A Method for Detecting Lines on Soccer Field by Color of Grass Variation

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***Abstract*— The line detection algorithm in a soccer field image is an important step in order to detect an offside situation. In this paper, a method of line detection in a soccer field is proposed by using color of grass variation. This method consists of three steps. Firstly, the soccer ground is segmented by a constraint color in RGB channel. Second, the edge in the image is detected. Finally, a line is detected by a line hough transform technique. To evaluate the performance of the proposed method, 50,000 image form 22 matches are used to detecting lines. Results is compared with ground truth data. The proposed method has shown a satisfactory result.**

Keywords*— Line detection; Soccer image analysis; Different color of grass

I. INTRODUCTION

Soccer is a most popular sport in the world. Offside in soccer is a significant situation that effect to the result of a game. Therefore, automatic offside detect technique is necessary. Offside is one of seventeen rules in soccer sport that error of judgment often occurs [1, 2]. There are many research proposed to solve the error of offside judgement by image processing [3-5]. The difficult of offside judgement is that referee have to focus on the players and the ball from a distance in the same time. To judge an offside situation, the position of player will be compared with a line on the soccer field. Variation of grass color is also used as reference for referees for offside judgment. To detect a line in the soccer field is an important step.

From our studying and research the researches that have already been published. We can see a lot of research that can use to detect the white line in the soccer field [6] but without the research that can use to detect the line in soccer field from the difference of color of grass. The line from the difference of color of grass is parallel with crosswise line of the soccer field. Therefore, we decide to find or detect the line in the soccer field from the difference of color of grass.

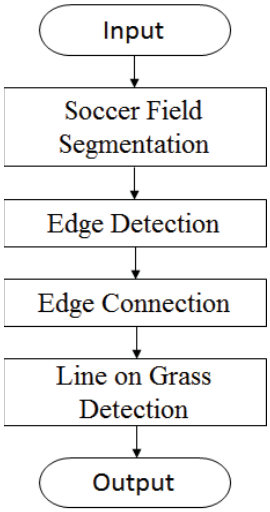

Figure 1 System Flowchart

This research use data from the broadcasted videos. The match that we select is FIFA world cup 2014 that available on internet. After getting videos we have to extract frame of video to save to image. The size of the image in our research is 1280x720 pixel. Finally, we select some frame that can use and delete frame are not use. The image that is out of our research scope is that a top view image, an image captured by a camera at back side of the goal, and an image that zoom into a player.

The limitation of existing technique is that line on the grass cannot be detected. Therefore, in our research present the method to detect a line in the soccer field from the difference of color of grass. First, we have to segment the field in soccer field to decrease the error from noise. Next, we use edge detection to create the line at the edge of the image. Then, we

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use dilate and erode to connect the line becomes to complete line. Finally, we use the hough transform algorithm [7] to detect the straight line.

The rest of this paper is comprised of the following sections. The details of the proposed method are provided in section II. Findings and Discussion are given in section III. Finally, the Conclusion and recommendations are shown in section IV.

II. Proposed Method

We can see the formal soccer field has 2 colors of grass is dark green and light green. Therefore, concept idea of this research is to detect the line from different of the color of grass. The system flowchart is shown in Fig. 1.

In this section present the method of our research for use to detect the line in the soccer field from the difference of color of grass. The process of our research has field area segmentation, edge detection, dilate and erode the line, hough transform algorithm.

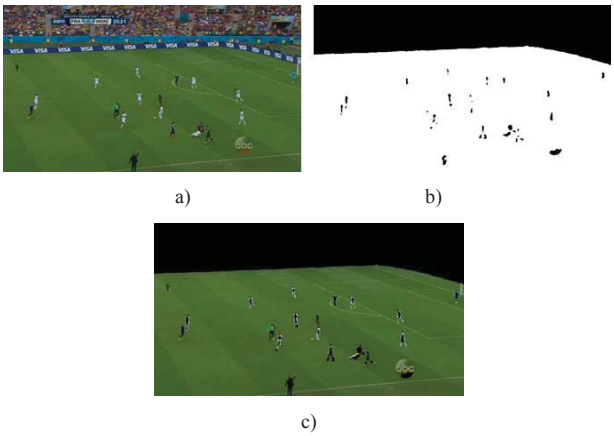
A. Soccer Field Segmentation

The aim of the soccer field area segmentation is the extract the green area from each image. The algorithm for extract the green area is derived by Eq. 1. The Eq. 1 shows an output of an image to be a binary image.

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

The R, G, and B define red, green and blue color channels. To remove 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.

Finally, the soccer field area is segmented as shown in Fig. 2.



a) b) c)

Figure. 2 (a) input image; (b) binary image before use Eq. 1; (c) Soccer field segmentation

B. Edge Detection

The aim of this process is to find and detect the edge from the difference of color of grass to create the line at the edge. We use the Canny edge detection algorithm [8]. First, we have to convert the RGB scale image to a grayscale image. Then, convolution image with a Gaussian filter to make the image to smooth. The Gaussian filter is shown in Fig. 3. Convolution between an image and a Canny filter in x-axis and y-axis is computed as shown in Fig. 4. Finally, set the threshold to reduce the noisy from edge detection. The output from this process is a binary image by white pixel is the edge from the edge detection algorithm. However, the output from this process is edge of object including lines as shown in Fig. 5.

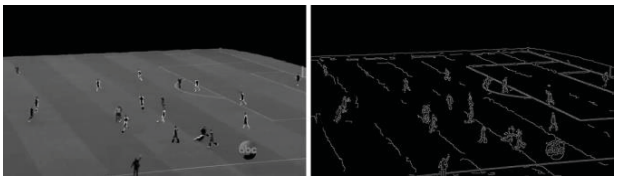
$$\frac{1}{273}\begin{bmatrix}1&4&7&4&1\\4&16&26&16&4\\7&26&41&26&7\\4&16&26&16&4\\1&4&7&4&1\end{bmatrix}$$

Figure 3. a Gaussian filter

$$\begin{bmatrix}-1&0&1\\-2&0&2\\-1&0&1\end{bmatrix}\quad\begin{bmatrix}-1&-2&-1\\0&0&0\\1&2&1\end{bmatrix}$$

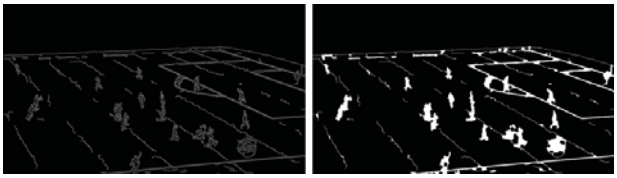
(Gx) (Gy)

Figure 4 (Gx) Canny filter in x-axis; (Gy) Canny filter in y-axis



a) b)

Figure 5 (a) grayscale image;(b) result of the Canny edge detection



a) b)

Figure 6 Result of Edge Connection Step

C. Edge Connection

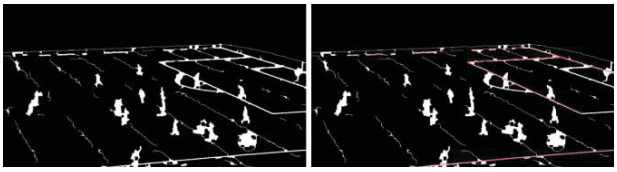
There are noise occurring in previous subsection. This subsection will remove such noise. The line from the previous process does not complete. We have to connect the little line to become to the long line. Therefore, the aim of this process is to connect the uncomplete line to become the complete line. We use dilate and erode to fill the little hole. First, we use dilate to expand all of the white pixels in the image by we want to expand the line to connect to another close line. Next, after expanding the white pixel in the image we have to reduce the white area size because we have to reduce the noisy from dilating process to become to normal size. If from dilate process can connect the line to become to complete line, the line will not cause holes by erode process. We repeat the dilation and erosion process more than 3 times to connect and fill the holes in the line. Finally, we will get the output of dilation and erosion process. Line will be connected. However, the white pixel of the output of this method has many white areas such as player, goal, line and noisy.

D. Line on Grass Detection

The aim of the process to find and detect the straight line in the previous process. The line hough transform algorithm use Eq. 2 to find and detect the straight line by r is distance of center to the straight line and θ is angle between the r and x-axis when defining r and θ for all of x and y, Then, the Hough transform algorithm have the Hough space for save and show the x and y value by the Hough space can specify the local maxima that the local maxima is the point of the straight line.

$$x\cos\theta + y\sin\theta = r \tag{2}$$

The hough transform algorithm can detect some shape such as straight line, circle, and ellipse but the hough transform cannot detect uncomplete shape. The uncomplete shape is the shape has some holes or shape does not same area. The output from the previous process has a white area such as the white line, the line from a different of the color of grass, player and noisy. We have to find and detect the straight line to get the white line from the soccer field and the line from a different of the color of grass only. The result of line detection is shown in Fig. 7.



a) b)

Figure 7 (a) input image; (b) output image

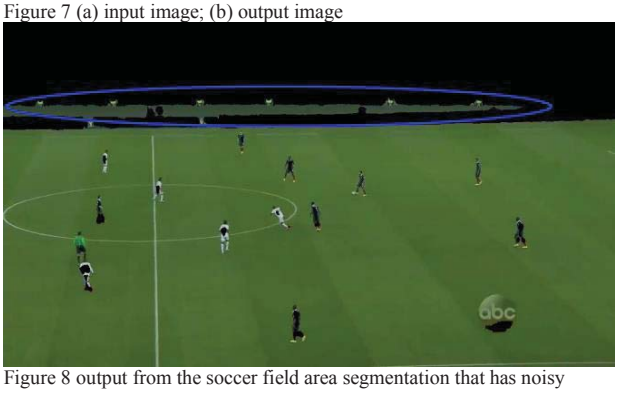


Figure 8 output from the soccer field area segmentation that has noisy

III. Experimental and Discussion

In this section, performance of the proposed method is evaluated. The result of the proposed method and discussion will be presented. To evaluate the performance of the proposed method, 50,000 image form 22 matches are used to detecting lines. Results is compared with ground truth data. The ground truth data is generated by experts. Lines are selected manually.

For soccer field area section experiment, some images have some noisy because the biggest area has some object such as people, billboards and flagstaff that some object is connecter between the soccer field and noisy. Therefore, the soccer field and noisy is the same area and the biggest area in this process as shown in Fig. 8.

In experiment of the dilation and erosion method, if the line from different of the color of grass has long between from side to side of the line from different of the color of grass, the line does not connect together completely. The result will be have some error as shown in Fig. 10.

From our experiment of the Hough transform method, some lines can be detected as shown in Fig. 11. Some result cannot be detected. This is because threshold after line detection process should be adaptive. However, the Hough transform can detect the white line in the soccer field.

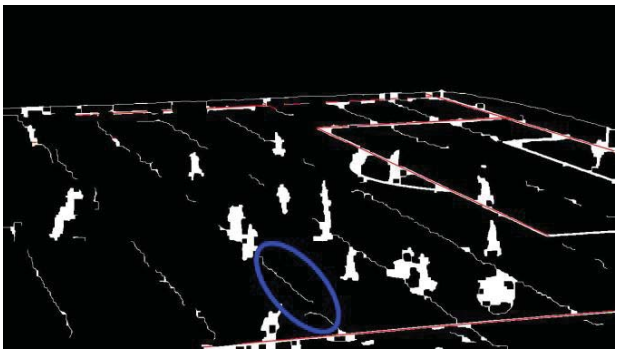
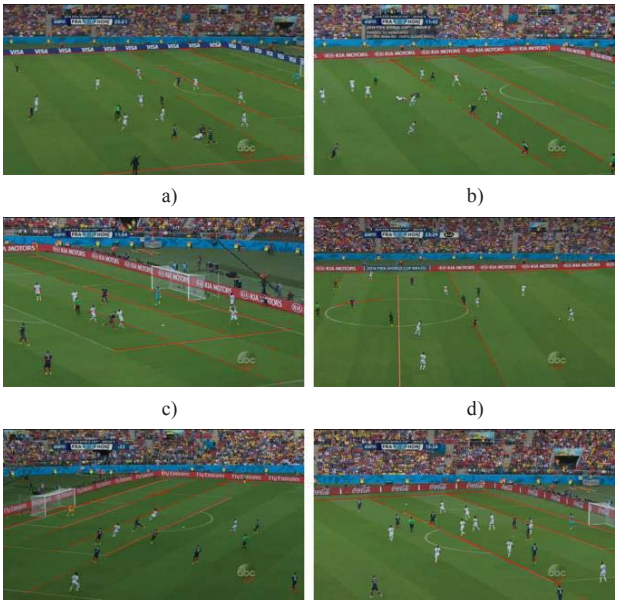


Figure 9 Error result of line detection



a) b) c) d) e) f)

Figure 10 Line detection result

From our experiment of all of our method, we can see the final output of my research can detect the white line in soccer field but it seldom detect the line from different of the color of grass.

From our experiment of the edge detection method, we found that some output image does not have the edge from different of the color of grass after use the edge detection algorithm. Therefore, output that has error it cannot use in our research because it does not have some line to use to next process.

This method detects line lie on edge of grass color variation. In real-world application, from detecting a line on the grass, there is in a distance far from the player. This condition is difficult to detect an offside. The line needs to be moved close to the players foot by ad additional algorithm.

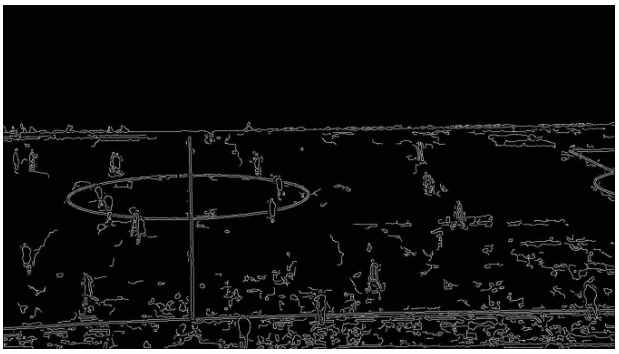


Figure 11 output from the edge detection process that has error

IV. Conclusion

In this research, we proposed a method to detect a line in the soccer field by using glass color variation. The lines are line along the different of grass color and standard line in soccer field. This method consists of three step. Firstly, the soccer ground is segmented by a constraint color in RGB channel. Second, edge in the image is detected. Finally, line is detected by a line hough transform technique. The result shows that the line along the color variation of grass can be detected satisfactory. It has potential to continuous improve the performance of this method in order to achieve the goal of offside detection system.

For future work, performance of the proposed method will be evaluated by more experiments, example, 1) number of lines that can be detected and comparing the result with an expert, 2) number of pixels in a line that the proposed method can detect, and 3) precision of detected lines, the results should compared with reference lines. An algorithm for detecting line more precisely should be continuously developed.

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