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Retraction

Retracted: Badminton Path Tracking Algorithm Based on Computer Vision and Ball Speed Analysis

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] Y. Lyu and S. Zhang, "Badminton Path Tracking Algorithm Based on Computer Vision and Ball Speed Analysis," *Journal of Sensors*, vol. 2021, Article ID 3803387, 13 pages, 2021.

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Research Article

Badminton Path Tracking Algorithm Based on Computer Vision and Ball Speed Analysis

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With the development of artificial intelligence and the rapid development of the computer industry, the practicability of computer vision programs is gradually improved. In this paper, the badminton path tracking algorithm based on computer vision analyzes the badminton trajectory and speed. This paper is aimed at analyzing the image processing technology and path tracking algorithm by using computer vision to obtain relevant data and then exploring the factors of badminton path and ball speed transformation, which provides reference significance for badminton players in future training. The path tracking algorithm is used to predict the rotation angle, the ball speed, and the athlete's body information during the badminton movement through sensors, and the position information of the moving target is captured based on the visual field tracking and target dynamic tracking. Combined with specific badminton players, we first analyze the angle of each limb and the speed of the racket in the process of movement and record the data. Determine different positioning points for different actions, such as pushing the ball, picking the ball, hooking the ball, and rubbing the hair. In this process, we aim at the connection between the highest point and the lowest point of the badminton trajectory and the ball speed. This process fully combines the theoretical knowledge of the path tracking algorithm. The experimental results show that different service skills have different effects on the trajectory and speed of badminton. In the test of relevant data by using the push and receive skills, the lowest point of the ball served by player A in the first three times is higher than that by player B. The most significant difference between the lowest points of the five times is the second time, with a difference of 0.2 m, and the third time, with a minimum difference of 0.03 m.

1. Introduction

With the development of science and technology, especially the advancement of computing power and the popularization of computer-related applications, people's demand for the use of computer technology to perceive and understand the world is also increasing [1]. The research object of computer vision is mainly a three-dimensional scene mapped onto single or multiple images, such as the reconstruction of a three-dimensional scene. The research of computer vision is largely focused on the content of the image. In badminton, pattern recognition uses various methods to extract information from signals, mainly using statistical theories. One of the main directions in this field is to extract information from image data. [2]. Path tracking in the field of computer vision is a cross-discipline that integrates graphics and image processing, intelligent systems, and procedural control. It has unique advantages in the application of industrial production control, and its applications can be found in every aspect of life. In computer vision, pattern recognition technology is often used to identify and classify certain parts of an image, such as segmented regions. Use the path tracking algorithm to determine whether a set of image data contains a specific object, image feature, or motion state. Vision-based field tracking and target dynamic tracking mainly use computer vision technology to discover, analyze, and process the field to be tracked in the incoming video clips, capture the position information of the moving target, and predict and track the impact position of the field. In addition, the computer vision surveillance system has been improved on the basis of manual monitoring and analysis of video surveillance pictures, and an intelligent analysis module has been added to enable it to realize real-time online video analysis and understanding, match behavior models, quickly respond to target behaviors, and process them in time problem. A digital image is produced by one or more image sensors, where the sensors can be various photosensitive cameras, including remote sensing equipment; before implementing specific computer vision methods on the image to extract specific information, some preprocessing is often used to make the image meet the requirements of subsequent methods. This greatly improves the efficiency of target behavior analysis and processing and greatly saves human and material resources. But computer vision, whether in the engineering field or the scientific field, still has many problems to be solved, so a general method that can completely simulate human vision has not yet been proposed [3]. The application of these methods is usually used as a component of some large-scale systems that solve complex problems. Computers are preset to solve specific tasks and provide information for decision-making.

In recent years, the field of behavior recognition research has attracted a large number of researchers, both in theoretical research and in practical applications [4]. A large number of relevant research results have been achieved in the recognition of target behaviors in simple backgrounds in experimental environments at home and abroad. In the current work, Ramirez-Pinero et al. introduced an improved version of the hyperspherical path tracking method suitable for piecewise linear (PWL) circuits. This enhanced version takes advantage of the PWL characteristics of the homotopy curve to achieve faster path tracking and improve the performance of the homotopy continuum method (HCM). This method allows providing an algorithm for nonlinear circuit analysis. In addition, a starting standard is proposed to obtain better HCM performance, and a technique to avoid regression phenomena is proposed [5]. Nagy and Vajk focus on the minimum time path tracking, which is a subproblem in the motion planning of the robot system. Taking into account the kinematic and dynamic constraints, a time-optimal speed curve is generated for the robot manipulator. Based on the special structure of constraints (called peaking constraints), contour generation is expressed as a linear programming (LP) problem. LP-based control problems are solved by sequential optimization methods. Compared with the general LP solver, the proposed algorithm reduces the calculation time [6]. Mori et al. described in their research the development of a robot configured to play badminton, using a gas-electric hybrid actuator, in order to achieve high precision and high power, integrating a tension sensor unit and a thermal countermeasure mechanism. Using the badminton robot as a practice partner to develop a variety of hitting methods, for this reason, the researchers also developed a humanoid robot arm. By using the actuator as a connecting rod structure, the overall weight is reduced, and the complex degrees of freedom (DoF) and a large range of motion are realized at the same time [7]. Quintero et al. describe the path tracking algorithm implemented in the intelligent transportation system to verify whether the vehicle correctly follows the specific path previously assigned. The algorithm is based on geometric analysis and designated GPS data and can track the current position of the vehicle in real time according to the previous digital map of the path to be tracked. As a case study, since Medellin is an important city in Colombia with a large number of public buses, the mobility within the city is very complicated, so this tracking algorithm was developed according to Medellin's public transportation regulations [8]. Sánchez-Ramírez et al. construct an interacting multiple model (IMM) structure to integrate a set of discrete generalized proportional integral observers (DGPIO) to improve the accuracy of visual tracking tasks. Two kinematic models based on constant velocity (CV) and constant acceleration (CA) motion curves are used. The finally obtained algorithm combines four important features: state interaction, Kalman filtering, auto-disturbance rejection, and multimodel combination [9]. Konovalov proposed and implemented a state-of-the-art quality-based algorithm and used the decommissioned Kalman filter to perform the initiation, motion detection, and data integration of all rotations in bistatic coordinates through the implementation of unauthorized Kalman, the approved patent simulation, and the transformation of measured values and their covariance from bistatic coordinates to Cartesian coordinates [10]. The purpose of Jaya and Krishna's experiment is to use the received signal in the antenna to investigate the moving quality of the synthetic aperture radar and calculate the moving speed of the moving object. In the process of moving target detection (MTD), fractional Fourier transform (FrFT) and fuzzy judgment methods are used to detect moving targets in the search space. Based on the correlation, identify the location of the target in the search space, use fuzzy language rules to detect the location of the target, and feed it to the fuzzy judgment module [11]. These studies are experiments all carried out through different angles and technical means, combining dynamic constraints, motion curves, and other factors involved in kinematics with moving objects for monitoring and analysis. However, the technical methods involved in their research are too complicated, and the cost is high. There are many uncontrollable factors in the experimental process, so the reliability of the experimental results remains to be discussed.

The article applies computer vision to the image analysis of badminton sports and applies dynamic target detection and tracking technology. It is difficult to monitor dynamic targets. Therefore, the visual sensor is built on the basis of the image recording and processing model for various data combination experiments. The analysis combines computer vision, image processing, and other methods to describe and extract the features of moving targets in videos, establish target behavior models, and analyze target behaviors.

2. Application Methods of Computer Vision in Badminton

2.1. Computer Vision Processing Images. The continuous development of science and technology and the continuous improvement of the level of automation have made science and technology have broader development prospects [12]. The purpose of early image processing was to improve image quality [13]. This advanced technology has attracted many domestic and foreign researchers devoting themselves to visual research. Visual imaging technology is a method that uses motion sensors to capture images and convert them into digital signals and then uses advanced computer software to process the digital images to obtain a large number of functions required by mass media, therefore, to understand, identify, monitor, and judge the new methods we discover. This can not only overcome the slow speed and large error of traditional sensors and meters and avoid the limitations of human eye detection speed and search methods but also know the specific time detection. In order to obtain accurate tracking effects and prediction accuracy, it is hoped that the target can be tracked accurately during the tracking process, and the target's actions can be accurately predicted. The basic processing of the image is essential, and the basic processing of the image will be directly related to the effect of tracking and forecasting. The basic processing of the image is good, which can make the moving target area appear and reduce the difficulty of moving target detection and the impact of detection time [14]. The text information in a visual image is a special type of visual target, which can reflect the important content in the image to a certain extent. It can describe or explain the content in the image concisely, which is an important way to understand the high-level semantics of the image or video content; it can automatically locate the target area in the image and extract it. After recognition and analysis, it has a good application prospect in mechanical intelligence and other fields [15].

Computer vision analyzes the content of the image, extracts the meaningful features, analyzes the obtained features, and extracts the semantic representation of the scene so that the computer has the capabilities of the human eye and the human brain. It processes multiple images or sequence images; of course, it also includes some single images [16]. Computer vision is a mature topic covering many fields [17]. From the current research, computer vision is trying to build a virtual system. More and more technologies are proposed to collect information from multidimensional images or data. It is very important for a high-performance vision system to recognize the shape and category of objects. Most of the original information generated by the computer are images, so this site has a very close relationship with image processing and sample recognition. The basic image processing in this article is to complete the basic processing of the image frames of the player's body movements, the movement of the badminton, and the path of the movement recorded in the video when the player beats the badminton, including the acquisition of the image information in the video and the image. Value segmentation lays the foundation for the precise tracking and prediction of sports targets and the training planning of players [18]. This process solves common vision problems and translates into the specific analysis of specific tasks.

2.2. Dynamic Target Detection and Tracking Technology. In order to study the robust quality detection and tracking technology, this test adopts the vision system and realizes automatic distance measurement by taking pictures with two cameras [19]. Take the badminton and the movement change of the athlete's limbs as a variable to establish a two-degree-of-freedom badminton plane motion model, and simplify it according to the control requirements to obtain a nonlinear badminton trajectory tracking control model [20]. Through the analysis of lines and nonlinear image templates, we understand the principle of distance measurement. Perfect distance measurement includes camera measurement, image processing, and stereo compatibility. The system adopts a balance method, using the check box as a reference to capture the internal and external camera positions and adjust the mute. A sine fringe is generated by computer programming, the sine fringe is projected to the object to be measured through a projection device, the CCD camera is used to capture the degree of curvature of the fringe modulated by the object, the phase is obtained by demodulating the curved fringe, and then the phase is converted into the height of the whole field [21]. Image processing is an important factor for stereo compatibility and an important way to improve the measurement progress. The combined image is processed and visualized by the computer to produce a realistic image. The geometric representation of the defined space is established, the light effect of the image is created, and the light effect is calculated through the light model. This kind of light effect is generally successful under an imaginary light source. The similarity algorithm between target features and visual features can be applied here [22].

The Gaussian probability density function involves the difference between the probability density function of a continuous random variable and the probability distribution function of a discrete random variable. Calculate the probability density estimation of the sample vector, return the probability density at that point, and draw a probability density curve based on this. The use of the Gaussian probability density function for target detection is a commonly used recognition method [23]. Since the trajectory of badminton is a parabola, the distribution points at different heights can be described as

$$g(o, m, n) = -\frac{1}{\sqrt{(2\pi)^h |n|}^2} * \frac{1}{2}(o - m)^\varepsilon n^{-1}, \tag{1}$$

$$P(O, M, N) = \prod_{i=1}^{x} g(o_i, m, n)^2, \tag{2}$$

where m is the mean value of the Gaussian function in the central area of the distribution point and n is the magnitude of the motion amplitude of the distribution point state. The best Gaussian function mean is calculated as

$$\forall_m l(m, n) = -\frac{1}{2}\sum_{i=1}^{x}\left[2n^{-1}(m_i - n)\right], \tag{3}$$

$$\sum_{1} = \frac{1}{x-1}\sum_{i=1}^{x}(a_1, b_1, c_1)^{\beta}. \tag{4}$$

(a, b, c) are the three-dimensional coordinates established for a certain distribution point. The minimum value of the best mean can be expressed as

$$g(\min) = \ln\left[\prod_{i=1}^{m} p(x_i)\right]\sum_{i=1} p(m-1), \tag{5}$$

$$\max\,(\delta|H) = \frac{1}{\mathrm{MAX}_H} H(\delta)H(H|\delta). \tag{6}$$

max is the estimation of the verification probability of the recorded image from the observation angle and the feature information of consecutive m frames of images and adjacent scenes, and the average value of consecutive m frames of the video sequence is calculated as

$$\eta_0 = \frac{1}{M}\sum_{I=0}^{I=M=1} I_t, \tag{7}$$

$$\vartheta_0^2 = \frac{1}{M}\sum_{i=0}^{I=M-1}(i-\eta_0)^2, \tag{8}$$

$$\vartheta_{i,j}^2 = (1-\rho)\vartheta_{i,j-1}^2 + \rho\left(i-\eta_{i,j}\right)^2. \tag{9}$$

Among them, $\vartheta_{i,j-1}$ is the background update speed, and $0 < \rho < 1$; the larger the value, the faster the update speed. M is a custom coefficient. In addition, there is a common influencing factor for the image detection in the video, that is, the noise value of the digital image, which is calculated using statistical data characteristics as

$$\bar{z} = \frac{1}{K \bullet L}\sum_{m=1}^{m}\sum_{n=1}^{n} z(m, n), \tag{10}$$

$$D_i(m, n) = \left|f(m, n)_i - f_{i+1}(m, n)\right|^2 - 1. \tag{11}$$

$D_i(m, n)$ is the noise mutual interference value between adjacent frames, (m, n) is the discrete coordinate, and the influence of the interference value on the size of the image target cannot be ignored. Rate its connectivity as

$$\varsigma_0^2(p, q) = \frac{1}{t}\sum_{i=0}^{T}\left[\int (p, q)^i - z_0(p, q)\right]^2, \tag{12}$$

$$\tau_i^2 = (1-\alpha) \bullet \tau_{i-1}^2 + \alpha \otimes (1-\beta_i)^2. \tag{13}$$

Among them, α is the continuity under a single action angle of the influence value, and τ is the image parameter value in the adaptive image detection.

2.3. Badminton Movement Path and Ball Speed. Badminton is an irregular moving sphere, and its flight path in the air is similar to a parabola. In fact, the aerodynamics of badminton in flight is complicated [24]. This flexibility model greatly reduces the difficulty of modeling. The training videos of badminton players are processed with advanced technology and output the instantaneous transfer speed of badminton, the size and frequency of the player's arm rotation, and other information. Since each video has many pictures per second, there are a lot of valuable items that cannot be taken by human eyes. Information needs to use imaging techniques such as grayscale and image release to minimize the impact of these problems on the results [25]. It can be used to analyze the technical defects of players and improve sports skills. Common badminton sports postures are shown in Figure 1.

The surface shape information of the badminton is calculated by the flight time of the path; the spatial modulation method is that the phase and light intensity of the structured light field will change after being modulated by the height of the object to be measured. The changes in these properties can be obtained by the shape information of the measured object [26]. Establish three-dimensional coordinates in the image coordinate system for the badminton movement acquired by the vision system, and use the stereo vision system to calculate the coordinates of a certain parabolic point of the badminton in the sky as

$$\begin{cases} S_c = \dfrac{C^2}{i \otimes c} S_{a,b}, \\[2ex] S_a = S_b = \dfrac{C}{j} S_{ab}. \end{cases} \tag{14}$$

S_c is the measurement accuracy value in the c-axis direction, and S_a and $S_b$are the measurement accuracy values on the a-axis and b-axis, respectively. i is the optical axis distance. Gaussian filtering can be used to statically capture badminton [27]:

$$F(a, b) = \frac{1}{2\pi\alpha^2}\left(r\left(a^2+b^2\right)\right)^{2\alpha^2}, \tag{15}$$

$$H(a, b) = \begin{cases} 0, & \text{what else}, \\ 1, & \text{if } [i(t) - i(t-1) > T]. \end{cases} \tag{16}$$

$H(a, b)$ is the background condition value of this static position [28]. The applicability of this static processing is $H(a, b) = 0$. Otherwise, it is a dynamic target because the result value is greater than all the prescribed limit thresholds, and the calculation of the limit threshold is

$$G_1 = 2\chi * \left(A * \sum_i \kappa(a, b)^2 B_i(i, j)\right), \tag{17}$$

$$G_2 = G_3 = 2\chi \otimes (B, C)\sum_{i,j}\kappa(b, c)^2 C_{i-j}. \tag{18}$$

Figure 1: Player pose.

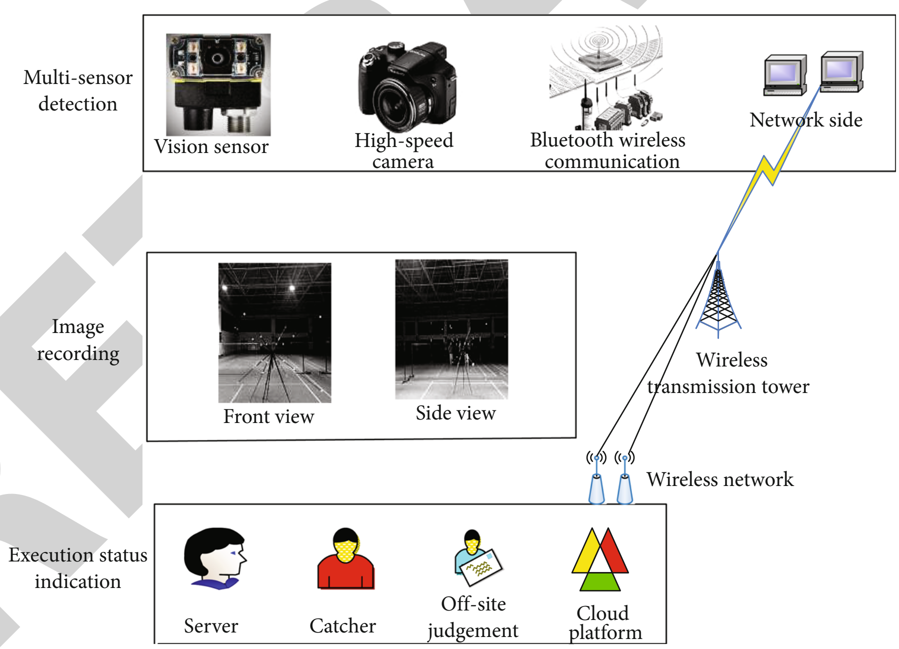

Figure 2: Application of the vision sensor in the badminton trajectory.

i, j is the size of the central value pixel of the video pixel template, where κ is the probability. Calculate the similarity of different pixels in different limited domains as [29]

$$\mu(i, j) = \frac{1}{w}\sum_{i=1}^{w} \exp\left(-\frac{v_i - w_j}{x}\right)^2, \tag{19}$$

$$\varphi_t = \frac{1}{w}\sum_{i=1}\sum_{j=1}^{v} \phi_i t(a, b, c). \tag{20}$$

Fixed stereo imaging technology combines a stereo image system with depth photography through a flat-panel display, uses edge detection image processing technology to create image descriptors, and then provides them to

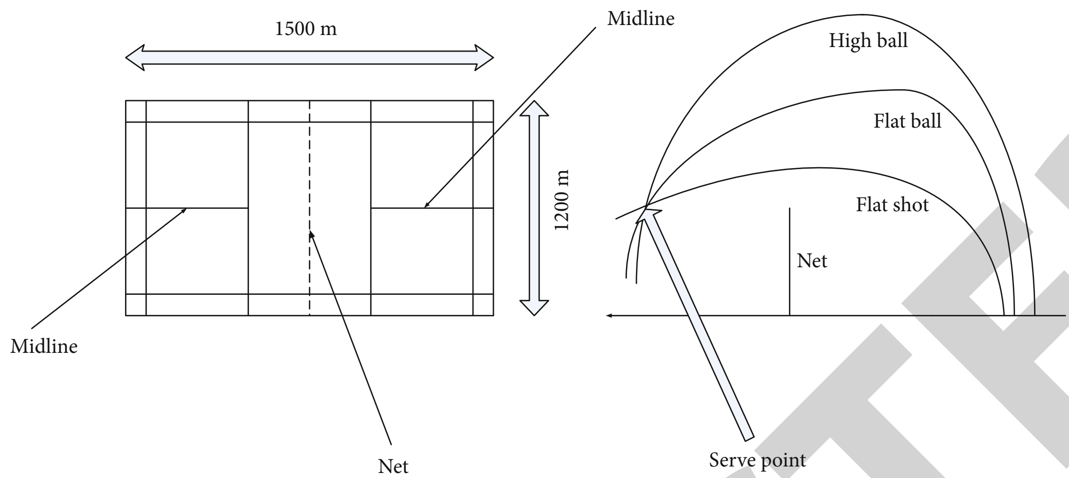

Figure 3: Common venues and service trajectories of badminton.

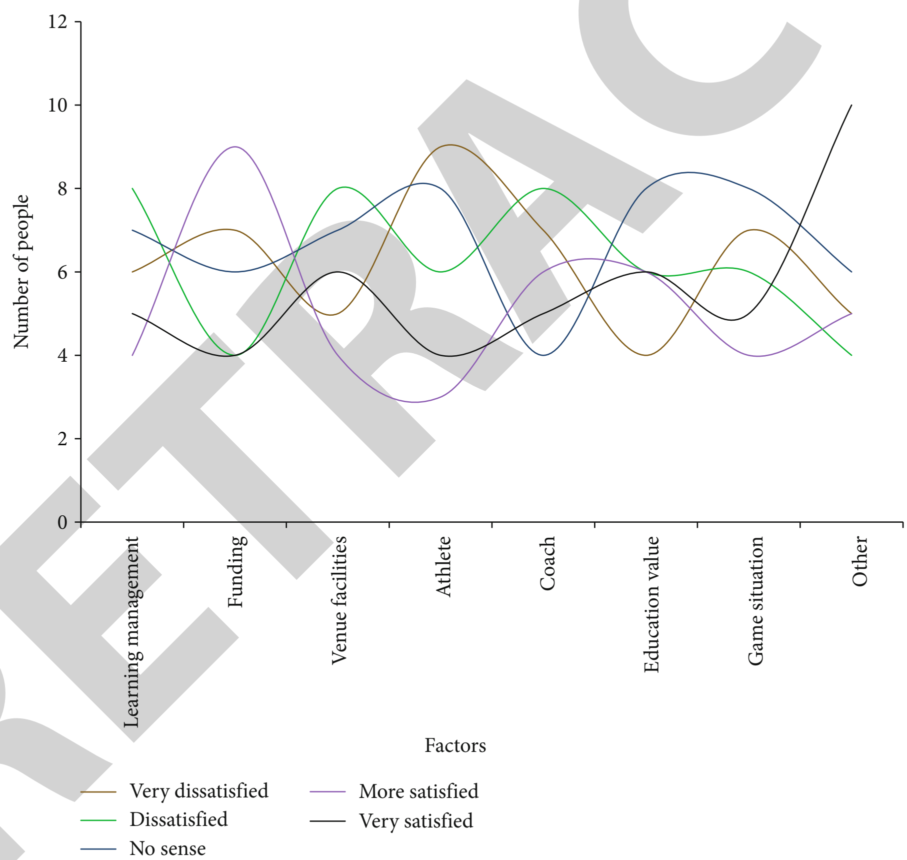

Figure 4: Factors affecting the development of badminton.

machine learning algorithms for classification for recognition tasks. w is the size of the threshold area defined in the video, and v_i and w_j are the gray values of the area block v and the area block w, respectively.

3. Computer Vision Path Tracking Experiment

Badminton has always been a major event in our country's competitive sports. In recent years, the development of badminton in colleges and universities has been rapid, and it has become one of the most popular and prestigious sports. Badminton training is an important suggestion to improve the quality of training. Foot training is an important part of college badminton training. Intensive and effective foot training can improve students' badminton skills, allow them to experience the success and enjoyment of sports, and prevent sports injuries. According to training and observation, many college students have different types

Table 1: Comprehensive test table of 30 players' physical fitness.

Category	Experimental group	T	P	Significance
100 m performance	11.98 ± 0.211	-0.423	0.609 > 0.05	No significant difference
One-minute push-ups	44 ± 5.23	-0.226	0.874 > 0.05	No significant difference
One-minute sit-ups	48 ± 3.274	0.555	0.672 > 0.05	No significant difference
Standing long jump	277.4 ± 3.924	0.807	0.377 > 0.05	No significant difference

Table 2: Basic situation of players.

Player number	Age	Height (cm)	Weight (kg)	Years of exercise	BMI
A	23	174	65	3	24.1
B	24	173	70	4	22.7
C	21	183	78	2	21.9
D	21	179	74	1	24.3
E	20	175	72	1	20.6

of foot problems. Many college students have different types of hand problems, which hinders the improvement of the college students' badminton level. Explore the current blind spots and problems of foot training in college badminton classrooms, propose matching standards, and help college students improve their badminton skills. Camera technology simulates a 3D human visual image of a person. Get the three-dimensional information of the image. The viewing angle difference between two faces when observing an object allows us to have depth and breadth changes when observing an object. Simulating the human eye, the computer replaces the brain to complete the picture process, but it is more advanced than the human eye in that the human eye can roughly see the position information of the object, and the computer can calculate an accurate distance. The application and construction model of the vision sensor to record the trajectory and ball speed of the badminton is shown in Figure 2.

The specific content of the program includes several aspects such as image capture, camera marking, image processing, feature extraction, stereo compatibility, and distancing calculation. According to the obtained multiframe badminton position, the takeoff speed and starting angle of the badminton can be calculated and then substituted into the established badminton aerodynamic model to predict the maximum jumping speed and the final field position of the badminton. The badminton reference determines the best attack point and drilling time according to the current position of the batter and the body of the robot and guides the badminton robot to complete the attack. Common badminton courts and service trajectories are shown in Figure 3.

Calculate the modulated phase from the collected four modulated fringe patterns. The phase map obtained here is a truncated phase map because the result of the four-step phase-shifting algorithm is calculated by the arctangent function. The main principle of the vision sensor for detecting the movement and ball speed of the badminton system is to first shoot a mass object from different angles with two

Table 3: Physical parameters of players.

Player number	Wrist angle	Elbow angle	Shoulder angle
A	141.231	77.847	68.256
B	156.403	89.273	87.394
C	170.236	72.468	62.105
D	158.746	66.243	66.205
E	162.674	76.362	88.743

cameras of the same specification, capture two binocular images in one project, and use the image processing method to preview the captured image processing and extract the required information. Then, the same quality image contrast is used on different statistical images to obtain stereo compatibility and corresponding depth information. One of the characteristics of badminton is stretching, which requires players to mobilize the whole muscle, the whole limb structure, and nerve cells to complete the game. The upper arm completes the stretching process, and the lower arm completes the leg process. In order to illustrate this application more vividly, first of all, we have a general understanding of badminton. Thirty badminton players were invited to conduct a questionnaire survey. The influencing factors of badminton development are shown in Figure 4.

From the data provided in Figure 4, it can be found that these 30 badminton players believe that current learning management, funds, venue facilities, players, coaches, and other factors play an important role in the development of badminton. The number of people who are extremely dissatisfied with the two influencing factors of the funds and the players is 9; only 6 people are satisfied with the badminton venues and facilities; and 8 people are dissatisfied with the coaching factor. Therefore, it is necessary to conduct research around these aspects. And this article is mainly for badminton itself, so starting from the players, data acquisition is carried out. The physical fitness of these 30 players is recorded in Table 1.

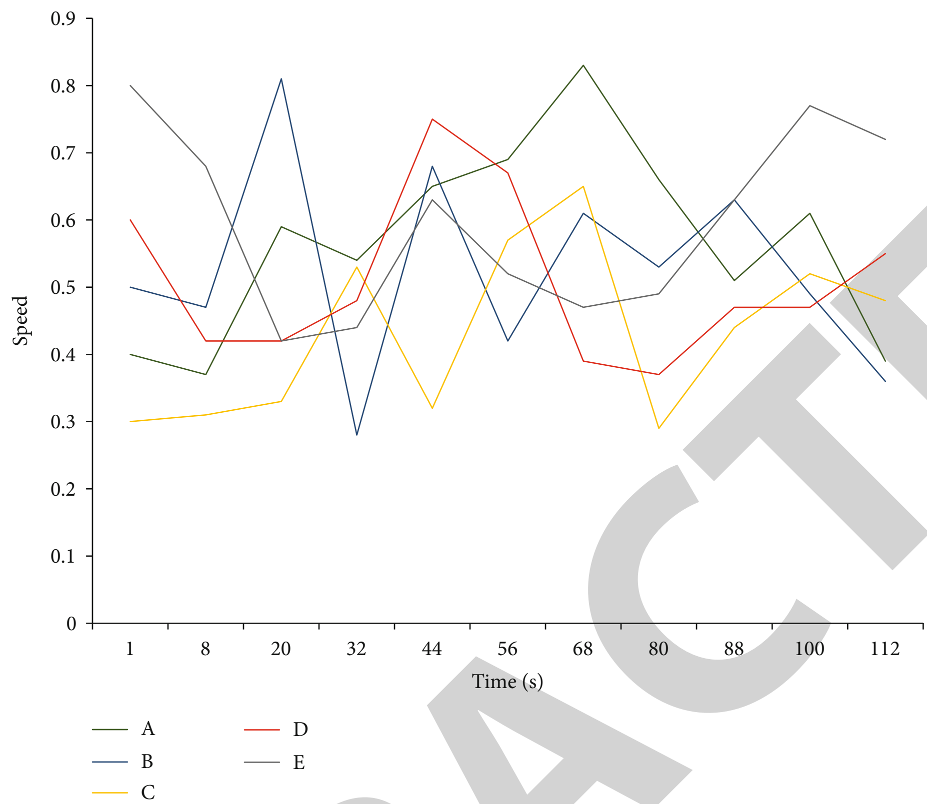

FIGURE 5: The change of the player's body center of gravity.

According to the data in Table 1, the average values of these 30 players are not much different from the standard values after the four tests of the 100-meter run, one-minute sit-ups, one-minute push-ups, and standing long jump. Therefore, the physical fitness of players may not be considered in the recording and analysis of experimental data in the following research. Five players were selected to participate in the shooting of this study. The basic situation of these 5 badminton players in our school is shown in Table 2.

Table 2 surveys the players' age, height, weight, length of time engaged in the badminton career, and BMI. The above data are all within the normal data range, so the results of this experiment are worthy of reference. Statistics on the relevant parameters of these 5 players' remote mobilization limbs are shown in Table 3.

These data are all measured using certain technical means and professional methods, and the data are authentic. Use the literature data method and logical induction method to count the game video. In the game, when physical fitness is declining, it is possible to maintain the stable performance of technical movements to reduce the proportion of active points lost, improve the ability of active defense and the awareness of defensive counterattack, and reduce the proportion of passive points lost to lay the foundation for the final victory of the game. The change of the player's body center of gravity during training is shown in Figure 5.

On the whole, the relationship between the center of gravity of the player's body and the speed of movement does not have certain rules. However, it can be found that regardless of the player's height or weight, the center of gravity fluctuates between 0.3 and 0.8 during physical exercise. Data statistics are made on the various parts of the right upper limbs and the speed change characteristics of the racket of these 5 players, as shown in Figure 6.

Player A's right hand has the largest change in speed, with a maximum value of 4.279. Player C's racket speed has the largest change, while player D's right shoulder has the largest change in speed of 11.276 during exercise. Player C's speed change is the fastest during exercise, reaching 3.476. In order to highlight the role of the visual sensor in recording the trajectory and ball speed of the badminton, specific data research studies were carried out on the two players A and B, respectively. Discuss the relationship between the service receiving technique and the badminton trajectory and ball speed. The number of times of using badminton hair extension skills in the past 5 years is summarized, and the data is recorded in Table 4. The first is the data statistics of the highest point of the badminton movement trajectory and the ball speed of the two players A and B in the state of receiving and serving the ball, as shown in Figure 7.

In the five tests, the highest point of the service received by player B exceeds that by player A at the first and fourth times, and the maximum difference is 0.6 m at the fourth test. The minimum difference between the two players at the highest point when they receive the service is 0.1 m from the first time. Similarly, during the second and fourth service

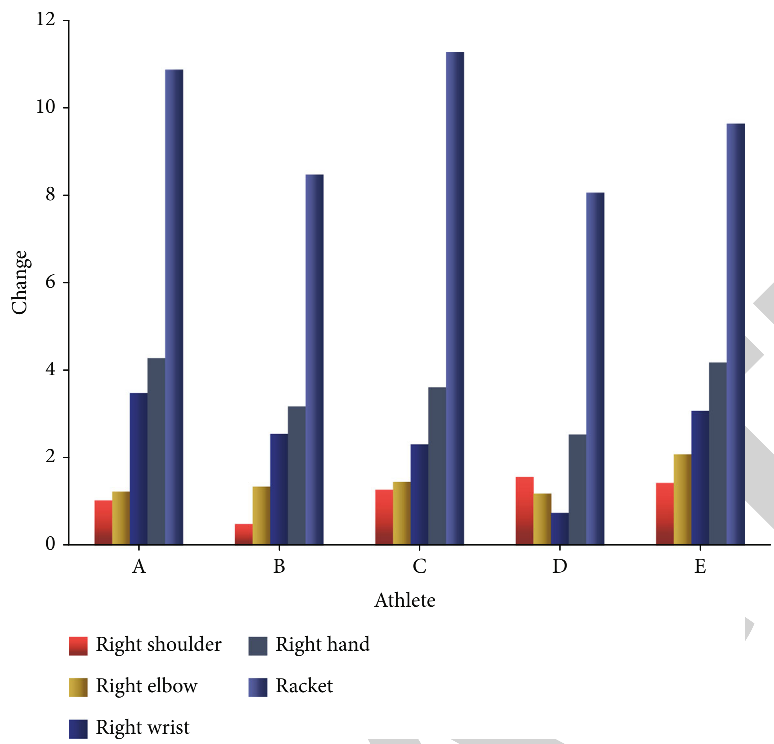

FIGURE 6: The characteristics of the speed changes of the players' right upper limbs and rackets.

TABLE 4: Number of occurrences of various receiving and serving techniques.

Year	Rubbing	Push the ball	Pick the ball	Hook kick
2016	34	18	19	27
2017	32	13	14	23
2018	17	19	18	21
2019	15	22	16	11
2020	25	17	28	26

returns, the speed of the ball served by player B at the highest point exceeds that by player A, and the biggest difference between the two is the fourth service return, with a speed difference of 4.9 m/s. In the receiving ground state, players A and B catch the ball back and forth five times. The data statistics of the highest point of the badminton trajectory and the ball speed are shown in Figure 8.

Using the technique of receiving and serving the ball to test the relevant data, the lowest point of the first three times of player A's serve was higher than that of player B's serve. The most significant difference between the lowest points of these five times of receiving and serving was the second time, with a difference of 0.2 meters. The third time has the smallest difference, with a minimum of 0.03 meters. For the measurement of the speed of the badminton ball during the push and return, the lowest point of the service received by player B is greater than the speed received by player A, and there is only the second time. The speed of the ball at the lowest point served by receiver A exceeds that by player B, which is 3 m/s. Statistics of the highest point of the badminton movement trajectory and the ball speed of the two players A and B in the state of receiving and serving the ball in the state of hooking are shown in Figure 9.

Through comparative analysis, in the process of receiving and serving the badminton using hook badminton for the 5th time, the highest point of the 3rd and 5th times of player B's serve was lower than the highest point of player A's serve. For these five times of receiving and serving, two players served the ball. The maximum difference between the highest points is 0.4 meters, and the maximum difference between the badminton speeds of two players is 4 m/s. Statistics of the highest point of the badminton movement trajectory and the ball speed of the two players A and B in the state of receiving and serving the badminton in the state of picking the ball are shown in Figure 10.

From the data in Figure 10, it is found that the badminton trajectory of player A's first use of picking and receiving the ball reached the maximum value in five tests. The lowest point of this badminton was 0.9 meters. The lowest point of a player receiving the serve is the same, which is 0.3; and for the study of the badminton speed, when player A uses the pick to receive the serve for the second time, the badminton ball has the highest speed, which is also the highest speed at the lowest point in the entire test process, which is 34 m/s. Use the regression model to calculate the badminton speed measurement error of two players in five tests, as shown in Table 5.

From the data in Table 5, it is found that whether it is picking, pushing, hooking, or rubbing, there is almost no

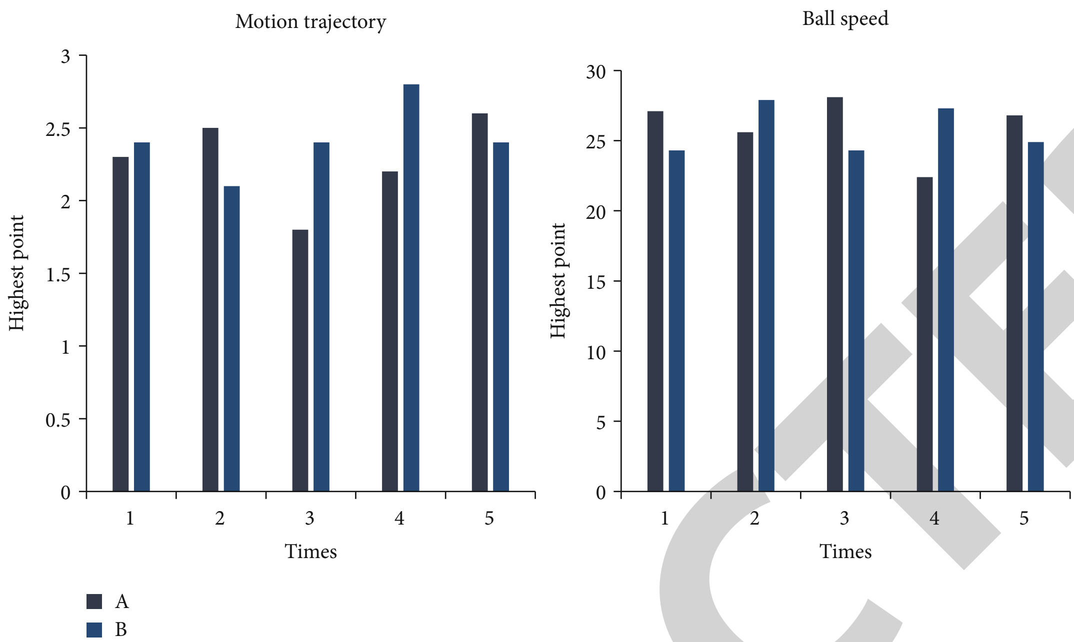

Figure 7: The trajectory and ball speed of badminton.

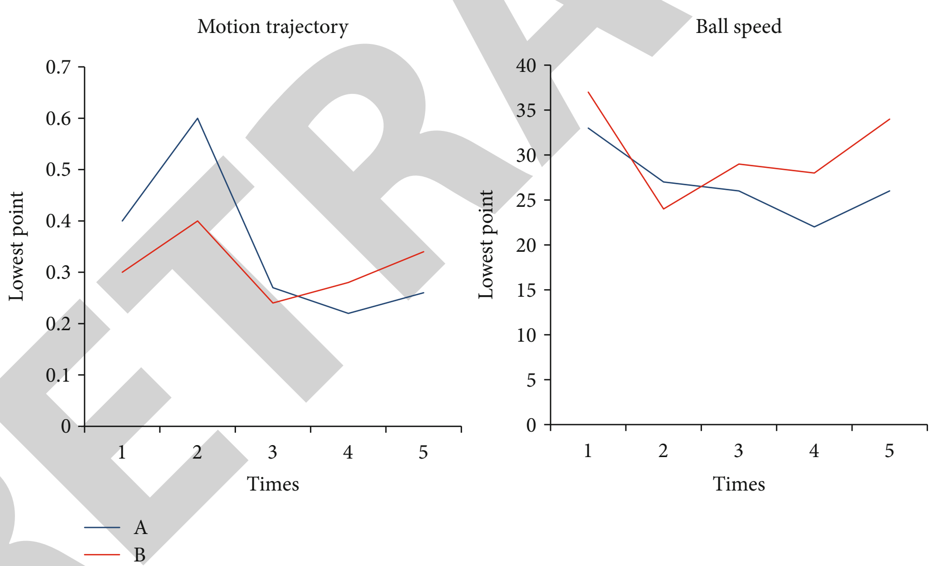

Figure 8: Badminton trajectory and ball speed.

data error value after image processing using visual sensors. It can be shown that it is feasible to apply the vision sensor to the analysis of the trajectory and ball speed of the badminton.

4. Discussion

The vision sensor captures the image on the computer, then realizes the image and recognizes it through imaging, and then converts the advanced image into white label information technology and performs phase recovery. This process records and presents the badminton trajectory. Image processing technology is an important part of the vision measurement system. Its main task is to correctly process and extract the effective information in the image so as to carry out the high-precision measurement. In the process of badminton prediction, due to the detection of model errors and measurement errors, the Bayesian method is used to calculate the maximum probability of the badminton ratio. The Kalman filter is a linear filter, and the statistical accuracy of the nonlinear model is poor. Analyze and compare two commonly used nonlinear filters. This article conducts in-depth research on the key image processing algorithms in vision measurement, including image filtering algorithms, image

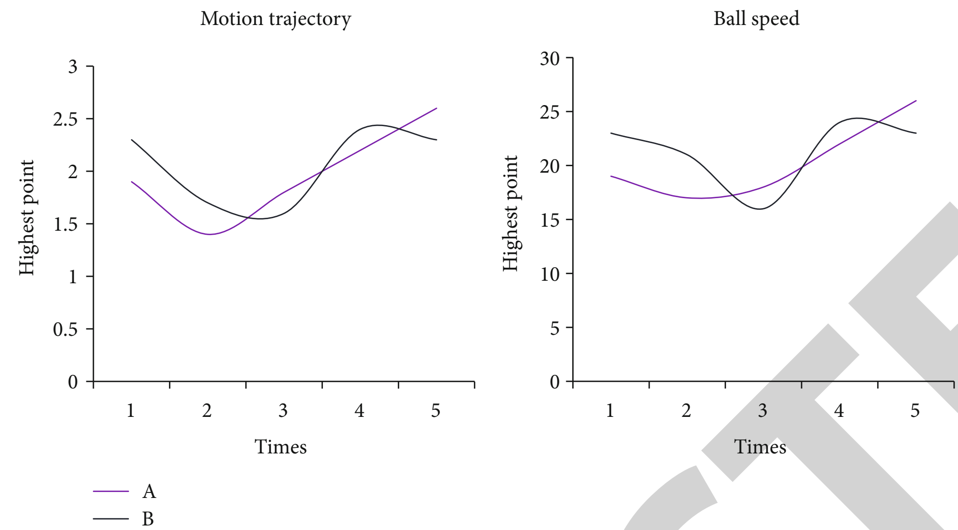

Figure 9: Hook and serve badminton movement trajectory and ball speed.

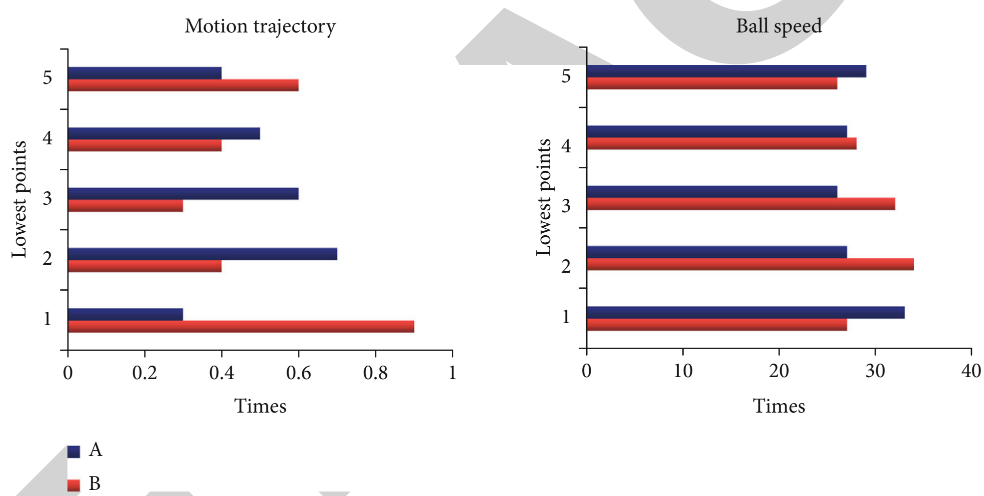

Figure 10: Badminton trajectory and ball speed.

Table 5: Ball speed measurement error.

Skill type	A	B
Rubbing	0.021 ± 0.012	0.009 ± 0.012
Push the ball	0.029 ± 0.007	0.029 ± 0.016
Hook kick	0.013 ± 0.002	0.021 ± 0.008
Pick the ball	0.025 ± 0.001	0.014 ± 0.003

threshold segmentation algorithms, and image edge detection algorithms. The feature-based method identifies moving objects by matching and tracking the structural information of the site. The theme of this article is to describe objects through a set of specific tribal representations such as the angle of right wrist rotation, the racket speed, and the highest point of the trajectory. In the subsequent posttracking process, instead of matching the stadium as a whole, it searches for areas with the same feature vector.

5. Conclusion

With the rapid development of computer technology and the information age, images are the most intuitive, vivid, concrete, and efficient form of expression among the information that humans can obtain. Therefore, the development of digital image processing technology is becoming more and more mature, and its related technologies play an increasing role in many fields. With the development of computer technology and the in-depth study of site tracking algorithms, many websites based on global compatibility have become the subject of research due to the limitations of single-site tracking algorithms. The advent of the big data era makes our daily lives produce massive amounts of audio, video, and image data at all times, and there is a lot of redundant information in these sequence image data, and the redundant information is removed through video compression and encoding technology. Information keeps the useful part of the change, saves a lot of storage space, and also improves the efficiency of reretrieval of this information. Although our country's badminton competition has always been at the forefront of the world, compared with other events, its scientific research and scientific development have always been in a backward position. In order to let more people share the results of badminton games, it is necessary to continuously innovate, develop, and improve this and the practice of badminton in our country and understand the direction, inheritance, and development of technology. By describing the position and trajectory of the landing point and movement trajectory of the arm pushing the badminton in the process of receiving and serving badminton, this research can provide badminton enthusiasts with the basic knowledge of sports technology and help enrich the specific basic technical movements and scientific development in the field of badminton analysis of optimization methods.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there is no conflict of interest with any financial organizations regarding the material reported in this manuscript.

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