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An Efficient Ball Detection Framework for Cricket

B.L. Velammal[1] and P. Anandha Kumar[2]

**[1]Department of CSE, Anna University,
Chennai, Tamilnadu 600025, India**

**[2]Department of IT, MIT Campus, Anna University,
Chennai, Tamilnadu 600025, India**

Abstract

Ball Detection and Tracking in Cricket image sequences has become a growing and challenging issue, with the rising popularity of Sports analysis. To identify the ball in cricket is very important for event recognition. It is also useful for summarization. Lot of methods has been proposed for ball detection in Soccer videos but ball detection in cricket is more challenging than Soccer because of the smaller ball and the ball deforms while moving. An anti-model approach is used to eliminate non-ball objects and remaining objects are identified as ball-objects. Region Growing segmentation is chosen for segmentation. After segmentation, the ball and non-ball objects are classified using the shape properties. The non-ball objects are eliminated and the resulting frames consists of only ball objects or ball-candidates. The ball candidates are to be processed further to detect the ball. This method eliminates false alarms in ball detection.

Keywords**:** *Segmentation, Ball Detection, anti-model approach, and ball-candidates.*

1. Introduction

Ball detection in cricket has achieved very much significance with the introduction of twenty - twenty cricket matches. Automatic ball recognition in the television image sequences is a fundamental task to be solved. Ball Detection in Cricket domain is very challenging as a great number of problems have to be managed such as occlusions, shadows, objects similar to the ball, etc. The Ball which is hit can be distorted in shape as it moves with certain velocity or it can be occluded with the pitch or outfield, the movement of the camera and the size of the ball is relatively small when compared to all other objects in a frame. Because of these it is difficult to detect the ball and find its position in the frame [4].

Instead of going for conventional ball detection methods, a different approach is adopted. To search and find the ball in an entire frame is a tedious task. First the frame is segmented and then the ball-candidates alone are generated from the frame. This is done by classification of the frame. The non-ball candidates are removed and only ball-candidates is used for further processing. Informally, the key idea behind this strategy is while it is very challenging to achieve high accuracy in locating the precise location of the ball, it is relatively easy to achieve very high accuracy in locating the ball among a set of ball-like candidates. An important feature of this paper is that it can be extended for detecting events. Interesting events such as boundaries and sixes hit etc. can be found out by extending this idea. Previously ball detection has been carried out for other sports like Tennis, Basket Ball and Soccer. The idea can also be further extended to obtain automatic highlights extraction in sports.

In the last decade object detection and tracking become very popular because of its applicability to daily problems and ease of production, e.g. surveillance cameras, adaptive traffic lights with object tracking, plane detection. The superiority of object-tracking to object recognition became apparent after the development in the video processing and motion estimation. Although object detection and tracking using motion vectors is a very powerful method, it fails to give a robust and reliable answer all the time.

Object detection is necessary for surveillance applications, for efficient video compression, for smart tracking of moving objects, for automatic target recognition (ATR) systems and for many other applications. The convergence of computer vision and multimedia technologies has led to opportunities to develop applications for automatic sports video analysis, including content based indexing, retrieval and visualization.

With the advent of interactive broadcasting and interactive video reviewing [14], automatic sports video indexing would allow sports fans to access a game in the way that they like rather than watch a game in a sequential manner.

Existing methods that do direct ball detection in Cricket are limited to several inherent difficulties associated like:

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- the very small size of the ball when compared to other sports like Soccer
- the ball is not exactly similar in all the frames due to high velocity it attains when the batsmen hits the ball and the bowlers bowls the ball at speeds as high as 160 kmph, and it is difficult to find the exact shape of the ball
- the presence of many ball-like objects in a frame and occlusion of the ball (say, by a player) in frames[1]

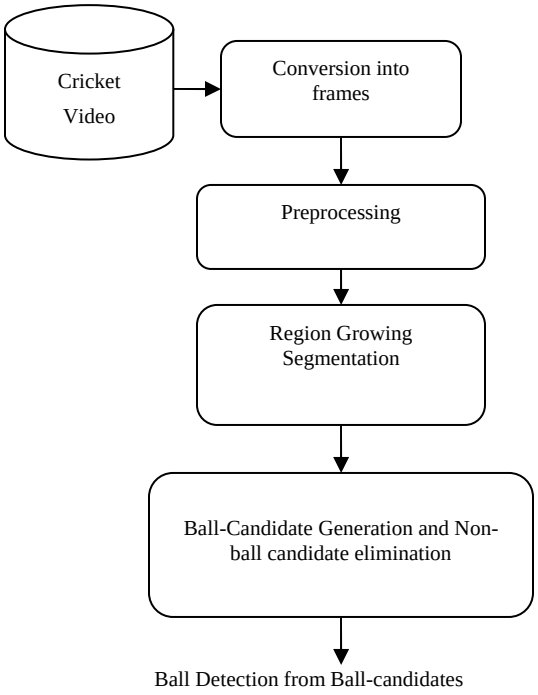

Fig. 1. Segmentation and ball detection in Cricket image sequences

2. Ball Detection Process

In the ball detection algorithm, the first step is to preprocess the video to remove noise, to enhance contrast etc. Before that, the video should be converted into frames for processing. Each and every frame is processed and the video is reconstructed from the frames in the final step. After preprocessing, segmentation is performed using the seeded Region Growing Algorithm. Various sieves such as shape, size, and color are used to sieve out the non-ball objects and the remaining objects are referred as ball-candidates which satisfy all the properties defined by the sieves.

2.1. Conversion of video to Frames

Instead of reading the video as it is, we converted the video into frames. Reading the video and directly processing the video is a tedious task and requires lot of memory and can work only on systems with high configurations. In a video clip each and every frame should be grabbed at a fixed frame capture rate. Now, each and every frame is an individual image and we can apply all image processing algorithms to these captured frames which is a major advantage and the size of the video does not matter here and no need of specific memory requirements. After performing all image processing operations, the video can be reconstructed from the frames by simple looping operations.

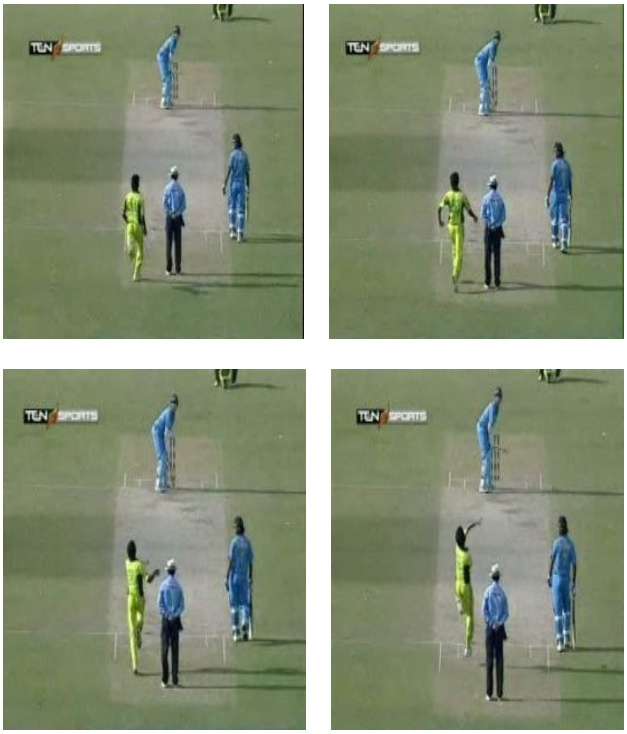

Fig. 2. Frame Sequences captured

2.2. Preprocessing of the Cricket video

Given any video frame, we need to preprocess the video to remove noise. With median filtering the value of the output pixel is determined by the median of the neighborhood pixels. The median is less sensitive than the mean to extreme values. Median filtering is therefore a good choice to remove these extreme values without reducing the sharpness of the image. Median filtering is applied since the goal is to remove the noise and preserve the edges, as it may carry useful information. The contrast should also be enhanced as a part of preprocessing. Proper preprocessing is always necessary as it enhances blurred or distorted images. Depending on the application exact filters should be applied and for this paper, median filter is chosen as the optimum one for noise removal.

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Fig.3.a) Input Frame

b) Preprocessed frame

2.3. Region Growing Segmentation

Effective Segmentation is carried out by using Seeded Region-growing (SRG) Segmentation algorithm. The image is converted into gray level first. The Seed values and the threshold values are provided. Region-growing approaches exploit the important fact that pixels, which are close together, have similar gray values.

Algorithm 1 *– Seeded Region Growing Algorithm*

Region growing procedure group pixels or sub-regions into larger regions based on predefined criteria of growth. Start with a single pixel (seed) and add new pixels slowly.

INPUT: Frame sequences
OUTPUT: Segmented Regions

1) Choose the seed pixel
2) Check the neighboring pixels and add them to the region if they are similar to the seed
3) Repeat step 2 for each of the newly added pixels; stop if no more pixels can be added.
4) More than one seeds can be used to segment the image.

Fig.4 Foreground Segmented frame

Fig.5 Region Growing Segmented Frame

By selecting appropriate seed value and by setting a proper Threshold, the frames are segmented using Seeded Region Growing Segmentation algorithm. The popping crease at both the batsman and bowlers end is to be detected because the occurrence of the ball at these points is very high. This is done by horizontal line detection method. A mask H=[-1 -1 -1; 2 2 2;-1 -1 -1], which is nothing but a horizontal mask is applied to detect the horizontal crease lines in the input frame. The players, stumps, crease were identified because in these areas, the ball occurrence is more.

2.4. Ball Candidate Generation

The major idea behind this strategy is that while it is very challenging to achieve high accuracy when locating the precise location of the ball, it is relatively easy to achieve very high accuracy in locating the ball among a set of ball-like candidates.

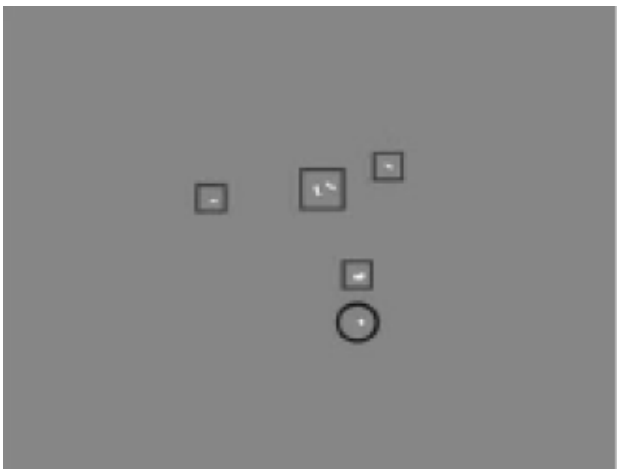

Fig.6 Sample Ball-candidates in a Sports video
(Image Courtesy: Xinguo Yu, H.W.Leong,
Changsheng Xu, Qi Tian)

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The key challenges for ball selection [1] are:

1) There are many ball-like objects in a frame and
2) There is no universal ball representation that can be used to distinguish the ball from other ball-like objects in the frame.

To partially resolve this challenge, the first key idea is to focus on generating a set of ball-candidates for each frame instead of attempting to identify the ball in each frame, an approach named anti-model approach is used to remove non-ball candidates and generate only ball-candidates. The effectiveness of the anti-model approach is dependent on the accuracy of the sieves defined. By storing only a small set of ball-candidates per frame, we can process all the ball-candidates in a long sequence of frames at the same time. When the ball-candidates are processed together, rich spatial and temporal information can be obtained. Even after the ball-candidate generation, it is very hard to identify the ball from among the ball-candidates in since they have all the properties of the ball. However, the probability that the ball among the ball candidates is very high rather than its occurrence in the entire frame. This is used to detect and subsequently track the ball in the frame. The anti-model approach, which is a type of model based algorithm is accurate than feature based or motion based algorithm.

We can significantly reduce the rate of false negatives, but at the price of a temporarily higher rate of false positives. We can measure each ball-candidate against a number of properties of the "ideal" ball image and use these to classify the ball-candidates obtained. Several sieves such as shape, size, and color are used to sieve out the non-ball objects and the remaining objects are referred as ball-candidates which satisfy all the properties defined by the sieves. The properties used in the algorithm are size, and circularity. These are called sieves. Sieves Definition and pruning out the non-ball candidates forms the major part of the process.

The more the number of sieves, more accurate will be the ball candidates generated The Resulting output contains only the ball candidates.

Algorithm 2 *– Ball Candidate generation algorithm*

1) For each frame F, the set of objects in the frame are identified, denoted by N(F).
2) Then, a set of sieves were developed based on properties of the image of the ball in F and the sieves are used to sieve out non-ball objects in F.
3) The remaining objects are the ball-candidates and they satisfy all the properties defined by the sieves.
4) This remaining set are denoted by B(F) , the set of ball-candidates for frame .
5) The probability that the ball is among the ball-candidates, namely, b € B (F) is very high.

This can be used widely for other sports videos like golf, basket ball, volley ball, table tennis etc. For sports like table tennis, we need to reduce false alarms. So, this method can be used for ball detection. The ball detection accuracy will be tremendously increased if this method is adopted. This is fairly superior to other algorithms like Atherton algorithm, Modified Atherton algorithm, CHT algorithm for ball detection and tracking.

The objects similar to ball such as front view of a player's shoe, heads of players and umpire, bottle lying near the boundary boards and several others comes under Ball-candidates category. These alone are preserved in the frames and other objects in the frame are eliminated. This approach makes the task simpler. Instead of processing the entire frame to search the ball, it is better to search the ball among the ball-candidates which will reduce time consumption and complexity.

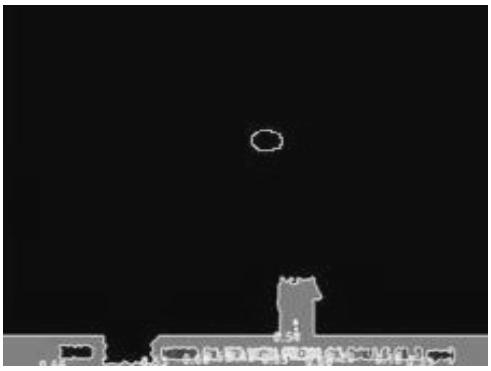

Fig.7 Ball and ball-candidates

The ball-candidates similar to ball are not present in the active region of the frame. They are only available as numbers in score board and hence can be neglected. To improve accuracy, neural networks is used to train the ball and from the Ball-candidates, the ball can be easily found among the Ball-candidates

3. Results and Discussion

The Results shown in the figures clearly depict the effectiveness of the ball detection algorithm for cricket. The Circular Hough Transform (CHT) based ball detection performs poorly when there are occlusions of the ball with the surface or with the players. The other proposed algorithms also did not give more accuracy in ball detection. We tested our system on real image sequences of actual Cricket video. India Vs Pakistan match held in Lahore was taken as input. The Frames were grabbed at a rate of 30 frames per Second at a resolution 320 X 240. Around 300 frames

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were obtained for experimentation. The algorithm minimizes the false alarms to a great extent.

The second sets of tests were performed on a match between India Vs Sri Lanka held in Kandy. Around 250 frames were extracted at a rate of 30 frames per second at a resolution of 320 X 240. The performance was equally good as the previous video.

Several other tests were performed on the videos from 1996 Cricket World Cup matches and performances were analyzed. Satisfactory outputs were obtained with all the videos.

Moving Object Segmentation is a major problem when it comes to object detection in videos. This is resolved in this method in a simple manner. In each and every frame in these videos, about five to seven ball-like objects(ball-candidates) were obtained and all other objects got eliminated. From these objects, by further classification in a detailed manner (i.e.) by defining more and more sieves, ball alone can be detected from the ball-candidates.

Lot of methods like feature based algorithms, which uses certain features alone for ball detection, motion based methods which uses motion vectors to find the ball position in the subsequent frames were previously used for ball detection . But they are not as accurate as expected which compels for a novel method for ball detection and subsequent tracking.

4. Conclusion and Future Enhancements

This work has presented a novel approach to detect the Cricket ball from Cricket video images. To reach the goal, the non-ball objects are removed by shape, size, and candidate feature images are created. This approach can detect occluded balls and balls that are merged with other objects in the frame.

In future this can be applied to other detection-and-tracking problems, most important problems such as wildlife tracking and various surveillance tracking problems. Another direction is to use the approach for other higher level tasks such as event detection in the sports video. For soccer it can be applied for events such as detection of events such as kicking, passing, shooting, and team ball possession. For cricket events such as bowling, playing a stroke, fielding the ball etc, the events which may be difficult to analyze based only on the low-level feature.

The ball detection can be applied for all the sports videos for event detection. Ball detection in golf will be much more challenging than cricket because of the small ball size and distortions due to high velocity of the ball. Automatic Highlights extraction is another application which can be developed based on this work. This will provide backbone to highlights on demand service in cable TV networks. Shadow removal process can be achieved with a more robust algorithm. This case will both improve object silhouettes and detection results.

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B.L.Velammal recieved Bachelors and Masters Degrees in 1999 and 2002 respectively, from Manonmaniam Sundaranar University. The author has worked as a Lecturer in various Engineering colleges. Currently, she is working as a Lecturer in Anna University. Some of the research works are published in International Journals. Her research area includes multimedia content adaptation and analysis.

Anandhakumar P received Ph.D degree in CSE from Anna University, in 2006. He is working as Assistant Professor in Dept. of IT, MIT Campus, Anna University. His research area includes image processing and networks. He has published a number of research works in International Journals. He is interested in guiding exceptional research works in the area of multimedia and networks.