

Retraction

Retracted: Detection Algorithm of Tennis Serve Mistakes Based on Feature Point Trajectory

Advances in Meteorology

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1].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.

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] H. Tang, "Detection Algorithm of Tennis Serve Mistakes Based on Feature Point Trajectory," *Advances in Meteorology*, vol. 2022, Article ID 6584827, 8 pages, 2022.

Research Article

Detection Algorithm of Tennis Serve Mistakes Based on Feature Point Trajectory

Hongxin Tang 

Ministry of Sport and Military Affairs, China JiLiang University, Hangzhou, Zhejiang 310018, China

Correspondence should be addressed to Hongxin Tang; thx027@cjl.u.edu.cn

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To address the issue of high recognition error in conventional action error detection methods, this article proposes a game of tennis serve error action detection algorithm based on feature point trajectory. To begin, a feature detection model for tennis serve images is established, followed by segmentation of the tennis serve images' multiscale features. Second, the path of the tennis serving image is effectively corrected, thereby raising the bar for tennis training and competition. Additionally, a visual feature acquisition system for tennis serving action is being developed using remote video monitoring in order to correct the path of the serving image during play. The corner mark of the serving action error point is determined using this algorithm, and the optimal modeling of the tennis serving image's path correction is realized using the developed edge segmentation algorithm. The results of simulations demonstrate that the aforementioned algorithm improves real-time performance and accuracy, and that it can accurately track players' visual edge information feature points while they are serving, conduct real-time evaluation and guidance via an expert system, effectively correct the tennis serving image path, and enhance your capacity for service.

1. Introduction

Tennis as we know it today originated in England in the nineteenth century. Tennis is a beautiful and intense sport that has become increasingly popular throughout the world and is now regarded as the second most popular ball game in the world [1–4]. Tennis serves and receives are critical components of a tennis match's structure. To be considered a good ball, the service must be delivered in the diagonal serving area of the court. The ability to master the serving action in tennis is extremely important for improving one's overall performance in the game. Tennis serving is a difficult technology to master, but it can have a surprising impact on the path correction and optimization of tennis serve images if done correctly. This method of tennis serve image path correction and optimization is extremely important, and it is represented by a diagram [5–11].

A tennis service error recognition model is being developed as a result of the advancement of digital image technology [12], which is combined with image information processing and information recognition technology. To

process the image information of tennis service movement, an image information fusion method is used, and a character analysis model of tennis service movement error is established. Image information fusion method using a combination of feature analysis and image edge contour detection, we were able to analyze the error information from a game of tennis serve action and improve the ability of the tennis action feature analysis method [12–14].

In recent years, advances in computer image processing technology have resulted in image acquisition and analysis technology that is based on computer vision analysis and image processing is applied to the acquisition and evaluation of moving scene images, among other applications. A significant amount of progress has been made in sports science and technology in recent years, owing to the advancement of modern electronics, computer science and technology, and other related fields of study [15, 16]. Application of high-tech means to sports training and competition scene judgment can allow for a more in-depth analysis of the movements and technical characteristics of sporting activities. Referees at training and competitions provide accurate data support for

the athletes. The motion range detection method is used for the tennis serve action in the traditional method; however, this method is not applicable to sports items such as the tennis serve action, whose motion range exhibits multidimensional characteristics of landing and rotation [17–25].

Tennis service error recognition methods used in the traditional method are classified into three categories: those based on feature discrimination and reconstruction, those based on joint feature analysis, and those based on multidimensional pixel feature analysis. Create a high-resolution feature analysis model for tennis serve action error recognition and then use multidimensional pixel reconstruction to detect tennis serve action errors during the serve action. On the other hand, the traditional method for tennis serve error recognition has a low capability for feature discrimination and a low capability for detection and recognition, which are both disadvantages of the method. In this regard, a number of enhancements and redesigns have been made to related literature. Several researchers, for example, have proposed a multidimensional feature vector space reconstruction of tennis serve image path correction and optimization modeling method under computer vision, which employs the critical node control method to extract limb features and improve the action's performance [26–28]. The algorithm, on the other hand, requires a significant amount of calculation and has limited applicability. It is also proposed a method for tennis service image path correction and optimization modeling that is based on the positioning of the bottom line hitting position on the tennis service image path [29–35]. The method makes use of fuzzy inference control technology to perform feature analysis and real-time monitoring of the player's service movement, while the computer vision system is integrated with the remote video monitoring system. While this system is susceptible to nonlinear distortion during the visual perception of the technical action characteristics data associated with the tennis serve action, its data collection accuracy is not as high as it could be [36, 37].

This paper proposes an algorithm for detecting tennis serve errors based on the trajectory of feature points, which addresses the issues raised previously. To begin, using remote video monitoring, a visual feature acquisition model of the tennis serve action is constructed. The visual image collected by the data acquisition system is used as a source of information for feature analysis in this paper, and an image processing method is used to design an edge segmentation algorithm for this visual image collection. The tennis serve error action detection method in this paper is based on the corner mark of the serve action's error point. The simulation results demonstrate that the method has superior performance, and an effective conclusion is drawn.

2. Tennis Hitting Technique Theory

This section investigates the serving style of tennis superstar Federer, which will aid us in the development of a tennis serve model in the future, as well as the implementation of the detection of tennis serve errors.

Despite the fact that Federer has been competing in professional men's tennis for more than two decades and has

achieved excellent competitive results, particularly as he has progressed through the stages of his career, he is still ranked among the world's top ten players. A combination of scientific training and logistical support keeps it operating at peak performance; on the other hand, its various technologies are constantly being improved and optimized. The serving technology has been sculpted over many years to be simple and practical, as well as beautiful to watch in action and extremely stable. It has the ability to score directly or gain an advantage in the game. As a result, the video clips of Federer's serve from 2019 Wimbledon final were chosen for analysis and the generation of kinematic parameters, and the serve technology was investigated using the kinematic parameters. Provide a technological reference while also improving the overall quality of service.

2.1. An Examination of the Position and Posture. Step-up and platform-style serving positions are the two types of tennis serving positions. The platform-type station technology has the potential to provide greater stability as well as a greater ground level reaction force. In terms of serving stance, Federer prefers to use the platform stance. It is necessary to use a specific method, which is as follows: the left foot is approximately 40 degrees away from the bottom line, the right foot is almost parallel to the bottom line, both feet are in a fixed position, and the distance between the feet is approximately the width of one shoulder. It is possible that Federer's selection of this position will result in increased ground reaction force, improved stability and concealment of the serve, and, as a result, an improved attack of the serve. Different service positions are one of the factors that contribute to the variation in the angle of the left shoulder joint when the ball leaves the hand. When the ball leaves Federer's hand, the angle of his left shoulder joint is 142.8 degrees.

On the top right front of the body, a reasonable tossing position should be established. When the torso rotates around and faces the net in order to swing a forward, it is possible for a ball to land directly in front of the racket, as shown in the image above. When you hit the ball, the body can produce a forward horizontal displacement and lengthen the forward swing, which is why you should hit it forward. It was at this point that Federer's left elbow angle measured 176°, and the height of the ball leaving his hand measured 1.92 m, indicating that his left elbow was fully stretched when throwing the ball and that he was capable of holding the ball horizontally between his knee and his eyes while throwing the ball. At the same time, the standard deviation of the two parameters, the speed with which the ball leaves the hand and the height with which the ball reaches its highest point, is small, which fully demonstrates the stability of the ball's throwing technique.

2.2. The Kinematics of the Knee Bending and Invoking Stages. While Federer completes the throwing motion of the ball, the knee joints of both legs are flexed, the hips are raised in front of the body, and the clap hand rotates around the shoulder joint as its axis of rotation. Drag your arm to one side and then back up to the crown of your head to finish the

entire action of throwing the ball and leading the racket. This position places Federer's clapping arm far away from the body, forming an angle of 85° with the body, and the right elbow angle is 65 percent, allowing him to turn the racquet head easily. The upward thrust of the lower body is the most direct source of tennis serve power on the court. When the extensor muscles of the lower limbs are stretched while in the state of eccentric contraction, the initial length of muscle contraction is increased, and elastic potential energy is stored, allowing for good kinetic energy support for subsequent movements. Federer puts the muscles of the lower limbs in a prestretched state by flexing the knee joint of the lower limb, which makes it easier for the feet to push the ground in the future when the knee joint is flexed. Using the flexion angle of the left and right knee joints, we can see that the left knee is larger than the right knee, indicating that the left leg is responsible for the majority of the body's stability when the knee is flexed in this position.

2.3. Kinematics of the Racket at its Lowest Point. Following the stretching of the legs upwards, the hand holding the racket causes the racket to sag naturally under the action of gravity, and the right elbow and forearm move in the opposite direction, the right elbow moves forward and upward, and the forearm and racket of the racket holding hand move down to make the racket. The head is at its lowest point, resulting in a reverse bow action that extends beyond the apparatus. If you look at the racket at its lowest point, the right elbow angle is 48° , the height of the lowest point of the racket head is 1.2 m, and the height of the body's center of gravity is also 1.2 m at this point. In tennis, the lowest point of the racket head is below the height of the center of gravity, which is called the center of gravity height. The group has been fully elongated in order to increase the explosive contraction force of the muscles in the grouping. The working distance of the racket, on the other hand, can be increased, and a faster swing speed can be achieved by increasing the acceleration distance between the racket and the ball.

2.4. An Examination of the Striking Posture. Federer's upper and lower limbs move towards each other as he hits the ball, and his body transitions from the reverse bow action beyond the equipment to the whipping action of the arm holding the clap hand. When hitting the ball, the speed of each joint is superimposed one after another, and the entire body is concentrated on the head of the racket, allowing the racket to achieve the fastest head speed possible and, as a result, hit the ball at the fastest possible speed at the hitting point. This process resulted in the angle of each joint part of Federer's body gradually increasing, as well as the lower limbs being fully stretched, in order to achieve the forward and upward extension of the torso, which allowed the whipping action of the arm with the clap hand against the ball to be successfully completed. When Federer's body is stretched, the angle of each joint part gradually increases, and the lower limbs can be fully stretched, allowing him to achieve both forward and upward stretching of the trunk, allowing him to complete the

whipping action of holding the clap arm. At the moment Federer hit the ball, the left knee angle measured 174° and the right knee angle measured 175° . Each parameter was significantly larger than the other and indicated that the lower limbs were fully extended, which was conducive to the gradual upward transmission of power through the lower limb joints. With a right shoulder angle of 171° and a right elbow angle of 179° , it can be determined that the arm of the racket-holding hand is stretched relatively straight when hitting the ball, which is conducive to hitting the ball at an elevated point, thereby increasing the success rate and aggressiveness of serving.

3. Proposed Method

3.1. Image Information Collection of Tennis Service Ball Path.

It is necessary to first construct a tennis visual acquisition model in order to achieve computer vision feature extraction of the tennis serve action. The design method for a remote video monitoring system is used in the development of the visual acquisition model. Compensation prediction can be used to delete unnecessary data from the time domain. The AD converter is used for digital-to-analog conversion of visual features during the transmission and acquisition of tennis serve action during the transmission and acquisition of tennis serve action. The hardware design of the visual feature acquisition system is based on MPEG-4, and the hardware uses the TMS320VC5509A for the main control circuit design of the visual feature acquisition system. With the MUX101 program-controlled switch, you can control two multiplications at the same time, as well as video image transmission. A chip called the AD8021 is used for pipeline operation in order to achieve anti-interference filtering of the video signal. The program-controlled amplifier VCA810 is used in the video acquisition of the tennis ball action, and it is controlled by the digital signal processor (DSP) to control the decoding and reading operands, which is beneficial in ensuring the real-time performance of the digital signal processing. Figure 1 depicts a visual acquisition model of the shape of a tennis serve action during play.

According to the analysis of Figure 1, the visual acquisition model of the tennis serve action body is primarily divided into the sensor signal acquisition module, the clock circuit module, the communication circuit module, the AD sampling module, and the DSP information processing module, among other components. It is primarily the clock generator liquid crystal display module that is included in the DSP module, and it is this module that is responsible for the actual reproduction of the visual characteristics of the tennis ball. Data buffers are implemented using flash and SDRAM.

When the tennis service ball image information is collected and the tennis service image path correction needs to be performed, the characteristics of rotating multidimensional features for the service action are presented for the service action. It is necessary to mark the corners of the error points in order to avoid confusion. It is necessary to use the critical node control method in order to achieve the extraction of limb features in the traditional method.

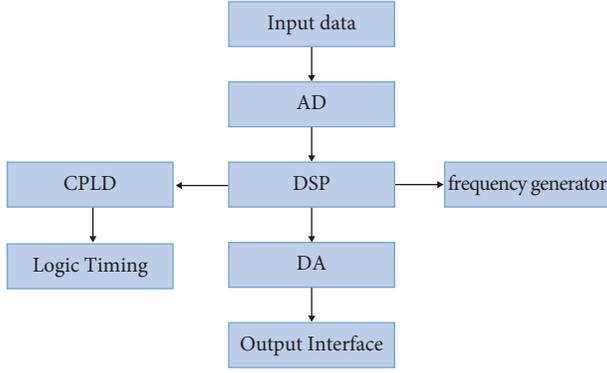


FIGURE 1: Visual acquisition flow chart.

Completed the path of the service image is corrected, but the error points in the service process are not marked, which reduces the accuracy of the path correction and causes it to be less accurate.

3.2. A Tennis Serve Error Detection Model. It is necessary to design the tennis serve action feature point extraction algorithm on the basis of the visual collection model of tennis serve action data and to combine the coding transformation, quantification, and change of the redundant coding of the predicted difference in order to improve the compression rate of the data stream in order to realize feature analysis. Making a decision on the ball's fault point, implementing the shape correction, and constructing the feature partition model of the edge contour feature point extraction of the shape are all important tasks.

$$P(I) = \alpha v_{id}(t) + \beta(p_{id} - x_{id}(t)). \quad (1)$$

After the encoder performs quantization and inverse quantization, it is possible to reconstruct the above process. Finally, using the edge contour viewpoint analysis, the communication coding error correction of the visual information feature transmission is accomplished, and the feature collection of the tennis serve action shape is completed. The multicontour 3D model of the tennis service player's multicontour 3D model of the scene modeling perspective switching motion equation is represented by the following equations:

$$\frac{\partial u(x, y)}{\partial t} = k \left[\frac{\partial G_x(x, y)}{\partial x} + \frac{\partial G_y(x, y)}{\partial y} \right]. \quad (2)$$

Various pieces of information, such as the position of the tennis player's body, the angular velocity of the tennis ball, and the rotation angle, are automatically collected by the sensor, and it is assumed that a set of position transformations relative to the root coordinate in the motion coordinate system has been established. For simplicity, let us assume that at time t , the body error of the action range of both the serving and receiving logic control units is

$$\eta = \frac{a}{a+b} \frac{E[D_1 + D_2]}{E[A_1 + A_2]}. \quad (3)$$

And then we have

$$E[D_1] = E[A_1] = \frac{1-p}{p}. \quad (4)$$

The detection model of the tennis serve action image is established in conjunction with the remote information recognition method, and the scale transformation method is used to collect the features of the tennis serve action image, resulting in the sparsity fusion model of the tennis serve action image being obtained. The fusion control function is composed of the following components:

$$F_c = \sum_{i=1}^n E_c A_i^c [r_c(l) - y_c(l)], \quad (5)$$

where the edge scale component of the tennis serve action image is represented by the symbol A_i^c in the formula. It is possible to generate the order mixed cumulant of the tennis serve motion image G_{new} using the edge scale feature segmentation approach, which can be stated as

$$G_{\text{new}} = h(j) h^3(j + \lambda) \left(\frac{T^2}{\Delta^2} \right), \quad (6)$$

where $h(j)$ is the feature set. The fourth-order cumulative mixed feature quantity of the tennis serve image H_s is expressed as

$$H_s = -m f_s \sum_{i=1}^n (g_l - g_i) R_i. \quad (7)$$

The trend function is denoted by the letter f_s , while the directivity of image features is denoted by the letter g_l . The boundary feature quantity of the video collection image of tennis service action R_i is rebuilt on the basis of the collection results of the points of contour information of the video collection image of tennis service action, which is represented as follows:

$$R_i = 3A_i^3 |\tau| \sum_{i=1}^s h_i^3(j), \quad (8)$$

where $|\tau|$ represents the frequency of the action and $h(j)$ is the feature set. The multimodal high-frequency components and low-frequency components of the video capture pictures of tennis serve actions are acquired as a consequence of the outcomes of multimodal state detection. It is possible to acquire edge scale information components for tennis serve activities from video capture pictures by combining the multiscale detection results of the video capture images of tennis serve actions with the edge scale information components for tennis serve actions.

$$SNR_i = Kr + \sum_{i=0}^s |\tau| A_i^3, \quad (9)$$

where SNR_i denotes the multiscale detection results. Then we have

$$K(a, b) = \sum_{i=0}^s h_b^2(j) m K r V. \quad (10)$$

In order to construct the world coordinate systems A and B, it is necessary to first construct the optimal state feature solution of the effect from the waist to the end of the arm, which is as follows:

$$\begin{aligned} \min F(x) &= (f_1(x), f_2(x), \dots, f_m(x))^T, \\ \text{s.t. } g_i &\leq 0, \quad i = 1, 2, \dots, n, \\ h_j &\leq 0, \quad j = 1, 2, \dots, p. \end{aligned} \quad (11)$$

where *s.t.* denotes the condition.

This paper uses the visual image acquired by the data acquisition system as an information source for feature analysis, and the image processing technique is employed to create an edge segmentation algorithm for this visual image collection. The following is a description of the modified and optimized models, as well as the better design of the algorithm. The sensor g_c is used to automatically capture information about the player's body during the tennis serve motion, such as the player's location, angular velocity, and rotation angle of the body. The rectangular image blocks N_0 and N_1 represent the visual regions holding edges and action information in plenty, and the viewpoint switching motion equation of the serving action is built, which is then used to calculate the speed of the serving action.

$$\text{image}F = [\text{quater}(R)] \times [\text{quater}(Q_i) \times W_{ij}] - W_{ij}, \quad (12)$$

where *imageF* is viewpoint switching motion.

As a consequence, the optimization of the mistake recognition of the tennis serve action is accomplished in accordance with the picture segmentation results obtained. Figure 2 depicts the process of putting the plan into action.

4. Experiment Results

Experiments are carried out in order to evaluate the performance of the tennis serve error detection algorithm developed in this work, which is based on the feature point trajectory proposed in this study. The picture has a resolution of 560 by 480 pixels. When 100 test samples in each mode are included in a set of simulation data, a total of 100 8 test sets are created, and 20 and 50 of the 100 training samples in each mode are chosen at random from each set of simulation data. Alternatively, all 100 of them combine to generate a training set of 20×8 , 50×8 , and 100×8 samples, if appropriate.

Figure 3 depicts the initial collection of tennis serve action diagram, which is compiled over time. The serving action of tennis can be divided into throwing and hitting actions. We use professional sports cameras to record the standard serving actions of professional athletes.

It is possible to accomplish the error recognition of tennis serve action by using the image in Figure 3 as the study object, as shown in Figure 4. The image error recognition result is presented in Figure 4.

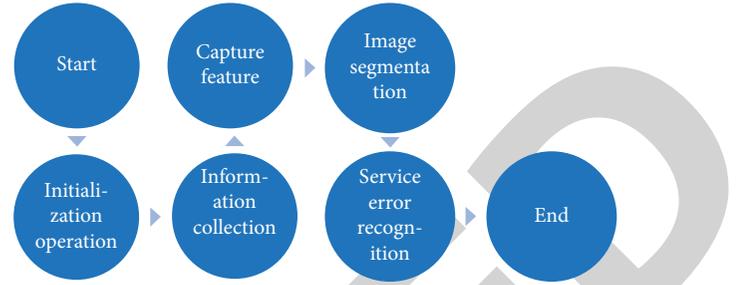


FIGURE 2: Algorithm flow.



FIGURE 3: Original tennis serve action.

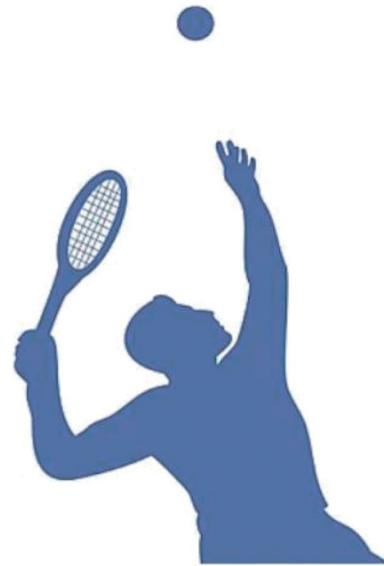


FIGURE 4: Image error recognition result.

The image processing method is used to segment the edge of the gathered visual image, and it is on the basis of this that the corner points of the serve action error spots are identified, and the process of tennis serve image path correction optimization

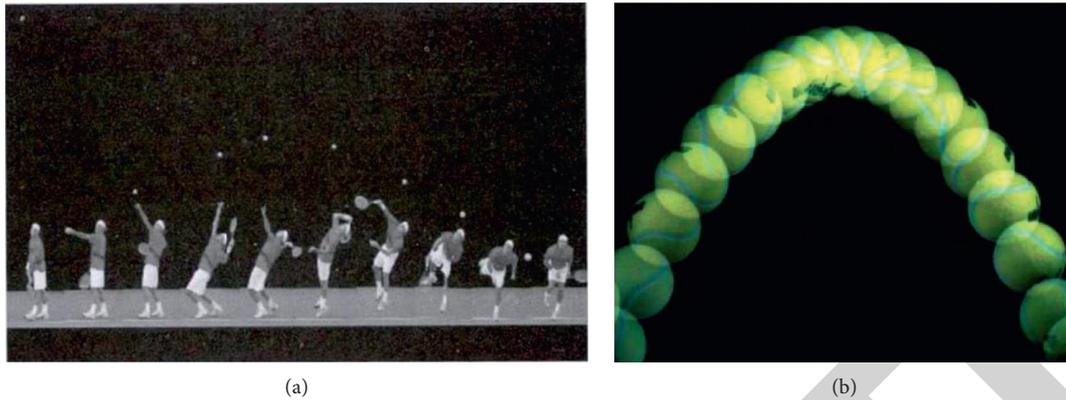


FIGURE 5: Correction results. (a) Tennis serve action correction results. (b) Tennis track.

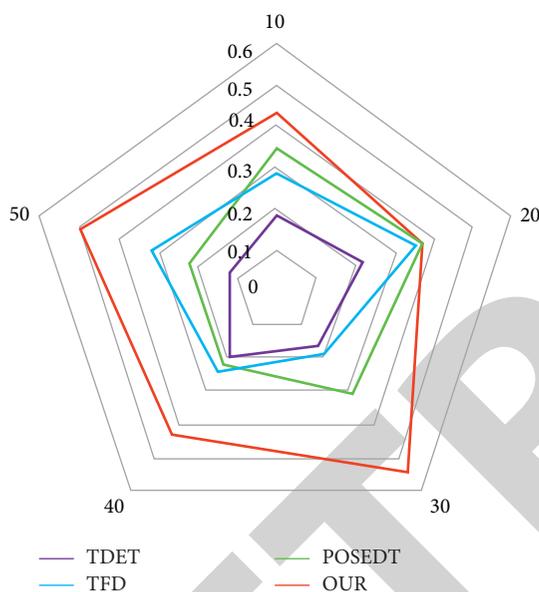


FIGURE 6: Comparison of the correct rate of service error detection by different algorithms.

and correction is carried out. According to the results reported in Figure 4, the rectified output is depicted in Figure 5. As shown in Figure 5, the approach described in this research is utilized to rectify the action shape of the tennis serving action in real time and with high precision, resulting in higher performance and real-time accuracy, providing tips and coaching, correcting improper serve trajectories, and improving serving capabilities.

Figure 6 depicts the results of a comparison between the improved method suggested in this article and the TDET, TFD, and POSEDT algorithms, respectively. It can be observed that the detection accuracy of this algorithm is substantially superior to the accuracy of the other three methods in this comparison.

5. Conclusion

This paper proposes a tennis serve error detection algorithm based on the trajectory of feature points. First, an error

recognition model of tennis serve action is constructed, and the image information fusion method is used to process image information of tennis serve action. Second, through adaptive learning and scale transformation method, joint feature point location and fuzzy action of tennis serve action video captured images are carried out. Feature detection to realize the optimization of tennis serves error recognition. Finally, the expert system is used for real-time evaluation and guidance, which can effectively correct the tennis serve mistakes. The research shows that the method in this paper has a higher accuracy rate and better recognition performance for tennis serve error detection. In the future, we will apply the technique of this paper to other ball sports, such as badminton and table tennis.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

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