# Detecting and Tracking a Moving Object in a Dynamic Background using Color-Based Optical Flow

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**Abstract— In this paper, a hybrid object detection and tracking system is proposed that combines object color and optical flow method to enable the optical flow method capable to track objects in a dynamic background. The proposed method uses the formula developed by the author to convert RGB images into corresponding intensity images that highlights the selected color in images and suppresses other colors. Thus, the object of interest is automatically detected without use of computationally expensive matching methods. This makes the overall process efficient. However, the proposed method is limited to only objects of primary color shades.**

***Index Terms*—Object tracking, Object detection, Optical flow.**

## I. Introduction

Detecting and tracking moving objects in videos and reconstructing trajectories are an active research area of computer vision [1]. Many techniques, such as optical flow, background subtraction, particle filter, Kalman filter, have been developed for moving object detection and tracking in videos. Most of the researches in this area assume situations in which backgrounds are assumed to be fixed. However, most of the real-life situations have changing background. The ability to track a moving object in a changing background is a difficult problem. Detecting and tracking objects in a dynamic environment has many practical applications, such as video surveillance, human computer interaction, robot navigation in a dynamic environment, etc.

Optical flow is very effective in tracking objects in a stationary background, but its performance degrades to an unacceptable level in a dynamic background. It cannot tolerate even a slight change in lighting conditions. On the other hand, color-based techniques have some tolerance to changing background situations, but its performance degrades if backgrounds contain colors similar to the colors of moving objects.

In this paper, a new method is proposed that can detect and track a moving object in a changing background. The method combines color feature with optical flow. This combination makes optical flow adaptable to changing background situations. Traditionally, optical flow uses intensity image to detect the motion of a moving object in two consecutive video frames. However, intensity images generated by the popular RGB to intensity conversion scheme have no discriminating power to highlight a particular color. Therefore, in this paper, the new intensity calculation formula developed by the author [2] for converting an RGB image into an intensity image has been used, which facilitates detection of primary color objects more accurately and efficiently.

The remaining part of the paper is organized as follows: section 2 reviews the related work. It introduces, briefly, the optical flow object tracking concept and the new intensity conversion scheme. Section 3 describes the proposed system. Section 4 presents some experimental results and finally, section 5 concludes the paper and sets directions for the future research.

## II. Related Work

Vision based object tracking has been actively researched for the past three decades. Many techniques, such as optical flow, background subtraction, particle filter, Kalman filter, have been developed for moving object detection and tracking in videos. Each technique has some strength that makes it suitable in a particular situation. Readers can find overview of various methods and their merits and demerits in [3]. The optical flow method is one of the most researched methods for object detection and tacking as it is found to resemble to the animal and human visual systems.

The moving objects in a scene form dynamic patterns, known as the optic flow field, on the retinas of our eyes. These patterns contain a wealth of information about the world around, which help us to extract many useful information, such as the directions of moving objects, the distances to objects from us and their relative positions in the observed scene, etc. However, it is unclear how the visual system accomplishes this task [4]. Motivated from natural visual systems, researchers in computer vision have developed various methods to detect and track moving objects using the concept of optical flow. In the context to computer vision, optical flow is a velocity field associated with the change of the location of a group of pixels, assumed to be the object of interest, with certain brightness, under the assumption of brightness consistency, in two consecutive image frames of a video [5]. In other words, optical flow is the apparent motion of brightness patterns in two consecutive video frames. The assumption of brightness consistency, which is rarely observed in real life situations, is the major limitation of the optical flow method. Due to this assumption,

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the method cannot handle object tracking in a dynamic background.

There are many methods to find optical flow from two consecutive video frames, such as Lucas-Kanade, Horn-Schunck, etc. In most of the methods, the optical flow in a video is determined by partial derivatives of the image signal. More detailed descriptions of popular methods of optical flow calculations can be found in [6]. In this paper, Horn-Schunck method is used for the calculation of optical flow.

## III. THE PROPOSED METHOD

In this paper, the new intensity conversion scheme developed by the author [2] is combined with an optical flow based object tracker to make the tracker robust to handle a dynamic background. The block diagram of the proposed method is given in Fig. 1. The main contribution of the author is enhancing the capability of the optical flow method to handle a dynamic background by using author's intensity conversion formula in the optical flow framework.

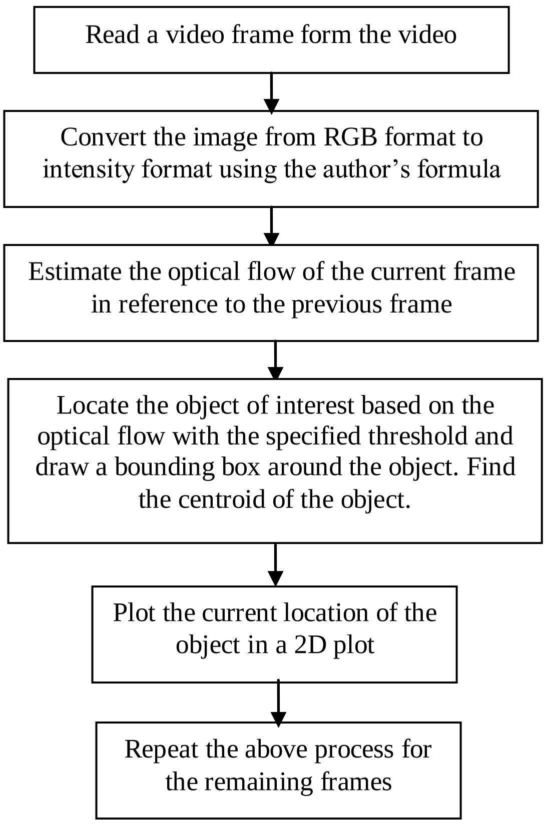



Figure 1: The block diagram of color-based optical flow detection and tracking system

In the current study, a red color object is tracked in a pre-recorded video. However, the proposed method is capable to handle real-time videos. In the beginning, the first two frames of the video are read. These frames are converted to intensity images using the author's intensity formula, which is given in equation 1, as it is found very effective in highlighting red color objects. Similarly, to highlight other primary color objects, the position of the desired primary color should be swapped with the red color in the numerator and the other two primary colors are to be used in the denominator of the equation 1.

$$I = \frac{R * R}{G * B} \qquad (1)$$

where *R*, *G*, and *B* are the red, green and blue values of the pixel and *I* is the calculated intensity of the pixel.

In addition to the above intensity conversion formula, the following thresholding operations are added to further strengthen the discriminating power of the proposed method to highlight the selected primary color: (a) pixels with R/G and R/B values less than a threshold value and (b) pixels with R values less than a threshold value are assigned zero during RGB to intensity conversion. After experimenting with various videos, the values of the thresholds are found to be 1.5 and 70, for (a) and (b) cases, respectively.

Intensity images generated by the above discussed method are used for the calculation of optical flow to track an object. Fig. 2 shows comparison of the optical flow results generated by the proposed method and the optical flow method available in Matlab 2017. It can be clearly seen from the comparative results that the proposed method outperforms the currently available MATLAB function, in terms of handling dynamic back ground.

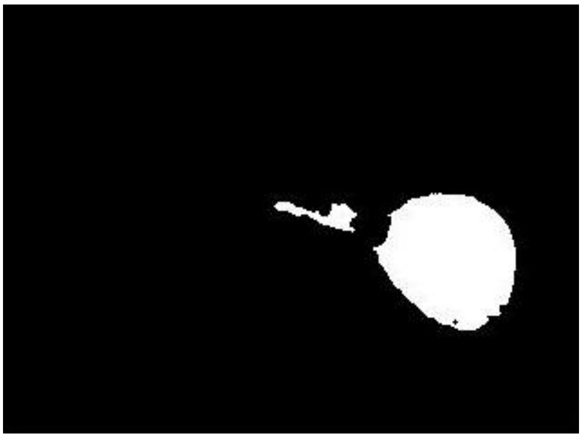
## IV. PROTOTYPE SYSTEM AND EXPERIMENTAL RESULTS

A prototype system is developed, as a Simulink model as well as a program in MATLAB 2017, to test the above concepts. Fig. 3 shows the Simulink model of the proposed method. For easy comprehension, various modules are labeled in Fig. 3. In the intensity conversion module, to avoid divide by zero situations, before applying the proposed formula, a bias of 1 is added to the relevant components of RGB image data. The optical flow module uses Horn-Schunck flow method. The output module shows the intensity images and optical flow lines superimposed on the image for each frame. The prototype system consists of a camera and a 2.27 GHz Intel(R) Core(TM) i3 CPU laptop running Windows 7. The videos are captured in a normal household lighting condition. For the evaluation of the prototype system, a video of 150 frames is captured, in which a red colored bat is moved along the chair handles and the back-support edges. Fig. 4 shows some frames along with optical flow vectors as blue arrows and the corresponding intensity images. Fig. 5 shows the 2D plot of the centroids of the tracked object superimposed on the last frame of the video.

(a) Original frame

(b) Optical flow intensity image with respect to the previous frame generated by the MATLAB function

(c) Motion vectors generated by the MATLAB optical flow method



(d) Optical flow magnitude vector generated by the proposed method

(e) Motion vectors generated by the proposed method

(f) The centroid of the red bat as calculated by the proposed method

Figure 2: Comparision of the results obtained by the proposed method and the currently available Matlab optical flow implementation

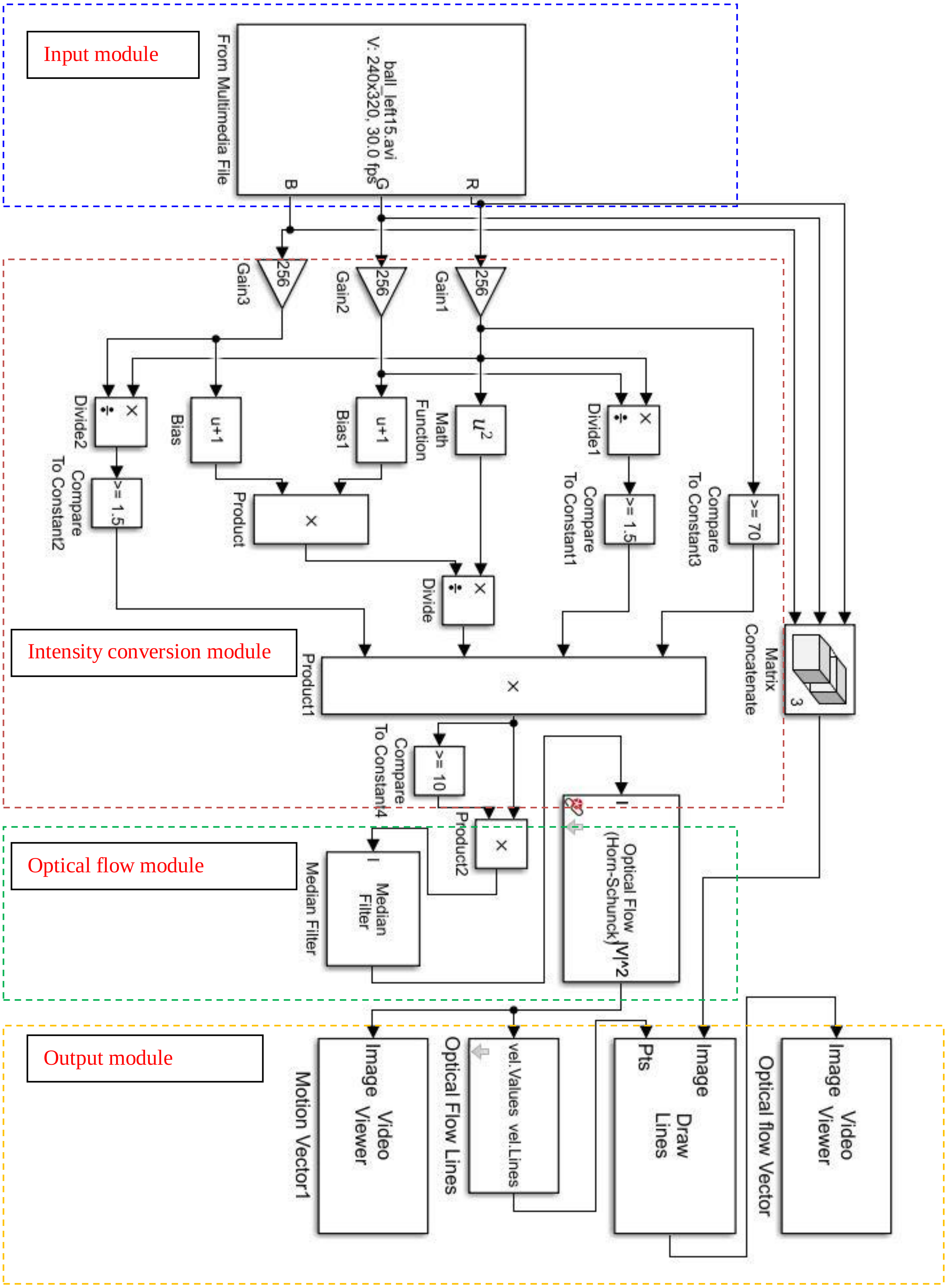
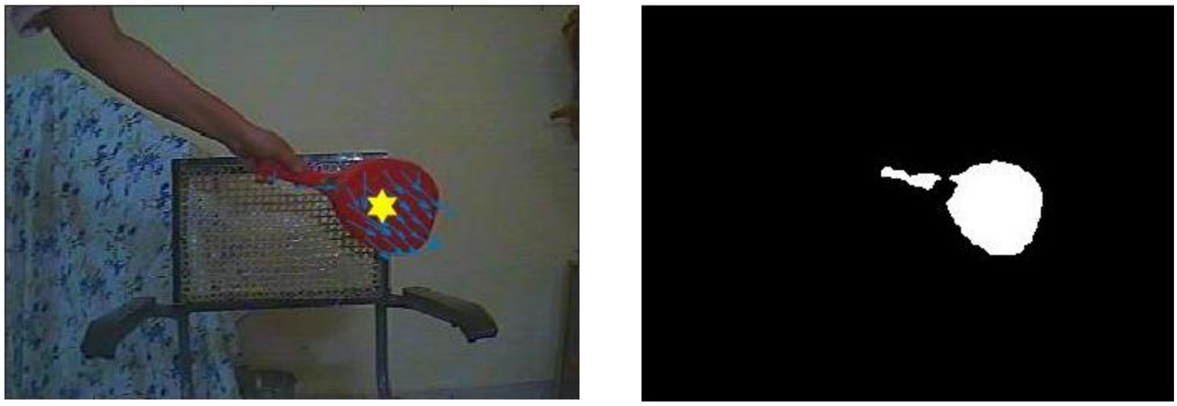



Figure3: Simulink model of the proposed method

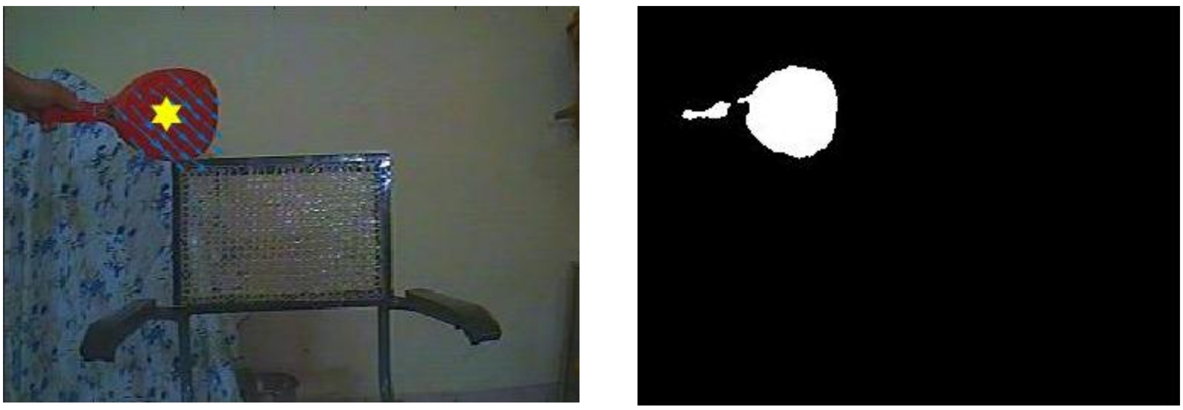
 

Frame 5

Frame 10



Frame 50



Frame 100

Figure 4: Some sample frames with optical flow and centroid (left) and the corresposning intensity images (right)

Figure 5: Tracked path(blue)

## V. CONCLUSIONS

Moving object detection and tracking in videos is an actively researched area for the last two decades, which has many practical applications, such as collision detection, game playing robots, human machine interaction, etc. This paper presents hybrid object detection and tracking system by combining color features and optical flow method. The use of color in optical flow makes the proposed method capable to track objects in a dynamic background. The results obtained are quite encouraging, but the proposed method, in its current form, is limited to handle only objects of primary color shades, i.e. objects of red, green or blue shades only. The method is incapable to handle colors that have equal strength of two or more primary colors, such as yellow, orange, etc. In future, efforts will be made to extend the capability of the method to include all colors.

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