Identifying Moving Objects in a Video using Modified Background Subtraction and Optical Flow Method

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***Abstract* – To identify the object in a video that changes its position from time to time in a video is amongst the crucial steps in various application of computer vision like extraction of objects, video surveillance, classification and pattern identification as well. In this paper a novel approach is proposed that is used to detect the objects that are not stationary in noisy environment. In the proposed algorithm Gaussian mixture model is used to extract the moving object and then the Optical flow method is used to acquire error free results quickly followed by frame differencing to obtain accurate extraction of shapes. The algorithm has been analyzed and tested over various videos in different environmental circumstances .The result acquired proves the algorithm to be more reliable, the detection is more precise and even low in terms of cost and memory requirement as well.**

Keywords – background modeling, frame differencing, gaussian mixture model (GMM), motion detection, optical flow

I. INTRODUCTION

Video is a form of multimedia data that consist of visuals, texts and audio. The video mining is destined to extract the relevant patterns from the videos [1]. Motion detection is one such application that uses video mining for the extraction of the objects that are not stationary in a video. Identifying an object in video that relocate one of the most crucial step in the computer vision applications[34] like face detection [2], monitoring traffic [3], detecting humans in video and predicting their activities [4-5] and various other fields as well. Amongst which the video surveillance has been the most active research domain due to increase in crime rate and many social issues as well [6].

There are various traditional approaches that are used for the purpose of motion detection in the video can be grouped into three classes namely background modeling, frame differencing, temporal difference and the optical flow method [7].

The figure 1 shows the various traditional approaches that are used to identify the active objects in a video. Amongst the various existing methods for motion detection, background subtraction has proven to be sturdier in different surroundings [7]. The background subtraction model is used to identify the moving objects, initially the objects in motion are identified and then they are isolated from background by evaluating frame difference [8-11].

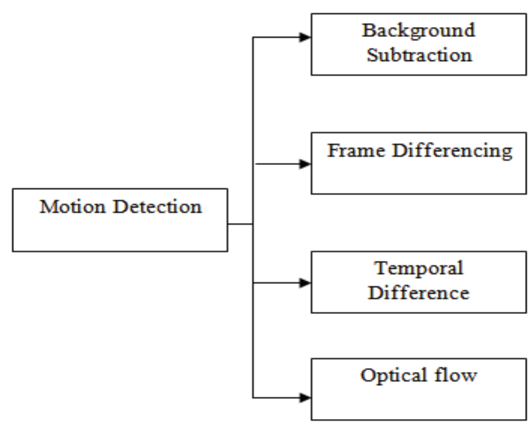

Fig. 1. Traditional approaches of moving object detection

There have been many algorithms proposed to overcome the challenges like illumination and shadows of the objects in motion [12-14] and presently, the Gaussian mixture model has gained popularity, due of its ability to handle slow illumination changes, slow and periodic object motion, camera noise, etc. [7] whereas ability to perceive each object individually [15-16] and it is also capable to handle the entire set of pixels at once and is known as dense method which also smoothens the frame by estimating the motion vector that enables precise detection of the object in motion[16] [17].

The optical flow method is the one that is used to detect the independent objects that are not stationary in a video by evaluating them on the basis of association with the common motion [18]. It involves a lot of calculation and detects the object in motion by approximating the optical field of the frame followed by the process of clustering on the basis of optical flow distribution of video frames[19] [20]. It enables the efficient and reliable detection of the non-stationary object by giving complete information about that may be required. It is sensitive to noise which makes it a better approach for real time scenarios [21].

Frame differencing uses the basic subtraction operator to evaluate the dissimilarity present in the consecutive frames by subtracting one frame from another frame. The calculations involved in this method are quite easier as compared to other models [22]. The advantage of using frame differencing method is that it is highly adaptive to the dynamic environment.

In this paper, a novel algorithm for motion detection in videos captured using static camera is proposed that combines the techniques that are Modified Gaussian mixture model and the optical flow method followed by frame differencing method. The algorithm classifies the pixels into two groups that is one group consisting of pixels of moving object and the other group incorporated with the pixels of the background, then the Optical flow method is used to acquire error free results quickly followed by frame differencing to obtain accurate extraction of shapes. The methods used in the algorithm complement each other and ensures the reliable motion detection. The Experimental results of proposed algorithm indicate better performance in terms of appropriate motion detection of an object for video monitoring.

The structure of the remaining paper is as follows: section II enlightens the proposed work along with the description of the phases of the proposed algorithm for motion detection, section III shows experimental results and efficiency of proposed algorithm and finally paper is concluded in Section IV.

II. PROPOSED ALGORITHM

The figure 2 represents the flow of the proposed algorithm by clearly showing the various steps involved in the extraction of the moving object. The algorithm involves detection of the object that is motion with the help of three basic techniques: background modeling, optical flow and frame difference. The three different approaches that are combined complement each other and provide efficient as well as precise identification and extraction of the object that is moving in the video.

The background subtraction method is a method that is used to extricate entire features of the object, frame differencing provides the initial coarse motion areas and optical flow is beneficial to detect the movement of objects by estimating the motion vector field from the image sequence seized with the help of a static camera [23].

A Background Modelling

Ideally the background subtraction methodology is employed for obtaining the objects of interest in static scenes [24]. The moving region in frame is extracted from the frames by calculating the difference between the current frame and the reference background frame. The region where the pixel value is found to be larger than the threshold value is classified as the area of interest or the foreground object [25].

The expression for background modeling is

$$dk = 1 \;\; if \;\; 1|Fk(1,m) - Bk(1,m)| \geq T \quad (1)$$

$$0 \;\; \text{otherwise}$$

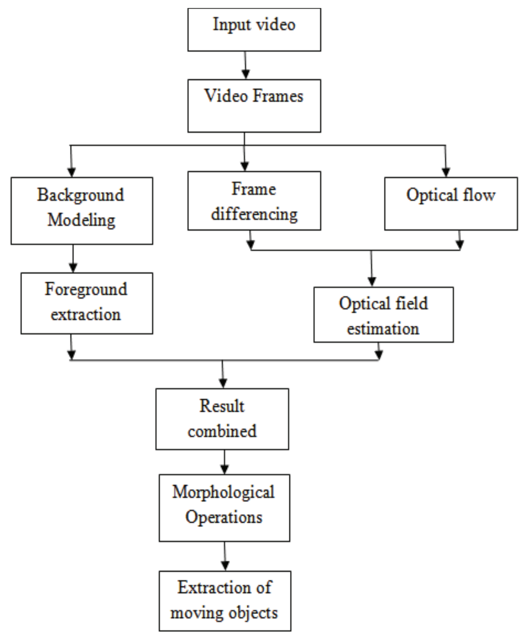

Fig. 2. The Flow Chart of the proposed work

The Gaussian mixture model is the most reliable a background estimation technique that was proposed by Stauffer and Grimson. It is amongst the most reliable methods for identification of the moving method due to its capability to account for multimodal background [26] [27]. It is one of the most accurate and robust models to detect objects in motion. GMM does not retain the background details in a buffer but updates the background on the basis of the input frame. This makes the technique computationally robust and utilization of memory also reduces [28] [29]. The Gaussian distribution is used to model every pixel of the scene [35]. The likelihood of a certain point in the frame having intensity X_i at time t can be represented as :

$$P(xi) = \sum_{i=1}^{k} \omega i * \eta(xi, \mu i, \textstyle\sum i) \qquad (2)$$

Where ω_I is weight ,μ_i is mean and the $\sum i$ is the covariance for i^{th} distribution and η is Gaussian probability density function [37].

B Optical Flow

The other methodology for the identification of a moving object is Optical Flow Estimation where vector field of the image sequence is calculated. In this technique optical flow is estimated with the help of two frames differential method to idenitify the moving object [30] [31].There are varied

techniques to estimate the optical flow. The foremost common one is gradient, matching and filter based techniques [25]. The contemporary study unveils that Lucas-Kanade gradient based method is unambiguous in providing the reliable results [24].
Let a point at a certain position (x, y, t) posses intensity value I(x, y, t) .Let this point be moved by moved by δ x, y and δ t in between the two image sequence that are seized at time intervals t and t + δt. Then the constraint equation will be [32]:

$$I(x,y,t) = I(x+\partial x, y+,\partial y\ t+\partial t) \quad (3)$$

Assuming that the object has covered a very small distance between the two consecutive frames the constraint at I(x, y, t) can be obtained by using the Taylor series:

$$I(x+\partial x, y+,\partial y\ t+\partial t) = I(x,y,t) + \frac{\partial I}{\partial x}\partial x + \frac{\partial I}{\partial y}\partial y + \frac{\partial I}{\partial t}\partial t \quad (4)$$

Where

$$\frac{\partial I}{\partial x}\partial x + \frac{\partial I}{\partial y}\partial y + \frac{\partial I}{\partial t}\partial t = 0 \quad (5)$$

That is

$$\frac{\partial I}{\partial x}Vx + \frac{\partial I}{\partial y}Vy + \frac{\partial I}{\partial t} = 0 \quad (6)$$

Where velocity components Vx and Vy are to be calculated for x and y or say that the optical filed is to be obtained for I(x, y, t) and $\frac{\partial I}{\partial x}, \frac{\partial I}{\partial y}$ *and* $\frac{\partial I}{\partial t}$ are derivatives the frame under reference.

C *Frame Differencing*

Once the rough optical field is obtained we can use frame differencing to improve the boundaries of the target object. In this step Otsu's Global threshold algorithm [33] is used to finally identify the variation in the sequential frames. The Otsu's algorithm is selected to determine the changes in the image by comparing it pixel wise, the pixels with higher intensity value than threshold value are considered as moving regions and the other as static region.

D Data Fusion

In this final step the result obtained by using all the three techniques: background modeling, frame differencing and the optical flow is combined so that the moving object can be extracted from the sequence of images captured with the help of a static camera and only those objects are considered to be moving whose amplitude values and the direction of optical field lie within the specified range.

III. EXPERIMENTAL ANALYSIS

The proposed algorithm was evaluated with the help of a video that is seized with the help of a static camera. The video under consideration consists of 56 frames of size 160 x 120. The following figures demonstrate the outcome at each step of the algorithm.

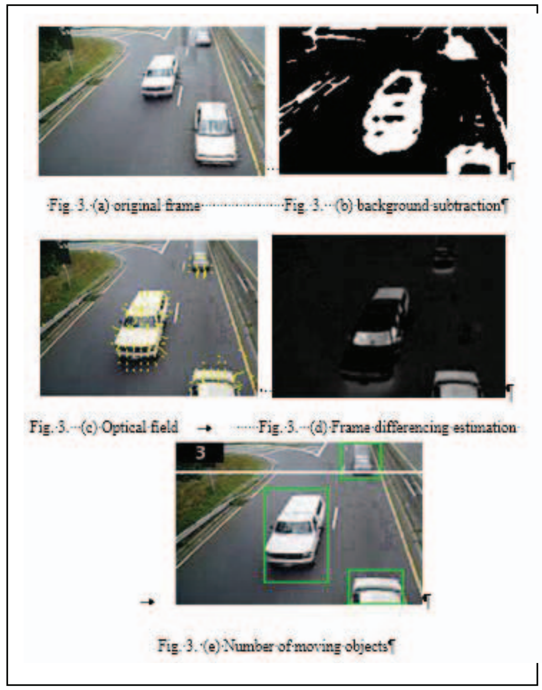

Fig. 3. (a) original frame Fig. 3. (b) background subtraction

Fig. 3. (c) Optical field Fig. 3. (d) Frame differencing estimation

Fig. 3. (e) Number of moving objects

After the operations of the proposed algorithm are performed, the objects that are in motion are detected and the detection has proven to be more reliable and la) represents the original video frame that is seized with the help of static camera, figure 3(b) represents the resultant frame obtained by applying background subtraction and then figure 3(c) represents the optical flow filed estimation. The figure 3(d) represents the resultant frame obtained after applying the frame differencing method and finally figure 3(e) shows the number of objects that are moving in a video.
The metrics that are used for the appraisal of the algorithms are Similarity and F1, Recall and precision where recall is the percentage of necessary positives upon the total number of true positive pixels and precision can be defined as the percentage of unnecessary positives by comparing total number of positive pixels in binary object mask that was detected through binary object mask.
Following are the representation of the metrics

$$Recall = \frac{TP}{TP+FN} \quad (7)$$

$$Precision = \frac{TP}{TP+FP} \quad (8)$$

TABLE I. EXPERIMENTAL ANALYSIS

Sequence of Frames	Sequence type	Object number	F1	Similarity Index
Sample 1	Outdoor	Medium	0.7918	0.6553
Sample 2	Outdoor	Medium	0.7318	0.5775
Sample 3	Indoor	Many	0.7523	0.6043
Sample 4	Indoor	Medium	0.7437	0.5951
Sample 5	Outdoor	Few	0.8844	0.7938
Sample 6	Outdoor	Few	0.7333	0.5827
Sample 7	Outdoor	Medium	0.9193	0.8538
Sample 8	Outdoor	Medium	0.7405	0.6004

The other two metrics that promise accuracy evaluation are as follows

$$F1 = 2\frac{Recall-precission}{Recall+precision} \quad (9)$$

$$Similarity = \frac{TP}{TP+FN+FP} \quad (10)$$

All metric-attained values must lie within the range of 0 to 1 only with higher is the value more is the accuracy and preciseness in the result obtained. The proposed method attains the highest Similarity and F1 values that assures better and accurate performance of the method proposed as shown in the table 1.

IV. CONCLUSION

The proposed method is a more efficient approach to diagnose the movement of the object in a stream of images seized with the help of stationary camera. The immense role of Gaussian mixture model accompanied by the optical flow and then followed by frame differencing method makes it more precise as the detection becomes more accurate. The algorithm proposed leads to accurate boundaries and the approach is satisfactory in terms of performance when exercised on the real videos seized with the help of static camera. The proposed approach is supported with the analytical and experimental results in the report and the results obtained are courageous in terms of robustness and preciseness.

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