A Method for Football Players Detection on the Soccer Field by Integrated Image Processing Techniques

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***Abstract*— the player detection algorithm in a soccer field image is an important step for an offside situation detection. A difficulty of player detection occur when the player is overlap with the crowd of cheering. In this paper, we propose a new method for football player detection on the soccer field by integrated image processing techniques. This method consists of two steps. Firstly, the soccer field area is segmented from the background. This step is used to avoid the error of player detection from overlap problem between player and crowd of cheering. Finally, the process to detect players in the soccer field from Morphological. To test the performance of the proposed method, the images used to test in this research have 150 images from three football matches. The detected players compared with the total players on the field by visual. Detection rate is 85.943% and the accuracy of the player detection process is 76.63%. The result show that the proposed method is satisfactory in order to continue for performance improvement.**

Keywords*— *Image processing, Field area segmentation, Football players detection, Morphological

I. INTRODUCTION

Soccer is a most popular sport in the world [1, 2]. In 2018, football's 43% vote equated to 736 million people across the surveyed football fans around the world [3]. The football industry and football-related business plays an important role in business and economy [4]. Offside in soccer is a significant situation that effect to the result of a game. Offside is one of seventeen rules in soccer sport that error of judgement often be found [5].

It is not an offence to be in an offside position. A player is in an offside position if: any part of the head, body or feet is in the opponents' half (excluding the halfway line) and any part of the head, body or feet is nearer to the opponents' goal line than both the ball and the second-last opponent. To judge an offside situation, the position of player will be compared with a line on the soccer field. Football players detection is also used as reference for referees for offside judgement [6].

The difficult of offside judgement is that referee have to focus on the players and the ball from a distance in the same time [7]. Therefore, automated offside detect technique is necessary for accurate and precise judgement. We focus on assistive technology such as image processing to support detect the offside offence. The automatic offside detection system consists of many importance processes starting from player detection and offside detection.

In soccer videos, there are many researches in the area of the players detection. M.M.N. Ali, et al proposed a method that could separate lines from the player and ball [8]. The ground and the edges of the original image were detected. Hough transform line detection algorithm was used to identify lines. The disadvantage is that the players are crowded in an area of an image, this algorithm failed to detect all the players. Y. Huang et al proposed an algorithm for detecting a football player using background subtraction and a modified Circle Hough Transform [9]. This work could not separate the players and referees when they overlapped or partially occluded each other. H. Najeeb et al proposed a system to detect the players in real-time by using background subtraction and sobel detection. [10]. This method consisted of two phases. The first phase got videos, extracted frame of video to save to image. The second phase performed filtering by applying edge detection using sobel detection and smoothing by morphology operations to achieve the object detection. This work was efficient in overcoming the shadow and illumination problem. It achieved a higher accuracy than that achieved using background subtraction or sobel detection. The accuracy rate is 93%. J.K. Slawomir Mackowiak et al proposed a dominant color-based segmentation method for football playfield detection [11]. A 3D playfield modeling based on Hough transform was introduced. This work could observe a clear saturation of both precision and recall metric values for a threshold parameter which turned to be the most reliable result confirmed also by the subjective detection results evaluation. This method proposed an efficient deep CNN-Based method to automatically detect football players from video matches directly. First, five convolution blocks were used to extract a feature map of football players with different spatial resolution. Then, features from different levels are combined together with weighted parameters to improve accuracy and adapt the model to input images with various resolutions and qualities. The experimental results achieved approximate 93.2% of accuracy.

The limitation of existing technique is that performance is reduced if player is overlapped or in an area of crowd cheering. Focusing on player detection, in this paper, we propose a new method to detect players in the soccer field by integrated image processing technique. We segment the soccer field from crowd of cheering. This step is reduced the error of player detection from overlap problem between player and crowd of cheering.

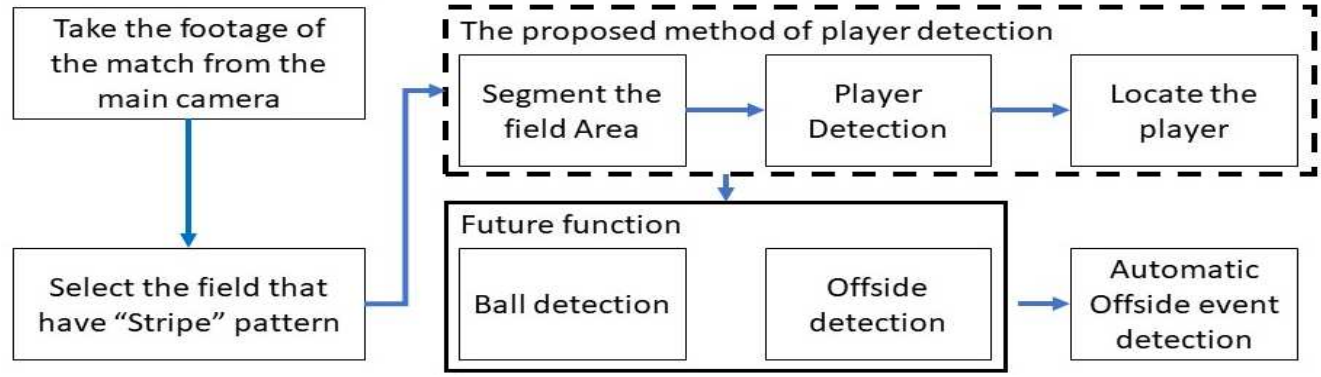
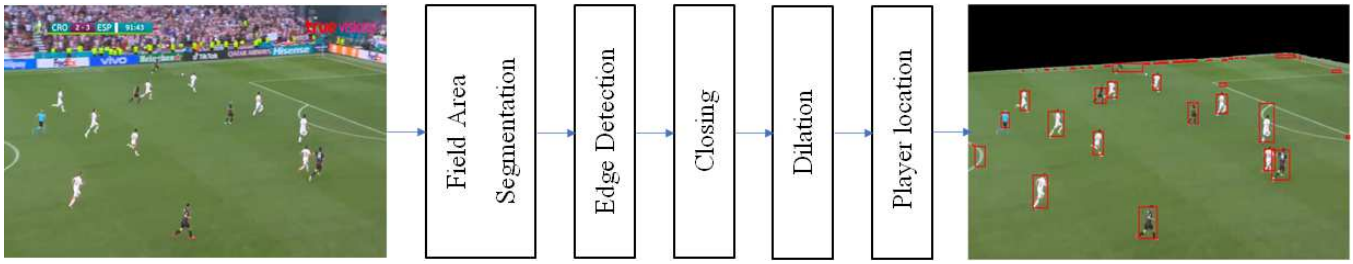


Fig. 1. Overview flow chart of the proposed method and automatic offside detect



Input image

Output image

Fig. 2. player detection flowchart

II. Problem Analysis and Concept Idea

To design the way that the detection will be able to detect multiple players efficiently, we need to understand what causes the detector to not be able to detect the players on soccer field. Which are (S) size of player, (V) variance of illumination, (Ov) Player overlapping, and (L) Line of the field as shown in Eq. 1-5.

After we input the image into the system the output will be out as (H) which is dependent on these variables.

First, (S) is the size of player. To remove the noise and the object that too big to be the player we need to specify the range into (d) the minimum pixel size, (D) the maximum pixel size, and (C) current player size.

(Ov) is Player overlapping. To detect the overlapping of the player we need to detect (k) variance of the color in specific area.

(V) is variance of illumination. When the area become brighter or darker due to field environment. It will affect our system, we need to specify the range that we going to use in our system, (y) is the amount grayscale value in the area.

(L) is line of the field, (m) is the slope, (c is the y-intercept). Sometimes we need to detect the player that stand on the line, we need to be able to remove the line when needed because some part of the field may have a line that make it harder for the detector to work efficiently.

$$H = f\{S, V, Ov, L\} \quad (1)$$

$$S = \begin{cases} 0 ; C \leq d \\ 1 ; d \leq C \leq D \\ 0 ; C \geq D \end{cases} \quad (2)$$

$$Ov = \begin{cases} 0, & k < Color \\ 1, & k \geq Color \end{cases} \quad (3)$$

$$V = Histogram > y \quad (4)$$

$$L = mx+c \quad (5)$$

We used field area segmentation and line detection method from Hough transform to help us do the detection part easier.

In this paper we mainly focus on the Eq. 2, The part that determine by the pixel size of the player on the field.

III. Propose Method

A. System Overview

To create a system that can automatically detect offside event in fast-paced sport like football, there are 3 essential parts that need to be created to achieve our goal. In this player, we proposed player detection. Fig. 1. is the proposed method. The proposed method will create an output that had the players covered by the bounding box and the location of the players. Fig. 2. the process of Player detection system.

B. Database

To develop our concept idea. We used the footage from football UEFA euro 2020 round of 16 final, three different matches with different stadiums. Croatia vs Spain at Parken Stadium in Denmark. France vs Switzerland at Arena Națională in Romania. Wales vs Denmark at Johan Cruyff arena in Netherland. The footage that we used were taken by

the main camera only. Number of images used in this research is 150 images, 50 each from 3 matches.

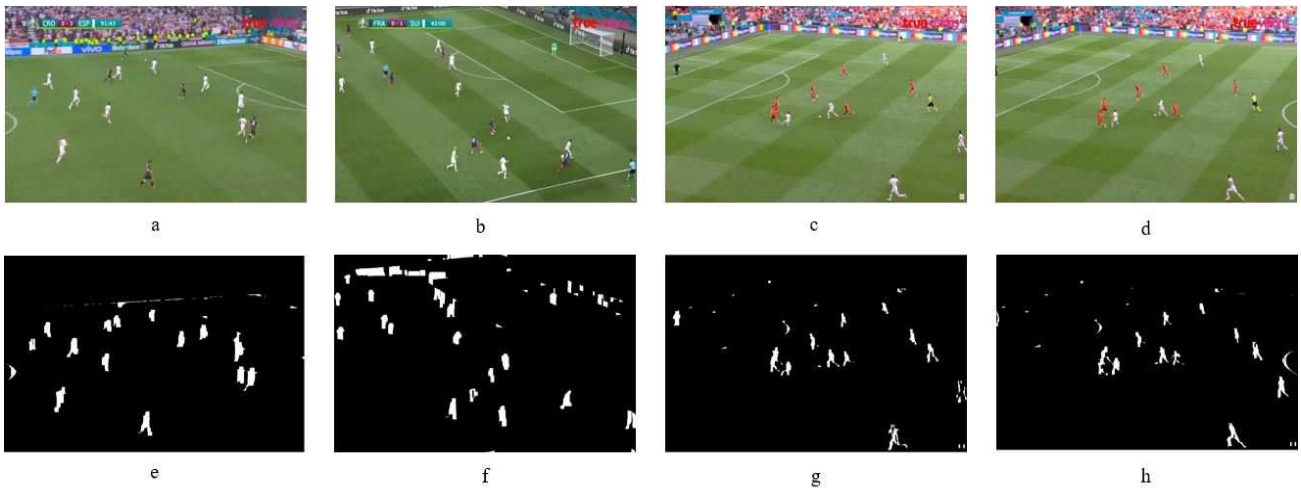


Fig. 3 Morphological results. Top row is input images.Second row is morphological results.

C. *Field area segmentation*

It will be impossible to detect the player smoothly if there are still advertisements, cameraman, crowd and so on. To fix these problems. Therefore, elimination of soccer field by field area segmentation method to get rid of lighting and shaded areas.

$$I(x,y) = \begin{cases} 1\ G(x,y) > R(x,y)\ and\ G(x,y) > B(x,y) \\ 0\ otherwise \end{cases}$$

The R as red, G as green, and B as blue color channels. To eliminate the noisy area in each image, find the biggest area of white area to delete the smaller area because the soccer field area is the biggest area in each image.

D. *Player detection*

For players detection. We use Morphological method. Our research propose method due to the nature of the soccer game, our method is very effective against rapidly morph. But there are still further things we must consider such as shadows, line of the field, player's velocity, occlusion, and additional lighting. To detect the player effectively we implement morphology operation using Closing to connect the object, next we use Dilation and Erosion to enlarge and reduce the object in the image.

E. *Player localization*

The properties of image regions are used to detect the players in our method. First, the average area of players must be calculated to determine the range between noise and non-players' object. Used the same method to extract the x-axis and y-axis of the players to help us calculate the accuracy of our detection system.

F. *Variables*

In the morphology, the Sobel part used the (size) filter

$$a + b = \gamma \qquad (7)$$

IV. Experimental Result and Discussion

For the result of our method. This research used data from the broadcasted videos. After getting videos we had to extract frame of video to save to image. The size of the image in our research is 1280x720 pixel. Finally, we could see a frame from the main camera, drone camera, goal camera, and frame that zoom to focus onto something. But this research used the frame from the main camera only. The images for use to test in this research have 150 images from 3 matches of football UEFA euro 2020. We used the footage from football UEFA euro 2020 round of 16. We chose 150 images from three different matches with different stadiums: Croatia vs Spain at Parken Stadium in Denmark as Match1, France vs Switzerland at Arena Națională in Romania as Match2 and Wales vs Denmark at Johan Cruyff arena in Netherland as Match 3. Our research had been implemented using MATLAB. The propose method was tested since 1-50 frames of Match1, 51-100 frames of Match2 and 101-150 frames of Match3. We experimented with MATLAB R2020b.

A. *Performance Measures*

The percentage of detection of this method is the number of detected players compare to all players on the soccer field from the image.

$$\%\mathrm{T}_{Percentage\ of\ detection} A = \pi r^2 = \frac{N_{True\ x\ 100}}{TP} \qquad (8)$$

The percentage of detection of this method was calculated by Eq. 6. (N_{True}) for true result and (TP) for the total number of players on the soccer field result and the yellow box covered all players. When the box covered the object will count as true.

The accuracy of this method will determine by true or false result, True result is a result that has the box covered the player, False result is a result that the box was not covered the player.

$$Acc_{Player\ detection} = \frac{N_{True}}{N_{True}+N_{False}} \times 100 \qquad (9)$$

The accuracy of this method was calculated by Eq. 6. (N_{True}) for true result and (N_{False}) for false result. When the box covered the object other than player will count as false. Lastly, we used visual inspection to determine which is true or false result.

In calculation process, we used 150 images from 3 different matches. After our method finished, each player will have their own box covered them. The box has 2 colors, Red for the output from our method and blue for the Real location of the player. The example of result is shown in Fig. 4.

B. The results of football players detection

In the result of experiment. Morphological, the number of players caught compared to total players on the field in visual (Percentage of Detection) is 85.94% and the accuracy of the Player Detection process is 76.63%. The example of result is shown in Table 1.

C. Discussion

In the result of experiment. Morphological, the number of players caught compared to total players on the field in visual (Percentage of Detection) is 85.94% and the accuracy of the Player Detection process is 76.63%. The example of result is shown in Table 1.

In case of green jersey such as Cameroon national and Nigeria national Team

Fig. 4 player detection result

Table 1 Performance of player detection.

frames	Our Method			
	Total number of play	Correct detection	Detection Rate (%)	Accuracy (%)
1-50	821	640	82.70	72.86
51-100	1114	372	87.83	74.97
100-150	1093	311	88.76	77.85
Total	3028	1323	86.43	75.23

V. CONCLUSION

In this paper, we propose a new method for football player detection on the soccer field by integrated image processing techniques. The soccer field area is segmented from the background. This step is reduced the error of player detection from overlap problem between player and crowd of cheering. To test the performance of the proposed method, the images used to test in this research have 150 images from three matches of football. The detected players compared with the total players on the field by visual. Detection rate is 85.943% and the accuracy of the player detection process is 76.63%. Cause of error is the result of detection is incorrect when play is almost overlapped each other. However, the result show that the proposed method is satisfactory and has potential to continue for performance improvement.

Our future work is to improvement accuracy of player detection from overlap image and continue to develop offside detection algorithm.

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