11th conference of the International Sports Engineering Association, ISEA 2016

Preliminary Investigation of an Innovative Digital Motion Analysis Device for Badminton Athlete Performance Evaluation

Zahari Taha[a], Mohammad Syawaludin Syafiq Hassan[a]*, Hwa Jen Yap[b], Wee Kian Yeo[c]

[a]*Innovative Manufacturing, Mechatronics and Sports Laboratory, Universiti Malaysia Pahang, Pekan 26600, Malaysia*
[b]*Department of Mechanical Engineering, Universiti Malaya, Kuala Lumpur 50603, Malaysia*
[c]*National Sports Institute of Malaysia, Kuala Lumpur 57000, Malaysia*

Abstract

Badminton is a sport that combines several different physical aspects. At a professional level, the sport demands excellent fitness criteria namely the player's aerobic stamina, agility, strength, speed as well as precision. This study fundamentally entails the development of an innovative training system that incorporates technology that could improve the athlete's performance. Although existing motion tracking technology can provide reliable and accurate tracking results, nonetheless, the product cost and complexity keeps them away from being employed in most sports. This investigation involves the comparison between Kinect Technology and inertial measurement unit (IMU). The kinematic movement of the arm from wrist until shoulder was observed in this study for the purpose of investigating the difference between the acceleration of skeleton detected by the Kinect motion tracking and a low-cost IMU. The results obtained were found to be promising, and it is important in enabling pattern recognition of different badminton strokes in the next stage of the study. The movement of the right-hand wrist is tracked by Microsoft Kinect that can track the skeleton of the player whilst the IMU that measures the acceleration is attached at the right-hand wrist. Although the acceleration of the wrist may readily be obtained from the IMU, the acceleration from Kinect may only be obtained through mathematical manipulation. It was found that the accelerations of the upper limb movement from both IMU and Kinect demonstrated good agreement.

Keywords: Kinect; motion tracking; IMU; kinematics

1. Introduction

Virtual Reality (VR) technology has been utilised in a variety of field. In sport, the VR technology are used for various training conditions i.e. simulating virtual opponents and three-dimensional sports environment [1]. There are a numbers of research conducted on VR training system in sport, but limited to "ball" type [2,3]. For instance, a virtual ping-pong training system has been developed by several countries, such as Korea, Taiwan and the UK [4–6]. Badminton is a technical sport that requires good motor coordination as well as sophisticated racquet movement techniques. At present, studies and development of the VR technology in this game is limited to 2D/video analysis [7].

Thus, the target of this study is to build a training system with technology that can improve the athlete performance and extend to a level beyond the current technology. Through the combination of two Kinects and other relevant sensors, the parameters needed for badminton analysis i.e. motion detection, player's acceleration movement and explosive force may be measured [8,9]. A virtual reality training system can then be developed based on this information. The system can be used by

* Corresponding author. Tel.: +6094246358
E-mail address: syawalhassan@imamslab.com

badminton athletes to watch and analyze their performance with the coach & bio mechanist. Motion capture is a process of recording a live motion event or human movement and transforming it into a digital model. The digital model gives access of information for different requirements. In sport technology, motion capture systems provide support to the experts through illustrating the athlete's movement from different view angles, access of sheltered parameters that cannot be seen by the naked eyes, parameters of the motion (e.g., speed, angle, distance, etc.) that can be computed for further analysis [10]. This valuable information may be used by either coaches or sports scientists to prepare a custom training plan for athletes to enhance further their performance. Furthermore, through this method, tailored training will be provided rather than pushing futile training programme [11].

A number of research has been performed in analysing the motion of that is involved in badminton. Kwan et al. investigated badminton racquet kinematics by means of motion capture [12]. They used eight high-speed cameras to conduct the study. Electro goniometers that are attached at the joints to observe the movement during the execution of a badminton smash was also performed by Teu et al. [13]. Reflective markers have also been utilised in examining arm movements during overhead badminton smash [14]. One of the motion capture technology that has gained traction amongst the sports research community is Kinect [15]. Kinect is deemed as a low-cost solution for expensive motion capture systems. In addition, owing to its non-intrusive and easy to set up nature it is preferred in sports research. Furthermore, the accuracy and validation of the skeleton tracking using depth sensor in Kinect have already been validated [16,17,8,18]. Kinect requires no markers, no motion sensors, and no special suits. Therefore, it does not affect or influence the players during competition. The significance of markerless and video technology in sports analysis has been extensively explained by Mauthner et al. [19]. Through such tracking system, the evaluation of athletes and opponents may be obtained without extensive technical support. Ting et al. and Che et al. have utilised Kinect technology in analysing badminton movements [20,11].

The combination of Kinect technology with IMU has also been studied. Tian et al. tested a combination of IMU and Kinect and used unscented Kalman filter (UKF) to fuse the data in order to provide robust hand position, which effectively corrected the accumulated errors of IMU and overcome the instability of Kinect [21]. IMU is widely used in sports for human motion detection [22], measuring real-time kayak cadence [23], recording the acceleration of swimmers [24] and other sports application. This wireless sensor system is normally equipped with accelerometers, gyroscopes, and magnetometers that is focus on sensor-based motion recognition system. The wireless IMU is often small in size and does not affect much on the athlete's performance.

Owing to the obtrusive nature of marker-based motion capture to badminton players, we believe that it is important to explore the use of Kinect to track parameters for use by coaches and sports scientists. In this preliminary study, we have acquired the kinematics movement of a badminton player focused on the upper limb body. The acceleration reading acquired from the IMU, and 20 joints from the Kinect sensor is used to obtain the joint accelerations through mathematical operations. Accelerations obtained from the Kinect are then compared with the values obtained from the IMU.

2. Methodology

A set of experiments to track the upper limb movement was performed. The research subject for the experiments is an amateur badminton athlete. The subject is asked to move the upper limb with basic movements, up and down. The IMU is mounted on the subject's right upper arm, as shown in Figure 1. It records the acceleration value of the right-hand motion that imitates smashing movement. The Kinect sensor is located on the side of the subject to avoid overlap view of the skeleton.
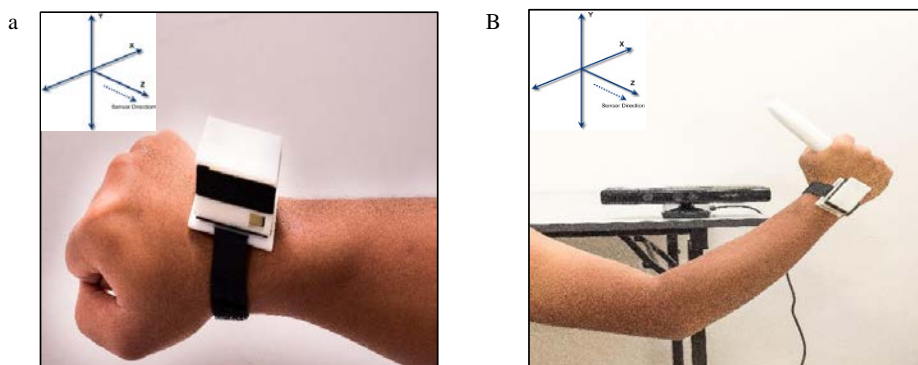

Fig. 1. (a) Installation of IMU accelerometer at the right-hand wrist; (b) real view of the experiment.