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Analysis of the players' behavior in the volleyball track under the computer vision

Heng Zhao[1,3], Qin Xia[2]

Abstract. For a long time, the sports competitions analysis is through manual not only fail to accurately record the effect, a lot of time also caused a waste of time and judgment errors of, and thus lead to events data statistics and strategy formulation deviations and errors. According to the volleyball tournament volleyball trajectory discrimination difficulty and player behavior guidance needs, this paper to volleyball movement route as the research target, and the use of computer intelligent acquisition technology, image analysis technique and movement recognition technology, so as to establish a path of volleyball trajectory equation, for the reasoning and analysis of tactics of Volleyball tournament in the process of detection and to formulate and player behavior provide intelligent detection service. Hope that through this study, to provide reliable technical support for the volleyball match.

Key words. volleyball; track equation; computer; player behavior;.

1. Introduction

With the extensive application of computer network and multimedia technology in all walks of life, people have more and more applications in the field of sports events. Through the research of the sports games videos to analyze the game, and making strategies, the level of competition and the winning rate effect are improved. As one of the fashionable and hot research points, to go beyond the field coaches?? visual observation to seize the characteristics of the competitive sports: faster, higher, stronger, so as to meet the requirements of high-quality competition in the whole control process, we must provide computer aid through graphic capture, intelligent computing, directional discrimination for the game.

Volleyball is one of the important sports events. The game has characteristics of

[1]Workshop 1 - Department of Physical Education, Southeast University, Nanjing, Jiangsu, China, 210096

[2]Workshop 2 - School of Computer Science and Engineering, Southeast University, Nanjing, Jiangsu, China, 210096

[3]Corresponding author: Heng Zhao; e-mail: zhaoheng@163.com

fast speed, variation and complex trajectory. To obtain volleyball path, replays and dynamics, computational techniques must be used to achieve on-site monitoring, in the absence of intervention, through the computer's video and image capture to achieve volleyball automatic tracking, identifying, determining and recording. And according to the data, the trajectory and movement tendency of volleyball are analyzed, to find out the mutual connection, so as to guide the coach to guide the counter attack strategy.

2. Get the Track of Volleyball

2.1. Moving object detection method based on frame difference

(1) Simple frame difference method

Simple image frame difference realizes the detection of moving target by subtracting two continuous images. Suppose the lighting conditions unchanged, if there is a series of images collected under the relative motion between the image acquisition device and the scene being shot, then motion information presented therein will help to image segmentation. But the inherent disadvantage of Simple frame difference method make it easily to be affected by the random noise and mistakenly judged the fixed point as moving point. To overcome the effect of random noise, we can take in a cumulative difference method.

(2) Cumulative Difference Method

The cumulative difference can analyze the motion of moving objects in a sequence of picture within a time section, and then get a more complete motion analysis. The adjacent numerical value within the area of the cumulative difference can estimate the speed and speed direction and the size of the moving objects. Meanwhile, the cumulative difference image contains all historical data occurs in a sequence of images of a moving object changes, so it can eliminate the noise in the scene and detect the motion of these objects which moves slowly.

(3) Image Subtraction: in theory, in case of unchanged background, the frame difference image could present the information about the objects of the sports. However, the actual scene is more complicated because there are various noises to intervene the information revealing. The monotonous relationship between adjacent elements in the area of accumulated discrepancy could be used to estimate the speed, direction and others of the movements. Those will intervene the judgment of the specific location of the objects, especially when the objects are not moving, the frame difference image could not be used to search for the location of the objects. Such a problem could be solved by the background subtraction method.

Background modeling is the most complicated part of the background subtraction method. In accordance with the various background modeling methods, background subtraction could be classified into two types: one type refers to method of establishing background model and making adjustment to the model parameters so as to gain the new image of the background. The classical methods of the first type include Kalman filtering method, Gaussian Modeling method, Mixed Gaussian

method, coding method, density estimating method in accordance with no parameters and Walflower method. The second type of methods are the acts of selecting pixel intensity from the previous images in accordance with specific hypothesis so as to constitute the present background image. This type of methods include self-adaptive smoothing algorithm, median algorithm, and W4 System. The above calculating methods requires that people should fully consider the complicated factors such as the background reconstruction and the change of the light during the updating process, the dynamic background and the shadow. Those methods could be applicable for testing the objects in complicated dynamic background. However, it is comparatively time-consuming and complicated.

2.2. Detailed Steps of The Method

The detailed steps of the above object-detecting methods could be introduced as followed:

From the image sequence (I_1, I_2,... I_M), one N frames image (f_1, f_2,... f_N) is taken from every two adjacent images. $f_i(x, y)$ could be used to indicate the brightness value of the pixel point (x, y) number i frame of image. Hence, the difference image could be gained.

$$d_{ij} = \begin{cases} 1, if \left| f_i(x,y) - f_j(x,y) \right| > T_g \\ 0, others \end{cases} \tag{1}$$

In the above formula, T_g is the brightness threshold used to determine whether there are noticeable difference between the brightness of the two images at different time. In order to gain the comparatively complete volleyball objects, it is necessary to select the proper interval l_0. The pixel of 0 in the difference image is equivalent to the place where the pixels are not changed during the former and latter time at the place where the movement does not takes place. The pixel of 1 in the difference image is equivalent to the place where the pixels are not changed during the former and latter time at the place where the movement takes place. Such difference is caused by the movement of the object.

At the same time, the pixel of 1 could be caused by various reasons: for instance, $f_i(x, y)$ is the pixel of the moving object but $f_j(x, y)$ is a background pixel or vice versa. Besides, it is possible that $f_i(x, y)$ is the pixel of a moving object while $f_j(x, y)$ is another moving object or even the pixels at different places of the same object. Due to the difference in the brightness value, deviation could appear. Hence, it is necessary to make further judgment after filtering the moving objects.

Given that the present frame is marked as $f_n(x, y)$; the difference frame is marked as $f_{n-1}(x, y)$, and the difference between them is marked as $D(x, y)$. So it could be concluded as followed:

$$D(x, y) = f_n(x, y) - f_{n-1}(x, y)$$

The original image is shown as the graph 1(a) and 1(b):

For the sake of the convenience of calculating the difference between the two pictures, it is necessary to apply the banalization processing to the two pictures; the

(a) $(n-1)^{th}$ frame of original (b) n^{th} frame of original

Fig. 1. Original figure

principles of the processing could be introduced as followed:

Given the specific pixel threshold, the pixels of the grayscale images are classified into two types: the pixels larger than the threshold and the pixels smaller than the threshold. For instance, the input grayscale image function is $g(x, y)$:

$$g(x,y) = \begin{cases} 0, f(x,y) < Threshold \\ 255, f(x,y) \geq Threshold \end{cases} \tag{2}$$

The threshold is the standard used to differ objects from background. The principle to select the proper threshold is to guarantee that as much information about picture as possible is preserved and that as much intervene of background and noise as possible is reduced. The threshold selected in this thesis is 128 and the result of the calculation is as shown in the figure 2(a) and 2(b).

(a) Binary image of $(n-1)^{th}$ frame (b) Binary image of n^{th} frame

Fig. 2. Binary image

At last, the calculation by means of frame difference method could lead to the result as shown in the following figure.

2.3. Filtering Objects

The frame difference method could help gain the moving region in various frames of the videos. The moving region include the detection objects (volleyball) various intervening region such as the athletes, shadow changes and others. The figure 3 shows that there are much other discrete noise that is mixed with the result after the brightness difference is reduced. In addition, there is plenty of tiny discrete noise in the whole region and such noise will affect the result of the detection of the volleyball object. In order to reduce the influence of the intervening regions on the

Fig. 3. Image got by Frame subtraction

final result of the detection, it is necessary to filter the moving region and select the real moving objects on which researchers are focusing.

In this thesis, the shape-oriented object detecting method is applied to filter the object.

The shape normally refers to the surrounded region with closed contour which could be described by curved lines or region. The description of shapes requires the insensitive to the translation, scaling and distortion so that the extraction from the region via the segmentation technology is necessary. However, the present automatic complete segmentation technology is not proven so the further development of this technology needs to be promoted.

The normally-used parameters to describe shapes could be listed as followed:

Aspect Ration(R): it is used to describe the shape of the object of description and it could be defined as $R = \frac{L}{W}$

In the above formula, L indicates the length of the long axis and W indicates the length of the short axis.

(2) Form Factor (F): in accordance with the perimeter B of the region and the total area (A), the F could be calculated by means of the following formula: $F = \frac{\|B\|^2}{4\pi A}$

The parameter is sensitive to irregular shapes and is effective to calculate the irregular round objects.

(3) Sphericity: Originally, it refers to the ration between the surface area of 3D object and the volume. The formula to calculate the 2D object is as followed: $S = \frac{r_i}{r_c}$

In the above formula, r_c indicates the radius of the circumcircle of the object; r_i indicates the radius of the inscribed circle. Normally, the center of the two circles is placed at the focus of the object. When the elongation of the object is flexible, this parameter is extremely useful to describe the changes of the irregular shapes.

(4) Hu Invariant Moment: Moment Character is a kind of global variable which is not sensitive to noise. Another feature of a moment is that it could identify the object when the object is closed or not. Hu M. K. could be used to construct 7

moment variables of translation, rotation and scale variation. Such variations could be gained via the normalization of the Moment 2 and Moment 3.

$$\phi_1 = \mu_{20} + 4\,\mu_{02} \tag{3}$$

$$\phi_2 = (\mu_{20} - \mu_{02})^2 + 4\,\mu_{11} \tag{4}$$

$$\phi_3 = (\mu_{30} - 3\,\mu_{12})^2 + (3\,\mu_{12} - \mu_{03})^2 \tag{5}$$

$$\phi_4 = (\mu_{30} + \mu_{12})^2 + (\mu_{21} + \mu_{03})^2 \tag{6}$$

$$\begin{aligned}\phi_5 = {} & (\mu_{30} - 3\,\mu_{12})(\mu_{30} + \mu_{12})[(\mu_{30} + \mu_{12})^2 - 3(\mu_{21} + \mu_{03})] \\ & + (3\,\mu_{21} - \mu_{12})(\mu_{21} + \mu_{03})[3\,(\mu_{21} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2]\end{aligned} \tag{7}$$

$$\phi_6 = (\mu_{20} - \mu_{02})[(\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2] + 4\,\mu_{11}(\mu_{30} + \mu_{12})(\mu_{21} + \mu_{03}) \tag{8}$$

$$\begin{aligned}\phi_7 = {} & (3\,\mu_{21} - \mu_{03})(\mu_{30} + \mu_{12})[(\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2] \\ & - (\mu_{30} - 3\,\mu_{12})(\mu_{21} + \mu_{03})[3\,(\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2]\end{aligned} \tag{9}$$

The definition of and the formula to calculate invariant moment should be based on the analysis of the internal and the border grayscale value of specific region. It is the description of a global volume so it could present the general features of the objects.

The analysis of the background of this research could help gain the area, outline, necessary parameters about the shape and other information about the volleyball object. After such information is filtered following specific optimized sequence and given different weights, one group of multi-dimensional feature vectors or matrix suitable for classification processing cold be chosen as the input of follow-up classification process. For instance, it is feasible to use various components as the only feature alone only if the needs are satisfied. In that case, the computation amount could be reduced and the speed of filtering could be improved. Besides, it is feasible to add the ratio between the smallest area and the smallest bound rectangular as part of the feature vectors so as to increase the accuracy of the classification. Only if the needs for the accuracy and performance could be satisfied, it is feasible to select specific feature vector combinations in accordance with the specific situation.

3. Acquisition of technical parameters in volleyball match

The use of the computer in the volleyball match is mainly related to the impact of such contents as the parameters of the speed, the way of hitting, distribution and others, the technical parameters required for the computer control in matches

include:

(1) The net distance of the center of mass movement of Volleyball

Moving net distance:

$$L = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \tag{10}$$

Among them, (xi, yi) (xj, yj) are the coordinates of any two points on the trajectory; L is the net distance of the center of mass motion.

(2) The level speed of the volleyball movement process

In order to facilitate the research, the volleyball speed is divided into horizontal speed and vertical speed, and the horizontal velocity expression formula is as follows:

$$v_x = \frac{D}{T_j - T_i} \tag{11}$$

Among them, D is the horizontal distance; Ti and Tj are the starting and ending time; v_x is the horizontal velocity;

(3) The number of shots in the game

The calculation of the number of shots is mainly based on the coordinates where the players hit the ball, and to determine the distribution of the offensive area and the number of shots according to the distribution of the players. Through the statistics of the two sides of the number of shots, the parameters are recorded.

(4) The detection of the foul and turn end

By the computer detection system to check in the volleyball net, out of bounds, tactical decisions, the volleyball movement detection and discrimination are achieved by computer. In addition, by calculating the motion equation of the volleyball trajectory prediction, the trend of round and foul can be predicted.

(5) The distance and track accumulation of Volleyball

According to the curve and the equation of the flight path of the volleyball, the accumulated flying distance from the i time can be calculated: the calculation formula is as follows:

$$D_{all} = \sum_{i=0}^{k} D_n \tag{12}$$

Among them, D_n represents each distance; D_{all} represents the total flight distance;

The total flight accumulation distance can effectively judge the type of players, through which, the different service lines can be better grasped meanwhile, which provides reference for the players to prepare for the offensive and defensive preparations.

4. Player behavior analysis algorithm selection

4.1. Players' ball hitting and recognition technology

The way and technology of the athlete's stroke play an important role in the formulation and decision of the strategy and tactics. The research progress of the change in the long term is shown in Table 1.

Table 1 Research progress of athletes' behavior and technology detection

Research representatives	Recognition method	Identify technical content	Recognition rate
US, Y.Gong etc.	The white line boundary, football, athletes etc.	Position, shot (shot or boundary ball)	position identification 92%; shot and corner identification 55%
Tsinghua University, Luo Ming, etc.	Image blur detection	Long pass, shot	Recognition rate reached 80%
US, Tacachi and Snooker	HMMS algorithm Decision Tree algorithm	Shooting, boundary ball, foul	High accuracy
University, Zhang Ting et al.	Motion in ST flow detection video	Moving objects, tracking objects, motion features, etc.	The accuracy of motion detection is 83%

It can be found from the above table that the identification of the current athlete onslaught ball technology is popular in computer aided sports research At the same time, it also shows that recognition technology of different types of strokes must be combined with its characteristics, and high accuracy can be realized by the computer. There are many researches on the football game, which can be effectively quoted in the volleyball match. In addition, related researches data on the volleyball match is less, coupled with its unique features, to further promotion and application the following angles can be interfered, such as sample size, the degree of nonlinearity dimension of meaning. For example, the vector machine (SVM) can be introduced to improve identification accuracy of the players' hitting movement, position and the techniques.

4.2. Classification and feature selection of types of Volleyball strokes

(1) Basic technical movements

The motion trajectory equation can be established by the video game. According to the relevant statistics, we found that the stroke types of the ball are about 40 kinds, and the players' movement can be refined to 150 kinds. Among them, the most basic technical actions include: long distance passing, short distance passing, rapid attack, totaled six kinds of basic movements in the two symmetrical directions.

See Figure 4 below.

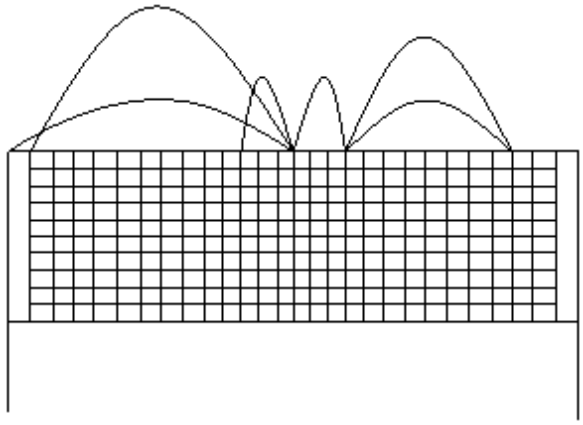

Fig. 4. Schematic diagram of the type of Volleyball strokes

(2) Key feature selection

In order to improve the accuracy of the technology identification, selecting the key feature as the recognition object is the key. Selecting based on the key feature requires the following several characteristics: it can be distinguished, independent and reliable, at the same time, combined with the characteristics of volleyball movement, selecting trajectory equation coefficient quadratic parameters c and d, and b flight distance and D_{all} as the main vector machine (SVM) of the input parameters.

4.3. Support vector machine (SVM) algorithm

SVM has characteristics of nonlinear mapping, maximizing the classification boundary conditions and support vector, which solves the problem of multi dimension and linear regression in Volleyball operation, so the application of SVM algorithm to introduce volleyball structure of sample has a very important value for Guiding volleyball players' Tactics.

(1) Boundary condition of SVM algorithm

The constraints are usually determined by the optimal interface of linear function, for example, n-dimensional space linear discriminant function f(x)=ax+b and g(x)=cx+d vector decides the boundaries conditions, boundary conditions together constituting area is the SVM algorithm of boundary conditions.

(2) Sample composition of SVM algorithm

The volleyball basic strokes have six categories, so six different strokes can be labeled, and each stroke is consisted of n feature samples, which also becomes n corresponding attributes. Game field samples can be collected by computer corresponding to 6 kinds of basic strokes, to identify sample's stroke type.

4.4. Volleyball movement recognition application

The current domestic famous volleyball movement software LibSVM, developed by the University of Taiwan, which is promoted into use in some regions at present. The software can be used based on computer Windows system, but the application is limited to small sample size.

LibSVM collection is based on volleyball videos, through the video to extract samples, the type of basic operations can be determined and judgments are made. Table 2 is the composition of the sample for LibSVM acquisition of a volleyball match .

Table 2 Sample composition of volleyball match

Number	Total samples	Type1 Long pass	Type2 Short pass	Type3 attack
01	260	70	100	90
02	160	40	60	57
03	100	25	45	30

Through field investigation and data comparison, it is found that accuracy of the computer's acquisition of action and identification can reach 94%. It is proved that use LIbSVM in volleyball tournament provides direct assistance for the volleyball movement data recording and the establishment of tactics.

5. Conclusion

Volleyball motion tracking and motion analysis are an important subject in the present researches on computer volleyball matches. This paper introduces knowledge on volleyball trajectory, the basic parameters and motion recognition technology and so on, using software Libsvm to collect and analyze basic athletes technical operation in actual volleyball videos, and the main conclusions are as follows:

(1) Facing the characteristics of complex and changeable volleyball movement trajectory, large quantity of calculation and so on, with the X-Y path equation and track fusion of volleyball trajectory to describe can achieve accurate trajectory recording, which effectively improves the trajectory recognition accuracy.

(2) The important parameters of the volleyball match Computer intelligent control mainly includes centroid net distance L, the horizontal velocity decomposition V_x, strokes, fouls, for a total flight distance D_{all} etc., which provides a guarantee for the volleyball match computer control directly.

(3) Volleyball algorithm and athletes recognition technology are the important content of the computer measurement and control, through the introduction of the SVM algorithm and Libsvm to make actual video game collection, the algorithm has achieved high precision and accuracy.

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