

Investigation of Sensor-based Quantitative Model for Badminton Skill Analysis and Assessment

Chew Zhen Shan^a, Sim Lee Sen^a, Yeong Che Fai^{b*}, Eileen Su Lee Ming^a

^aFaculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

^bCentre for Artificial Intelligence and Robotics, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

*Corresponding author: cfyeong@fke.utm.my

Article history

Received :15 June 2014

Received in revised form :

15 September 2014

Accepted :15 October 2014

Graphical abstract



Abstract

Badminton is one of the most popular sports in Malaysia. The main aim of this project is to investigate sets of movements in badminton training using sensors, to identify the good movement that enhance badminton performance. In addition, this project also aims to identify measurable parameters to quantify badminton skill levels. The performance of elite players will be studied to identify benchmark values for these measurable parameters. A quantitative model will be proposed using these measurable parameters to help in the objective assessment of skill levels. Findings of this project will help badminton players to improve their techniques, as well as providing an objective measurement to assess badminton skills.

Keywords: Badminton; skill assessment; wireless sensor; inertia measurement unit; movement analysis

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1.0 INTRODUCTION

The Badminton World Federation estimated about 150 million people play badminton worldwide and more than 200 players participate in international competition [1]. Badminton is listed as top three of Malaysian most popular game. Most of Malaysian grown up playing Badminton, but only less than 10 Badminton athletes listed in top 100 players in BWF (Badminton World Federation) ranking [2]. Studies have shown that exercises using different joints surprisingly showed similar muscle activation and that strength training was not helpful for functional tasks that involved multiplanar movements [3]. Therefore, it is crucial to study specific exercises for specific type of sports.

A research on several movement-based or “functional” exercises has been carried out to assess their effect on technique change [4]. The exercises investigated included walkout in sagittal plane, overhead cable pushes, lateral cable walkouts, the good morning exercise and the bowler’s squat. It was found that despite the activities being rather strenuous, muscle activation levels were relatively modest. In addition, the exercises uses similar joint moments but the patterns of activity between muscles were different. The study further conclude that strength training muscles may not help in functional multiplanar tasks. Data from this study indicated that selection of exercise and movements are crucial for performance enhancement. In the context of badminton players, those at their beginning of training may require different sets of exercises from those who are at the intermediate level or subsequent higher levels.

Researches had been carried out to analyze the movement by athletics through the years. Efforts at player motion tracking have traditionally involved a range of data collection techniques from live observation to post-event video analysis where player movement patterns are manually recorded and categorized to determine performance effectiveness [5]. Two most popular solutions are highlighted here. Firstly, a precise system that required high speed video camera and markers to record the athletics’ motion like Marker Instrumented Player [6]. Secondly, wireless inertial measurement unit that is portable and usable at any environment like Opal sensor from APDM, Inc [7]. There are custom-made products such as Zepp Tennis [8] for tennis players, developed by Zepp US Inc to track the useful data like power, spin, court time and connect with APPLE I-Pad to get the instant feedback. At the same time, Sony Corporation had announced the prototype of smart tennis sensor [9] at CES2014 which can detect the speed of the ball hit on the racket.

A review of vision-based motion analysis in sport study by Sian Barris had mention that problem of current motion analysis system by using video recording or motion capture such as TRAKUSTTM, SoccerManTM, TRAKPERFORMANCETM, PfinderTM and ProzoneTM is hard to apply at crowded place, often compounded by the quality of video capture, the relative size and occlusion frequency of people, and also changes in illumination [5]. Besides that, Inertial measurement unit or IMU had the advantage of high sample rate, tiny size and weight so it wouldn’t affect player’s performance much, no hidden spot, portable, low cost and suitable to use at real training condition. IMU is widely

used on vibration and impact detection, low velocity movement like gait and jogging, and detect orientation.

Hassan Ghasemzadeh had introduce a sensor-based quantitative model which takes into consideration signal processing techniques on the collected data and quantifies the correctness of the performed actions by a Golf player [10]. Linear projection methods, PCA and LDA which used as classification and dimension reduction technique used in this project to build a regression model which can provide feedback on quality of movements for the purpose of training. The model is able to provide information on quality of golf swing with respect to angle of wrist rotation. This model is good for gather the information on quality of swinging movements with the player wrist rotation which is suitable to apply on Badminton game but this method required at least five sensors to collect enough data for accurate analysis.

Thomas Jaitner and Wolf Gawin had develop a mobile device to quantify the influence of variables that describe movement of arm on parameters of racket acceleration and shuttlecock speed by using Pearson's correlation analysis [11]. He stated that about 70% of the variance of the shuttle velocities can be explained by the acceleration of the racket. And the remaining 30% might be explained by racket properties such as string stiffness and string gauge. Gowitzke also stated that around 53% of shuttle velocity can be explained by the last rotation performed by shoulder and elbow [12].

El-Gohary proposed to combine kinematic models designed for control of robotic arms with state-space methods to directly and continuously estimate human joint angles from inertial sensors [13]. They developed an inertia tracking algorithm and compare with unscented Kalman filter (UKF) based method. These algorithms can be applied to any combination of synchronized sensors and suitable for both regular and fast speed movement.

Despite sensor for motion analysis being widely available, sensor-based assessment for badminton skill is currently unavailable. Since badminton is one of the most thriving sports in Malaysia, it is reasonable to investigate methods to make it easier to train more badminton players without being too dependent on the availability of expert coaches. Players who do not have coaches to train them could use these sensors to rate their own performance, improve their skills while avoiding movements that will lead to long term injuries. Even players with coaches sometimes have to train on their own without supervision and these sensors could help record their data for real-time feedback or post-analysis.

The main aim of this project is to investigate and create a database of sets of movements in badminton training to differentiate the good movements that enhance performance from the bad movements which potentially lead to musculoskeletal injuries. Besides investigation sets of movements in badminton training, this project also aims to identify crucial kinematics parameters to quantify badminton skill levels. The performance of elite players will be studied to identify benchmark values for these measurable parameters. A quantitative model will be proposed using these measurable parameters to help in the objective assessment of skill levels. This will help badminton players to improve their techniques and prevent some sports injuries, as well as providing an objective measurement to assess badminton skills.

2.0 METHODOLOGY

2.1 Interview Section

Interview had been conducted for three badminton players comprising a state elite player, a coach and a casual player. Some useful information had been obtained about training and expectation on modern techniques. From these interviews, we found that the conventional badminton training is focused on skill and stamina training. The badminton coach stated that the modern training technology should be able to track the position of shutter lock and player location to determine the agility and skill of a player. Several algorithms need to be proposed and tested in producing the most precise and accurate evaluation of badminton players movements. The best way to achieve this is through collaboration with BAM (Badminton Association Malaysia), sports center, players and coach where pilot study can be conducted and feedbacks can be obtained from groups of interest.

2.2 Hardware sourcing

An inertial measurement unit, or IMU, is an electronic device that measures and reports on a craft's velocity, orientation, and gravitational forces, using a combination of accelerometers and gyroscopes, sometimes also magnetometers. IMUs are typically used to manoeuvre aircraft, including unmanned aerial vehicles (UAVs), among many others, and spacecraft, including satellites and landers. Recent developments allow for the production of IMU-enabled GPS devices. An IMU allows a GPS receiver to work when GPS-signals are unavailable, such as in tunnels, inside buildings, or when electronic interference is present. In this project, a wireless IMU device will be used to collect data from athletics.

Opal sensor from APDM INC. [9] had been selected in this project. Opal sensor is a miniature, wireless inertial measurement unit that can both log kinematic data and stream it in real-time continuously for over 8 hours. A wireless network of up to 24 Opals is possible, maintaining time-synchronization of ≤ 1 ms between Opals. WIMU like Opal sensor is useful to collect the kinematics value from athletics. Zepp Tennis sensor and X-IMU sensors also been considered in this project to validate the Opal sensor.

2.3 Experiment Setup

Experiments had been conducted for the purpose to validate the selected sensor and for data collection for smash performance. Figure 1 shows the axis of selected WIMU.

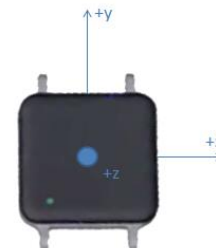


Figure 1 Axis of APDM Opal sensor

Then the sensors are attached on wrist and right arm of the subject as shown in Figure 2 where sensor A is attached on the arm and sensor B is attached on the wrist.

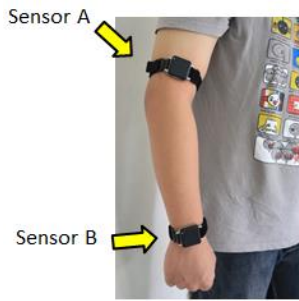


Figure 2 Opal sensor are attached on subject's arm and wrist

2.3.1 Experiment 1–Swing hand 180° upward

The objective of this experiment is to provide a simple movement that can be used as references for other complicated Badminton stroke like smashing. This experiment also aims to validate the Opal sensor. Figure 3 shows that the subject swinging hand upwards around 180°. The swinging are repeated 4 times.



Figure 3 Flow of Experiment 1

3.0 RESULTS AND DISCUSSIONS

In this project, the Opal sensors which are attached on subject's body are used to measure the kinematics parameters like acceleration, rotational velocity, magnetic force, temperature and orientation. Then, there are a APDM station that play the role to collect data via Bluetooth technique and transfer it to a PC application called APDM Motion Studio.

3.1 Data Analysis

The collected data during Experiment 1 is shown in Figure 4 where Sensor A represent the Arm Sensor and Sensor B represent the wrist sensor. From the graph, we can observe that there are total 4 minor changes for all accelerometer, gyroscope and magnetometer which show that the 4 swinging performed by subject in experiment 1.

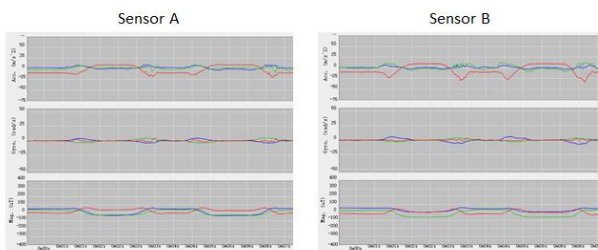


Figure 4 Acceleration, rotational velocity and magnetic impact of sensor A and sensor B

Then, from the collected orientation value, Euler angle had been calculated by using MATLAB. From Figure 5, we can clearly observe that there are around 180° swinging for 4 times in the graph.

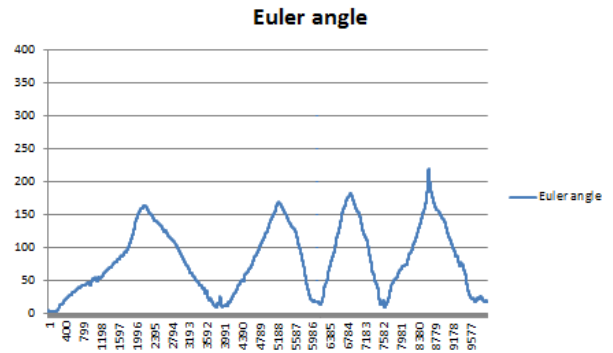


Figure 5 Euler angle of Experiment 1

From this experiment, we observed that the sensor is stable and validate for further study and experiments in this project due to its accuracy and the data of this experiment will become the references of future experiment such as smashing movement and etc.

4.0 CONCLUSIONS

From this stage of study, the most expected outcome is to identify the benchmark value of crucial parameters that affected player's skill performance, an objective assessment is expected in this project. A study and review of investigation of sensor-based quantitative model for badminton skill analysis and assessment need to be continuing more in depth. The full training model for the purpose of improve player skill is expected in the future research. Other experiments which is focus on Badminton stroke like smashing, clear, drop and service will be conducted among larger population of sample subject who involve various level Badminton player from casual player to professional player. Position of player on the game court should be detected in future research to obtain a more completed automatic Badminton skill evaluation system.

Acknowledgement

The authors would like express their gratitude to Universiti Teknologi Malaysia. This work is supported by the Universiti Teknologi Malaysia Research grant 04H66 and 08J91.

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