An Efficient Algorithm for Detection of Soccer Ball and Players

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Abstract: In this paper we propose an effective algorithm for detection of a soccer ball and players. In the currently available methods, the ball may not be detected when it is attached to the lines in the ground. To overcome this problem, we introduce a method to separate lines from the ball and segment the ball effectively. At first we detect the ground and the edges of the original image. Then an efficient line detection method is applied, and finally players and a ball are extracted. The experimental results show that our algorithm is robust when the ball is attached to the line.

Keywords: Ball detection, Line Hough transform, Image analysis, Object Recognition

1 Introduction

In the field of machine vision, detection of moving objects is an interesting and difficult issue. Moving object detection is applied in different application areas such as medical image processing, human tracking, traffic system monitoring and sports video analyzing. Nowadays, sports video is one very popular research area, which involves players' movement analysis, tactics, referee's decisions, and so forth. So, automatic detection of players and a ball in the soccer video is notably important [1]. Usually, the color [2] and shape [3] are used to segment the ball. The method proposed in [4] tracks the objects present in the scene and considers the object that is tracked for the longest time as the ball. However, these simple features may fail to detect the ball when similar objects such as socks of the player, and the ground line appear in the scene.

A trajectory-based algorithm is proposed in [5] to estimate the ball candidates in each frame based on the size. A circle detection algorithm based on circle Hough Transform is proposed in [6] to detect the circular shape ball in the image frames. In [7], color, shape and size are evaluated to detect the ball. In [8], density based approach is used to separate the players and the lines. However, as we focus on frames involving long-shots, the ball is

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sometimes very small in size and may not be always circular in shape and the ball may not be detected if it is attached with the line of the ground.

In this paper, we propose a real time ball detection framework for long-shot frames. The proposed method comprises four steps. At the first step, we apply an automatic ground detection algorithm to eliminate the ground. The players and the ball candidates are extracted using Sobel gradient method in the second step. In the third step, ground straight lines are eliminated using line detection algorithm. In the last step unwanted objects are eliminated using different thresholds.
The rest of the paper is organized as follows. In section 2 the proposed algorithm is described. Experimental results are shown in section 3 and we conclude the paper in section 4.

2 Proposed Algorithm

In most previous works, it is assumed that green color of the soccer field is dominant over other colors and it appears in a large area of an image sequence, especially in long shots, which contains the major parts of the whole video. For example, the value of hue used in the HSV color space ranges from 54 to 90 [9], from 60 to150 [10], and from 65 to 85 [11]. However, it is very difficult to select an actual range to detect the ground, as the small range will miss some ground pixels not in that color range and the broader range will include non ground pixels as ground. In [12], the authors mention a color feature present in ground pixels. The rule $G>R>B$, where G, R, B are the Green, Red and Blue components in the RGB space, respectively, is held for the majority ground pixels. In our proposed method, we apply this feature to extract the ground at first and construct a binary image where the non ground pixels detected according to this rule are marked using equation 1. Figure 1 is an example of this.

$$Ground(x,y) = \begin{cases} 0, & (g(x,y) > r(x,y) > b(x,y)) \\ 1, & otherwise \end{cases} \quad (1)$$

However, this feature also appears in the gray color objects such as ball, line and goal post, and these are excluded here being detected as ground pixels. As a result, we apply Sobel gradient algorithm to the RGB image to detect the sharp changes to preserve the ball [13]. In Sobel gradient algorithm, the derivative of the intensity values across the image is calculated and the change is found where the derivatives are maximum. The gradient is a vector and the components are measured in the x and y direction. The components are found using Eq. 2 and Eq. 3.

(a) Original Image (b) Color-based elimination of ground

Figure: 1

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= Δ~ = ____________________________(3)

#=$~Δ%&Δ~%~

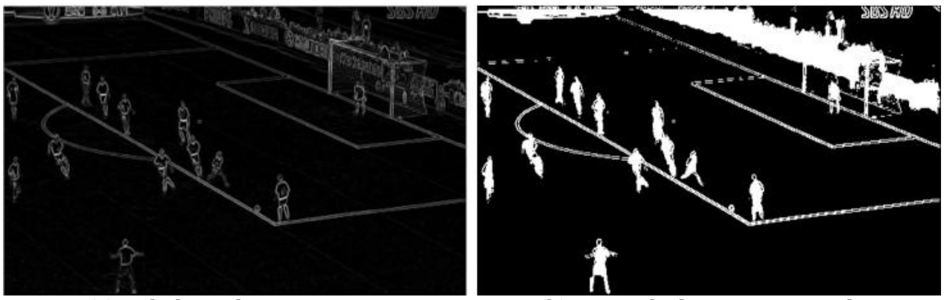
where f is an intensity function. To detect the presence of a gradient discontinuity, the change in the gradient at (x , y) is calculated and the magnitude (M) and gradient direction (") are found using the following equations:

(4)

"=~'~!()Δ~

Δ~* (5)

In figure 1(b), the ball and the lines in the ground were discarded. However, Sobel method retains the ball and the lines. Figure 2(a) is an example of this.



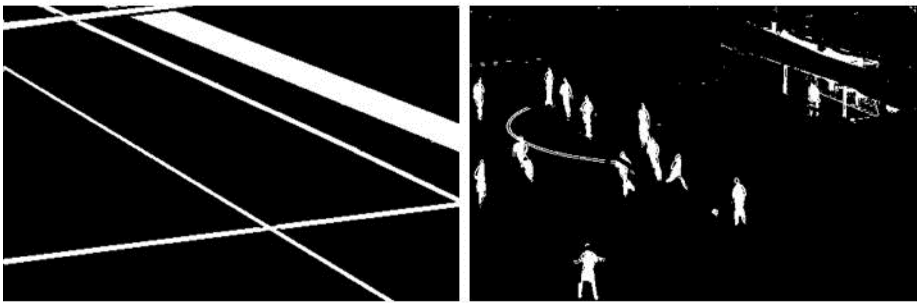
(a) Sobel Gradient Image (b) Ground Elimination Result

Figure: 2

Then the image containing the non ground pixels (figure 1(b)) and the Sobel gradient image (figure 2(a)) are added, which yields an image with the players, ball, lines, goal post, spectators and scoreboard. Then the image is converted to binary and ground is eliminated from the resultant image shown in figure 2(b). Dilation and erosion methods are applied to connect the disjoint lines.

As we only need the information of the soccer ball and players, the objects such as lines, goal posts, scoreboard and the spectators are removed using some salient features. The scoreboard and the spectators are eliminated as they are large in size compare to the ball and the players.

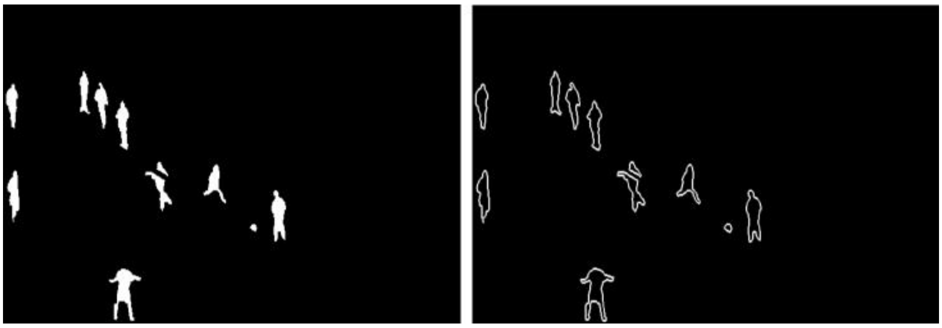
The straight lines in the ground are detected using kernel based Hough transformation [14] and eliminated. In [15], the point-line duality is utilized to classify the supporting lines of set of collinear pixels in images. In this method, pixels are mapped to lines using a slope-intercept parameterization in a discretized 2D parameter space. Later in [16], slope intercept is replaced with an angle-radius parameterization. However, these methods require high computational cost for real time implementations. In this paper we use an improved voting scheme for the HT that reduces the computational cost and real time performance [14]. The method operates on clusters of approximately collinear pixels. It uses an elliptical Gaussian kernel that forms the uncertainty associated with the best fitting line regarding the corresponding cluster. This method produces a very clean voting map to detect the spurious line of the image shown in figure 3(a).



(a) Line Detection (b) Line elimination result

Figure: 3

After the line is detected, the players and the ball are distinguished if they are attached with the line. Then the lines are eliminated. The remaining objects include players, ball, some dotted lines, some small objects and some large objects in the ground as shown in figure 3(b). Our main purpose is to keep the ball and the players in the ground. So, at first we calculate the area and the perimeter of all single the objects. If the size of an object is very large, it is eliminated. Then the ratio of area and perimeter is calculated to select an optimum threshold value. The players and the ball have a higher density of pixels hence the ratio of area and perimeter is high compare to the dotted lines and the small objects. The optimum threshold value discards the majority of the unwanted objects. In all our experiment, we use the threshold value 1.3. The unwanted object elimination result is shown in figure 4(a).



(a)Unwanted object elimination result (b) Gradient of the resultant objects

Figure 4

Finally, we detect the gradient of the objects kept after unwanted object elimination using Sobel gradient method shown in figure 4(b) and the final output is shown in figure 5.

Figure: 5 Final Output

3 Experimental Result

We have used a 6 second 640x360 soccer video of 25 Frames per second from a match in the 2002 FIFA World cup played between Brazil and Germany. The algorithm robustly detects the ball in the video sequences when the ball is attached with the line. We have applied this algorithm to various soccer game images, especially when the ball is attached with the line. We have compared our results with the proposed detection method of J-Y Kim *et al.*[8]. Our proposed method more robustly detect the ball, while the method proposed by J-Y Kim *et al.* may fail to keep the ball when the ball in attached with line. The experimental results are shown in figure 6 and figure 7. However, when the players are crowded at the same place, this algorithm fails to detect all the players as the size of the object becomes large and detects it as a single object. This algorithm eliminates single large objects which contains more than one player.

(a) Original Image

(b) Method proposed by J-Y Kim *et al.* (c) Proposed Method

Figure: 6 The outcome of different methods

(a) Original Image

(b) Method proposed by J-Y Kim *et al.* (c) Proposed Method

Figure: 7 Another set of experimental results

4 Conclusion

The main objective of this paper is to detect the soccer ball and players within a video footage, especially when the ball is attached with lines in the ground. The experimental results show the capability and robustness of detecting ball.

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