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Artificial intelligent third umpire runout decision making using image processing

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Abstract. Cricket is the most interesting game watched by the people all over the world. The decisions given by the umpire play a vital role in deciding the game winning situation. As human decisions are prone to error, the need of smart technology intervention is mandate. The advances in image processing and computer vision techniques has now paved the way for making effective and correct decisions on all phases of the game and in automatic scoring. This paper proposes a new approach for detecting the run out using stump detection and from the intersection of the bat and the crease line, named Artificial Intelligent third Umpire (AITU). The accuracy of decision making is improved thereby reducing the third umpire work.

Keywords: Cricket,Runout decision,Third umpire

1.Introduction

Cricket is an international game played between two teams consisting of 11 players each. As each and every ball decides the winning or losing of the game, the decisions made on each ball is very crucial. There will be two on field umpires who decides on wide, no ball, run-out, bye, etc., But sometimes if they have any doubt then the help of an off-field umpire, called third umpire decision is sought. From the zoomed images and the video clippings, the third umpire makes a decision as shown in figure 1. So, technology has a vital role to make accurate decisions thus avoiding human errors. Recently, the technologies like Hawk Eye for lbw detection and Snicko Meter for detecting the edging of the bass with the bat has been in place to make a fair decision. But still, decisions of run-out and automatic scoring may require the technological intervention for a fair game playing. Hence here we propose a new method to overcome the issues on time and accuracy of the human decisions.

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Figure 1. Third Umpire

2. Related Work:

[8] proposed key-frame extraction from videos by extracting entropy and identified as Global and Local Feature. The algorithm was doing well in automatically identifying the video key-frames but the difficulty was in the calculation of entropy. [9] proposed a stereoscopic Vision System approach to detect and predict ball following. It was done by taking help of a block matching method related to that of MPEG Video. Their proposed algorithm also discarded straight lines, isolated and angular points and distinguished the arc direction and hence was claimed computationally efficient. [4] mooted a real-time object detection, fast YOLO. It processed further than 155 frames per second simultaneously attaining double the map of other realtime detectors. The limitation was that the localization errors are high but less likely prediction of false positives on background was accomplished. [7] emphasized an automatic method for detecting the red light violation for Indian vehicles. Their system was successful in tracking 92% images of violating vehicles, when the traffic signal shows Red Light, but it causes some difficulties in real time implementation. [6] proposed an effective ball detection framework for cricket. This method eliminated false arms in ball detection. Limitations arose when there are occlusions of the ball with the surface or with the players. [10] proposed the key-segments for idea object segmentation. This method exhibited a better performance than the state-of-the-art techniques. Some errors are visualized under the region with the highest appearance-based score. [11] emphasized an approach to automatically unfurl the third umpire's decision and scoring system using a Convolutional Neural Network (CNN) with Inception V3. [3] proposed an approach for no ball detection. Several other literatures define their own methodology like [5], automated decision making and simulating the match activity

3. Proposed Approach for Run-out Detection

3.1 Existing Decision making System

A batsman may be announced 'out' for the case of run-out or stumping, if the wicket is 'put down'. This may due to the removal of the bails from the stumps. The wicket may also be putdown if the batsman is caught between the two creases. Hence, an 'out' decision may be given. But these things happen all on a sudden. If the field umpire within this fraction of a second was not able to make a decision, then the decision from the third umpire is sought. Then the third umpire view various TV replays at various angles and will declare the result as 'out' or 'not out'. If the umpires are not sure about the decision that a batsman is 'out' or not, as they are deficient with more convincing evidence, the standard practice is to set free the batsman, known in cricket phrasing as "the benefit of the doubt". The existing system has following problems:

- The time taken for some critical decision makes some delays in match.
- More Investment in Salary for Third Umpire (1.75 lakh per match)
- More Investment in Technician side.
- Wrong Decision by Third Umpires also happens sometimes.

Figure 2. Batsman is present inside the Line

Figure 3. OUT decision given by the umpire

Third Umpire Review System has a significant role in the game of cricket. Some of the decisions cannot be predicted using our naked eye. The on-field umpires request the off-field umpires to predict the output. Sometimes human error also influences the third umpire review system. Therefore this type of review system does not always declare a correct decision. There also incidents of Gambling or match fixing. This causes the overrule in the cricket match, because the player cannot have rights oppose the decision made by the third umpire. From the figure 2, it is seen that the stumping action is portrayed, the on-field umpire calls for the third umpire's decision. Figure 3 shows the decision as 'OUT'. But the decision is wrong, because the batsman is present inside the crease. This situation makes the batsman and every player to the depression state.

3.2 Proposed System

The block diagram of the proposed artificial intelligence based third umpire system using image processing is shown in figure 4.

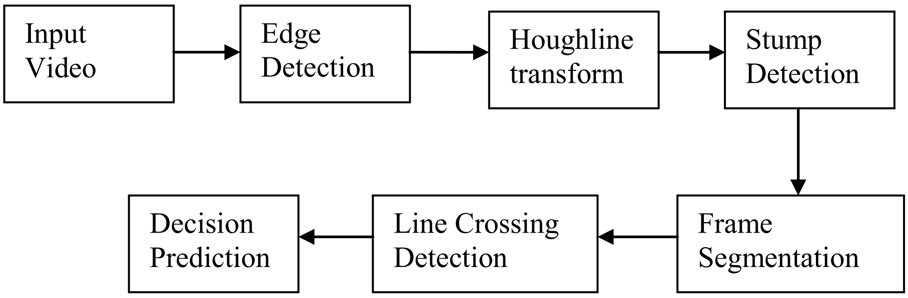

Figure 4. Block diagram of the proposed approach

The input to the proposed module is a video. A digital video encompasses a succession of digital images displayed in quick progression. The match video is processed to get the frames which are then used for making the decision. The foreground is extracted by performing background subtraction. Initially preprocessing is done to enhance the image quality. Frame segmentation is process of changing the representation of the image to make it easier for analysis. It is done on video frames to locate object boundaries like lies, curves, etc.

3.2.1 Canny Edge Detection:

From the extracted frames the first operation performed is edge detection. For edge detection Canny Edge Detection method is utilized. It is a multistage algorithm for finding thedges. It extracts the useful information from the objects and hence reduces the amount of image data. The advantage of canny edge detector is 1) Low error rate 2) Good localization 3) Minimal response. Canny edge detection algorithm follows the steps given below:

- Application of Gaussian filter for image smoothening
- Determination of intensity gradients

- Non-maximum suppression to remove the spurious response
- Finding potential edges by utilizing double thresholds
- Edge tracking by hysteresis: Edge detection is finalized by removing the edges that are weak and not connected to strong edges.

Gaussian Filter: As the result of edge detection is affected by noise, it is essential to perform filtering in order to avoid false detection [12]. The image is smoothened by convolving it with a Gaussian filter. The Gaussian filter equation for the size of the kernel (2k+1)×(2k+1) is given by:

$$H_{ij} = \frac{1}{2\pi\sigma^2} exp\left(-\frac{\left(i-(k+1)\right)^2+\left(j-(k+1)\right)^2}{2\sigma^2}\right); 1 \leq i,j \leq (2k+1) \quad (1)$$

The selection of size of the kernel is crucial in determining the performance of the filter. As the size of the kernel is increasing, the detector becomes less sensitive for noise detection with increase in localization errors.

Determination of intensity gradient: To detect edges present in an image in all directions, canny edge detector uses four filters for detecting horizontal, vertical and diagonal directions. The edge gradient can be determined as

$$\boldsymbol{G} = \sqrt{\boldsymbol{G_x^2} + \boldsymbol{G_y^2}} \text{ and } \boldsymbol{\theta} = \mathbf{arctan}(\boldsymbol{G_x}, \boldsymbol{G_y}) \quad (2)$$

Where G_x and G_y are the first order derivatives in the horizontal and vertical directions. The edge direction angle is rounded to one of four angles representing vertical, horizontal and the two diagonals (0°, 45°, 90° and 135°).

Non Maximum Suppression: This is used to determine the largest edge. The algorithm is, for every pixel:

- Compare the edge strength of the present pixel with that of the edges in the positive and negative directions.
- The value of the present pixel is retained if its comparison is the largest among the compared values. Otherwise it is neglected.

Double Threshold: After non maximal suppression, the resulting pixels are real edge pixels. Along with those pixels some more pixels due to noise and color variations may also be present. These are further selected by setting a low and a high threshold. If the edge gradient value is higher than the high threshold it is retained and if it is less than low threshold, it is discarded.

Edge tracking: The weak edge pixels may be resulted from a strong pixel or due to noise or color variations. This can further be identified by blob analysis which identifies the connectivity of a weak pixel to a strong pixel. If there is a strong edge pixel identified in a blob, then, that weak pixel is considered otherwise it is neglected.

3.2.2 Hough Line Transform

The purpose of the technique is to determine defective incidences of objects within a certain class of shapes. It is achieved by means of a new voting procedure. The classical Hough transform identified the lines in an image, but presently it is extended for the identification of circles or ellipses. The simplest Hough transform detects straight lines ($y = mx + c$). However detecting vertical lines impose a problem, because of the unbounded value of the slope 'c'.

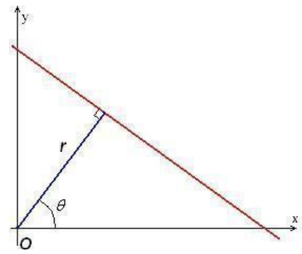

Figure 5. Hesse Normal form

The Hesse norm proposed by [2] Duda and Hart shown in figure 5 is used for computational purposes.

$$r = xcos\theta + ysin\theta \quad (3)$$

where r is the distance between the origin and the closest point on the straight line, and θ (theta) is the angle between the x axis and the line connecting the origin with that closest point. Hence, for each line in the image a plane named, Hough space can be associated.

3.2.3 Stump Detection

Stump denotes three vertical posts for supporting the bails are placed on the two sides of the pitch, representing the wicket. The stumps are referred as:

- Off Stump: The stump on the same side of the batsman's bat i.e., offside of the wicket
- Midddle stump: Centre of three stumps
- Leg Stump: The stump on the same side of batsman's legs i.e., onside of the wicket

When the match is played professionally, a camera is fixed with a vertical alignment on one or more stumps. These stump camera videos can be useful for visualizing action replays and batsman bowling positions. Detecting stump region is the key process in this proposed AITU. There are a variety of algorithms such as object recognition is used in the literatures. As the complexity of the same is more, a different technique to detect the stump is proposed in this paper. The proposed method uses the detection of line in the pitch. There is a constant distance between stump and the line in the pitch. So the line detection is completed first and then by moving certain pixels from line the stump is identified and a bounding box is drawn over the stump and makes the part as Region of Interest (ROI).

3.2.4 : Frame Segmentation

Segmenting a frame from a video is done to process the videos easily for predicting the result. In 2015 ICC world cup, flashing LEDs were affixed in the stumps. The Red LEDs starts flashing, if any one of the stumps got hit by the ball. Here the ROI stump region is continuously monitored by applying a red mask to it. Whenever the stump goes red, the value in the masking region gets changes. When the color intensity in the masked region is changes, then a condition is imposed to separate the particular frame from the video. The that frame is used for identifying the line crossing detection.

3.2.5: Line crossing detection

Detection of line crossing is a crucial and vital feature in the proposed AITU. Hence, if the batsman crossed the crease lines, the camera will automatically perceive it and it prompts the decision or recording if it is pre-configured. Object detection is a computer technology under the field of computer vision and image processing, that is applied for identifying instances of semantic objects of a certain class (such as humans, buildings, or cars) in digital images and videos. Well-researched domains of object detection include face detection and pedestrian detection. Line crossing detection is the algorithm to detect whether the object/humans /animals cross a line or not. Intersection is the basic idea behind this algorithm. When the two lines formed by the edge of the bat and white line intersect each other, then it is known that the object is crossing the line. This approach can also be used to detect people crossing over the fence or entering into a restricted area.

4. Results and Discussion

The input to the AITU system is a video representing Run-out. The segmented frames are used for detecting stump region by detecting the red light and the crease line. Then based on the intersection of bat edge and the white line, the final decision is made. The output images for each step of the AITU process is shown below in figure 6 to figure 17.

Figure 6. Original Video

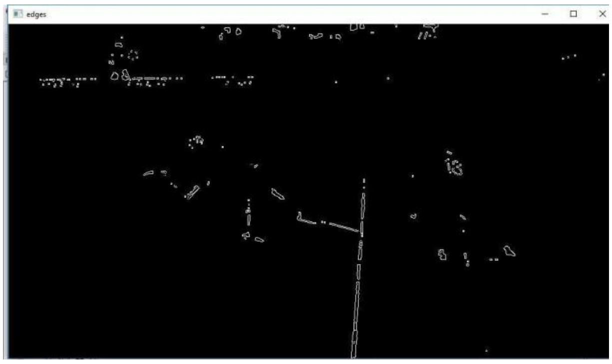

Figure 7. Hough transformed Image

Figure 8. Line detection

Figure 9. Stump Detection

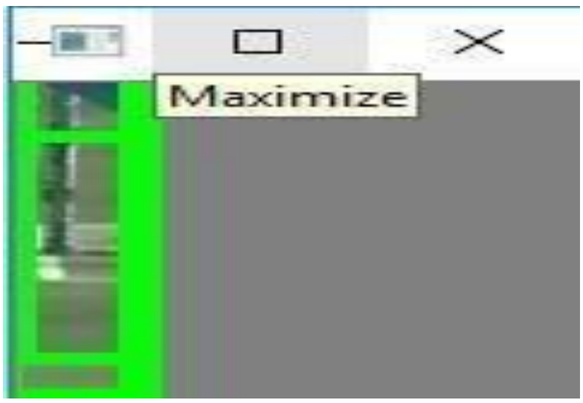

Figure 10. Extraction of Stump region

Figure 11. Segmented Frame

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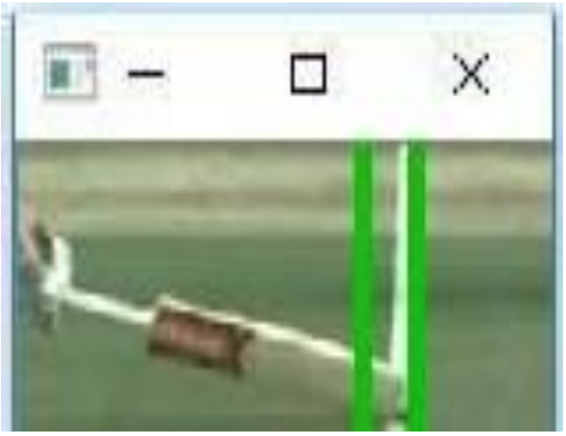

Figure 12. Line crossing Detection region

Figure 13. White masking on line crossing region

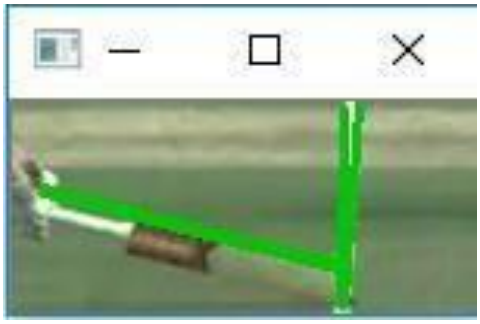

Figure 14. Lines drawn on edges

Figure 15. Co ordinates of Lines in Bat and White Line

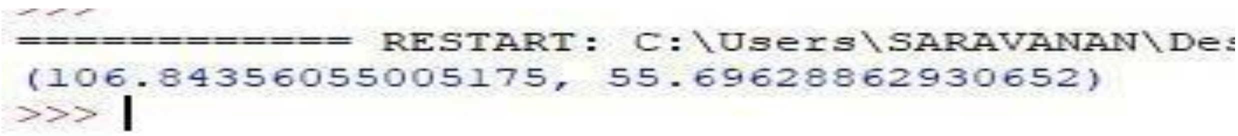

Figure 16. Intersecting Point of the Two Lines formed by bat and line

Figure 17. Predicted Decision

4.1 Discussion

Figure 17 shows the output (Decision predicted by the AITU) for the corresponding input video figure 6. This reveals that the critical decision can easily be predicted by AITU within a fraction of second by uploading the video. This output can be accurately predicted with the help of numerical values i.e point of intersection. Figure 16 gives the coordinates of the point which is formed by the intersection of edges of white line and cricket bat shown in Figure 12 and Figure 14 respectively. If there is a value present in the point of intersection decision given is 'not out' otherwise the predicted the decision is 'out'.

4.2 Conclusion

AITU is the proposed system which makes the decision for run out without human intervention. This system helps in making accurate decisions at crucial time of decision making like run out. In accuracy and delay to predict decision, the problems of the television replay method are solved using AITU. This system is more helpful for the players and viewers of the game.

4.3 Future scope

In cricket, the need of accuracy and speed of prediction are big challenges for the researchers. Therefore future implementation of AI may be on no ball detection, LBW detection and catch detection.

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