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Kinect-based Badminton Motion Sensor as Potential Aid for Coaching Strokes in Novice Level

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Abstract

Objectives: In this paper, we explore the potential of Kinect-based motion sensor as an aid for coaching badminton stroke in novice level. **Methods:** To determine the potential use of Kinect-based motion sensor as an aid for coached, we need to determine the difference between human observation and system analysis on a badminton stroke. Both human observation and system analysis will be used to determine the mistakes made by novice players. **Findings:** For a coach to properly analyze a stroke movement, multiple tries of action will need to be performed by an athlete in order for the coach to properly recognize the mistakes. Generally, a coach will focus on the important section of the stroke and tries to correct the movement. By utilizing the Kinect-based motion sensor, the system can cover a wider range of area of the human body. The system also properly quantifies the movement so that the coach can determine the severity of the mistake done by the athlete. Manual observation can only provide a qualitative point of view of the movement. **Improvement:** The system can offer to modes of comparison, benchmarking against different athlete especially better athlete and monitoring consistency of the stroke movement. Improvements can be made to automatically categories the stroke to determine the stroke's quality.

Keywords: Badminton Stroke, Kinect, Movement Comparison, Qualitative Stroke Performance

1. Introduction

Badminton is a racket sport played throughout the whole world. The game was developed in British India during the 18th century. Originally named poona, the name badminton was given by badminton house by the Duke of Beaufort in the English county of Gloucestershire. The sport's popularity has enabled it to be featured in Summer Olympics in 1992 at Barcelona. In addition to the Summer Olympics, various levels of tournaments had been introduced by Badminton World Federation (BWF), the primary governing body of the game internationally[1]. Level 1 tournament consist of BWF World Events such as BWF World Championships, Thomas Cup (World Men's Team Championships), Uber Cup (World Women's Team Championships), Sudirman Cup (World Mixed Team Championships). Level 2 tournament consist of BWF World Super series. Level 3 tournament mainly consist of Grand Prix while level 4 tournament are made up of BWF events. Badminton demands excellent fitness, precision, strength, aerobic stamina, speed, agility, motor coordination and tactical skills[2]. To properly develop these skills, elite players spends a good amount of time in training in order to master these skills.

The basic form of the game is called the stroke. Stroke is an action where a player strikes a shuttle using a racket. There are various strokes that an elite player must master in order to control and dominate a game. The stroke consists of three stages: the ready phase, the strike phase and the recovery phase. For a novice player who started the journey to learn the proper stroke, there are a few options that can be chosen, engaging a coach, watching a video or reading up a book. The most effective method will be engaging a coach as there is interaction between the coach and the player to point out the player's mistake during the execution of the stroke while the latter methods simply depend

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on the player's imitation skill to imitate the shown action. For a coach to assure the player's stroke is acceptable, several factors must be taken into account such as the stance, position of different body joints in each stroke phase, the grip on racket in each stroke phase and joint movements.

For novice level, the coach would first demonstrate the movement, by breaking down major movement as necessary so that players can imitate the motion. Then the coach will observe how the player execute the stroke first by observing the lower part of the body, position of the foot in ready stance, movement of the foot during the stroke, and the recovery movement. Any mistakes done by players are corrected there and then by the coach until the movement is deemed satisfactory to the coach. The next area for the coach to focus is the upper body region, which consists of swinging motion of shoulder, arm, wrist and the racket grip. The final observation is then focused on the quality of the shot, to make sure the player attains the needed accuracy to place the shuttle on the desired spot. This process of observation and correction takes a lot of effort from both the coach and players. The coach will need to observe the same stroke motion several times to determine the mistakes done by the player.

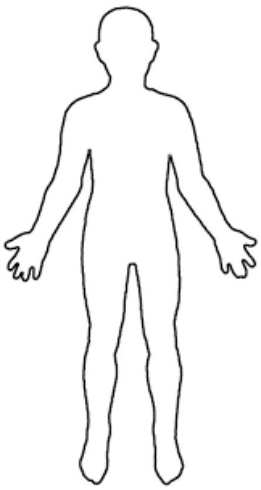

Figure 1. Human figure for coach to evaluate.

There are several methods to utilize technology to aid in analyzing the quality of the stroke. Among the work done are in smashing[3-6], service[7-9] and swinging motion[10]. All these works involved marker sensors, with attachment to the players' body or the racket itself. Sensors attached to the player or racket will affect the quality of strokes because of added weight and might hinder player movements. In order to overcome this challenge, an alternative method to analyze the quality of stroke is vision-based analysis using Microsoft Kinect by[11]. This marker less method has an advantage compared to marker-based sensors because the player has total freedom in their action without the extra weight or obstacle hindering their strokes.

2. Problem and Research Experiment

In order to detect mistakes or bad habits in a stroke, a coach will need some time to observe the player performing the stroke. The coach will have to focus on certain section of the body to make sure the action is flawless and move on to the next section. It is impossible for the coach to detect the mistakes done by the player at first glance. During this process, the player might still make the same mistake that had been corrected by the coach.

The experiment was designed to determine the ability of a coach to detect mistakes made by a novice player. The mistakes are the differences between the strokes performed by the players against the strokes done by elite player. In this research four coaches were chosen to access strokes performed by two right-handed novice players. The coaches have an average of six years of experience in coaching badminton players while the two novice players have an average of four months of playing badminton experience without guidance from a coach.

The experiment began with an elite badminton player, a state player with ten years of competition experience to perform two strokes, a forehand lift and a backhand lift. These two strokes are chosen because they are among the most common stroke and our vision motion sensor produced good results with the two strokes[12]. The two strokes were recorded with a Kinect-based motion sensor developed with Microsoft Kinect as a reference. The next phase of the experiment involves the two novice players performing the same stroke without having watched the stroke performed by the elite player. The total number of the same strokes performed by the players is five for each stroke. The number of strokes done by the player is to determine the players' consistency in performing the strokes and to determine if the coaches can detect the region of each stroke with the mistakes. The coaches were given a shown in Figure 1 for them to circle the region where the novice players perform differently from the elite player.

The main objective of this research is to gather coaches' opinion on the difference made by novice bad-

minton players by comparing the novice badminton players' stroke with the stroke made by an elite badminton player. All the strokes done by the novice players will be recorded by Microsoft Kinect so that each stroke can be used to bench marked against the reference stroke to determine the difference in each region.

3. Results from Coaches and Kinect

The following tables show the summary of the results collected from the coaches as well as the results shown in the Kinect-based motion sensor system. In this research, we categorized the region of player body according to the following according to Table 1.

Table 1. Region Category

Region	Area Covered	Acronym
Head	Head	H
Right Arm	Right shoulder, Right elbow, Right wrist, Right hand	RA
Right Leg	Right knee, Right ankle, Right foot	RL
Center	Left Hip, Right Hip	C
Left Arm	Left shoulder, Left elbow, Left wrist, Left hand	LA
Left Leg	Left knee, Left ankle, Left foot	LL

Based on Table 2, the coaches can easily detect the main area mistake of the players, which is the arm area as it is the main motion for the stroke. Certain region such as the left arm area was detected on a letter attempt by the players.

Table 3 show the results generated by the vision based motion sensor. The area shown by the system with mistakes was based on the difference between the stroke performed by the player against the reference stroke performed by an elite player. Figure 2, 3 the percentage shows the similarity of the stroke between the two players. The higher the percentage, the similar the movement of a joint. Any joint that shows less than 90% similarity will be considered as a mistake done on the novice player. Table 3 shows that the system detected more area with difference than the elite layer than what the coaches had identified.

Table 4 shows the overall similarity of the players with the elite player. The percentage is relatively high because the central region and the lower body region scores higher percentage as there is not much movement. Table 5, 6 shows the breakdown of the region of Table 3 where the system detected the difference with similarity lower than 90%.

4. Results and Discussions

Based on the results given by the coaches and the results generated by the system, there is a significant gap in the

Table 2. Results from coaches

Players' Attempt	Mistakes Detected by Coaches			
	Player A Forehand Lift	Player A Backhand Lift	Player B Forehand Lift	Player B Backhand Lift
1st	RA	RA	RA	RA
2nd	RA	RA	RA	RA
3rd	RA	RA	RA	RA
4th	RA, LA	RA	RA	RA, LA
5th	RA, LA	RA	RA	RA, LA

Table 3. Results from Kinect motion sensor

Players' Attempt	Mistakes Detected by Kinect			
	Player A Forehand Lift	Player A Backhand Lift	Player B Forehand Lift	Player B Backhand Lift
1	RA, LA	RA, LA, H	RA, LA, H	RA, LA
2	RA, LA	RA, LA	RA, LA, H	RA, LA
3	RA, H	RA, LA	RA, LA, H	RA, LA
4	RA, LA, H	RA, LA	RA, LA, H	RA, LA
5	RA, LA, H	RA, LA	RA, LA, H	RA, LA, H

Table 4. Overall similarity of stroke with reference

Attempt	Similarity with reference (%)			
	Player A Forehand Lift	Player A Backhand Lift	Player B Forehand Lift	Player B Backhand Lift
1	93.91	89.60	86.75	91.22
2	94.44	93.07	81.84	92.02
3	94.34	90.80	86.35	90.02
4	92.44	95.54	82.47	93.16
5	91.36	93.99	83.87	87.94

ability to differentiate badminton stroke motion between the two evaluators.

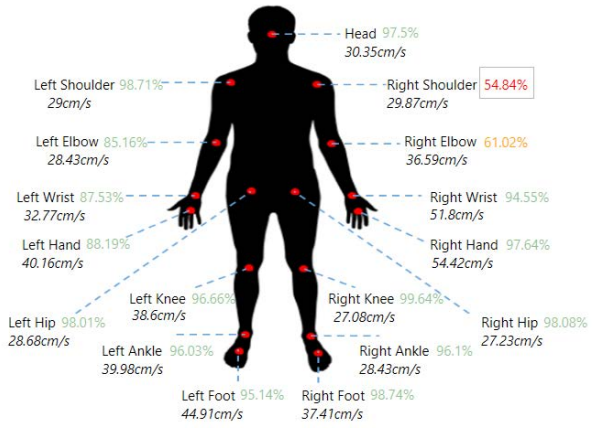

Figure 2. Difference between Player A forehand lift against the elite player.

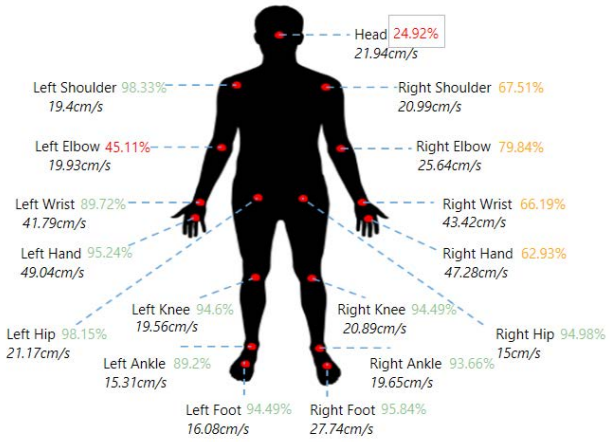

Figure 3. Difference between Player B backhand lift against the elite player.

The Kinect-based motion sensor detects more regions with differences with the reference sample, mainly the left arm region and head. In general, the coach will focus the few strokes on the hand arm area of the player because it is the most important region of the stroke. The quality of the shot depends a lot on the correct motion of the main arm region which leaves the left arm area and the head unattended during early observation. With the system as an aid for coach in future training, the coach can detect more regions with difference against their reference stroke motion. Players and coach needs less time and effort to detect the player's mistakes.

Table 5. Player A's similarity (%) with reference according to region

Attempt	Forehand Lift			Backhand Lift		
	RA	LA	H	RA	LA	H
1	82.6	89.1	95.6	71.2	89.1	85.5
2	83.5	89.2	94.3	75.6	89.3	96.7
3	83.0	90.2	84.5	78.3	88.9	97.5
4	8.5	89.1	75.6	79.2	88.8	96.8
5	84.7	89.6	77.8	81.5	86.5	93.9

Table 6. Player B's similarity (%) with reference according to region

Attempt	Forehand Lift			Backhand Lift		
	RA	LA	H	RA	LA	H
1	73.6	83.2	42.7	66.5	89.1	90.7
2	75.8	85.3	24.9	67.1	89.3	90.8
3	74.8	84.5	76.7	71.7	88.9	95.6
4	78.1	85.2	60.8	69.5	88.8	93.8
5	69.5	86.5	49.3	68.3	79.9	82.5

Another significant result is that the results given by the coaches were all in qualitative form while the Kinect-based motion sensor provides quantitative results. The

Kinect sensor shows the similarity action down to the individual joints. The Kinect sensor will show which area or joints with the most significant difference with the reference sample. This result will greatly help the coach to detect the non-essential area earlier so that the mistake will not develop into a bad habit. Quantitative results will alert the coach and player if the similarity is too far apart; this allows the coach to pay more attention to the specific area or even specific joints.

5. Conclusion

In conclusion, we have identified the Kinect-based badminton motion sensor to be a suitable aid for coach during training session. The Kinect sensor can detect all area with difference with reference sample than the coach, who needs several tries of stroke to be able to detect all the differences. The Kinect sensor is able to quantify the results to show critical area that the coach should pay attention to. The sensor can accurately pinpoint specific joint to pay attention to.

To further enhance the sensor, efforts will be focused on quantifying the stroke data to produce the range in which a stroke is considered acceptable with no mistakes. The data will be used to categorize the quality of the stroke into several categories. This effort will need participation of players with different level of skills. Through this effort, a player can relate their skill level by using the sensor, making benchmarking easier without a coach's presence.

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