Study on Sports Volleyball Tracking Technology Based on Image Processing and 3D Space Matching

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ABSTRACT The tracking technology of the 3D space position of the target is of great use to the analysis and understanding of professional volleyball match, but there are many factors that affect the volleyball tracking rate in the competition. In this paper, the image processing technology is combined with 3D spatial matching technology, and a sports volleyball tracking system framework is established with particle filter, which improves the accuracy of volleyball tracking more effectively. This article begins with a 3D tracking volleyball workflow diagram and selects using particle filters to improve tracking success rates. Secondly, the paper puts forward the similarity estimation method according to the characteristics of volleyball itself, mainly the similarity estimation of the base and HSV color space, to solve the problem of the super-computing of real-time tracking. Finally, the results of the simulation experiment can be seen that the method can greatly improve the tracking success rate, high efficiency and high accuracy of the characteristics of the dynamic video sports volleyball tracking, has an unpredictable application development value.

INDEX TERMS Image processing, 3D spatial matching, particle filters, tracking technology.

I. INTRODUCTION

With the rapid development of science and technology, multimedia data is increasing day by day. A large video database that facilitates the automated systems and tools based on multimedia information retrieval. Sports Video because of its potential business interests and entertainment function, attracting more and more people’s attention. As the pace of life accelerates in the information society, most people want to be able to relive the highlights of the game, rather than watching the whole game.

Today, most of the analysis of sports videos is based on the audience’s experience. However, more and more coaches, and sports professionals, want to use the technical analysis of video to conduct tactical analysis [1], [2]. Traditional interactive video viewing systems allow you to quickly browse video, but this indexed and overview-type sports video no longer meets their requirements. Professional sports professionals prefer to count match data and better understand tactical patterns so that they can improve technical and tactical quality and better adapt to relevant business policies.

In order to achieve this, the current trend is to take some man-made notes and get tactical analysis and statistics from the game video. However, although this artificial technology is accurate, but time-consuming and labor-intensive, then automatic tactical analysis, collection and statistics of game data, is undoubtedly the current research hot spot and focus [3].

Although more and more research is already under way on sports video, such as techniques such as ball tracking and track-based tactical analysis, the vast majority of these studies focus on sports video for tennis and football, and few research is on volleyball video. However, as one of the three balls of volleyball, its game of wonderful and intense still attracted a large number of spectators. In volleyball, how to understand the movement trajectory and drop point of the ball sent out by the player, and to judge the direction of the player’s kicking ball more accurately, is very important for the coach to make targeted tactical arrangements and analyze the characteristics of the opposing players. However, in the volleyball test, the field space is relatively small, the ball

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field density is relatively high, which makes the volleyball detection in the volleyball video brought great difficulty [4]. Therefore, in order to track the trajectory of volleyball more accurately, we must make full use of video data and get more space information about volleyball.

In order to achieve the above accurate tracking volleyball, it is necessary to obtain a wider range of 3D spatial information, after obtaining this space information, can make more full use of these space information, these have become the focus and difficulty of this paper. Compared with other about volleyball positioning, tracking method is an ideal solution [5]. On the one hand, volleyball tracking is more efficient than volleyball’s recognition and more reliable than other approximations. More importantly, tracking targets in 3D real-world space became more feasible as tracking technology matured.

Therefore, in order to obtain more reliable and in-depth tactical analysis in volleyball games, it is very important to obtain more accurate information on volleyball tracks [6]. Therefore, the analysis of the factors affecting the accuracy of volleyball tracking and design a more suitable scheme to solve them, has become the focus of this paper.

Given the unique environment of volleyball matches and the limitations of shooting conditions, it is difficult to obtain accurate tracking through general tracking methods. There are some problems with ball tracking as follows:

(1) The ball moves quickly and irregularly, making it difficult to predict and track.

(2) The small size of volleyball in the game video makes the ball lack feature points, making it difficult to extract the features of the ball. What’s more, the size of the ball changes in flight, thanks to projection theory.

(3) The texture of the ball in the each direction video is different from the texture in the other direction video, and it changes constantly causing rotation.

(4) In the video scene, there is a large audience and a lot of staff, making the background very complex and causing a lot of noise during the tracking process, which greatly affects the tracking results.

(5) Sometimes in the video, dozens of players on the pitch have to move constantly to block the volleyball, which can be easy to track the failure.

II. 3D VIDEO TRACKING TECHNOLOGY RESEARCH STATUS

A. 3D TRACKING VOLLEYBALL RESEARCH STATUS

Early, based on 2D space extraction ball movement trajectory has developed more mature, its physical characteristics, such as the shape of the ball, the color of the ball and the ball’s motion trajectory, can track the ball relatively accurately [7]. But when dealing with more complex situations in the actual space, such as the analysis of the volleyball video game, the 2D space is not enough to accurately track the position of the volleyball. Because the background is more complex and the “masking” phenomenon that occurs. Therefore, the 3D extraction trajectory method is proposed.
approximate the volleyball motion trajectory is not very high. Therefore, this paper improves the traditional method.

B. THE SELECTION OF PARTICLE FILTER
Particle filtering is based on the Monte Carlo method, which uses the random sampling of particles to represent a certain probability, and then redistributes the particles according to the principle of importance sampling. In the target tracking technology, the simplicity and easy realization of particle filtering have become the favorite algorithms of a wide range of researchers.

(1) Hess proposes a training method with discrimination capability within the tracking range of multiple targets and applies it to particle filters. The birth of this method is due to the difficulty of manually adjusting the parameters of multiple models, and the results of testing in many application areas show that the training method with the ability of discrimination is usually better than the resulting training method [8].

(2) Huang proposed a positioning method for relatively small targets, which integrates detection and tracking. The system is initialized by a strong detector, which then repeatedly locates the target by using a weak detector and a temporary tracker. The strong detector and the weak detector are based on the division of foreground and background, strong detector is produced from the front of the speckled shape analysis and the use of trigger object tracker two aspects. The weak detector is formed by the output value of the foreground detection probability and the observation probability integrated into the tracker. As a case study, this method is suitable for football detection and tracking in football videos. However, the strong detectors and weak detectors that have been used are based on the division of foreground and background and are not well used in the detection and tracking of complex backgrounds. Therefore, although this method can detect and track video matches in simple backgrounds such as football matches, the use of this method in the detection of volleyball video sits is not very high performance, because in volleyball video, the video background composed of spectators and staff, etc. is more complex [9].

(3) Guo proposed an estimation model based on the HSV color space and gradient direction model, and applied it in combination with particle filtering to the detection and tracking operation of the actual target. As shown in Figure 3, the gradient direction model obtains the objective gradient direction feature without passing the traditional HSV color spatial model. Before establishing the gradient direction model, the Sobel gradient generator is used to deal with the noise of the picture in order to obtain the gradient information. In this method, both the HSV color spatial model and the gradient direction model are represented by histograms [10]. Through the proposed observation model, the object can be detected more accurately, and the uncertainty of detecting the target is greatly reduced compared to the individual color space model. However, this method based on the gradient direction model is not well used for the target of its own feature changes. Since volleyball itself rotates during the course of sports, the estimation method proposed by Guo is not suitable for volleyball detection in volleyball videos.

C. THE OVERALL STRUCTURE OF THE RESEARCH SCHEME PRESENTED IN THIS PAPER
The basic knowledge and experimental preparation needed in this paper are introduced in the first part, and the concept and working principle of the particle filter used in this paper are emphasized. This section mainly introduces the content structure of the research project. Figure 4 shows the overall structure of the research proposal [11].

Firstly, the state space vector representation of the particle filter is established in physical coordinate system. In state space, the state sequence of the evolutionary equation of the target object to be tracked \( (X_k) \) is represented as the following equation:

\[
X_k = [x_k, y_k, z_k]^T, \quad k \in N \tag{1}
\]

\[
X_k = f(X_{k-1}, v_k) \tag{2}
\]
In this case, the independent, identical distributed process noise.

\[
\begin{align*}
    x_k &= x_{k-1} + R \cdot N(0, 1) \\
    y_k &= y_{k-1} + R \cdot N(0, 1) \\
    z_k &= z_{k-1} + R \cdot N(0, 1)
\end{align*}
\] (3)-(5)

In the equation above, \((x_{k-1}, y_{k-1}, z_{k-1})\) represents the position of the particle in the \(k-1\) frame, \((x_k, y_k, z_k)\) represents the predicted position of the object to be tracked in the \(k\) frame, \(R\) is a constant value. \(N(0,1)\) represents the system noise, the system noise is defined as a GAUSS random number with an expectation of 0 and a variance of 1.

In the estimation of the similarity of each particle, the 3D coordinates of the corresponding particles in different camera directions are projected into the 2D image spatial coordinates using the calibration matrix of the corresponding camera. Then according to the corresponding projected coordinates, the approximate estimate of the image, can be calculated by the characteristics of the particle tracking window. In this way, the similarity of particles can be obtained from the similarity of 2D images using the similarity measurement method. This paper proposes the similarity estimation method based on the characteristics of volleyball, which contains three aspects:

1. The use of adaptive volleyball size tracking window can automatically adapt to the size of the volleyball in the image taken by the camera in different directions;
2. In order to obtain more accurate similarity of particles, a similarity model based on volleyball features is proposed.
3. This paper also provides multiple cameras to shoot video at the same time to avoid the “occlusion” problem, so as to obtain more accurate particle similarity.

After calculating the similarity of all particles, each particle will be resampled based on its similarity value to get a new particle distribution, and the area where large amounts of particles are considered to be the target to be tracked. In general, the phenomenon of tracking failures is unavoidable on the basis of current technology, and the success rate of the entire tracking decreases in the event of a tracking failure [12]. In order to solve this problem in order, this paper gives the automatic recovery particle filtering method based on volleyball detection, which is used before the prediction of the next frame of the picture. In the event of tracking failure, the detection of volleyball by frame through the image obtained by the camera, if not detected, then continue to detect the next frame, if the detection of volleyball, then give the particle filter feedback an enabling signal, let the particle filter initialize, and thus let the tracking action continue.

III. 3D FEATURE DETECTION AND AUTOMATIC RECOVERY TRACKING TECHNOLOGY

A. SIMILARITY MODEL BASED ON VOLLEYBALL CHARACTERISTICS

In the process of motion tracking of the ball, designing similarity model according to the characteristic information of the ball itself is beneficial to the detection of the target object [13]. In this experiment, because volleyball is not a single color or a highly uniform color of the ball, from a different perspective in the past, see the color and texture of the volleyball are different. Therefore, in the process of similarity estimation, the extraction of the texture characteristics of volleyball is very difficult to do. Therefore, in order to reduce the interference of the background with high complexity and to solve the rotation problem in the course of volleyball to some extent, we have adopted some methods to extract the unique characteristics of volleyball, and then the unique characteristics of these volleyballs are converted into the characteristic similarity model of volleyball, so as to improve the performance of volleyball tracking [14]. In this paper, the characteristic similarity model of volleyball consists of three parts: the similar model of the circle, the similar model of the HSV color space, and the similar model of moving similarity. As shown in Figure 5, these similar models are based on three characteristics of volleyball: shape, color, and movement.

The video image captured by the camera, respectively, using the HSV color space method, The Sobel operator to take feature value method, and the background differential method to analyze and calculate each frame of image, can obtain the similarity of HSV color space, circular similarity and volleyball motion state similarity. Then the values of similarity under these three methods are combined to obtain a whole model of similarity based on volleyball characteristics, so that the accuracy of the tracking process is guaranteed. The four pictures in Figure 6 are four consecutive 2D images at a certain angle and at a certain time. Most of the objects in the image have not moved significantly, but the volleyball position has been significantly moved. The volleyball position is circled with a yellow rectangle.

Because the features we use to get the similarity are the features of the image, the observation space \(I_k\) is constructed from discrete time \(k\) and the \(m\) cameras. As shown in formula (6) below:

\[
I_k = \left\{ I_{k}^{1}, I_{k}^{2}, \cdots , I_{k}^{m}, \cdots , I_{k}^{M} \right\}
\] (6)

Estimation Based on Circular Similarity: One of its most obvious features is the circular shape presented in the video image captured by the camera as the ball tracking process [15]. The same is true of volleyball tracking. In volleyball
game videos, only a portion of the circular object exists in a larger noise environment, so how to distinguish these small round objects from the large amount of noise in the background is extremely important. Therefore, this paper uses the ring detection method to detect volleyball and some other round or near-circular objects, which also helps to calculate the similarity of the circle. In the volleyball tracking testing study of this paper, the similarity of the circle is defined in Figure 7:

In the process of volleyball match video tracking detection, in order to ensure that the probability of tracking window appearing in the video is higher, we give the concept of roundness. A circular Area C, shown in figure 7, can be defined by a given position P and a given distance d. At the edge of the circular area C, for each pixel i, the three black points in Figure 7 are any three pixel points, and the components of the gradients that point to the circular area C are defined as a circular gradient. The value of the circular gradient gi, can be calculated from the values of the vertical gradient (7) and the Horizontal Gradient (8), and the formula is as follows:

\[ \theta = \tan^{-1} \frac{y_i - y_p}{x_i - x_p} \]  

\[ |g_i| = |g_x| \cdot \sin \theta + |g_y| \cdot \cos \theta \]  

In the upper equation, \((x_i, y_i)\) are the coordinates that represent the pixels of i, \((x_p, y_p)\) are the coordinates of the points of \(p\), \(\theta\) are the coordinates of the angle of the x-axis in the coordinate system and the line from \(P\) to \(i\). \(|g_x|\) and \(|g_y|\) represent the values of the circular gradient vector module, the vertical gradient vector module and the horizontal gradient vector module respectively. After defining the direction of the gradient and the modulus of the circle, the roundness of the circle \(C\) \((\text{Cir}_C)\) is defined as the sum of the values of the gradient of the circle \(C\) of all the pixels on the edge of the circle, expressed in the formula (9):

\[ \text{Cir}_C = \sum_{i=0}^{n} |g_i| \]  

In this formula, \(n\) is the total number of pixels on the edge of a circle, the roundness of the Image region determined by the particle’s tracking window is greater when a particle’s adaptive size circular window is positioned on the circular object in an image. In contrast, if the particle’s adaptive-size circular window is not at the circular object, the roundness of the image region determined by the particle’s tracking window is small [16]. Thus, the roundness of this monitored image region can be expressed as the particle’s circular similarity according to formula (10). In this formula, \(L_{\text{circle}}(x_k; I^n_k)\) is the circular similarity of the particles in the observation space of \(I^n_k\) in the \(x_k\) state. \(A\) and \(\alpha\) are two fitness coefficients, and the magnitude of their values can be determined experimentally.

\[ L_{\text{circle}}(x_k; I^n_k) = A \cdot \log_{\alpha} \text{Cir}_C \]  

IV. ESTIMATES OF AN ADAPTIVE TRACKING WINDOW BASED ON VOLLEPatrick SIZE

Usually design a tracking window to track the target during the tracking process. The tracking window is used to locate the specific location of the target to be tracked in the video sequence. In general, the target to be tracked is usually not stationary, but at every moment in motion, especially when the target is doing irregular free movement, to track it in real time, then the tracking window is necessary [17].

In the current tracking strategy study, researchers have been able to design tracking windows based on different types of video, size, texture characteristics and other objects, with a tracking window, so that the video to be tracked objects can be clearly identified. However, designing a tracking window that can mark the target is no longer sufficient to meet the requirements of an increasingly complex video environment and higher tracking accuracy, because in many cases, the object to be tracked in the video is often affected by its trajectory, resulting in the target appearing in the video at different times of the time, in which case, If you continue to use a pre-designed tracking window to track targets, it will lead to tracking errors, and even lead to the wrong target lead to the failure of the tracking strategy [18]. In this case, the use of fixed-size tracking windows has not kept up with the needs of life and research trends. Therefore, to ensure the size of the tracking window and volleyball in the volleyball tracking strategy occupies a very important position.

In the volleyball video, the camera and the background of the playing field remain still, a normal volleyball game, it is not possible to ensure that the movement of the volleyball from the left side of the screen to the right side of the screen, and usually appear volleyball due to the players from different
angles to different directions, volleyball sometimes move in the direction of the camera, sometimes the camera is moving in the direction of the volleyball [19]. These situations are unavoidable, and when these situations occur, the size of the volleyball seen in the video changes. In general, we ask that the tracking window be kept the same size as volleyball, but when volleyball is affected by its trajectory and cannot be guaranteed to match the size of the tracking window, it can result in a lower tracking success rate, or even a tracking failure. This is because if the tracking window is larger and larger than the size of the volleyball in the video, there is a lot of background content in the tracking window at this time, in addition to the volleyball itself. Because the background content is unknown, it is not possible to guarantee that the background information will have an impact on volleyball detection, and how much impact will be made. On the contrary, if the tracking window is small, so that the size of the volleyball in the video, it will lead to the loss of the edge information of volleyball, and in the volleyball detection, the edge information of volleyball contains a large number of information conducive to tracking, therefore, this situation will be due to the lack of information, resulting in incomplete detection of the target area and tracking failure. Therefore, the tracking characteristics of volleyball will be seriously disturbed and damaged.

This paper puts forward a method of changing the size of the tracking window to make up for the change of volleyball size in the process of volleyball tracking [20]. The concept of adaptive size tracking window based on volleyball size, how to calculate and define the radius size of the tracking window, and the projection strategy of the relevant volleyball projection to the camera are shown in Figure 8.

In volleyball projection 2D image, taking into account the distortion, difference and other errors in image processing or camera shooting game video, the radius of volleyball projection to 2D image is only a theoretical mathematical calculation, and does not represent the accurate value of the actual measurement and calculation. Therefore, we need to introduce a variable factor to the projection radius. The calculated radius of volleyball on the 2D image is multiplied by this variable radius to estimate the radius value of the volleyball tracking window. Because the video is shot in real time, continuous, so the camera in the working state, every moment in the use of calibration matrix to the actual space of the volleyball projected into the 2D image, so every moment is repeated calculation of the projection of the 2D image of the radius of the volleyball. The radius value of the tracking window is controlled according to the radius value of each frame of volleyball, so that the tracking window of adaptive size can be obtained.

V. TEST RESULTS AND PERFORMANCE ANALYSIS

A. RELATED WORK

This article uses a combination of 4 cameras to work. Because the coordinate distance of the same point in different 3D spaces needs to be matched, at least 3 cameras are required. In order to avoid the inability to implement the 3D matching strategy due to the obstruction of the player’s body, thereby reducing the success rate of volleyball tracking, this article uses four cameras to be placed at the four corners of the rectangular geometric design of the court to effectively improve the tracking success rate. If more cameras are used, the tracking success rate will be further improved, but the increase is small, and the workload and experiment cost will be greatly increased. Therefore, this paper uses 4 cameras to collect information.

At the same time, taking into account the unavoidable objective conditions, such as the uneven brightness of the playing field, the speed of the volleyball in the air, the speed of the volleyball, or the size of the volleyball in the camera’s perspective at different times. It is necessary to adjust the parameters of the camera so that it can adapt to the optimal value of the actual situation.

The video captured in this experiment is a 1920 * 1080 pixel HDTV video with 60 frames per second. In this article, we choose such video parameters because, compared to high-speed video with only 720p pixels, HDTV video has higher pixels, which can obtain a clearer video, which facilitates the detection and tracking of volleyball, making the experimental results more accurate. Similarly, compared with 4K high-quality video, its frame rate is only 30 frames per second. Therefore, using HDTV video can have a higher frame rate while ensuring a high pixel, which is also beneficial to the experimental process in this article. We know that in the video of volleyball games, the speed of volleyball is usually very fast. If a video with a lower frame rate is used, then the volleyball may have moved a long distance in the two adjacent frames. Not only that, in order to prevent the motion blur caused by the volleyball with a fast speed, we choose a higher shutter speed of 1000 frames per second and a color temperature of 4000, which belongs to the intermediate color temperature.

B. EXPERIMENTAL ENVIRONMENT AND DEFINITION OF ALGORITHM PARAMETERS

The implementation of all algorithms in this paper is based on the advanced programming language of C, combined with the technical support of open CV 2.4.8 version. Heterogeneous platforms are used to accelerate the entire algorithm model [21]. This section will give a brief introduction to the parameters required in this paper and give the best definition value, so that it can ensure the smooth running of this experiment and the accuracy of the experimental results. Before the experiment, as analyzed earlier, the calibration matrix of the camera is essential for the 2D image of the object being converted from the actual 3D spatial coordinate system to the video sequence, and may even have a significant impact on the experimental results, which cannot be carried out and the experiment fails. In the process of camera calibration, first of all, to determine the target point from the physical coordinate system, here, we select 6 (at least 6 target slots to complete the
calibration) calibration, as shown in Figure 9, in this experiment we selected 6 physical coordinate system of the target points are A (450,900,0), B (450,−900,0), C (−450,900,0), D (−450,−900,0); E (445,0,240) and F (−450,0,140). Therefore, based on the six selected targets, we can calculate the calibration matrix for each camera and their coordinates in the 2D image.

The tracker used in this article is implemented by particle filtering algorithm based on multi-command queues and step parallel iterations. First, implement a parallel framework for tactical thread allocation to implement the base thread [22]. Second, on the basis of the first proposal, the step-by-step addition of the combination selection section sits in K4 and K5. In addition to iterative algorithms, some parallelism within the iterative algorithm is further realized. Finally, multiple command queues are added to the entire structure to achieve parallelism between the kernels that have been finely executed. Here we define particle filters.

In the experiment, we used a total of 1024 particles, first, the 1024 particles were artificially dispersed in the initial position of volleyball. In the next prediction, all particles will be redistributed in the image according to the Gaussian distribution. According to the statistics of volleyball, of course, volleyball will not exceed 130km/h except in exceptional circumstances. This means that under HDTV video in this experiment, the maximum distance of movement between any two frames of image is less than 56 cm if the frame rate is 60 frames per second. Therefore, during our experiment, we set the Radius of the Gaussian window at 150 cm, which is greater than the range of the volleyball. Also, during the particle resampling phase, we will select the position of the more similar particle in the position of the volleyball to be tracked.

In addition, we also need to define some parameters in the estimation of particle similarity. For the Similarity Estimation Algorithm Based on HSV Color Space, we define that 8 color samples are needed to calculate the similarity under the algorithm, and in the similarity estimation algorithm based on the characteristics of the circle, we define that the bounding thickness of the circular area is 2 pixels.

Finally, in the automatic recovery process of the tracker based on the similarity of the volleyball characteristics, we also need to define a threshold for extracting candidate volleyball areas from 2D images, which in this experiment we define as a threshold of about 10, which is defined as a constant attempt at the experiment [23]. This threshold can effectively filter out the noise in the image and ensure that the candidate area is not lost. Here is a good balance between de-mania and ensuring no loss in the effective area.

C. EXPERIMENTAL RESULTS
After defining the various parameter values required in the experiment, the specific experimental process begins. First
of all, we will give a definition of tracking success rate, and the results obtained by this experiment with the results of past researchers to verify that the algorithm proposed in this paper is feasible, and the tracking results have been further improved [24]. Finally, according to the tracking process of volleyball, the 3D movement track of volleyball is extracted.

1) COLOR/GRAYSCALE FIGURES

Volleyball is both physically and conceptually estimated by event units, because the true value of physical states is impossible to obtain. During an event cell, if the ball track has a continuous curve without sharp gaps and all projected 2D image coordinates are within the area of the ball in the image frame, we determine that the ball tracking of the event cell is successful [25]. To visualize the tracking results, we selected a test sequence and plotted the tracked 3D track in the figure, figure 10. Once the physical state of volleyball changes, the trajectory is drawn by different markers and colors.

The experimental process based on the research method proposed in this paper is based on the 3D video timing of the realization of volleyball in real space. To observe the results more intuitively, we used Matlab simulation software to represent the tracked volleyball movement in a 3D coordinate system. As shown in Figure 11, we have developed a volleyball track for six rounds of the game in the experimental video sequence. Among them, Figure a, Figure b and Figure c show three ordinary match rounds, including one tee shot, one receiving shot, one pass and one dunk, the end of the final round. Figure d, Figure e and Figure f show rounds
that contain more HITS. In particular, the match round shown in Figure d, which contains a total of 26 HIT, was successfully tracked by the theoretical algorithm presented in this paper. In each of the simulations shown, the movement trajectories of the volleyball’s 3D space are successfully extracted.

VI. CONCLUSION

The research on sports volleyball tracking technology based on the matching of image processing technology with 3D space can greatly improve the tracking performance of the system, so as to further meet the needs of competition analysis. By extracting the position of volleyball in 3D space, we can provide more valuable information resources for professional volleyball matches, and facilitate the understanding of the game and the formulation of tactics. These valuable information includes the trajectory of volleyball, the speed of the ball and the time of play, the direction of the volleyball flight every time the volleyball is hit. Using this data, it is possible for professional teams to analyze the opponent’s tactics, and then develop effective tactics. Not only that, the research results of this paper can also be used for volleyball team training, through the recording of training videos, coaches can develop different training methods for the characteristics of different players, so as to improve the individual strength of the players, but also enhance the strength of the team. From the point of view of practicality and industrialization, it is necessary for a target to track with a high success rate, and to be able to track and analyze in real time. At the same time, in the current program, the camera position and parameters of the setting will also limit the application of the theoretical algorithm of this paper to a certain extent. Since the video sequence of this study is captured by still cameras, future work will focus on video captured on mobile cameras as a research object.

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