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# Human Object Detection and Tracking using Background Subtraction for Sports Applications

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**Abstract**: In the sports video analysis, the most important part is the movement of player (object) detection and tracking. The purpose is to detect the movement of player from the background image in video sequence and for the player tracking. This paper proposes a new method to detect players based on background subtraction. A reliable background updating model is established. A dynamic optimization threshold method is used to obtain a more complete behaviour of moving player and tracking. Motion of a moving player and tracking in a video stream is studied and its velocity is detected. The centroid of object is computed to use in the analyses of the position of the moving human body. The experimental results show that the proposed method runs quickly, accurately and fits for the real-time detection.

**Keywords**: Background subtraction, Object detection, Object tracking, Velocity estimation

## I. INTRODUCTION

The main aim of object (player) tracking and detection is to establish a correspondence between object parts in consecutive frames and to extract information about objects such as trajectory, posture, speed and direction. Tracking detected objects frame by frame in video is a significant and difficult task [1]. It is a crucial part of smart surveillance systems since without object tracking, the system could not extract cohesive temporal information about objects and higher level behaviour analysis steps would not be possible. Moving object detection is the first step in video analysis. Some of the applications are as follows [2]:

(i) Visual surveillance: A human action recognition system process image sequences captured by video cameras monitoring sensitive areas such as bank, departmental stores, parking lots and country border to determine whether one or more humans engaged are suspicious or under criminal activity.

(ii) Content based video retrieval: A human behaviour understanding system scan an input video, and an action or event specified in high-level language as output. This application will be very much useful for sportscasters to retrieve quickly important events in particular games.

(iii) Precise analysis of athletic performance: Video analysis of athlete action is becoming an important tool for sports training, since it has no intervention to the athletic.

In all these applications fixed cameras are used with respect to static background and a common approach of background subtraction is used to obtain an initial estimate of moving objects. First perform background modelling to yield reference model. This reference model is used in background subtraction in which each video sequence is compared against the reference model to determine possible variation. The variations between current video frames to that of the reference frame in terms of pixels signify existence of moving objects. The variation which also represents the foreground pixels are further processed for object localization and tracking. Ideally, background subtraction should detect real moving objects with high accuracy and limiting false negatives (not detected) as much as possible. At the same time, it should extract pixels of moving objects with maximum possible pixels, avoiding shadows, static objects and noise [2].

The main objective of this paper is to develop an algorithm that can detect player motion and tracking. We carry out various tasks such as motion detection, background modelling and subtraction, foreground detection, player tracking and velocity estimation.

The rest of this paper is organized as follows. Section II describes the object detection using background subtraction algorithm. Object tracking and velocity estimation is performed in Section III. Results are presented in sections IV, followed by conclusions on section V.

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## II. Object detection using BACKGROUND SUBTRACTION

To obtain background subtraction, the background has to model first. Then, the incoming frame is obtained, and subtract out from the background model [5]. With the background model, a moving object can be detected. This algorithm is called as 'Background Subtraction' [10]. The efficiency of a background subtraction technique correlates with three important steps: modelling, thresholding and data validation as shown in fig.1.

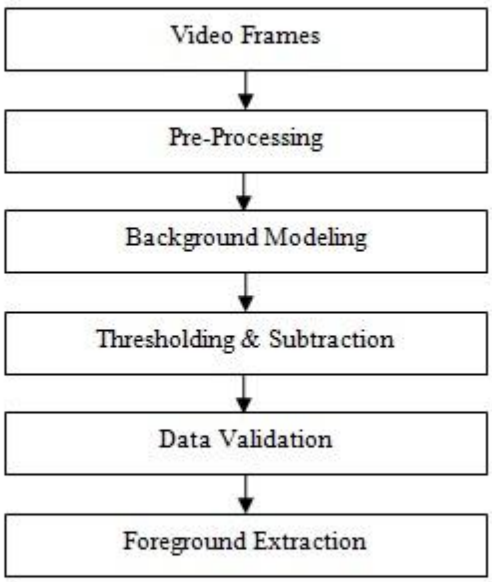


Fig.1 General Flow Diagram of BGS System

Background modeling [3], is the backbone of the Background Subtraction algorithm. Background model defines the type of model selected to represent the background, and the model representation can simply be a frame at time (t-1) formula such as the median model. Model Adaption is the procedure used for adjusting the background changes that may occur in a scene. Thresholding is a procedure that eliminates an unwanted range of pixels in the scene with respect to certain threshold values. Data validation is involved with the collection of techniques to reduce the misclassification of pixels.

In the recent papers, many background subtraction algorithms are proposed, because no single algorithm is able to cope with all the challenges in the sports applications [10]. There are several problems that a good background subtraction algorithm must resolve. Therefore in this paper the most commonly used, GMM based background subtraction algorithms are discussed.

A Gaussian mixture model (GMM) was proposed for the background subtraction in Friedman and Russell, [6] and efficient update equations are given in Stauffer and Grimson, [7]. In Power and Schoonees, [8] the GMM is extended with a hysteresis threshold. This method uses a Gaussian probability density function to evaluate the pixel intensity value. It finds the difference of the current pixel's intensity value and cumulative average of the previous values. So it keeps a cumulative average (μ) of the recent pixel values. If the difference of the current image's pixel value and the cumulative pixel value is greater than the product of a constant value and standard deviation then it is classified as foreground [11]. That is, at each t frame time, the I pixel's value can then be classified as foreground pixel if the inequality: $|I_t - \mu_t| > k\ \sigma$ holds; otherwise, it can be considered as background, where k is a constant and σ is standard deviation.

Here background is updated as the running average:

$$\mu_{t+1} = \mu_t * I_t + (1- \alpha) * \mu_t \qquad (3)$$

$$\sigma^2_{t+1} = \alpha\, (I_t - \mu_t)^2 + (1- \alpha)\, \sigma^2\, t \qquad (4)$$

where,

σ, the learning rate, is typically 0.05,

$I_t$ is the pixels current value and

$\mu_t$ is the previous average.

## III. Object tracking and velocity estimation

Object tracking is the process of locating and following the moving object in sequence of video frames. Object tracking is the process of locating and following the moving object in sequence of video frames. Smart cameras are used as input sensors to record the video. The recorded video may have some noise due to bad weather (light, wind, etc. or due to problems in sensors). Few algorithms are tested to improve the image quality, to detect moving object, calculation of distance and velocity of the moving object. Extraction of objects using the features is known as object detection. Every object has a specific feature based on its dimensions. Applying feature extraction algorithm, the object in each frame can be pointed out.

The task is performed by recording a video using digital camera with 30fps. The implementation is initially performed on matlab and various methods for object tracking are tested.

The process of locating the moving object in sequence of frames is known as tracking. This tracking can be performed by using the feature extraction of objects and detecting the objects in sequence of frames. By using the position values of object in every frame, we can calculate the position and velocity of the moving object.

### *A. Rectangular Bounding Box*

A rectangular bounding box is plotted around the foreground objects produced from GMM based Background subtraction. By using the dimensions of rectangular bounding box, a centroid is plotted. The position of the centroid is stored in the array and the distance is calculated using Euclidean

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distance formula. The velocity of the object movement from frame to frame is calculated by using the distance and frame rate of the recorded video.

*B. Distance*

The distance travelled by the object is determined by using the centroid. It is calculated by using the Euclidean distance formula. The variables for this are the pixel positions of the moving object at initial stage to the final stage [4].

$$\text{Distance} = \sqrt{(X2 - X1)^2 + (Y2 - Y1)^2}$$

Where
X1=previous pixel position
X2=present pixel position in width
Y1=previous pixel position
Y2=present pixel position in height

*C. Velocity of object*

The velocity of moving object is calculated by the distance it travelled with respect to the time. Euclidean distance formula is used to calculate the distance between the sequences of frames [4]. By using the values of distance with respect to frame rate, the velocity of the object is defined. The defined velocity is of 2-dimension (since camera is static).
Velocity of moving object is determined by using the distance travelled by the centroid to the frame rate of the video.

Velocity =Distance travelled / Frame rate

The velocity of moving object in the sequence frames is defined in pixels / second.

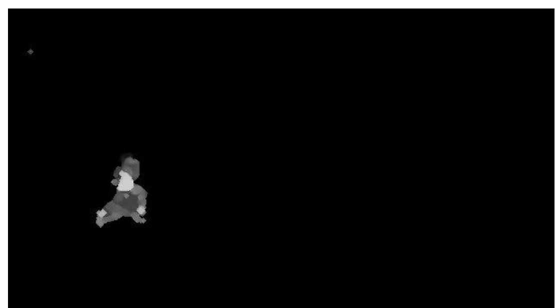
## IV. RESULTS

The proposed work has been developed using MATLAB 7.10(R2010a) on Intel dual core processor, 2GB RAM and Windows XP SP2. The real time video sequences are acquired at the rate of 30 frames/second with the frame size of 640×360 pixels resolution.

(a)

(b)

(c)



(d)

Fig 4: Foreground objects detected by using different algorithms (a) Original Image (b) Grayscale Image (c) Background Model (d) Mixture of Gaussians algorithm for threshold 0.25, learning rate α = 0.01, and Positive deviation threshold, D = 2.5.

(a)

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(b)

Fig 5: Foreground objects tracked by using centroid (a) Frame 41 (b) Frame 71

## V. CONCLUSIONS

In this paper, a real-time video of moving object detection and tracking is proposed, based on background subtraction. For object detection, we establish reliable background model, use threshold method to detect moving object and update the background in real time. At last the moving object is tracked by finding the area and centroid. A benefit of this method is that it is time efficient, and it works well for small numbers of moving objects. Target detection and process is realized on the video image. Video image data of the human body is processed, and its geometrical centroid is obtained in different time intervals. Then, the velocity has been computed.

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