Sports Video Tracking Technology Based on Mean Shift and Color Histogram Algorithm

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Abstract. With the development of society, people pay more and more attention to sports. In this context, sports video tracking technology has become a research hotspot. At present, a lot of research has been done on target tracking technology at home and abroad, and great breakthroughs have been made. However, there are still some deficiencies in the existing video tracking algorithms. On this basis, this paper combines the mean shift algorithm with color histogram algorithm, and proposes a new sports video tracking technology algorithm. In the study, in order to verify the effectiveness of this method, we select two videos to do experiments. In order to highlight the advantages of this method, we will use the mean shift algorithm for sports video tracking method and the color histogram algorithm for sports video tracking method as a comparison. The results show that, overall, the tracking accuracy of the proposed method is the highest, with an average tracking accuracy of 95.9%, followed by the mean shift algorithm for sports video tracking. The average tracking accuracy of this method is 90.35%. Finally, the color histogram algorithm is used to track sports video, and the tracking accuracy of this method is accurate the rate was 89.8%. In addition, the tracking speed of the proposed method is better than the other two methods. It can be seen that this method has good performance and can track sports video quickly and accurately.

Keywords: Mean Shift Algorithm, Color Histogram Algorithm, Video Tracking Technology, Tracking Accuracy

1. Introduction
In recent years, more and more attention has been paid to sports competition, and constantly improving the level of sports competition has become the ultimate goal of national sports training. With the improvement of the level of sports competition, how to quickly and conveniently understand the training level and sports parameters of athletes, and help athletes carry out more efficient training, has become a new demand of sports competition [1, 2]. We know that if we only rely on the coaches' observation records and intuitive judgment for sports training, it is far from enough, and can no longer meet the needs of today's society for a higher level of competition [3, 4]. If the computer vision technology is applied to sports training, it may be able to achieve good results. Compared with human eyes, machine vision has many advantages, not only with better accuracy, but also with better memory,
so it can quickly capture moving objects and record various motion data of objects [5, 6].

Video surveillance technology is the process of detecting each independent moving object in each frame of the image and identifying the target in the next frame. In sports, due to the non-rigid characteristics of human body, the difficulty of target tracking is increased, and the stability and accuracy of the algorithm are required to be higher [7, 8]. Most video tracking algorithms are computationally cumbersome, consume a lot of computer resources, and are sensitive to the noise, occlusion, illumination changes and other issues of the scene, which fails to meet the requirements of real-time and accurate tracking. Therefore, it is of great significance to find a better video tracking technology for solving the problem of sports video tracking [9, 10].

In this paper, the mean shift algorithm and color histogram algorithm are combined, and a new sports video tracking algorithm is proposed. At the same time, in order to verify the effectiveness of the proposed method, we carry out simulation experiments. In the experiment, we choose two videos as experimental materials, use the method of this paper and other two methods to track the athletes in the video, and analyze the tracking speed and accuracy of the three methods. The results show that compared with the other two methods, the proposed method has higher tracking speed and tracking accuracy, and has better performance.

2. Mean Shift Algorithm and Color Histogram Algorithm

2.1. Mean Shift Algorithm
Mean shift algorithm has a profound statistical theoretical basis, and its nonparametric technology has ideal robustness of statistics and probability distribution. It can be said that the probability distribution along the maximum density of the shift function is based on the maximum density. So, what is the principle of nuclear density assessment? This principle is similar to histogram technology. Usually, histogram is used to record the number or frequency of each interval point, so as to ensure that the height of rectangular bar increases with the number of values. Because the numbers are different, it is difficult to give more accurate density estimation.

The formula of kernel density estimation method is as follows

$$\hat{f}(x) = \frac{1}{nh^d} \sum_{i=1}^{n} K \left( \frac{x - X_i}{h} \right)$$

(1)

The gradient estimation of probability density is defined by the gradient of kernel function density estimation

$$\nabla_x \hat{f}(x) = \nabla_x \hat{f}(x) = \frac{1}{nh^{d+1}} K \left( \frac{x - X_i}{h} \right)$$

(2)

Mean shift algorithm has a profound statistical theoretical basis, and its nonparametric technology has ideal robustness of statistics and probability distribution. The statistical robustness is that the weighted kernel density estimation method ignores the influence of noise, interference objects and occlusion on the edge data points of the target, and enhances the weight of the central neighborhood of the target to enhance the overall adaptability and robustness. At the same time, the mean shift vector is used to quickly search pattern points in the direction of density gradient, which improves the operation efficiency and speed of the tracking algorithm.

2.2. Color Histogram Algorithm
We know that color space, also known as color model or color system, is an acceptable simplified color specification provided according to some standards, and it is also a method to describe color characteristics easily. On the other hand, there are essential differences between color image and gray image. In short, in color space, the image capacity of a color image is represented by a vector (usually
including three elements), while the pixel characteristics of the image in gray scale are only represented by a scalar. Therefore, in color image processing, we only need to deal with vector function, but in gray image processing, we only need to deal with scalar function. Generally speaking, the color image is composed of red, green and blue, and each primary color is a gray image. Therefore, it can be said that the enhancement of color image is based on the enhancement of gray image.

We know that the most reliable feature of an image can be said to be the color distribution in the image, which can be described by color histogram. Color histogram is to measure the frequency of different colors in the whole image in a specific color space, which is usually used to describe the statistical characteristics of image colors. However, the color histogram does not consider the spatial position of each color, only records the number of pixels of each color.

The algorithm principle of color histogram is as follows:

Assuming that the shape of the non rigid human object is ellipse, the selection of the target in the current frame image is initialized, and then the shape of the target can be approximately obtained by calculation:

\[
V_0 = \sum (x_i - \theta_0)(x_i - \theta_0)^T
\]  

As we know, color histogram divides the color space into \( m \) discrete color sub regions. Then, the value of the \( M \) color sub interval can be calculated by the following formula:

\[
O_m = \sum_{i=1}^{N_0} N(x_i; \theta; V_0) \delta[b(x_i) - m]
\]  

The similarity between current frame candidate target and target model can be obtained by calculating the similarity of histogram

\[
\rho[r(\theta,V),o] = \sum_{m=1}^{M} \sqrt{r_m(\theta,V)O_m}
\]  

Different color images have different color histograms, but the main hue of each color image will be reflected in the color histogram. In the calculation of color histogram, the color histogram is sorted from high to low according to the height of color column, and the level serial number of each color column is determined. The color column corresponding to different color histogram is regarded as the same level feature, and the similarity measurement is carried out.

3. Simulation Environment

(1) Experimental environment

The color histogram of 16×16×16 in RGB color space is used in this program. The experimental platform is configured as interi3-2310 CPU and 2G memory.

(2) Experimental materials

In order to comprehensively investigate the performance of the proposed algorithm in different scenarios, this paper selects two videos to test.

1) Video 1
Video 1 is taken from table tennis players. The pixel size of the video image is 352×240, the frame rate is 15 frames / second, and the total number of frames is 60 frames. The purpose of video 1 is to track the movement of athletes' heads. In this video, the head and the background color difference is big, in the whole movement process, it is not blocked by other objects.

2) Video 2
Video 2 is a video of athletes running. The pixel size of the video image is 385 × 288, the frame rate is 30 frames / second, and the total number of frames is 100 frames. The purpose of video 2 is to track the athletes' walking position. In the video, the background color of the characters changes
obviously when the athletes are running on the track.

(3) Evaluation index

In order to verify the superiority of the proposed algorithm, we compare the tracking speed and accuracy of the three methods by using the mean shift algorithm and the color histogram algorithm.

4. Analysis of Sports Video Tracking Technology Based on Mean Shift and Color Histogram Algorithm

4.1. Comparison of Tracking Speed of Three Sports Video Tracking Technologies

The tracking speed of three kinds of sports video tracking technology is compared, and the results are shown in Figure 1 and Figure 2.

![Figure 1. Tracking speed analysis of video 1](image)

It can be seen from Figure 1 that in video 1, the tracking speed of sports video based on mean shift and color histogram algorithm proposed in this paper is the fastest, with an average tracking time of 0.043s, a maximum tracking time of 0.06s, and a minimum tracking time of 0.038s. The average tracking time is 0.05 s, the maximum tracking time is 0.068 s, and the minimum tracking time is 0.042 s. The average tracking time is 0.055 s, the maximum tracking time is 0.072 s, and the minimum tracking time is 0.048 s. Therefore, in the case of video 1 without background color change, the tracking speed of this method is the best, the average shift algorithm is the second, and the color histogram algorithm is the worst.
Figure 2. Tracking speed analysis of video 2

It can be seen from Figure 2 that in video 2, the tracking speed of the proposed sports video tracking technology method is still the best among the three methods. Among them, the average tracking time is 0.053 s, the maximum tracking time is 0.072 s, and the minimum tracking time is 0.042 s. Secondly, the color histogram algorithm is used to track sports video. The average tracking time of this method is 0.061s, the maximum tracking time is 0.082s, and the minimum tracking time is 0.05s. The average tracking time is 0.069s, the maximum tracking time is 0.086s, and the minimum tracking time is 0.056s. This is because the background color has changed, and it is difficult to distinguish the correct target and background by color representation, so the tracking speed is reduced.

In conclusion, when the background color of video 2 is generated, the tracking speed of this method is the best, followed by the color histogram algorithm, and the worst method is the mean shift algorithm.

4.2. Comparison of Tracking Accuracy of Three Kinds of Sports Video Tracking Technology

The tracking accuracy of three kinds of sports video tracking technology is compared. The results are shown in Table 1 and Figure 3.

Table 1. Tracking accuracy of three kinds of sports video tracking technology

| Method                        | Video 1    | Video 2    | Average accuracy |
|-------------------------------|------------|------------|------------------|
| The method of this paper      | 96.5%      | 95.3%      | 95.9%            |
| Mean shift algorithm          | 92.1%      | 88.6%      | 90.35%           |
| Color histogram algorithm     | 88.5%      | 91.1%      | 89.8%            |
It can be seen from Table 1 and Figure 3 that in video 1, the tracking accuracy rate of sports video tracking technology proposed in this paper reaches 96.5%, while the tracking accuracy rate of sports video tracking method using mean shift algorithm is only 92.1%. In addition, in sports video tracking technology using color histogram algorithm, the tracking accuracy rate is lower, only 88.5%. In video 2, the tracking accuracy of sports video tracking technology proposed in this paper is slightly lower than that in video 1, which is only 95.3%. However, in sports video tracking technology using color histogram algorithm, the tracking accuracy rate is only 88.6%. Moreover, the tracking accuracy rate of sports video tracking technology using color histogram algorithm is not as good as the method in this paper the accuracy was only 91.1%. In addition, from the average accuracy of the overall analysis of the three methods, the sports video tracking technology proposed in this paper has the highest average tracking accuracy, up to 95.9%. In the second place is the method of sports video tracking using mean shift algorithm. The average tracking accuracy of this method is 90.35%. Finally, color histogram algorithm is used the tracking accuracy of this method is 89.8%. In addition, in the tracking process, the method can lock the correct target position and maintain a high similarity.

5. Conclusions
With the development of society, people pay more and more attention to sports, sports video tracking technology has become an important research hotspot. In order to achieve the purpose of monitoring the non rigid object of human body in sports video, this paper combines the mean shift algorithm and color histogram algorithm, and proposes a new sports video monitoring technology, and the superiority of this method is verified by experiments. In this paper, we use the statistical robustness of the mean shift algorithm and the fast convergence along the density gradient direction, as well as the color histogram algorithm to match the shape of the target, which solves the problems of the non rigid target shape changing and tracking complexity, and has achieved good research results.

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