Research on the Algorithm of Motion Track Recognition in Football Video

Qilin Han

1Shangrao Preschool Education College, Jiangxi, China, 334000

*Corresponding author e-mail: hanqilin@srsf.cn

Abstract. It is relatively difficult to obtain the real-time information of the football position in the connected area formed by the ball and the line of the stadium in the football match video. This paper proposes a method for identifying the football trajectory. The least squares algorithm is applied to the football movement trajectory recognition function, and the Viterbi algorithm detection is screened according to the movement recognition function, and the football movement trajectory information is complemented for the error of the football movement in the football video. Finally, the results of an example show that the method proposed in this paper can accurately identify the changes in the motion trajectory in the video.

Keywords: Detection, Recognition, Viterbi Algorithm, Least Square Method, Motion Trajectory

1. Introduction

Football has the largest number of spectators and fans of all ball sports, and the automatic analysis of football videos has therefore become a hot research topic [1-2]. Related research covers video indexing, video retrieval, video annotation, video summarization, event detection, tactical and strategic analysis, etc. The detection and recognition of the ball in the football video is the research basis. The quality of the detection and recognition directly affects the analysis and retrieval of the football video [3-4], so it has been widely concerned by many researchers. In recent years, some classic algorithms have emerged in football detection and recognition. Segment the targets according to the motion information, and then recognize these targets based on the Kalman algorithm, thereby generating multiple paths, and then filtering the resulting multiple paths to obtain multiple trajectories of the ball movement, and finally, in these motion trajectories Based on this, retrospectively infer that those frames where the ball is not detected are caused by the occlusion of the ball or the holding of the ball with the player, and determine the position information of the ball [5-6].

In order to effectively solve the above problems, a football detection and recognition method based on motion trajectory is proposed, as shown in Figure 2. The algorithm mainly consists of three parts: football detection and recognition, motion trajectory generation, and retrospective reasoning. The article focuses on the detection of football, explains how to generate the trajectory of the football, solves the problem of football occlusion and integration with the stadium line, and gives experimental results, conclusions and further research directions.
2. Football recognition and motion trajectory generation

2.1. Building a right map

After the candidate balls of consecutive T frames are detected, a weight map is constructed for the candidate balls of consecutive T frames. The so-called weight graph refers to adding an associated number (weight value) to the node, edge or arc of the graph. The nodes of the weighted graph represent candidate balls, the edges of which the Euclidean distance between two candidate balls in adjacent frames is less than a certain threshold, the weight of the node represents the degree of similarity between the candidate ball and the ball, the weight of the edge indicates the degree of similarity between two candidate balls. The construction of a weight map is the process of constructing edges between candidate balls in two adjacent frames and assigning weights to these edges and each candidate ball. The values on the nodes and edges in the figure represent their respective weights, and the values above the nodes represent the cumulative weight of the candidate balls in multiple frames. The weight of the node can be assigned according to formula (1). The distance between the two nodes of the two frames is less than a set threshold can be considered as an edge (the speed of the ball is limited, therefore, the time between the two frames Within the interval, the displacement of the ball can be set to a threshold. If it is greater than this threshold, it is considered that there is no edge between the two objects). The threshold is set to 40 in the system. The weight of the edge is assigned according to the similarity of the two-node contour. Weights.

\[
\text{weight} = 0.5 \ast F + 0.5 \ast R
\]  

2.2. Ball recognition based on Viterbi algorithm

On the basis of the detected ball, the ball is identified based on the Viterbi algorithm. The recognition process is shown in Figure 1. The recognition process is very similar to the detection process, except that there is an additional process of using the detected ball to initialize the weight map. The main steps are as follows: ① Take a continuous T frame from the video sequence, and detect the candidate ball of the continuous T frame; ② Construct the weight map; ③ Initialize the weight map with the position information of the ball detected previously; ④ Get the position information of the ball based on the Viterbi algorithm. The process of initializing the weight map is to use the detected ball as the only node in frame 0, and assign a weight of 1 to this unique node, and it is the same as the edge of each node in the first frame of the weight map. The size of the establishment and weighting is still based on the distance and similarity between the two. The double-lined circle in the figure represents the detected ball.

![Figure 1. Identification of the ball.](image-url)
2.3. Generate ball motion trajectory function

For the obtained data points, the least squares method is used to fit the motion trajectory function. Figure 2 shows the parametric equations in the x direction. The abscissa represents time t, the ordinate represents the displacement of the ball in the x direction, the hollow circles represent the data points obtained based on the Viterbi algorithm, and the filled circles represent the ball position obtained based on the trajectory. For two-dimensional image coordinates, there will be two sets of these equations.

\[ X(t) = x(t_0) + v(t_0)(t-t_0) + \frac{1}{2}a(t_0)(t-t_0)^2 \]

\[ Y(t) = y(t_0) + v(t_0)(t-t_0) + \frac{1}{2}a(t_0)(t-t_0)^2 \]

**Figure 2.** Interpolation function of football trajectory in the x direction.

3. Obtain the position information of the missed ball based on the track

3.1. Backtracking reasoning and get ball position information based on trajectory

In the following situations, the ball cannot be detected based on the Viterbi algorithm: the ball merges with the court line, the ball is blocked by the player during the movement, the player holds the ball, and the ball flies off the court. First, determine whether the ball has flown off the court based on the detected ball position and speed information, and then determine whether the ball is fused by the court line or temporarily blocked by the player, or the player holds the ball. If the ball cannot be detected in only a few consecutive frames, it is considered that the ball merges with the court line or is blocked by the player during the movement. If the number of frames in which the ball cannot be detected is large and continuous, it is considered that the player has the ball. In the first two cases, it is only necessary to find the function value in the time domain t according to the trajectory parameter equation of each dimension on the coordinate system. For example: in a two-dimensional image, given the ball trajectory function X(t), Y(t) (representing the interpolation function in the x direction and the interpolation function in the y direction), find the time tN (as shown in Figure 2) The location information of the ball. Then only X(tN)=x(t0)+v(t0)(tN-t0)+1/2a(t0)(tN-t0)^2 and the corresponding Y(tN) are required. (X(tN), Y(tN)) are the coordinates of the ball in the two-dimensional image. When it is judged that the player is holding the ball, the player closest to the predicted point of the trajectory function is identified.

3.2. Experimental results

The experimental video comes from the 2006 World Cup Germany vs. Costa Rica group match. The ball is indicated by a red rectangle. The sequence (1) in Figure 6 is a video sequence of a ball crossing the court line. Here, based on the interpolation function, the position information of the ball when it is on the court line is accurately obtained. In the sequence (2.1) of Figure 3, the player touches the ball and passes it, (2.2) (2.3) is a video sequence of two headers, in which the player and the person form a connected area. Based on the trajectory, through retrospective reasoning, the position information of the ball is obtained more accurately.
Figure 3. An example of a connected area formed by the ball and the court line or players.
Table 1 uses different T statistics on a video sequence of more than 700 frames. "Ball" indicates the number of frames of the ball in the court. "#Block" means the number of frames in which the ball is in the court but invisible to the machine, including video frames under various occlusion situations such as fusion with the court line, occlusion by the player, and player holding the ball. "Ball" means the number of frames in which the ball is correctly identified in the detection result. "False detection" means that the ball is considered to exist in the detection result, but the detection result is not the frame number of the real ball. In the 201st to 400th frames, the recall rate and accuracy rate are not ideal, mainly due to the presence of multiple occlusions, and the small fragments obtained by improper segmentation of the court line and players may be very similar to the ball. The Viterbi algorithm optimizes the path among the candidate balls of consecutive T frames, and the accuracy of the algorithm is also different if the number of frames is different. When T is small, because the court line may appear or the player is improperly divided in several consecutive frames, and the ball is just blocked or merged, the path of these court lines or small pieces of the player may be more similar to the path of the ball Motion trajectory, so it is prone to misdetection of consecutive multiple frames; when T is large, this situation will basically not appear, but the response speed of the algorithm will be relatively slow. In the actual application process, it is necessary to consider different applications, weigh efficiency and accuracy, and choose a suitable algorithm. The experimental results show the effectiveness of the scheme, and more accurately obtain the ball's position information when the ball and the court line are fused and in simple cases the ball and the player form a connected area.
Table 1. Experimental statistics

| T       | Serial number | #ball | #Occlusion | Ball | False detection | Recall rate (%) | Accuracy(%) |
|---------|---------------|-------|------------|------|-----------------|----------------|-------------|
| 1~200   | 180           | 26    | 168        | 22   | 93.3            | 88.5           |
| 201~400 | 164           | 36    | 112        | 21   | 65              | 77.4           |
| 401~600 | 189           | 11    | 98         | 22   | 88.1            | 80             |
| Total   | 650           | 78    | 548        | 77   | 84.3            | 87.6           |
| 1~200   | 201~400       | 180   | 26         | 172  | 21              | 95.5           | 90.5        |
| 8       | 401~600       | 189   | 11         | 98   | 88.1            | 80             |
| Total   | 650           | 78    | 584        | 43   | 89.6            | 93.1           |
| 16      | 189           | 11    | 108        | 92.3 | 97.8            |                 |

4. Conclusion

In this paper, by calculating the continuity of the football movement by the motion trajectory recognition algorithm, the football position can be accurately detected, and the boundary between the football and the stadium is calculated according to the backtracking of the motion trajectory, and the problem that cannot be detected between the football and the player is solved according to the fusion situation. Finally, it is verified through experiments. The results show that the algorithm proposed in this paper can reduce the change of the football trajectory in the video, and has been widely used in the football video trajectory.

References

[1] Zeng, J., Huang, J., Yu, Z., & Zhang, Y.. (2017). Research on human motion detection and tracking algorithm based on adaptive dynamic video image scaling technology. Revista de la Facultad de Ingenieria, 32(4), 455-463.
[2] Lu, Y., & An, S.. (2020). Research on sports video detection technology motion 3d reconstruction based on hidden markov model. Cluster Computing, 23(3), 1899-1909.
[3] Sheng, W., & Hobbs, S. E.. (2011). Research on compensation of motion, earth curvature and tropospheric delay in geosar. Acta Astronautica, 68(11-12), 2005-2011.
[4] Hong, S., Chung, C., Sakamoto, K., & Asai, T.. (2011). Analysis of the swing motion on knuckling shot in soccer. Procedia Engineering, 13, 176-181.
[5] Rucci, M., Hardie, R. C., & Barnard, K. J.. (2014). Computationally efficient video restoration for nyquist sampled imaging sensors combining an affine-motion-based temporal kalman filter and adaptive wiener filter. Applied Optics, 53(13), 1-13.
[6] Shi, H. B., & Dong, W. J.. (2011). Application and research of rotate-lookup-summation in robot motion. Key Engineering Materials, 467-469, 186-191.