

# A Smart Position Optimization Scheme for Badminton Doubles Based on Human-computer Interactive Training in Wireless Sensor Networks

Bo Yao (✉ [huangzheng529sjp@163.com](mailto:huangzheng529sjp@163.com))

Dalian Maritime University

Na Liang

Dalian Maritime University

---

## Research

**Keywords:** Multimedia human-computer interaction; Badminton doubles; Station optimization; Wireless sensor networks

**Posted Date:** September 23rd, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-23101/v4>

**License:**  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

**Version of Record:** A version of this preprint was published on November 12th, 2020. See the published version at <https://doi.org/10.1186/s13638-020-01847-6>.

# A Smart Position Optimization Scheme for Badminton Doubles Based on Human-computer Interactive Training in Wireless Sensor Networks

Bo Yao<sup>1\*</sup>, Na Liang<sup>2</sup>

<sup>1</sup>Physical Education Department, Dalian Maritime University, Dalian 116026, China

<sup>2</sup>Public Administration and Humanities Faculty, Dalian Maritime University, Dalian 116026, China

E-mails: huangzheng529sjp@163.com

**Abstract:** In the continuous development process, robot technology based on multimedia interactions has been widely used in aerospace, medical, education and service industries. The relationship between robots and humans is getting closer. The improvement of robot intelligence is a process of continuously learning the outside world. Since 1959, multimedia human-computer interaction technology has provided more and more technical support for human research robots. In this paper, we firstly study the characteristics of badminton competition, including the technical characteristics, tactics characteristics, and the collection requirements about on-site training. The technical description of the badminton doubles station is also completed. Furthermore, in terms of the digitalization of the gait-based sensation, the automated acquisition of the gait technology, the simultaneously with the video, and the high-speed imaging system, the system implement information is integrated. After that, badminton multimedia techniques and tactics are designed based on the extensive statistical analysis. The skills and tactics of athletes are expressed in the form of video, graphics and text. Finally, the operators can carry out the technical and tactical analysis processes through good human-computer interactions. This increases the end user's game information. The related attention and understanding can strengthen the strength and depth of technical and tactical ability analysis. Thus, we propose the station optimization plan for badminton doubles.

**Keywords:** Multimedia human-computer interaction; Badminton doubles; Station optimization; Wireless sensor networks

## 1. Introduction

With the development and progress of science and technology, robot technology has been widely used in aerospace, medical, education, service industries and other fields. In this process, the robot is accessible to ordinary people [1]. Airports, restaurants and other local service robots are getting closer to people, and people are indispensable for the control of robots. People are more concerned about robots' understanding of human intentions, so the intelligence and safety of robots are now extremely important [2]. Humans have put forward higher requirements for robots, so that robots can serve humans more humanely. Human-computer interaction has always been the focus of robotics research. A successful interaction often relies on more factors, such as whether the interaction is acceptable or not; in a restricted environment, interaction can work better [3]. Therefore, in order to improve the recognition of human-computer interaction by the society, the primary problem to be solved is the adaptation of the robot to the characteristics of the human body [4].

Robots participate in human activities and coexist with people called human-computer interaction [5]. The purpose of human-computer interaction exists in a knowledge channel that opens up the interaction between humans and robots. After decades of development, human-computer interaction technology is mainly divided into the following aspects [6]. TTS (Text to Speech) technology allows the machine to speak, its success is based on the foundations of linguistics and psychology, with the help of a speech processor that converts text into speech output through a hidden Markov model. TTS is widely used in computer human-computer interaction. It can help people with perceptual disabilities to read information on the computer, or simply to increase the readability of text documents [7]. STT (Speech to Text) technology can convert speech into text output. It is based on engineering acoustic models and language models, and converts speech into text through hidden Markov algorithm. It is used in many fields, such as voice control in in-vehicle systems, and voice recognition technology in the medical field can play a role in both medical front-end systems and terminal systems. Introducing speech recognition technology into robot embedded speech recognition system [8], designed a local speech recognition system and an online Google speech recognition system, which successfully demonstrated the role and advantages of speech in human-computer interaction [9].

Image, as a medium of human-computer interaction, is a recognition technology based on robot vision [10]. Image interaction uses hardware such as a camera to replace the visual function of the human eye, so that the robot can complete the processing and recognition of the surrounding environment [11], machine vision technology mainly includes image acquisition and acquisition, image transmission and post-processing [12]. The acquisition of an image actually converts the image visible to the human eye into a matrix for storage, and the process is reversible. Image transmission and post-processing technologies mainly include image segmentation, image sharpening, image encoding and decoding, and image feature extraction. Image processing technology is widely used in the field of robotics, such as target positioning based on image processing and recognition, and facial recognition based on image processing [13]. Data interaction is the most traditional but

also the most important form of human-computer interaction. It completes the human-computer interaction task by inputting interactive commands to the machine to the computer to complete the instructions, and continuous data interaction. The input data is not limited to any one format, and the input content is also diverse. It can be either a control command or a voice or image [14]. In addition to the three ways of human-computer interaction mentioned above, sometimes people use their own body movements to interact with the robot to achieve more effective interaction. The action interaction is usually obtained by first acquiring the human body posture (joint coordinates, etc.) through the sensor and then completing the interaction pre-defined task [15]. Motion interaction requires the robot to have a strong sensory ability to capture human motion. The interaction of the action is relatively high for the robot, because the number of joints is generally large, and the amount of data processing is relatively large. The interaction between motion and speech is the focus of this paper. The Kinect sensor is used to acquire human joint data, which is sent to the robot for human-computer interaction [16].

Aiming at the above-mentioned problems in the badminton doubles game, the characteristics of the badminton doubles game, the characteristics of technical and tactics and the collection requirements of on-site training are studied, and the technical description of the badminton doubles game is completed. By automatically acquiring gait-based digital technology and synchronizing with video and high-speed imaging systems, the system realizes information integration. Subsequently, a statistical analysis of badminton multimedia technology and tactics was designed. The skills and tactics of the athletes are expressed in the form of video, graphics and text. This technology provides a reference for the technical and tactical development of badminton doubles.

The rest of this paper is organized as follows. Section 2 is our recommended badminton doubles position optimization. Section 3 is about performance analysis. Section 4 is about the experimental results. Section 5 is the conclusion and future work.

## 2. Our proposed Position Optimization of Badminton Doubles

Robot motion simulation learning is divided into basic behavior imitation and imitation learning based on control strategy [17]. The imitation of basic behaviors is first to establish a basic library of motion behaviors. First, the basic behavior library is gradually enriched through motion simulation, and then more complex control strategies are proposed. Finally, complex motion learning is realized according to the scene, and the complexities obtained based on the basic behavior library Technical action [18].

### 2.1 Robot motion simulation steps

Remote control of robots has always been an interesting research topic, and motion is the most intuitive way to remotely control robots. For humanoid robots, replicating the motion of the human body has always attracted the attention of robotics researchers. For most people, programming humanoid robots is not easy. For example, drag-and-drop actions can be programmed to create a reliable program interface, but an experienced controller is still needed to perform stable and reliable actions to imitate a robot. Therefore, a somatosensory device is introduced to obtain the joint parameters of the human body, which are then converted into joint parameters and sent to the robot to replicate the actions [19].

#### 2.1.1 Virtual coordinate system establishment and coordinate conversion

Since the joint space of the human body is to be converted into the joint space of the robot, this test is selected. The coordinates of Kinect are the original coordinates, and the coordinate space of the robot is the destination coordinates. As can be seen from the foregoing, the torso plane of the robot is the you coordinate plane, and the right shoulder to the left shoulder direction of the robot is the positive direction of the Y axis. According to the Cartesian coordinate system criterion, the x axis is perpendicular to the you plane, and the orientation of the robot is defined as the positive direction of the x axis [20].

Assume that the three points  $A$ ,  $B$ , and  $C$  represent the torso (Spine), the middle point of the shoulder (Shoulder center), and the head (Head). Its spatial coordinates are  $A(x_1, y_1, z_1)$ ,  $B(x_2, y_2, z_2)$  and  $C(x_3, y_3, z_3)$ . Therefore, according to the vector operation, the direction vector of the torso to the middle point of the shoulder can be obtained as:

$$\overrightarrow{AB} = (x_2 - x_1, y_2 - y_1, z_2 - z_1) \quad (1)$$

Therefore, for the human joint acquired by Kinect, the direction vector between every two joints can be marked with their respective coordinates. The vector  $\overrightarrow{dv1}$  represents the shoulder left to elbow left vector, and the vector  $\overrightarrow{dv2}$  represents the shoulder left to shoulder center vector. When any two direction vectors  $\overrightarrow{dv1}$ ,  $\overrightarrow{dv2}$  are determined, the angle of the direction vector can be found according to Eq. (2).

$$\cos \theta = \frac{\overrightarrow{dv1} \cdot \overrightarrow{dv2}}{|\overrightarrow{dv1}| \cdot |\overrightarrow{dv2}|} \quad (2)$$

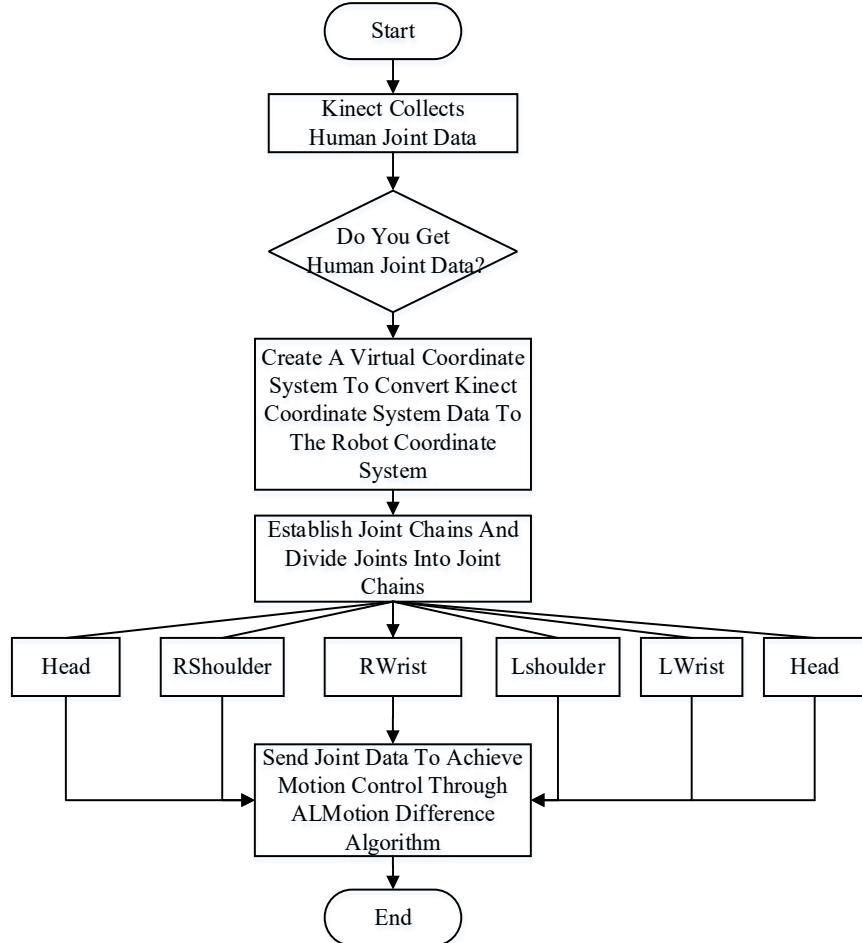
The value  $\cos \theta$  range is  $[-1,1]$ . When  $\cos \theta$  taking a certain value. If the angle  $\theta$  between them is  $[0,1]$ , the value  $\theta$  range is  $[-180, 180]$ . Thus, it leads  $\theta$  to the angular quadrant to be two values. To solve this problem, we calculate elbow left ( $z_2$ ) and shoulder\_left ( $z_1$ ). The difference in depth values between the two joints ( $z_3$ ) determines the direction of the arm. When this algorithm is used, the demonstrator must stand upright in front of the Kinect and in the direction of Kinect [21]. The direction vector for any two joints can be determined by the following method.

$$\begin{aligned}
 z_3 &\leftarrow z_2 - z_1 \\
 \text{if} \\
 z_3 < 0 \\
 \text{then} \\
 -\theta &\leftarrow \theta // \theta \text{ choose positive} \\
 \text{end if}
 \end{aligned} \tag{3}$$

Using the above method, the direction vector of any two joints can be determined, and the angle between any two joints can be determined according to the difference between the depth values of the joints.

## 2. 1.2 programming implementation

The Kinect sensor is used to obtain the spatial coordinates of the 20 joints of the human body, and then the coordinate system is converted to the target coordinate system. Since the unit of data acquired by Kinect is the angle, the unit of the robot motion control is radian, and the angle to radian needs to be made before being sent to brain. As mentioned above, human joints and robot joints do not form a one-to-one correspondence, so some joints are not involved in this test. The overall program flow framework is shown in Figure 1[22].



**Figure 1** Robot simulation process

(1) Set Kinect human bone tracking to passive mode, when the relevant bones are tracked to obtain their position data and save, and use HashMap to quickly find joint data;

(2) Establishing a virtual coordinate system, converting the Kinect coordinate system data to the robot coordinate system;

(3) Establish a joint chain that divides the human joint into individual joint chains. Calculate the angle data of each degree of freedom of the robot separately;

(4) Compare the K coordinate values of each joint with Kinect and determine the robot motion angle quadrant. When the value is negative, assign the negative of the angle to the true value of the angle;

(5) Create a robot AL Motion module and send the data to the robot to simulate the robot motion on the simulation platform.

## 2.2 Kalman filtering based robot motion simulation optimization

Kalman filtering is a filtering algorithm invented by Rudolf E. Kalman. The Kalman filter is a highly efficient recursive filter based on linear functions and hidden Markov models. The true state of the prediction system in a series of incomplete or noisy systems. The state of the system is represented by a Markov chain, and the noise of the system conforms to the distribution characteristics of Gaussian white noise. When the system changes, a new state is generated by the Markov chain and new noise is added. For systems with control states, their control state equations are also added. A discrete control system is introduced into the description of Kalman filtering, which can be described by a linear stochastic differential equation [23].

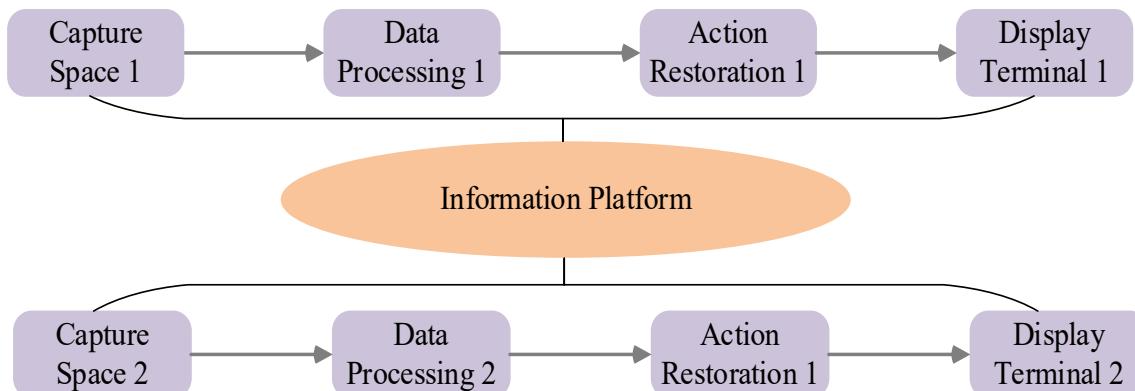
$$X(k) = AX(k-1) + BU(k) + W(k) \quad (4)$$

Then, the system variable are defined as follows:

$$Z(k) = HX(k) + V(k) \quad (5)$$

In which,  $X(k)$  represents the current state of the system,  $X(k-1)$  represents the state at the previous moment of the system, and  $U$  (persuades the control of the system at the current time. System state and system control). The parameters are  $A$  and  $B$  respectively. For simple systems, the values are constant. For complex systems, the values are matrix. In Equation 4,  $Z(k)$  represents the measured value of the current system, and  $H$  represents the system. Measuring parameters, the value of a simple system is a constant, and the value of a complex system is a matrix.  $W$  in Equation 3 the illusion represents the process noise and measurement noise of the system respectively [24]. In general, they It is assumed to be Gaussian white noise, which mimics the system, and its values are  $Q$  and  $R$  respectively [25].

When the system is linear and is a stochastic differential system, Kalman filtering is an ideal signal processor when measuring noise and white noise are Gaussian. The optimal solution process obtained by the Kalman filter includes the following 5 steps [26]. Double-player action recognition structure diagram is shown in Figure 2.



**Figure 2** Double-player action recognition structure diagram

(1) Use the process model of the system to predict the state of the system at the next moment. Assuming that the current system state is  $X(k)$ , the state in which the system is predicted based on the previous state of the system is predicted, as shown in Equation 6.

$$X(k | k-1) = AX(k-1 | k-1) + BU(k) \quad (6)$$

In which, the result of predicting k time using k-1 time is represented.

The optimal result of the system at time  $k-1$ ,  $U(k)$  represents the current control of the system. In the robot motion simulation system, since there is no additional control, its value is  $O$  [27].

(2) After the first step of calculation, the results of the system have been updated. The principle of Kalman filtering is based on the recursion of covariance. It can be seen that the relative covariance  $X(k | k-1)$  has not been updated. Using  $X(k | k-1)$  for the corresponding covariance can be expressed as shown in Equation 7 [28].

$$P(k | k-1) = AP((k-1 | k-1)A' + Q \quad (7)$$

In which,  $P(k | k-1)$  is the corresponding covariance,  $P((k-1 | k-1)$  is the corresponding covariance  $X(k-1 | k-1)$ , and the transposed matrix of  $A$  is  $A'$ . The  $Q$  described above represents the process variance of the system. Equations 5 and 6 above are the formulas for Kalman filtering to predict the system [29].

(3) Collect the measured values of the current state. The Kalman filter can derive the current system's optimal estimate  $X(k | k)$  based on the predicted values and measurements of the system, as shown in Equation 8.

$$X(k | k) = X(k | k-1) + Kg(k)(Z(k) - HX(k | k-1)) \quad (8)$$

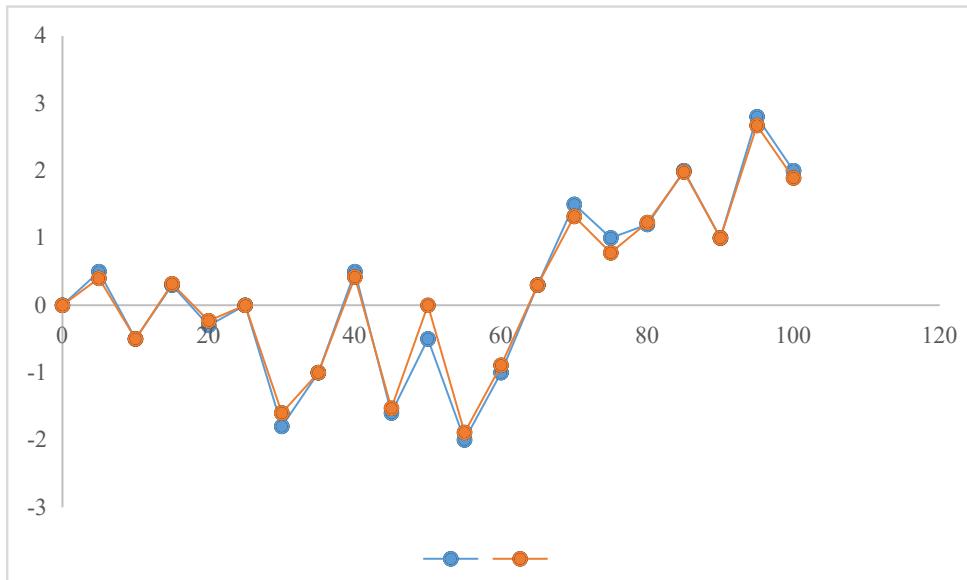
In which,  $Kg(k)$  is the Kalman gain, as shown in Equation 9.

$$Kg(k) = \frac{P(k | k-1)H'}{HP(k | k-1)H' + R} \quad (9)$$

After the first three steps, the optimal solution of the system has been obtained. Kalman filtering is based on the recursion of covariance in order to make the model smoother. The model continues to run continuously, and the covariance of the system is constantly updated, as shown in Equation 10.

$$P(k | k) = (I - Kg(k)H)P(k | k-1) \quad (10)$$

In order to complete the recursion of the algorithm  $P(k | k)$ , when the system enters the next moment, it represents  $P(k | k-1)$ . After accepting the data acquired by Kinect, the robot obtains new data by Kalman filtering according to the state equation of the system itself, which is more accurate than the data sent directly by Kinect. In addition, Kinect has been sending data to the robot. Uses Kalman filter to bring the predicted value closer to the true value is shown in Figure 3. After Kalman filtering, the data transmission will not be shaken, keeping the motion imitation smooth [30].



**Figure 3** Uses Kalman filter to bring the predicted value closer to the true value

### 3. Performance Analysis

The system design must be based on the scientific guidance and scientific training requirements of the coaches and athletes must meet the characteristics of the badminton sport [31]. Therefore, in the sports special technical and tactical ability analysis system based on gait tactile information recognition, the analysis of badminton technical and tactical information collection technology through badminton game technology and tactical description method is based on gait tactile information recognition [32]. According to the classification characteristics of badminton skills and tactics, design a comprehensive, accurate, convenient and efficient badminton technique and tactics description method, and then design a fast, high-precision acquisition method, and finally through a good human-computer interaction interface, thus ensuring gait-based [33].

#### 3.1 Badminton skills and tactics collection method

In the research background and status of the subject, a variety of technical and tactical statistical software are mentioned. It is mainly through the scientific research personnel to watch the live game and statistics on the technical and tactical information based on certain indicators. Whenever the technical action occurs at the game

site, the paper carrier or form prepared in advance is recorded [34]. The most primitive technical and tactical statistics are completed in this way. The accuracy of statistical analysis mainly depends on the scientific research personnel who operate [35]. Therefore, when using this method to collect technical and tactical information, they need to concentrate on it, otherwise it is easy to miss or misremember some important information.

With the advancement and development of computer technology, the computer replaces some of the manually collected work content, which improves the work efficiency to a certain extent, but also inherits all the shortcomings of manual collection. At present, there are two main methods for semi-manual collection and recording techniques: the first is to use some shortcut keys designed in advance, the operator can click to enter and enter the shortcut; the other is to use the keyboard or mouse to collect input technical and tactical information [36]. Then use some functional modules of the system to convert these technical and tactical information [37].

Automatic collection completely replaces manual collection, and the movement process is collected on-site through digital electronic automatic collection equipment. The device can analyze the collected data at the same time, and obtain statistical analysis results at the end of the game. Combined with the research needs of this project, the selection of the collection method is a combination of semi-manual collection and automatic collection, that is, on the basis of semi-manual collection of technical and tactical information, the footsteps of a large area are synchronously used to capture the footwork technical information of badminton players. And use the synchronized video information to correct the data. Although there are certain problems, semi-automatic collection is basically realized. A variety of collection methods complement each other to better realize the collection of technical and tactical information required by the project.

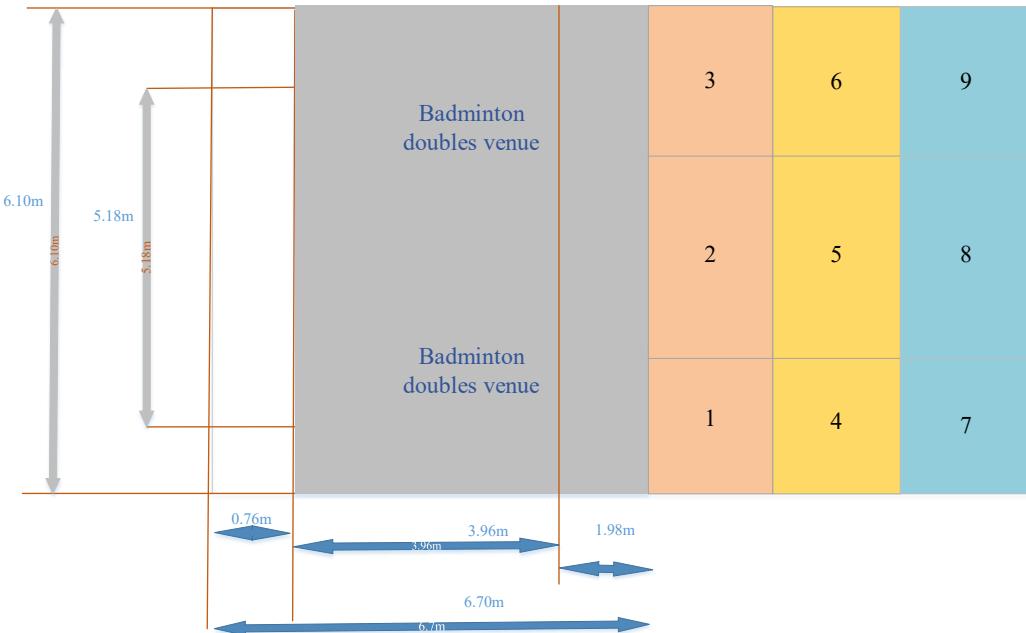
### 3.2 Digital venue based on gait touch

The Institute's automated collection of footprint information mainly utilizes the world's first developed flexible array sensor-based digital site in Hefei Intelligence of the Chinese Academy of Sciences. It can detect and acquire the shape, time and shape of the contact between the foot and the ground during human motion in real time. Information such as ground force and supporting force, so as to obtain the step size, stride frequency and action sequence of the human body, according to which the speed, acceleration and other information of the human body at the corresponding moment can be accurately obtained, and the kinematics and dynamics information can be synchronously acquired. The real-time nature of the system and project adaptability are also guaranteed. The overall technical level of the product is high. The data communication method adopts high-speed industrial Ethernet bus (multi-unit connection, 400 m interconnection has been realized), and the communication rate reaches 100 Mbps or more. The modular unit combination can realize large-area site laying requirements, and the single-point sampling speed reaches 1000 Hz. Comparison of various gait tactile pressure technical parameters is shown in Table 1.

**Table 1** Comparison of various gait tactile pressure technical parameters

	Digital Site	Texan Walkway	Rescan	SPI TACTILUS
Comprehensive precision (%)	5	10	5	10
Time resolution (Hz)	500	100	500	250
Space resolution (point / cm)	9	4	2.6	2.5
Unit sensitive (points)	90,000	50,688	16,384	4,096
Combination measurement area ( $m^2$ )	Configurable to any shape and face	1.39	0.62	0.62

The badminton court is a length of 13.40 meters, doubles width 6.10 meters, singles width 5.18 meters, doubles stadium diagonal length is 14.723 meters, singles stadium diagonal length = 14.366 meters. The badminton center is divided by the average net of the ball net, the height of the site is 9 meters, 2 meters around, the height of the poles on both sides is 1.55 meters, and the height of the middle net is 1.524 meters. There is no obstacle in the badminton court. Theoretically, it is divided into the front field, the middle field and the back field, but it is divided into the front field and the back field. The middle field is geometrically divided into the front field and the back field. In order to distinguish the inner boundary, the outer boundary area is also needed. Schematic diagram of badminton court is shown in Figure 4. Marked by the athlete facing the net, the course area is divided into the right front field 1, the left front field 2, the back field 3, the left back field 4, and the outer 0. At the same time, the system can also add a new effective area according to actual needs.



**Figure 4** Schematic diagram of badminton court

### 3.3 Badminton technique and tactics analysis method

The ultimate goal of collecting technical and tactical information is to effectively implement technical and tactical analysis. In training and competition, coaches, athletes and researchers can judge the athlete's game state based on gains and losses, offensive rate, defensive rate, tactical execution rate, and turnover score. By adjusting the training method, you can give full play to the athlete's ability, and finally provide training. The quality of the game. Coaches and researchers should also be able to better analyze training through footwork lines, areas for technical movements, and a round of video recordings of athletes during the game.

In the research of this project, technical and tactical analysis is mainly carried out from two aspects: technical and tactical data analysis and video analysis. First of all, according to the collected technical and tactical information, statistical analysis of the team's score, technique, area, footwork, action, offense and defense and other statistical data, and output in the form of graphs, such as statistical training of a single part of the score, situation, Overall game score, etc. At the same time, it can also analyze the route of footwork movement according to the corresponding query conditions. Users can watch the corresponding video clips and perform corresponding operations by reviewing the technical actions and tactics of each round.

### 4. Experimental Results

As shown in Table 2, the world's best badminton top men's doubles competition, the highest number of serve is the No. 1 area, accounting for 42.7% of the total number of shots, followed by the No. 5 area, the proportion is 27.6%, The proportions of Zone 3 and Zone 4 are 10% and 9.2% respectively. The proportion of District 2 and Zone 6 is 5%, 5.8%, and the area of Zone I, 2, and 5 in the front field is 0. 75. 2%, the rear field area 3, 4, 6 area accounted for 24.8%, indicating that the tee area of today's high-level badminton men's doubles competition is mainly concentrated in the front field area, and the back-field area is suitable for the serve when combining the front field. Make changes, especially in the top three areas, attacking them, and disrupting the opponent's pace of receiving the ball.

**Table 2.** The situation of the teeing area

	zone 1	zone 2	zone 3	zone 4	zone 5	zone 6
<i>Number of shots</i>	700	83	160	150	450	95
<i>Percentage</i>	42.7	5.0	10.0	9.2	27.5	5.8
<i>Average</i>	16.1	1.9	3.7	3.4	10.4	2.1

It can be clearly seen from Table 3 that in today's world's best badminton men's doubles players, mainly in the push and serve, mainly based on push and release technology, supplemented by other technologies,

combined with changes, increase the change of receiving and landing points, hit Chaos opponents back to the ball preparation strategy. Pushing the use of 45% of the tee-off technology, 30% of the game, the ball and the ball accounted for 12.7% and 5.6% respectively, the high ball, the ball, the ball and the ball took the lowest proportion.

**Table 3** statistics on the use of receiving technology

	<i>Push</i>	<i>Open Ball</i>	<i>Smash</i>	<i>High ball</i>	<i>Pounce the ball</i>	<i>Drop ball</i>	<i>Pick the ball</i>
<i>Number of beats</i>	757	501	207	20	9	27	107
<i>Percentage</i>	45	30	13	1.3	0.6	1.5	6.6

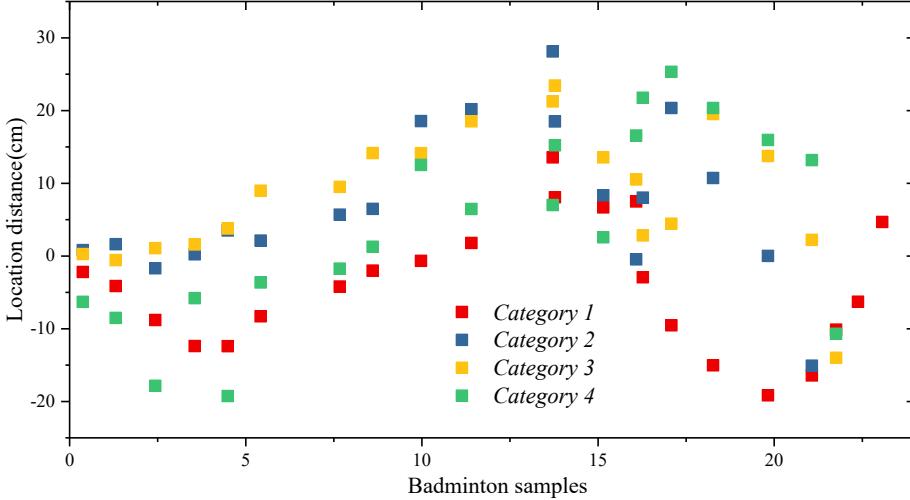
Analysis of the characteristics of the five pairs of combined full-field tactics is shown in Table 3. In today's badminton five single-level competition, the closest strength and the widest distribution is the male pair. At present, the top 7 men's doubles in the world are from Indonesia, Denmark, Japan, South Korea, Chinese Taipei, China and Malaysia. They play different ways, but their strengths are close and they have won each other. With the continuous improvement of the level of competition, the offensive and defensive imbalance in the men's doubles method is more and more prominent. The party with more offensive opportunities always has a higher probability of winning. Therefore, the focus of the men's doubles competition gradually moves from the middle and back field. Contest, turn to the contest of the mid-field control. The so-called air superiority is to see who can first grab the "high hitting point" initiative in the middle and front field, and then continue to pressure, forcing the opponent to pull the high ball, thus creating an offensive opportunity for themselves.

**Table 4** Analysis of the characteristics of the five pairs of combined full-field tactics

	<i>Average</i>	<i>Usage rate</i>	<i>Scoring rate</i>	<i>Loss rate</i>	<i>Fall rate</i>
<i>Frontcourt</i>	135.6	24.7	22.8	23.7	24.5
<i>Midfielder</i>	288.5	52.1	46.7	65.3	49.2
<i>Backcourt</i>	128.3	23.2	30.5	10.9	26.3
<i>Total</i>	552.4	100	100	100	100

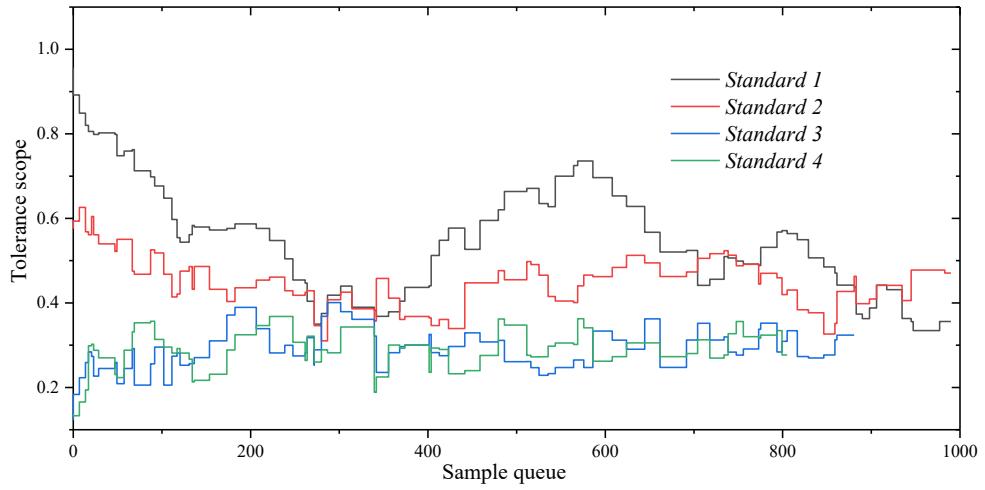
Among today's badminton doubles players, the percentage of total batting skills is the highest, and the percentage of midfield batting skills is the highest, accounting for 52% of the total batting skills. Excellent men's doubles players use flat opening techniques and fast closing techniques to make the ball pass through the net with a downward trend to seal the opponent, increase the difficulty of the opponent's recoil, and create opportunities for attacking the ball. The use rate of frontcourt and backcourt hitting skills are similar, accounting for 24.7% and 23.2% respectively. The frontcourt mainly uses push, racket and net play techniques to create favorable offensive opportunities for the next shot. The technology used in the backcourt is mainly the killing of offensive technology.

The kill chance in the backcourt has a lot to do with the use of frontcourt technology, so the ratio of the two is similar. In terms of scoring rate, midfield hitting technique scored the highest in these three regions, accounting for 46.7%. Compared with the frontcourt and the backcourt, the midfield has the highest use rate of batting techniques. The midfield draws the ball fast, the arc of the ball is relatively flat, and the landing point is far. It is very difficult to return the ball to the two players. At the same time, the midfielder shot rate is also the highest, accounting for 65.3%. The backcourt scoring rate is higher than the frontcourt scoring rate. The backcourt is 30.5% and the frontcourt is 22.8%. The backcourt scoring technique is mainly based on hitting and lobbing. The batting technique is mainly based on netting and swat. By watching the video, you can find that most offensive scores, backcourt and frontcourt are coherent, and this is an offensive chain. Adopt the "first attack, then attack" tactic. The prediction error of badminton position is shown in Figure 5.



**Figure 5** Badminton position prediction errors

Figure 6 shows the comparison of response errors of badminton based on wireless sensors. Using the "post-attack before the seal" tactical score is relatively easier to rely on the absolute attack ability score than the simple backcourt, the physical energy consumption is not so large, the scoring probability is high, and there is no easy to be countered by the opponent to implement the "defensive counterattack" tactics. From the point of view of the loss rate of the whole game, the midfielder has the highest score, and the loss rate of the frontcourt is higher than that of the backcourt. The frontcourt is 23.7% and the backcourt is 10.9%. The frontcourt is the "big battalion" of the world's best badminton men's doubles players. The front of the net is an important area for creating offensive opportunities. Through the techniques of front-end and light-shifting, the opponents are forced to passively play high-ball and create for the backcourt teammates. The backcourt is mainly to kill and sling.

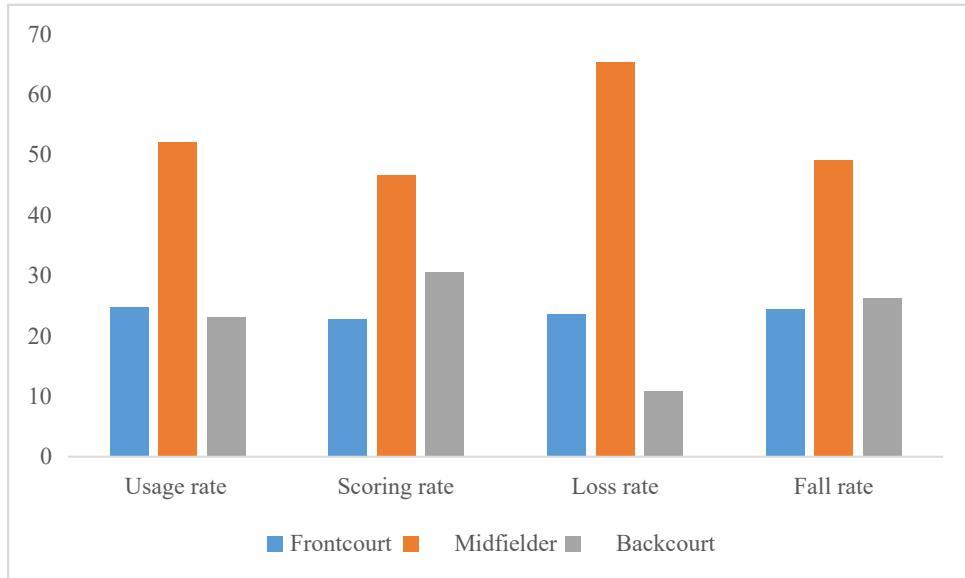


**Figure 6** Comparison chart of response errors of badminton based on wireless sensors

The intensity of the fight between the two players is obviously not as good as that of the frontcourt. Therefore, the loss rate of the backcourt is better than the backcourt. From the analysis of the audience's drop rate, the midfielder's drop rate is the highest, accounting for 49.2%. The drop points of the front and backcourts are not much different, accounting for 24.5% and 26.39% respectively. In the badminton men's doubles competition, because of the tacit action of the two people on the field, the tactical cooperation between them is crucial. The double-playing tactical DeMarcus is like the "two people walking on three legs". The midfield area is often in the course of the game. It is the combination or overlap of the two. Therefore, the drop rate of the midfield is the highest. The world's top athletes are more used to hit the middle. When the two are slightly uncomfortable on the court, the opponent will seize the loophole and attack. Therefore, the drop rate of the midfield area is the highest.

The characteristic distribution of the whole experiment process is shown in Figure 7. It can be clearly seen from Figure 7 that the hitting technique usage rate, the score of winning and losing points and the drop rate of

the midfield area are significantly higher than those of the front field and the back field. From the analysis of the scoring rate, the middle and front field is the battleground for the high-level men's doubles competition. The scoring rate of the mid-field field is higher than that of the back field. The mid-field attack distance is short and the rebound speed is fast.



**Figure 7** Analysis of the characteristics of the whole game

The faster the speed, the more difficult it is for the opponent to return the ball, the lower the score, the longer the backcourt is, and the return speed reaches the opponent's field of vision. The speed is relatively slow, the threat to the opponent is small, and the difficulty of the opponent's return is relatively low in the front court. From the analysis of loss rate, the loss rate of midfield strike technology is the highest, followed by the frontcourt and backcourt. The midfield is flat, the speed is fast, the arc is flat, the reaction time to hit the ball is short, and the lines change. The midfield passive ball transition is unwilling to give the opponent high ball, which usually leads to the highest turnover rate. The frontcourt area is an important area for creating offensive opportunities in the backcourt. The technical requirements for handling the ball are more delicate and the quality requirements are higher, otherwise the opponent will be blocked, so the turnover rate is relatively high. In the backcourt area, the turnover rate of the hit technique is the lowest. The backcourt errors are mainly used to actively contain the offense or exit the boundary, and are forced to make fewer mistakes. From the analysis of the turnover rate in the midfield of the entire game, the decline rate is higher than that of the frontcourt and the backcourt, and there is not much difference in the decline rate of the frontcourt and the backcourt. Receiving the ball and pushing the center, flat dribbling technique and active offensive ball. These skills are the main hitting skills in doubles matches, so the midfielder has the highest position rate. From the perspective of overall batting technique utilization rate, the utilization rate of batting technique in the midfield is higher than the frontcourt and backcourt.

## 5. Conclusion and Future Work

The two-player combination can hit and receive the ball more effectively, all of which account for about 90%; the direct scoring rate is low; the service area is mainly in the first and fifth areas, combined with the other four regional changes, the service technology is mainly Based on push and smash; among the nine receiving areas, midfields No. 2 and No. 5 have the highest area. The analysis of the usage rate of the duo in the entire game is: the frontcourt is dominated by push, the midfield is dominated by blocks, and the backcourt is dominated by killers. The duo has a wealth of active scoring methods, the frontcourt scoring is mainly based on the ball and the net, and the midfield scoring is mainly blocked. Backcourt scoring is mainly based on batting and slamming. The feature of the full-time double-scoring combination is that the midfield loss rate is much higher than the frontcourt and backcourt. The scores of full-court batting techniques are: the highest scoring technique in the frontcourt and the dribble in the midfield. These two techniques have the highest concealment rate and the highest scoring in the backcourt. The drop rate of double full-court hit technique is distributed as follows: midfield is higher than backcourt, and backcourt is higher than frontcourt. The middle and front court is where today's top men's doubles matches are played. Whoever has the initiative in the midfield and frontcourt will win the game. The doubles combination has common technical and tactical characteristics: strong offensive

and defensive capabilities; through the rapid continuity of the midfield and the frontcourt, the tactical guiding ideology for creating offensive scoring opportunities for the midfield and the backcourt is very clear.

In the future, we will further carry out research on badminton doubles. We will further carry out statistical analysis on badminton multimedia technology and tactics. This technology will greatly improve the skills and tactics of athletes in the form of video, graphics and text. We hope that this technology can provide a reference for badminton doubles technology and tactics.

## Abbreviations

TTS: Text to Speech

STT: Speech To Text

## Acknowledgements

We wish to thank the anonymous reviewers who helped to improve the quality of the paper.

## Authors' contributions

Bo Yao is responsible for the collection of experimental data, and Na Liang is responsible for the writing of the paper.

## Funding

None

## Availability of data and materials

Data sharing not applicable to this article as no datasets are generated or analyzed during the current study.

## Competing interests

The authors declare that they have no competing interests.

## References

- [1] A. Mark, F. Mark, A. Serva, J. Baroudi, Clarifying the integration of trust and tam in e-commerce environments: implications for systems design and management. *IEEE Transactions on Engineering Management* 57(3), 380-393 (2010).
- [2] F. Paweł, K. Adam, Information systems integration in the supply chains. *e-mentor* 4(3), 6-15 (2018).
- [3] Q. Duan, J. Li, Y. Wang, The application of fuzzy association rule mining in e-commerce information system mining 6(7), 631-635 (2012).
- [4] Y. Baghdadi, A business model for B2B integration through Web services. *e-Commerce Technology*, 2004. CEC 2004. Proceedings. IEEE International Conference 3(2), 187-194 (2015).
- [5] A. K. Stock, K. Gohil, R. J. Huster, C. Beste, On the effects of multimodal information integration in multitasking. *Sci Rep* 7(1), 19-27 (2017).
- [6] W. Jiang, C. Miao, L. Su, Q. Li, S. Hu, S. G. Wang, Towards quality aware information integration in distributed sensing systems. *IEEE Transactions on Parallel & Distributed Systems* 1(1), 99-112 (2018).
- [7] V. S. Verba, V. I. Merkulov, D. A. Milyakov, The features of the information integration and complex processing in the airborne situational awareness systems. *Procedia Computer Science* 10(3), 273-279 (2017).
- [8] G. Hiebel, K. Hanke, G. Goldenberg, M. Staudt, C. Grutsch, Information integration in a mining landscape 1(2), 692-702 (2017).
- [9] X. Suo, Information integration models in a dream of red mansions 1(1), 309-314 (2017).

- [10] Y. G. Zhong, L. Wen, T. Feng, Badminton training analysis system based on physiological computing. *Computer Engineering & Applications* 1(7), 428-431 (2014).
- [11] M. I. Rusydi, M. Sasaki, M. H. Sucipto, N. Windasari, Local euler angle pattern recognition for smash and backhand in badminton based on arm position. *Procedia Manufacturing* 3(5), 898-903 (2015).
- [12] B. Depraetere, M. Liu, G. Pinte, I. Grondman, R. Babuška, Comparison of model-free and model-based methods for time optimal hit control of a badminton robot. *Mechatronics* 24(8), 1021-1030 (2014).
- [13] S. Li, Z. Zhang, B. Wan, B. Wilde, G. Shan, The relevance of body positioning and its training effect on badminton smash. *J Sports Sci* 35(4), 1-7 (2016).
- [14] T. Liu, M. Shao, D. Yin, Y. Li, N. Yang, R. Yin, The effect of badminton training on the ability of same-domain action anticipation for adult novices: evidence from behavior and erps. *Neuroscience Letters*, 660-669 (2017).
- [15] G. Cimen, H. Ilhan, T. Capin, H. Gurcay, Classification of human motion based on affective state descriptors. *Computer Animation & Virtual Worlds* 24(34), 355-363 (2013).
- [16] R. Winder, C. Haimson, J. Goldsteinstewart, J. Grossman, A model-based analysis of semi-automated data discovery and entry using automated content extraction. *International Journal of Human-computer Interaction* 29(10), 629-646 (2013).
- [17] S. Bauer, R. Wiest, L. P. Nolte, M. Reyes, A survey of mri-based medical image analysis for brain tumor studies. *Physics in Medicine & Biology* 58(13), 15-26 (2013),
- [18] X. H. Shi, Z. G. Zheng, Y. L. Zhou, H. Jin, L. G. He, B. Liu, Q. S. Hua, Graph Processing on GPUs: A Survey. *ACM Comput. Surv.* 50(6), 35-49 (2018)
- [19] Y. H. Ho, S. Y. Lee, D. W. Jeong, E. J. Choi, K. J. Nam, Y. J. Kim, the association between a low urine ph and the components of metabolic syndrome in the korean population: findings based on the 2010 korea national health and nutrition examination survey. *Journal of Research in Medical Sciences* 19(7), 599-604 (2014).
- [20] M. Goran, P. Lidija, K. Miran, Structural analysis of technical-tactical elements in table tennis and their role in different playing zones. *Journal of Human Kinetics* 47(1), 197-214 (2015).
- [21] Phomsoupha, G. Laffaye, The science of badminton: game characteristics, anthropometry, physiology, visual fitness and biomechanics. *Sports Medicine* 45(4), 473-495 (2015).
- [22] M. I. Rusydi, M. Sasaki, M. H. Sucipto, N. Windasari, Local euler angle pattern recognition for smash and backhand in badminton based on arm position. *Procedia Manufacturing* 3(8), 898-903 (2015).
- [23] T. Liu, M. Shao, D. Yin, Y. Li, N. Yang, R. Yin, The effect of badminton training on the ability of same-domain action anticipation for adult novices: evidence from behavior and erps. *Neuroscience Letters*, 3(4).660-669 (2017).
- [24] J. Ebrahim, M. Ali, H. Maryam, M. Razieh, A. Ebrahim, Comparison of blue-yellow opponent color contrast sensitivity function between female badminton players and non-athletes. *Asian Journal of Sports Medicine* 4(2), 107-113 (2013).
- [25] W. Gawin, C. Beyer, M. Seidler, A competition analysis of the single and double disciplines in world-class badminton. *International Journal of Performance Analysis in Sport* 15(3), 997-1006 (2017).
- [26] S. Li, Z. Zhang, B. Wan, B. Wilde, G. Shan, The relevance of body positioning and its training effect on badminton smash. *J Sports Sci* 35(4), 1-7 (2016).
- [27] D. J. Hancock, D. M. Stemware, Gaze behaviors and decision-making accuracy of higher- and lower-level ice hockey referees. *Psychology of Sport & Exercise* 14(1), 66-71 (2013).
- [28] F. Hu, G. Wu. Distributed Error Correction of EKF Algorithm in Multi-sensor Fusion Localization Model. *IEEE Access* 12, 93211-93218 (2020).
- [29] Z. Huang, X. Xu, J. Ni, H. H. Zhu, C. Wang. Multimodal representation learning for recommendation in Internet of Things. *IEEE Internet of Things Journal* 6(6),10675-10685(2019).
- [30] Z. Liu, B. Hu, B. Huang, L. Lang, H. Guo, Y. Zhao, Decision Optimization of Low-Carbon Dual-Channel Supply Chain of Auto Parts Based on Smart City Architecture. *Complexity* 2020(5),1-14(2020).
- [31] F. Long, N. Xiong, A. V. Vasilakos, L. T. Yang, F. Sun, A sustainable heuristic QoS routing algorithm for pervasive multi-layered satellite wireless networks. *Wireless Networks* 16(6), 1657-1673 (2010).
- [32] C. Lin, N. Xiong, J. H. Park, T. Kim, Dynamic power management in new architecture of wireless sensor networks. *International Journal of Communication Systems* 22(6), 671-693 (2009).
- [33] H. Liang, J. Zou, K. Zuo, M. J. Khan, an improved genetic algorithm optimization fuzzy controller applied to the wellhead back pressure control system. *Mechanical Systems and Signal Processing* 142(1) ,106-114 (2020).
- [34] H. Liang, J. Zou, Z. Li, M. J. Khan, Y. Lu, Dynamic evaluation of drilling leakage risk based on fuzzy theory and PSO-SVR algorithm. *Future Generation Computer Systems* 95(4),454-466 (2019).
- [35] J. Li, N. Xiong, J. H. Park, C. Liu, M. A. Shihua, S. Cho, Intelligent model design of cluster supply chain with horizontal cooperation. *Journal of Intelligent Manufacturing* 23(4), 917-931 (2012).

- [36] Z. Chen, D. Chen, Y. Zhang, X. Cheng, M. Zhang, & C. Wu. Deep learning for autonomous ship-oriented small ship detection. *Safety Science* 130, 104812(2020).
- [37] W. Guo, N. Xiong, A. V. Vasilakos, G. Chen, C. Yu, Distributed k-connected fault-tolerant topology control algorithms with PSO in future autonomic sensor systems. *International Journal of Sensor Networks* 12(1), 53-62 (2012).

# Figures

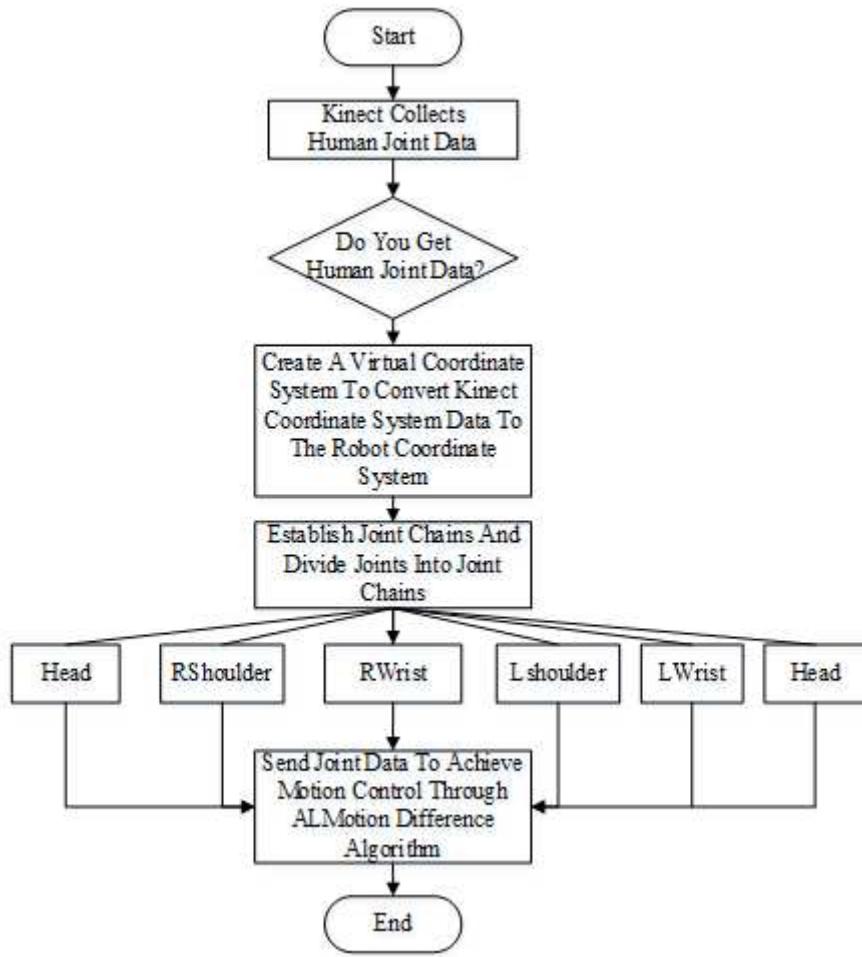


Figure 1

Robot simulation process

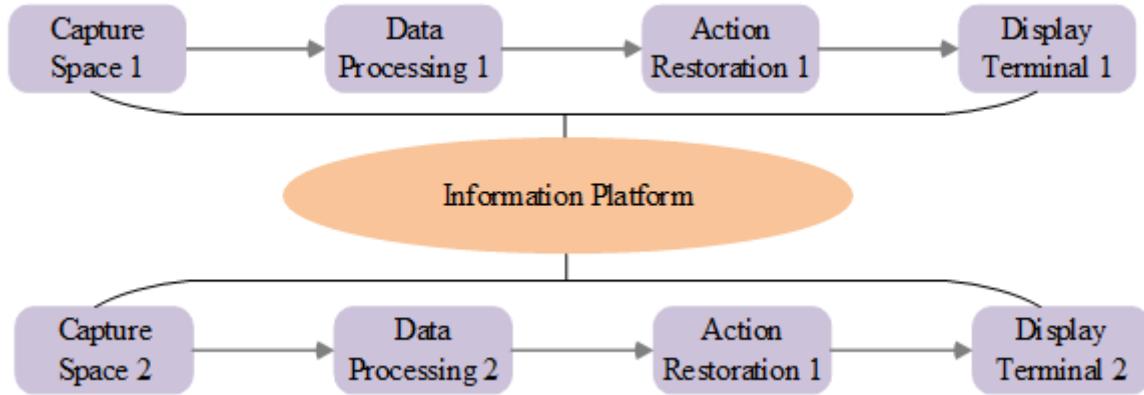
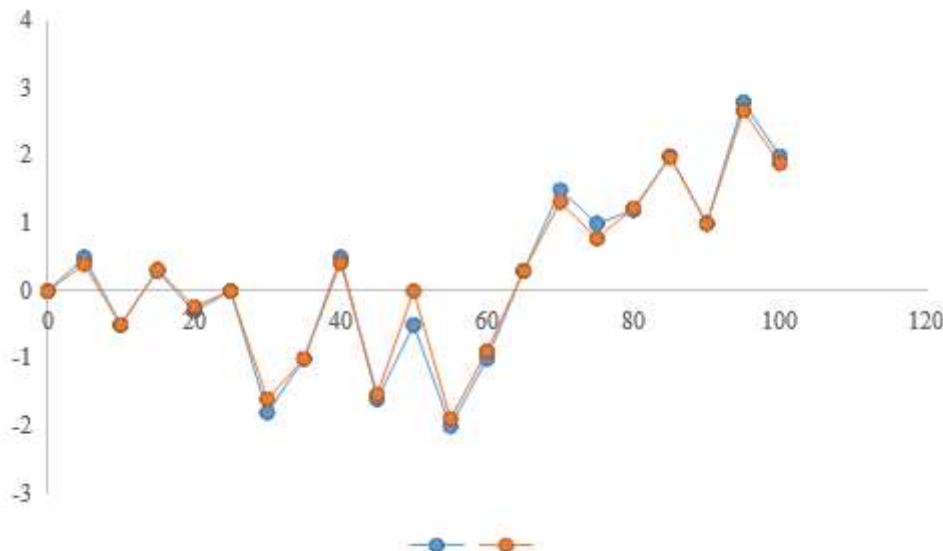


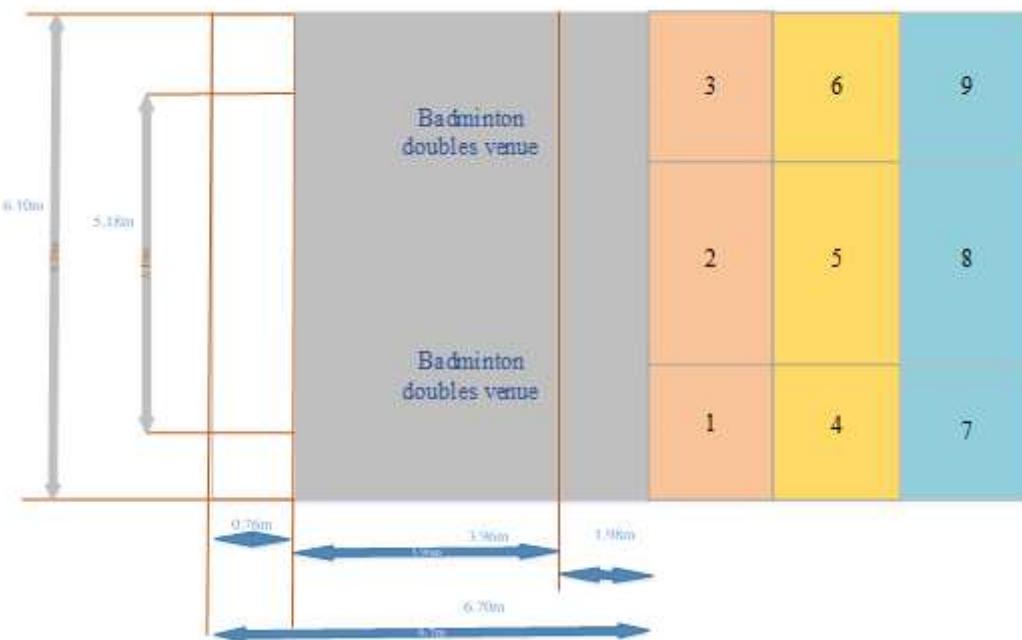
Figure 2

Double-player action recognition structure diagram



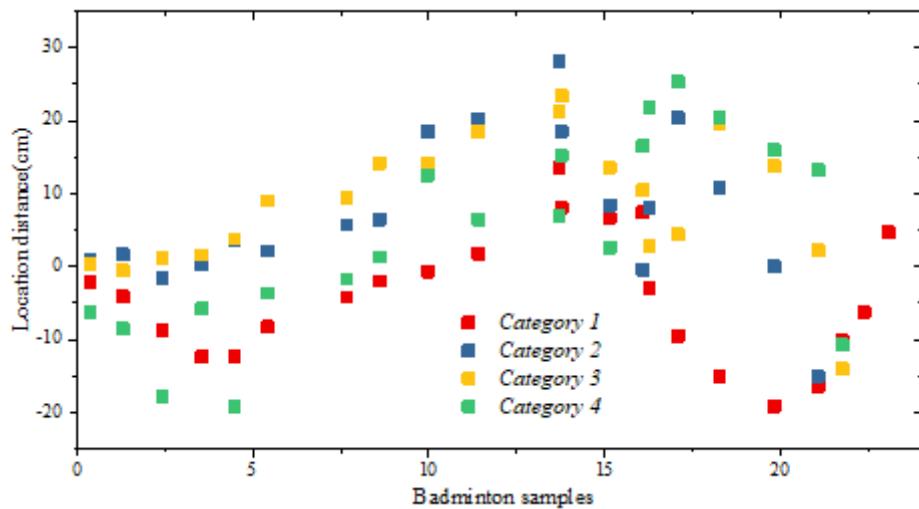
**Figure 3**

Uses Kalman filter to bring the predicted value closer to the true value



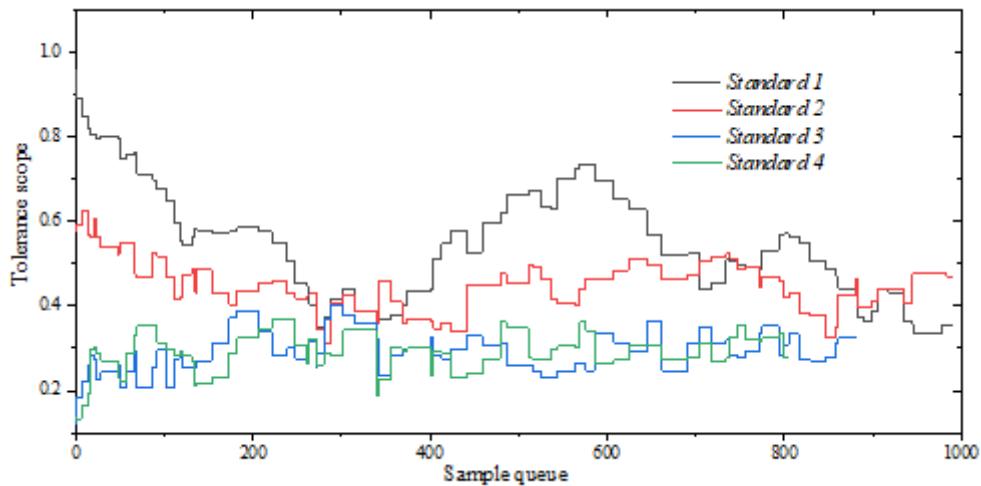
**Figure 4**

Schematic diagram of badminton court



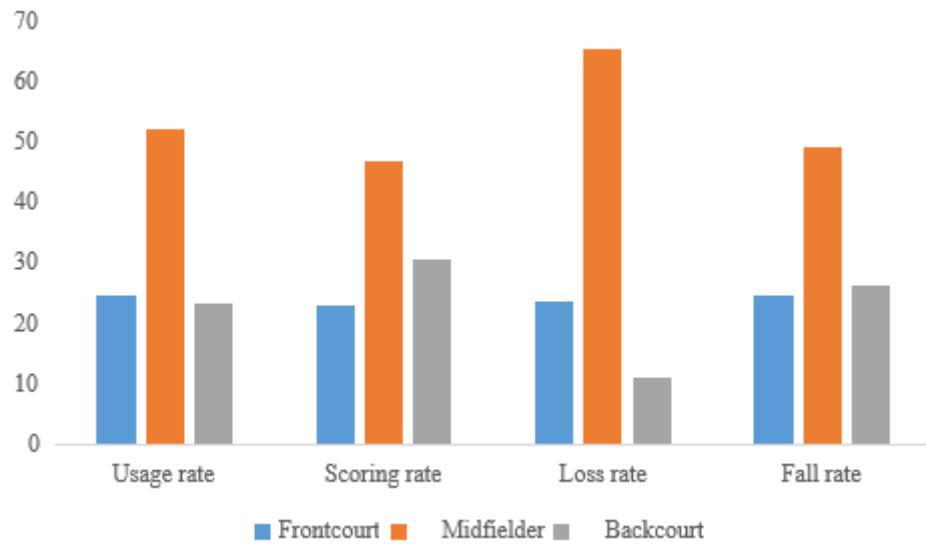
**Figure 5**

Badminton position prediction errors



**Figure 6**

Comparison chart of response errors of badminton based on wireless sensors



**Figure 7**

Analysis of the characteristics of the whole game