices. With such ability, the science of human motion analysis is fascinating and gains tremendous attention, particularly in last decade with the rising of applications in surveillance, human-computer interaction, sport sciences, entertainment, and so on.

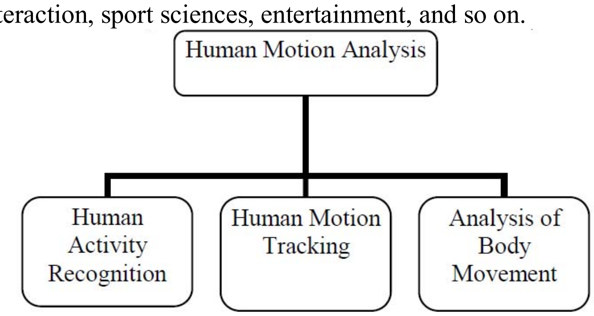

Fig. 1. Three categories of human motion analysis.

A common method in sport science to analyse and evaluate body movements is to film the athletes using a video digitisation system. The footage is later annotated in an offline mode manually. Such popular method, however, requires system expert to annotate the videos in order to extract essential contents. Besides, motion capture and tracking system can be served as an alternative to extract athlete's skeleton model automatically using physical body markers and perform manual motion analysis later in an offline mode. Although such technology produces a more precise human body in 3D representation, but it involves cumbersome placement of body markers. Also, the method is laborious and is inconvenient particularly to the athlete.

In this paper, we focus on the state of the art human motion analysis techniques particularly applied on badminton sport since it is one of the most played sport in Malaysia, as well as in other countries. This paper aims to lay a solid foundation for the exploration of further research on badminton movement analysis. Generally, our review covers three areas: 1) badminton smashing analysis, 2) badminton service recognition, and 3) analysis of badminton swing and shuttle trajectory.

II. BADMINTON MOTION ANALYSIS

In this section, related reviews on badminton smashing analysis, badminton service recognition, and analysis of badminton swing and shuttle trajectory are discussed.

A. Badminton smashing analysis

Badminton smash is one of the fastest motions among various racquet sports. It plays a crucial role as it may turn into a shot that determines a victory in badminton game. [14] developed a sensory system to investigate the relationship between the racquet speed and the shuttle ball speed in badminton smash analysis. In their work, a light weight two axes piezoelectric accelerometer and acoustic shock sensor (to detect the instant of contact event) were mounted on the head of the badminton racquet as exhibited in Fig. 2. A good correlation was found between the racquet and shuttle speed by using adaptive neuro-fuzzy inferior system technique. In addition, [15] presented an arm movement analysis system for badminton smash. In their study, reflective markers were attached on male and female subjects' arm segment and their smash movement were acquired by five Oqus cameras and analysed subsequently. The experimental results indicated that male subjects performed higher velocity as compared with female subjects for racquet grip.

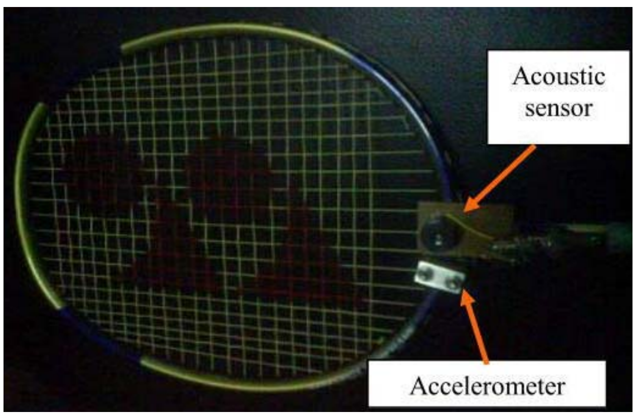

Fig. 2. Accelerometer and acoustic sensors mounted on badminton racquet [14].

[16] studied on badminton forehand and backhand smash using kinematical analysis. Their study was concentrated on forearm, wrist segments, and upper arm on six male elite badminton players. Results of the study revealed that the difference in between forehand and back hand smash is insignificant in terms of shoulder angle, flight angle, angular velocity of wrist joint and elbow angle. Nonetheless, the major dissimilarities from the experiments were wrist angle, contact height, angular velocity of shoulder and elbow joints, racquet angle, and shuttle speed. Moreover, [17] proposed a method that maps badminton smash motion from Space-G to Space-V. Particularly, Space-G is denoted by space-time which is standardised by Karhunen-Loeve transform [18]. Then, mapping to Space-V which is expressed as space-velocity is performed. Such mapping classifies the badminton smash motion into three type of shapes, such as curve, circle, and a line with respective to the centre of the body. As for the analysis results, theoretical verification was done by computer simulation. On the other hand, [19] described a methodology to quantify the torques that are exerted by racquet-side upper limb joints and racquet shaft restoring in order to produce racquet head speed during badminton smash motion. Fig. 3 portrays the model of three racquet-side rigid segments (segment 1: upper arm; segment 2: forearm; segment 3: hand) and a badminton racquet model included grid handle and shaft. Equations of the motion model were computed and the results validated that motion dependent term relies heavily on racquet head speed and shaft restoring torque.

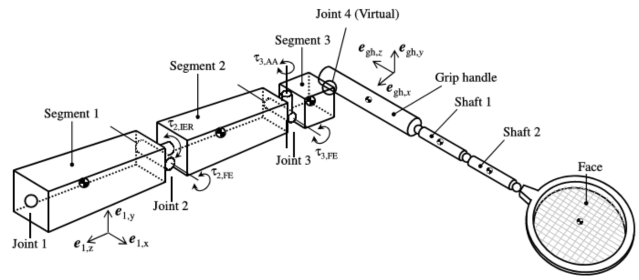

Fig. 3. Model of racquet-side upper limb joints and badminton racquet [19].

B. Badminton service recognition

Apart from the badminton smashing skill, badminton service is also an important skill to be mastered in order to start a badminton game. [20] proposed an automatic badminton service scene detection from RGB video using cubic higher-order local auto-correlation (CHLAC) and multiple regression analysis (MRA). The advantage of using CHLAC is no requirement of prior knowledge. Additionally, features extraction of postures and motions for multiple persons necessitate no segmentation procedure. Then, MRA is adopted to detect particular scenes, such as badminton services from CHLAC features. Experiments were conducted on self-collected RGB video sequences of five badminton matches with average precision and recall rates of 95.1% and 96.3%, respectively. Similarly, [21] addressed two challenges in their research for badminton service detection which were court in view frame identification and badminton service activity recognition. Court in view frame identification is indeed essential in order to serve as a trigger to begin detection of the badminton service activity in a video. Fig. 4 depicts the framework of court in view frame identification. As for the badminton service activity recognition, three rules have been utilised which are slice-based optical flow weightage algorithm, angular, and distance computation of badminton player's centroid. Experiments were carried out on a broadcast badminton RGB video sequences to prove the effectiveness. In addition, [22] performed an analysis on arm movement in badminton for forehand long and short services. In their research, the biomechanical variables for analysis were wrist angle, elbow angle, shoulder angle, shuttle height at contact, shuttle speed, shuttle attaining maximum height, and shuttle angle. The results of the study revealed that there were obvious differences between forehand long and short services with the predefined biomechanical variables.

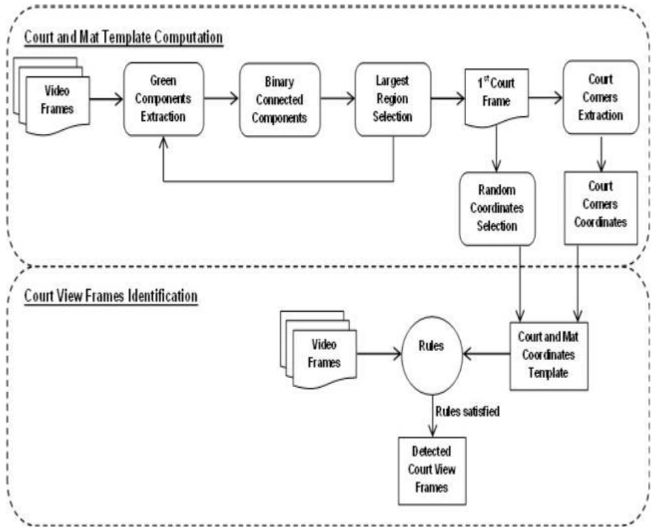

Fig. 4. Court in View Frame Identification Framework [21].

C. *Analysis of badminton swing and shuttle trajectory*

Besides the badminton smash and service activities, the trajectory of shuttle is an important study as well. [23] investigated the relationship between the air resistance force and the velocity of shuttle. The finding results indicated that the shuttle flight trajectory is influenced by the terminal velocity. In addition, the stroke activity which includes angle and strength that performed by a badminton player will affect the trajectory of the shuttle. Finally, the authors also suggested that their proposed method could be used to replace the conventional subjective method by the Badminton World Federation. Furthermore, [24] presented badminton swing motion recognition in broadcast badminton RGB video sequences. In order to solve the problems from RGB video sequences like non-static video cameras and low resolution of player image, spatial distribution features of optical flow of tracked players using grid classification method was proposed. The motion of player is subsequently classified by SVM classifier. As compared with the existing recognition methods, their work achieved better recognition rate. Table I summarises the state of the art in badminton motion analysis.

TABLE I. SUMMARISATION OF BADMINTON MOTION ANALYSIS.

Method	Description
[14]	This paper presented the development of a sensory system for analysis of badminton smashes.
[15]	In this paper, a sequence of badminton smash movements, from the position of holding racket to smashing motion was captured by the Qualisys Track Manager (QTM) software and five Oqus camera system. They were used to record and analyse the overhead smash performance of male and female badminton players.
[16]	This study identified the difference of forehand and back hand smash as flight angle, shoulder angle, elbow angle and angular velocity of wrist joint, shuttle velocity, contact height, racket angle, wrist angle, angular velocity of shoulder joint and elbow joints.
[17]	This paper presented a novel method for analysing human motion from badminton smash image where the human motion in the Space-G which expresses position-time was mapped to the Space-V, which expresses position-velocity with the KL transform.
[19]	This paper developed a methodology that quantifies the contributions of the racket-side upper limb joint torques and shaft restoring torque to the generation of racket head speed during the badminton smash motion.
[20]	This paper described an automatic serve scene detection method employing cubic higher order local autocorrelation (CHLAC) and multiple regression analysis (MRA) from in-play scenes of badminton sport videos.
[21]	This paper presented a rule-based approach to identify frames with court in view and detecting service activity in a badminton game.
[22]	This study revealed from video analysis there were significant differences between forehand long and short serve in elbow angle, shuttle height at contact and shuttle attaining maximum height.
[23]	This paper constructed and validated a motion equation for the flight of the badminton and to find the relationship between the air resistance force and a shuttlecock's speed. The study also suggested that a scientific approach can be used to measure a shuttlecock's velocity objectively when testing the quality of shuttlecocks.
[24]	This paper presented a low-resolution video human action recognition algorithm to recognize player motions in broadcast sports video. The study employed the grid classification method to extract descriptive characteristics of movement recognition with SVM as model classifier and the application of time-sequential voting strategy.

III. CONCLUSION

In this paper, we had summarised the state-of-the-art of human motion analysis research on badminton sports due to its popularity in Malaysia. We have covered 1) badminton smashing analysis, 2) badminton service recognition, and 3) analysis of badminton swing and shuttle trajectory. In conclusion, with the recent advancement of technology, computerised motion recognition and analysis are gaining increasing attention of many researchers as a promising solution for quantitative sports performance analysis. Its application in sports, particularly in badminton, certainly bears a bright outlook for further research and development.

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REFERENCES

[1] J. Y. Guillain, 'Badminton: an illustrated history', Publibook (2004)

[2] M. Connors, D. L. Dupuis, B. Morgan, 'The Olympics factbook: a spectator's guide to the winter and summer games', Visible Ink Press (1991)

[3] C. L. Tsai, S. S. Chang, 'Biomechanical analysis of differences in badminton smash and jump smash between Taiwan elite and collegiate player', XVI International Symposium on Biomechanics in Sports, 259-262(1998).

[4] K. K. Teu, W. Kim, J. Tan, F. K. Fuss, 'Using dual euler angles for the analysis of arm movement during badminton smash, Sport Engineering, 8(3), 171-178(2005)

[5] T. B. Moeslund, A. Hilton, V. Krueger, 'A survey of advances in vision-based human motion capture and analysis', Computer Vision and Image Understanding, 104, 90-126 (2006)

[6] C. H. Lim, E. Vats, C. S. Chan, 'Fuzzy human motion analysis', Pattern Recognition, 48(5), 1773-1796 (2015)

[7] K. V. Bhaltilak, H. Kaur, C. Khosla, 'Human motion analysis with the help of video surveillance: a review', International Journal of Computer Science and Information Technologies, 5(5), 6586-6590(2014)

[8] L. Wang, W. Hu, and T. Tan, 'Recent developments in human motion analysis', Pattern Recognition, 36(3), 585-601(2003)

[9] R. Poppe, 'Vision-based human motion analysis: an overview', Computer Vision and Image Understanding, 108(1-2), 4-18(2007)

[10] S. R. Ke, H. L. U. Thuc, Y. J. Lee, J. N. Hwang, J. H. Yoo, K. H. Choi, 'A review on video-based human activity recognition', Computers, 2, 88-131(2013)

[11] J. K. Aggarwal, B. Bhanu, C. V. Ravishankar, A. K. Roy-Chowdhury, H. Aghajan, D. Terzopoulos, 'Motion analysis: past, present and future', Distributed Video Sensor Networks, 27-39(2011)

[12] J. K. Aggarwal, Q. Cai, 'Human motion analysis: a review', Computer Vision and Image Understanding, 73(3), 428-440 (1999)

[13] J. K. Aggarwal, M. S. Ryoo, 'Human activity analysis: a review', ACM Computing Survey, 43(3) (2010)

[14] T. Chang, K. Chan, 'Local sensor system for badminton smash analysis', IEEE Instrumentation and Measurement Technology Conference, 883-888(2009)

[15] M. S. Salim, H. N. Lim, M. N. Salim, M. Y. Baharuddin, 'Motion analysis of arm movement during badminton smash', 2010 IEEE EMBS Conference on Biomedical Engineering and Sciences, 111-114(2010)

[16] I. Hussain, M. A. Bari, 'Kinematical analysis of forehand and backhand smash in badminton', Innovative Systems Design and Engineering, 2(7), 20-25(2011)

[17] M. Nagasawa, Y. Hatori, M. Kakuta, T. Hayashi, Y. Sekine, 'Smash motion analysis for badminton from image', The IIEEJ Image Electronics and Visual Computing Workshop

[18] E. Oja, 'Subspace methods of pattern recognition', Research Studies Press

[19] S. Koike, T. Hashiguchi, 'Dynamic contribution analysis of badminton-smash-motion with consideration of racquet shaft deformation', The 2014 Conference of the International Sports Engineering Association, 72, 496-501(2014)

[20] F. Yoshikawa, T. Kobayashi, K. Watanabe, N. Otsu, 'Automated service scene detection for badminton game analysis using CHLAC and MRA', World Academy of Science, Engineering and Technology, 4, 841-844(2010)

[21] S. L. Teng, R. Paramesran, 'Detection of service activity in a badminton game', 2011 IEEE Region 10 Conference, 312-315(2011)

[22] I. Hussain, S. Ahmed, M. A. Bari, A. Ahmad, A. Mohammad, A. Khan, 'Analysis of arm movement in badminton of forehand long and short service', Innovative Systems Design and Engineering, 2(3)

[23] L. M. Chen, Y. H. Pan, Y. J. Chen, 'A study of shuttlecock's trajectory in badminton', Journal of Sports Science and Medicine, 8, 657-662(2009)

[24] G. Liu, D. Zhang, H. Li, 'Research on action recognition of player in broadcast sport video', International Journal of Multimedia and Ubiquitous Engineering, 9(10), 297-306(2014)