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# Research on detection of field Lines in Soccer Videos

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**Abstract.** A novel field line detection method is proposed based on the directional information of field line. First, the special character of modern soccer playfield is considered, and a novel soccer field model is introduced which includes offside assistant lines. By designing a directional filter, these field lines can be accurately detected. Moreover, the field line detection and tracking for a clip is developed, which can further improve the performance of field line detection.

**Keywords:** Video content analysis, Soccer videos, Tactic analysis, Field lines detection

## 1 Introduction

The field is a main element in football match videos [1-2]. Almost all such match shots are on the background of the pitch. Furthermore, those highlights in the football videos occur in the field too. At some point, soccer games are activities that are constrained to a certain area. So football videos record images of activities in a defined area [3]. Players, judges and the rubber ball are all limited to such a place, even coaches and audiences are staying around it. Thus to analyze football videos, it's quite necessary to process and detect videos regarding field lines [4-5].

As mentioned above, we can classify shots to close-up, medium and long shots according to photographic intention and included objects. Of them, long shots are views against the pitch [6-7]. They often take up over ninety percent of all shots. For a specific purpose of reviewing what's contained in shots in a more detailed manner, we need to divide long shots into six different types like upper left, upper middle, upper right, lower left, lower middle and lower right part (Figure 1), to separately represent which pitch area a long shot is focusing on. However, that is not adequate for us to make profound investigations. Our final goal is to examine football match strategies. We need additionally to detect footballers' position and their movement trajectory, analyze their motional pattern as to eventually find out the strategy pattern which is decisive to the success of the ball competition. To reach it, we have to do in-depth analytics of long shots, in particular, to pick up lines of football venue of precisely and efficiently. The accurate extraction of those lines is premise to camera

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calibration and the fetch of targets' real track, which is the foundation to do strategy analysis. So in a word, field line extraction is basis to strategy analysis [8-9].

## 2 Single frame detection of field lines based on direction information

The common methods for detecting field lines are performed with the color information that field lines are all white. But in our football field model, offside symbol lines among field symbol lines are not white. Being located in the intersection of deep green and light green areas, those offside lines are hardly detected by the direct use of color information. Offside lines have distinctive luminance variances. Their angles of inclination are limited to a small range like 35-55°for the demi-court gauche and 125-145°for the demi-court droit. Based on the priori knowledge, we develop a detection method based on directional filter banks. It is shown in Table 1.

**Table1.** Field lines detection algorithm based on directional filter

| |
|---|
| Input: The $i$ frame image $I_{input}^{i}$ in video sequence |
| Output: N field lines $L_n^i, n=1,2,...,N$ in the image $I_{input}^{i}$ |
| 1 Separated the stadium area from image, image $I_{input}^{i}$ converted to grayscale images, And edge enhancement using Sobel operator, retaining only the stadium area, got the image $I_{field}^{i}$. |
| 2 Enhanced the field line, used the filter matrix respectively four yuan directional filter banks $(H_l^1, H_l^2, H_r^1, H_r^2)$ respectively to filter for image $I_{field}^{i}$, filtered four images using conjunctive (or) operation to get filtered image $I_{field}^{i}$ |
| 3 Detected field lines, image $I_{field}^{i}$ was Hough transformed, detected the most significant N field lines $L_n^i, n=1,2,...,N$ |

## 3 Track of field lines based on Kalman filtering

Many existing detection methods for field lines are executed by line color or direction information, as proposed in section 2. By Hough Transform, every $(\theta, \rho)$ in the space $P_m = (\theta_m, \rho_m)$ suggests a straight line $L_m^f$ in the image; a group of straight

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lines in the image correspond to a cluster of points in the space $(\theta, \rho)$; also every straight line has a Hough transform intensity, which indicates the possibility of the line existing in the image. In general, the clearer and longer the line is in the image, the bigger its intensity value is. So the real field lines in the image all have bigger intensity values, while those illusory noise field lines accordingly have smaller values. From the methods based on direction information, we can learn that after Hough transform is made for football match images, field lines appear in clusters. In one cluster, there is often one real field line and therefore others are virtual noise lines. In the methods based on direction information, K-means clustering algorithm is applied for clustering in the space $(\theta, \rho)$ .After clustering, N classes are obtained, $C_n^f \ (n = 1, 2, \ \ldots, \ N)$. For each $C_n^f$ , the straight line which has the biggest Hough transform intensity is selected for the real field line $L_n^f$ .

As the image in the football broadcast videos is of low quality, the performance of the method is not satisfactory, there are many noise field lines in the image, which would be regarded mistakenly as field line if we perform directly clustering for them. To improve the accuracy of detection, here we present a pre-processing mechanism, allowing to remove lots of false field lines before clustering.

## 4 Experiment Design and Discussion

As mentioned previously, GMM-based filtering methods for principal angles and the clustering methods based on minimum spanning trees are both used to improve the performance of detecting field lines. Here we compare them with those based on K-means clustering. We choose randomly 300 images from six types of goals videos for the comparison. By the following equation, we calculate recall ratio (R) and precision ratio (P) as to evaluate qualitatively the effect of them.

$$\begin{aligned} R &= n_c / (n_c + n_m) \\ P &= n_c / (n_c + n_f) \end{aligned} \tag{1}$$

Where, n c is the number of field lines detected in a right manner; n m is the number of field lines not detected; n f is the number of field lines detected falsely. In table 2, the first column is result of methods based on K-means clustering; the second column is performance of clustering methods based on minimum spanning trees; the third column is result of the clustering method combing GMM-based principal angle filtering and minimum spanning trees. From table2 we learn that the clustering methods based on minimum spanning tree can improve recall ratio effectively; GMM-based principal angle filtering method is good for the improvement of precision ratio.

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**Table 2.** Comparison of single frame field lines detection performance

| Video clips | The algorithm based on direction information | | Minimum spanning tree based on clustering method | | The main filtering method based on GMM and Minimum spanning tree based on clustering method | |
|---|---|---|---|---|---|---|
| | precision ratio | recall ratio | precision ratio | recall ratio | precision ratio | recall ratio |
| S1 | 87% | 90% | 89% | 94% | 92% | 94% |
| S2 | 83% | 80% | 85% | 94% | 90% | 95% |
| S3 | 84% | 82% | 85% | 95% | 90% | 94% |
| S4 | 87% | 88% | 90% | 96% | 92% | 95% |
| S5 | 84% | 81% | 86% | 91% | 89%% | 93% |
| S6 | 81% | 79% | 87% | 90% | 92% | 93% |
| Average | 84% | 83% | 87% | 93% | 90% | 94% |

## 4 Conclusion

Football field is an important object in the videos, for the effective detection of the target, extraction of its trajectory and analysis of related game strategy. The field analyzing is a basic but important step. The paper concerned about how to effectively and accurately pick up field lines. It developed a new field model, in which offside auxiliary lines are important element. Then a new detection method for field lines was designed based on the direction information. Further considering video continuity, we showed another method for detecting and tracking field lines in videos. It proved its effectiveness in decreasing false detection rate and loss rate through tracking mechanism.

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