**Digital Image Processing Solutions for Offside Recognition in Football**

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A close up of a sign

Description automatically generated

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**Abstract**

Football is one of the most popular sports and is played all over the world thoroughly. The result of the football matches is highly dependent on referee rather than the football player skill regarding the violations of the offside rules. Offside is a rule in soccer deducted with international soccer board to influence on movement confine of players when they attack. Offside law says when an offensive would be in a situation that there are less than two foe players between him and the goal and gives a pass from teammate player, offside is happened. Offside has some exceptions: Pass would be from teammate, player at foe half playground. Pass is not from out or corner kicking. So, Location of hands doesn’t influence in offside events. We know decision to declare and not to declare offside is the most mistakable decisions of referees in the soccer history. No digital image processing system has presented to solve this problem yet and there is no system contoured that FIFA has accepted it.

1. **Introduction**

The football matches have high value in the sports market and make the significant impact to an economy in many countries. In a football match, many goals are the key to competition, and offside is an important rule for making the

competition fair for offense and defence to fight for getting and protecting the goal. To judge the goal and offside, the linesman who is running on the sidelines will assist the referee to give a sign as the second opinion for goal, offside, faults, and the referee would make a final decision. On the other hand, offside is a kind of strategic plan for offence side to get a goal so that the lineman has to be very careful to check it. However, since linesman sometimes cannot see important scenes for suggesting judgment to the referee due to the limitation of seeing the ability of human, afterimage, occlusion, and so on,

the automatic system of linesman for detecting offside is urgently required.

In the development of the system, since the lineman normally pays intention on boundaries of offensive player who is playing a ball and the most back defending player, salient image regions of those players are the goal. Extracted saliency maps are widely used in many computer vision applications including object-of-interest image segmentation, object recognition, adaptive compression of images, and image retrieval. Saliency originates from visual uniqueness,

unpredictability, rarity, or surprise, and is often attributed to variations in image attributes like color, gradient, edges, and boundaries. Visual saliency, being closely related to how we perceive and process visual stimuli, is investigated by multiple disciplines including cognitive psychology, neurobiology, and

computer vision. Theories of human attention hypothesize that the human vision system only processes parts of an image in detail while leaving others nearly unprocessed. The early work on saliency model is motivated by simulating the visual attention mechanism of Human Visual System, through which only the significant portion of the scene projecting onto the retina is thoroughly processed by human brain for semantic understanding. Based on the biologically plausible visual attention architecture and the feature integration theory, Itti et al. proposed a well-known saliency model, which first computes feature maps of luminance, color and orientation using a center-surround operator across different scales, and then performs normalization and

summation to generate the saliency map. Salient regions showing high local contrast with their surrounding regions in terms of any of the three features are highlighted in the saliency map. Besides, some recent saliency models also exploit object/background priors and cues at different levels for a better saliency detection performance. They can highlight salient object regions more completely with well-defined boundaries, and suppress background regions more efficiently compared to previous saliency models. However, these state-of-the art saliency models are still insufficient to effectively handle some complicated images with low contrast between objects and background, heterogeneous objects and cluttered background. In the recently proposed hierarchical saliency model, saliency cues are calculated on three image layers

**2. Literature Review:**

* Researchers have done a lot of research to develop the idea of evaluating players’ position on the football field and getting a way to find out the events occurred in the field. Guoying Jin et al. have presented a video processing model called Hidden Markov Model to detect every event of a football match like offside. An experiment was done to find out the result and their method worked correctly as the model can find any event effectively. Their experiment worked perfectly as the games have primitive patterns like shoot, heading, jump etc. (Jin, 2004).
* Tracking any object from the data given from the camera is also challenging. P. Mazzeo et al. have done an excellent work to classify players in multiple camera environments. They have used an unsupervised algorithm to generate class models of objects from different cameras. They also used a cumulative brightness transfer function to classify same colored objects like players in the same team or referees and they found a good result (Mazzeo, 2010). S. de Sousa et al. also have done a good research to detect an offside during the match.
* This idea can also be used for tracking the players as players have less speed than a football. As their experiment worked correctly, it can be used to track the players on the field. The shadow is one of the most complex barriers to track players especially when a game occurs at night. J. Renno et al. have done a research to classify shadow to detect players perfectly. They used unsupervised learning procedure to get RGB from the images to distinguish the foreground and shadow.

**3.Problem Statement:**

* To increase the precision of the onside decision a system has been aimed that is called Tracking Technology in where quantify players positions and runs an algorithm to detect which players are onside or not.
* To develop a system that recognizes offside in a live soccer game by analyzing the live stream or videos captured during the game by using digital video processing.

**4.Objectives:**

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* When the captured film of an object consists of soccer players and ball is shown in the central system, It is necessary to get coordinate’s abscissa and breadth of objects. On television during a soccer game a line parallel to breadth line of playground as offside line is seen and they spot the intersection of this line and abscissa line, abscissa location(X) of players or ball. This small mistake causes large mistakes in analysis of soccer umpire.



* Above shown are the steps of the algorithm .i.e. the flow of the algorithm. This diagram is the whole framework to detect offside

**Capturing image from video:**

In order to track an offside successfully my proposed system uses two fixed cameras in behind the both sides of goal post that will give a flag whether the ball is in the contact with a player or not. That means both side cameras will give a false value when players touch the ball because there is no chance of occurring offside when the player touches the ball. The cameras will give a true value when no one touches the ball because there is a good chance of occurring offside event when the player releases the ball to another player. The both side cameras also give a timestamp when the value goes from false to true. On the other hand, six cameras will be on the top of the field perpendicularly on the both side of the field which will capture the image of the field. They will capture the image at the given timestamp that means when both side cameras give value from false to true six cameras will capture the whole field condition.

**Detecting the ball:**

The ball is the main part of a match and detecting a ball from the captured image is also a hard task as the size of the ball is relatively small and its pattern sometimes matches with the field pattern. An algorithm named top hat is used to detect the ball. It is actually subtraction process and with this process, the non-ball part is deleted from the image.

**Detecting the players:**

An event like offside detection goes much complex because of lack of player detection and it is the key part of detecting this event. The image data is analysed based on the image processing more specifically via color detection. Color is first normalized with the help of normalized RGB method. RGB (Red, Green and Blue) value is divided by the sum of all the value and it gets more readable on each pixel.

**Making imaginary offside line:**

This line is made based on the last player’s position of the opposition team and this line is moving dynamically as players are moving. This imaginary line is created on the both side of the field for both teams from the images taken from the perpendicular cameras.

**Making offside decision and giving the output:**

This part checks which coloured player releases the ball and find which players crossed the offside line having the same colour because there is a chance of occurring an offside event. So if the players who already crossed the imaginary line gets the ball the offside will be detected and output will be a true value. Otherwise if other player gets the ball who has not crossed the line, offside will not occur and the output will be a false value. The data will be collected from two types of cameras as images with a timestamp which makes the difference from one frame to another frame.

**5.Scope:**

* The football matches have high value in the sports market and make a significant impact to an economy of a country.
* Offside is an important rule for making fair competition for offence and defence to fight for getting and protecting the goal.
* However since linesman sometimes cannot see important scenes for suggesting judgement to the referee due to limitation of the seeing ability of human, Afterimage, occlusion, and so on, the automatic system of linesman for detecting offside is urgently required.
* To maintain the tempo of the game is one of the major aims of this project.

**6.Application:**

This system can be used by the International Federation of Association Football (FIFA) and the Union of European Football Associations (UEFA) for instant decisions in tight offside situations. This system can be used at the highest of the levels as the FIFA World Cup as well as the biggest of the European Championships such as the UEFA Champions League. Making use of the system makes more sense in the higher levels as the stakes are high and one small incorrect decision such as an offside one may shift the whole momentum of the matches.

**7. Technology Stack:**

* MATLAB
* C, C++, PYTHON
* Libraries-OpenCV, PCL.

**8. References:**

* <https://ieeexplore.ieee.org/document/5159423/>
* <https://ieeexplore.ieee.org/document/8261213/>
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