An Instantaneous Image Based Detection of Offside in the Sport of Football

P.Nandha Kishore, G.Deepak Raj,
Department of Electronics and Communication Engineering,
SSN College of Engineering,
Chennai, India.

Abstract- **This paper concerns itself with the calculation and the detection of offside mechanism in soccer matches using image processing. The images are obtained from an ultra-slow motion camera. From the captured images, the player positions and the co-ordinates of the ball are obtained. The players are detected using a colour separation mechanism and the ball's co-ordinates are obtained by morphological processing. The possession of the ball is decided by calculating the distance between the players and the ball. All distances and measurements are based on "pixel" units. Using an algorithm, the players are checked for an offside offence and the results are indicated. The algorithm is verified using MATLAB.**

Keywords-Offside Mechanism, Player positions, Ball Co-ordinate, Image Processing.

I. INTRODUCTION

The judgment of offside in football matches is prone to human error. Refereeing mistakes have often led the result of the match being invariably altered. This deficiency can be rectified by the use of technology. By using image processing, any offside foul can be detected with precision.

The rule of offside is explained as follows: A player is said to be in offside position if he is nearer to the opposition goal line than both the ball and the second last opponent. If he is in offside position when a pass is collected by him, then it is ruled that he has committed an offside offence.

In the proposed method, initially, the match is captured using a high image precision, high shutter speed video camera. The captured frames are simultaneously processed using a processor. The position of the players is detected using their jersey colours and ball detection is done using morphology. The possession of the ball is determined by calculating the distance between the ball and the players. After every pass, the teams are checked for offside. Thus offside offences are detected.

II. IMAGE SENSOR REQUIREMENTS

The method proposed makes use of ultra slow-motion cameras that are placed in each halves of the playing field. The image sensors are positioned in such a way that they are capable of covering the entire half of the field. They are connected to processors that can process the image signal. The image sensors[1] ie., ultra slow-motion cameras should possess the features like high image precision, high frame rate and wide angle capture range and maximum signal to noise ratio. The two image sensors can communicate with each other through the means of a protocol to transfer information[2]. This is to ensure that the proceedings of the match are processed parallel by both the processors. The image sensor constantly records the images and sends them to the processor as input. Any variation in the signal is adjusted. The input image is further processed to detect offsides.

III. PLAYER DETECTION

The players are detected based upon the colour of their jerseys. A truecolour image or an RGB image is basically consists of three gray scale images superimposed together. Each grayscale image represents the intensity of the primary colours(RGB) available in the truecolour image.

Any player who is wearing a primary colour jersey (RGB) can be detected by image separation[3] or any other colour based algorithm[4]. Players sporting jerseys with secondary colours like yellow, cyan and magenta can also be detected by an extension of the image separation algorithm. In case the team wears a white or a black jersey, the players can be detected by the property that "white and black are mixtures of other colours". White indicates the presence of all three primary colours while black indicates the absence of all three. Thus, field players can be detected by converting the RGB image into a binary image and thresholding it, making each player a connected component in the binary image.

The goalkeeper sports a jersey of a colour that is different from that of his team. Such a condition is handled by detecting the colour of goalkeeper's jersey separately and adding that to his team. If the player thresholding is not proper, then their positions are obtained by morphological operations like dilation and erosion. The position coordinates of the players from both the teams are calculated and stored.

IV. BALL DETECTION

Detecting the position of the ball accurately is crucial to the increased efficiency of the algorithm. The football is detected by using image morphology. The basic property that a football is a circle when recorded in an image is used to detect it.

A football is a sphere with a fixed radius in real time, considering three dimensions. The projection of a sphere in two dimensions is circular[5]. Thereby, to detect the ball, each connected component is analyzed and every round object is identified.

To identify whether the connected component is circular, a quantity termed "metric" is used. Metric is given by

$$\text{Metric} = (4*\Pi*a)/(p\hat{}2) \quad (1)$$

where a is the area of the connected component and p is its perimeter.

"Metric" equivalent of a perfect circle is always 1. This is because the area of circle is Π times square of the radius of the circle and the square of its perimeter will be equal to 4Π times its area. The circular components are thus detected. Circles can also be detected using these methods[6].

In order to avoid other circular objects being identified as the ball, the area of the ball is specified as another criterion for ball detection[7][8]. Dilation, erosion end thresholding are performed to avoid noise signals. Thus the position of the football in the match is detected.

V. OFFSIDE DETECTION

With the position of the players and the ball detected, the distance between the ball and the players is calculated. The distance is measured by using number of pixels between spatial co-ordinates of the players and the ball.

A. Ball Possession:

A person with the least distance from the ball is considered to be the possessor of the ball. The distance between the possessor of the ball and the ball in pixels is determined by the frame rate of the image sensor. The accuracy is enhanced by an image sensor with a higher frame rate.

B. Offside calculation:

According to FIFA's offside rule, there must be at least two opponent players before the attacker who receives the ball. This decided by analyzing the frame where the pass is made.

The method to find the offside players depends upon the number of opponent players ahead of attacker who passes the ball.

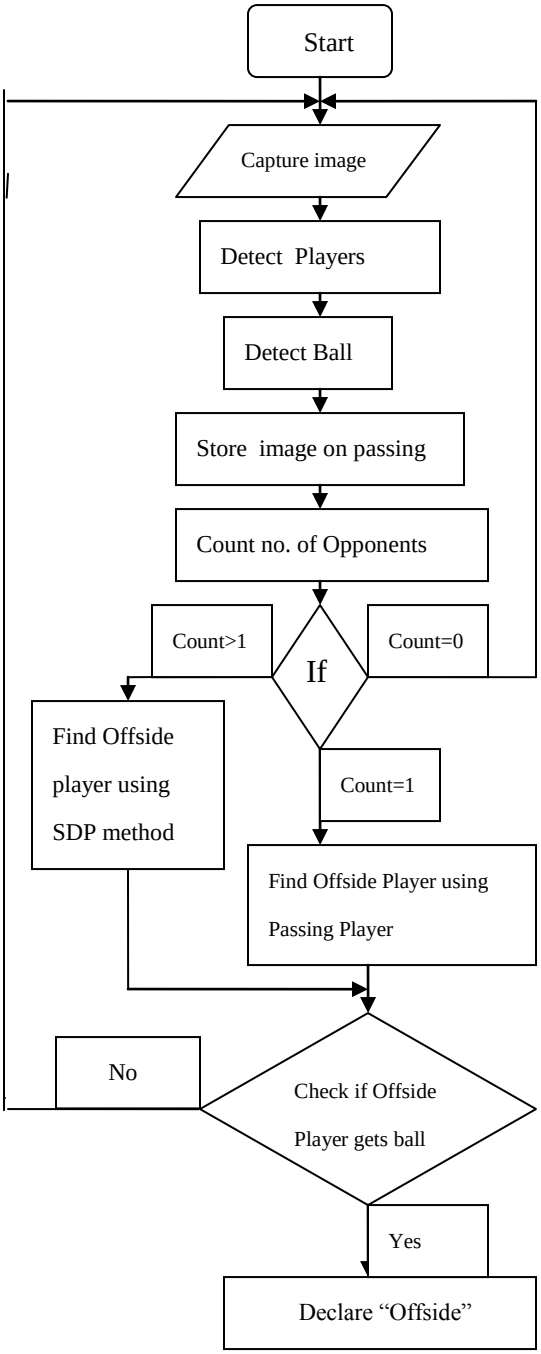

Figure 1: Flowchart of Offside Algorithm

Case 1:

If the number of opponents ahead of the player passing the ball is greater than one the offside players are determined by using second defensive player method. The player with second least distance from the goal line is concluded to be the second defensive player. If the distance between the goal line and attacking player is less than that of second defensive player then he is in offside position.

Case II:

If there is only one opponent player ahead of the attacker who passes the ball, the passing player method is used to find the players at offside position. If there is any other player from the attacking team ahead of the ball possessor then he is declared to be in offside position.

Thereby, the players who are in the prospect of committing an offside offence are identified.

C. Offside detection ;

The players who are found to be in offside position are marked with references. As play progresses, the reference numbers are incremented or decremented according to their formation in the half of the play field. The references are based upon the frame rate of the ultra slow motion camera. Hence, players who are found to be in offside position are continuously tracked by references.

The ball, being tracked throughout the play time, if found to be under the possession of the players identified to be in offside, it is indicated that an offside offense has occurred. Suppose the ball is not passed to a player in offside region the entire mechanism is repeated for every pass made throughout the duration of the game.

Thus, it is concluded that the image based algorithm can detect and indicate offside offenses efficiently.

VI. VERFICATION AND RESULTS

The above algorithm has been executed and verified using Image Processing in MATLAB and the results are shown.

The example considered is a sequence from FIFA World Cup 2010, in a match between South Africa and Mexico.

Figure 2 shows an image recorded during the course of play. It consists of the main image (play area) and other noise signals. The noise signals are removed using filters. If the algorithm is applied to original image directly without removing noise, it may not work efficiently.

Figure 2: Original Captured Image

Figure 3 displays the players of South Africa, wearing yellow jerseys, in white. The players have been identified using the colour separation technique.

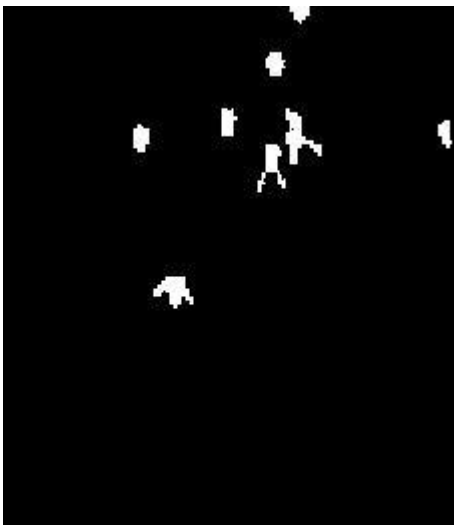

Figure 3: Image displaying the players clothed in yellow

Figure 4 displays the players of Mexico with dark jerseys. They are detected by sampling and thresholding the image with suitable values.

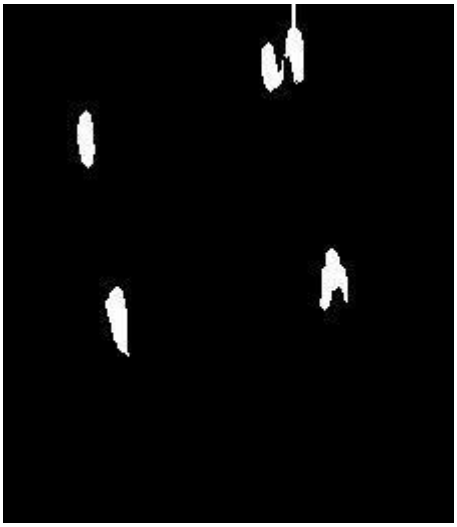

Figure 4: Image showing the players in black

Figure 5 shows the image that has been used for offside analysis, ie , the moment at which the pass has been made. This image is analysed and players in offside position are identified.

Figure 5: Stored image

As per the algorithm, it is checked whether the offside player receives the ball. Figure 6 displays the image in which the player who is marked offside receives the ball. The algorithm continues if he does not receive the ball.

If the player is found to be found offside, it is indicated to the linesmen or the referee that very instant.

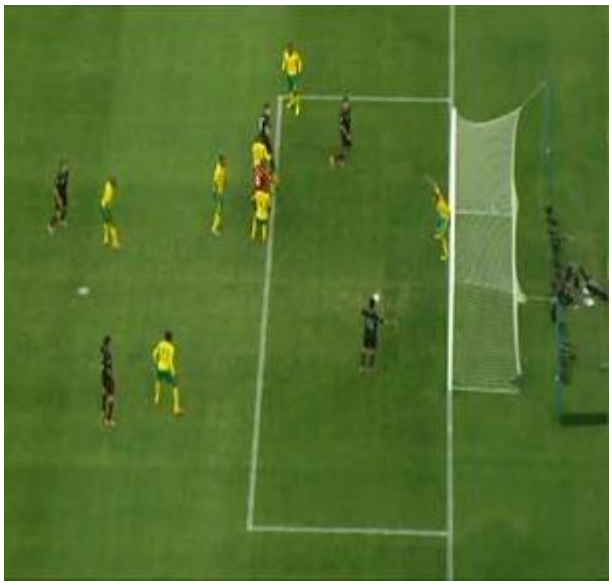

Figure 6: Image with detection of Offside

VII. CONCLUSION

A. Drawbacks of previous approach:

The methods[9][10] currently being suggested have the following drawbacks.

1) They make use of twelve to sixteen cameras increasing the complexity and expense.
2) The ball is tracked in three dimensions to plot the path in which the ball has traveled.
3) The speed of the system comes down due to the result of three dimensional tracking.

B. Features of the proposed method:

Some of the features that make this system efficient are:

1) The complexity of the entire detection process comes down since the number of image sensors is reduced.
2) There is no need to plot the trajectory in three dimensions.
3) The speed with which the offence is detected is improved.

C. A Comparison between Three Dimensional Ball Detection System and Image Based Offside Detection:

In three-dimensional ball tracking, the accuracy of offside detection is efficient compensating the speed of the algorithm. Football, being a sport in which gameplay happens fairly quick, demands a better system with greater speed. The system proposed is more advantageous as it calculates the offense instantaneously and notifies the referee.

Image based Offside detection is fast to execute with reliable accuracy and also can be easily implemented in football matches.

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