Improved Multiple Object Detection and Tracking Using KF-OF Method

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Abstract—Object tracking is a procedure of movement estimation in computer vision application we present a combined multiple object tracking technique for a video. A video is a frame by frame sequence of images. Optical flow is a flexible representation of visual motion that is particularly suitable for computers for analyzing digital images. In this work the Horn & Schunck method is used to find the optical flow vectors which in turn pave a way for the detection and tracking of the single moving object in a video. Kalman filter removes the noise that effects a background subtracted image and predicts the position of an object accurately. A combination of Optical flow and Kalman filter method is designed in order to attain an accurate object tracking system. The accuracy of occluded object in dynamic background is promising compared to simple background subtraction. The experiments are conducted on different videos to prove the efficiency and the results are discussed.

Keyword- Kalman Filters (KF), Optical flow (OF), Background Subtraction, Occlusion Handling.

I. Introduction

Tracking systems have served well in the field of video surveillance, militarily guidance, robot navigation, artificial intelligence and medical applications during the last two decades. Its vigor to the variability in the visual by dynamic, over the top environment. In many cases, there are multiple objects to track. The motion based object tracking can be partitioned into two sections.

1. Moving object detection from one frame to another.
2. Analysis of tracked objects and Handling the occlusion

Tracking uniform movement was effortlessly done by the background commonly implemented background modeling however of non-uniform movement was tricky. Background subtraction or foreground detection is the extraction technique or the detection of moving objects in recordings or static foundations. The majority of the movement of image is uniform in nature and it could acquire the on tracking.

Gaussian mixture model is a background subtraction procedure that monitors objects in uniform or non-uniform movement. After the extraction of object from closer view of image, object limitation made utilization of this procedure. The prediction and correction of objects were finished with the Kalman filter or linear quadratic estimation. It is a calculation utilized for object tracking to predict an object detected location to take noisy measures and to relate numerous objects.

The appropriation of the speed of objects in an image of video frame is known as optical stream. To describe and evaluate the movement objects in a video stream there by movement based object detection and tracking systems can obtained by optical flow. The challenging task in tracking multiple objects was difficult when the objects are occluded. Optical flow algorithm overcomes this risk. The execution of tracking relies on upon the exact feature extraction and the position of the moving objects from the continuous video.

The proposed method tracks the multiple objects in a moving frame is as follows:-

Step 1: Extraction of objects through GMM, the uniform or non-uniform moving objects were tracked.

Step 2: Objects were filtered updated through Kalman filter.

Step 3: Optical flow algorithm was used to avoid the occlusion and for the better accuracy of tracking objects.

The proposed strategy tracked numerous objects in a scene utilizing Kalman filter and when they were blocked, Optical Flow was utilized to settle between objects. As the Optical flow method was coordinated to Kalman filtering, the proposed method could proficiently track numerous objects under high impediment.

II. Related Work

A lot of research is done on various multiple object detection and tracking methods. The research conducted so far for object detection and tracking objects in video reconnaissance framework are talked about. Tracking is the procedure of object of interest inside of an arrangement of edges, from its first appearance to its last. The kind of object and its depiction inside of the system relies on the application. Amid the time that it is available in the scene it might be blocked by different objects of hobby or altered hindrances inside of the scene. A tracking system ought to have the capacity to foresee the position of any impeded objects. Object tracking systems are ordinarily equipped towards observation application where it is sought to screen individuals or vehicles moving around a territory. There are two locale ways to deal with the following issue, top-down and another is base up. Top down strategies are objective situated and the greater part of tracking systems are composed in this way. These ordinarily include some kind of segmentation to locate region of interest, from which objects and features can be extracted for the tracking system. Bottom-up react to jolt and have as indicated by observed changes. The top-down approach is most prominent strategy for creating reconnaissance system. System has a typical structure comprising of a segmentation step, a detection step, and a tracking step.

Object tracking systems are commonly equipped towards reconnaissance application where it is fancied to screen individuals or vehicles moving around a territory. Object following has a great deal of use in this present reality. But it has many technological lacuna still exist in the methods of background subtraction.

A novel approach of object to detect single moving object in a video using Horn-Schunck optical flow method was proposed by Akshay S [1]. In this work a use of correlation, gradient and frequency information to detect an object is explained. To meet the drawbacks of traditional methods, Optical flow-based algorithm is proposed which functions with a minimal degree of user involvement

To meet the drawbacks of traditional methods, Optical flow-based algorithm is proposed which functions with a minimal degree of user involvement. Points identified at the outset of a video sequence, and within a small subset of frames spaced throughout, can be automatically tracked even when they become occluded or undergo translational, rotational, or deformational motion. The proposed algorithm improves upon previous optical flow-based tracking algorithms by providing greater flexibility and robustness. [3]

The production of optical flow image using Horn &Schunck technique for finding the optimal parameters are done by combining parameters and the different types of displacements. . Different types of displacements used are small, medium and large. Optical flow is generally carried out through utilizing a brightness constancy constraint equation (BCCE), which makes use of spatiotemporal derivatives of image intensity. Methods utilizing the BCCE are referred to as differential techniques.

There are many different methods to estimate the optical flow, which can be divided into correlation, energy, phase and differential based method. The differential based method of estimating optical flow, based on partial derivatives of the image signal and the sought flow field and higher-order partial derivatives, can be solve using Horn &Schunck method and Locus Kanade method. [2]

Sanjivani Shantaiya [5] proposed a work based on Kalman filter and optical flow algorithm. In another paper, Hitesh A Patel[6] proposed a method which is based on background subtraction and Kalman filter. Mohamed Jedra [7] combined new method called PCA-GMM-KF attempts tracking multiple moving objects, the size and position of the objects along the sequence of their images in dynamic scenes. Meenatci .K [8] proposed a method using motion and object segmentation with help of Kalman filter for tracking an object. Kusuma Kumari[9] combined a new method using particle filter and GMM method. Malik M. [10] proposed method combines extended Kalman filter with past and color information for tracking multiple objects under high occlusion. The proposed method is robust to background modeling technique. Object detection is done using spatio-temporal Gaussian mixture model (STGMM). Pranab Kumar Dhar[11] proposed a method using Gradient Directional Masking, Edge Localization, and Object Detection for tracking an object in different environment

III. PROPOSED METHOD

A. *Kalman Filters:*

During this approach, Kalman filter recursively appraises the condition of the objective target objects. Kalman filtering is inconceivably utilized as a part of various areas such as object tracking, economics and navigation systems. However, here we would just survey it for object tracking. A Kalman filter is utilized to estimate the state of a linear system where the state is thought to be disseminated by a Gaussian. Kalman offered an object predicting so as to follow the object position from the past data and confirms the anticipated position and verifies the predicted position of the object's existence. The Kalman filter is the condition of the dynamic system and represents its degree of freedom. The noise can disturb this dynamic system. Kalman filter is made out of two stages which are the prediction and correction.

The prediction is the state of first step with the dynamic model.

$$\overline{X}^{t} = DX^{t-1} + W$$

$$\overline{\sum} = D\sum^{t-1} D^{t} + Q^{t}$$

Where Xt and ∑t are the state and covariance predictions at time t. D is the state transition matrix which defines the relation between the state variables at time t and t-1. Q is the covariance of the noise W. Similarly the correction step uses the current observation Zt to update the object state.

B. Gaussian Mixture Model:

The color estimations of a specific pixel as a blend of Gaussian is utilized to implement a current Gaussian mixture model based on background model to recognize the moving objects in video frame. Be that as it may, the pixel values just fits forefront. The expectation maximization algorithm estimated the parameters of a mixture of a Gaussian for which every method of a sensor system had diverse blending coefficients' probabilistic methodology is utilizing as a part of blend of Gaussian for distinguishing background.

The probability of observing a given pixel quality is given by

$$P(pt) = \sum_{i=1}^{k} \omega_{i,t} \eta(pt, \mu_{i,t} \sum i, t)$$

k= number of Gaussian mixture with the consideration of each new pixel all parameters are redesigned because of an iterative procedure. Before update, if the matrix of k existing Gaussian is resolved through correlation, then the Gaussian blend is redesigned in the accompanying way.

$$\omega_{i,t} = (1-\alpha)\omega_{i,t-1} + \alpha$$

$$\mu_{i,t} = (1-\rho)\mu_{t-1} + p_t \rho$$

$$\sigma^2{}_{i,t} = (1-\rho)\sigma^2{}_{i,t-1} + \rho(p_t - \mu_t)^T (p_t - \mu_t)$$

Where

$$\rho = \alpha\eta(p_t \mid \mu_{i,t-1}, \sigma_{i,t-1})$$

If the match remaining (k-1), then Gaussian are updated as,

$$\omega_{i,t} = (1-\alpha)\omega_{i,t-1}$$

$$\mu_{i,t} = \mu_{i,t-1}$$

$$\sigma^2_{i,t} = \sigma^2_{i,t-1}$$

After the redesign is performed all the Gaussian weights are standardized. Background is displayed by conveyance while the remaining dispersion are demonstrated as frontal area for the following pixel.

C. Optical Flow:

The pattern of obvious velocity of objects surfaces and edges in a visual scene brought about by the relative movement between an eyewitness and the scene called optical flow or optic flow. The movement of item that is closer can be assessed all the more clearly that inaccessible object in a video stream moving at a steady speed. A dynamic image as a element of position and time allows a persistent image to be communicated. In a given spot of a picture the optical stream portrays the course and the time pixel in a period succession of two dimensional speed vectors. Where each bearing and the speed of movement is allocated to every pixel. Optical flow algorithm is for impediment taking care of. For handling occlusion and to track the object moving with changed force we have enhanced existing optical stream calculation. The exploratory brilliance of any object point is steady after some time. Near focuses in the picture plane move in a comparable way (the velocity smoothness constraint). Suppose we have a continuous image; f(x, y, t) refers to the gray-level of (x, y) at time t. Representing a dynamic image as a function of position and time permits it to be expressed.

- Assume each pixel moves but does not change intensity
- Pixel at location (x, y) in frame1 is pixel at (x+Δx, y+Δy) in frame2.
- Optic flow associates displacement vector with each pixel.

The optical flow delineates the course and time pixels in a period arrangement of two ensuing dimensional velocity vector, passing on bearing and the pace of development is designated to each pixel in a given spot of the edge. For making calculation less complex and snappier we exchange this present reality three dimensional (3-D+time) objects to a (2- D + time) case.

D. Algorithmic module

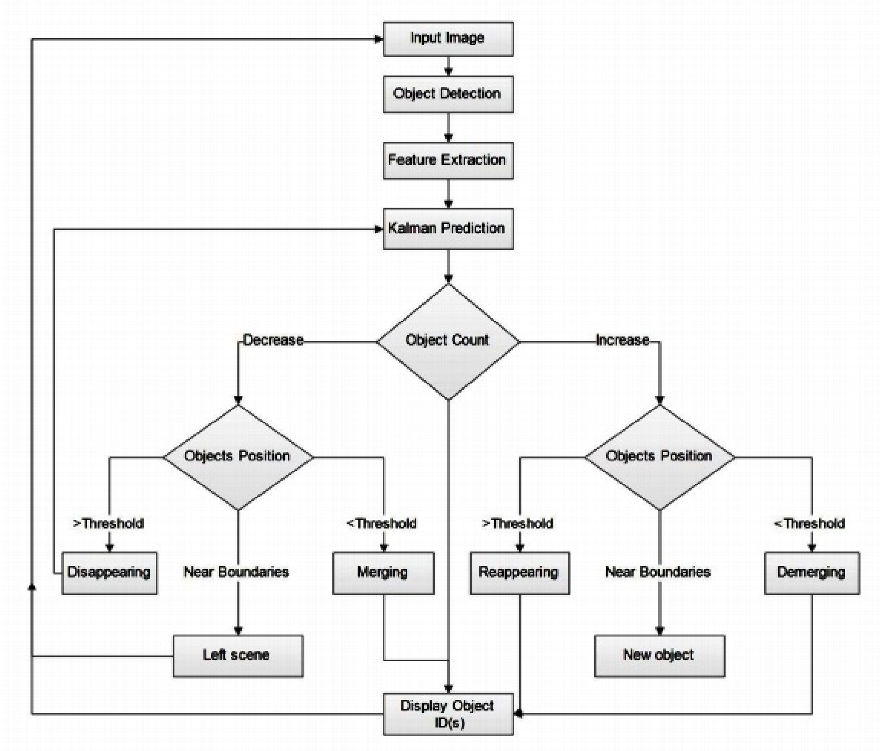

Fig 1: Object Detection and Tracking

Figure 1 demonstrates the flowchart of the proposed technique. The proposed method comprises of four stages; background modeling, Kalman filtering, Optical Flow extraction and lastly putting away the followed data. Object detection method is asked for to consequently segment each object so that there can be a unique tracking connected with the object. It incorporates five stages: background estimation, background updating, and background subtraction, moving cast shadow elimination, and object detection and tracking the object. Additionally follows along on impeded object in the video frame.

Algorithm:

Step 1: Create System objects used for reading the video frames, detecting foreground objects, and displaying results.

Step2: Create objects for reading a video from a file, drawing the tracked objects in each frame, and playing the video.

Step3: The initialize tracks capacity makes a variety of tracks, where every track is a structure representing a moving item in the video. The reason for the structure is to keep up the condition of a tracked object.

Step4: Read the following video outline from the video record and the recognize objects capacity gives back the centroids and the bouncing boxes of the identified objects.

Step5: Use the Kalman filter to predict the centroid of every track in the present casing, and update its bounding box appropriately.

Step6: Assign object detections in the present frame minimizing so as to case to existing tracks is finished expense. The expense is characterized as the negative log-probability of an identification relating to a track.

Step7: The update allotted tracks function redesigns each assigned track with the relating recognition. It calls the right strategy for vision. Kalman Filter adjust the area location estimate.

Step8: To track the objects more accurately use optical flow algorithm proposed in [1].

Step9: The lost tracks function deletes tracks that have been undetectable for an excess of successive edges. It likewise erases as of late made tracks that have been imperceptible for an excess of edges by and large.

Step10: Create new tracks from unassigned detection. Accept that any unassigned identification is a begin of another track.

Step11: The display tracking results function draws a bounding box and label ID for each track on the video frame and the foreground mask.

The probability of tracking blunders can be decreased by using a more complex movement model, for example, steady increasing speed, or by utilizing numerous Kalman channels for each object. While optical stream calculation tracks numerous items yet it is neglected to track if there is change in intensity of moving objects. It was not able to track impeded protests moreover. We have enhanced existing optical stream calculation for taking care of impediment.

IV. Experimental Results

This section explains the results of experiments using video dataset which contains multiple objects and people constantly moving. For Experiment, we took five different scenario. First, we took a traffic Video. The vehicles will move according to the signal. The pedestrians will be walking through the zebra crossing and the footpath. So there are multiple objects which are in motion. The proposed system successfully detects and tracks the multiple objects and partially detects the occluded objects in the video. Second scenario is a cricket ground. In this case there are many moving objects such as ball, bat, batsman, bowler, keeper etc. The system did analysis on the ground and successfully detected and tracked the multiple objects in motion. In another scenario, there will be group of students in the classroom and we can able to detect the students as an object and same as been tracked. The next scenario is to detect objects on the runway, ranging from debris, objects that would otherwise affect the quality of the landing. The proposed system successfully detects and tracks the multiple objects in motion. Finally, considering an aquarium with six fishes. The fishes will be in motion. Using the proposed system, all the moving objects(six fishes) were identified. The system successfully detected and tracked the multiple objects in motion.

Both Kalman filter and optical flow estimation using Horn Schunk method were experimented on the video dataset. Figure 2(a) shows the binary image and Figure 2(a) shows the result obtained after applying kalman filter with the moving objects detected. Figure 3(a) is the original video frame and Figure 3(b) shows the results obtained for the estimation of flow vectors. Figure 4(a) is the binary image and Figure 4(b) give the object detection output for the frame.

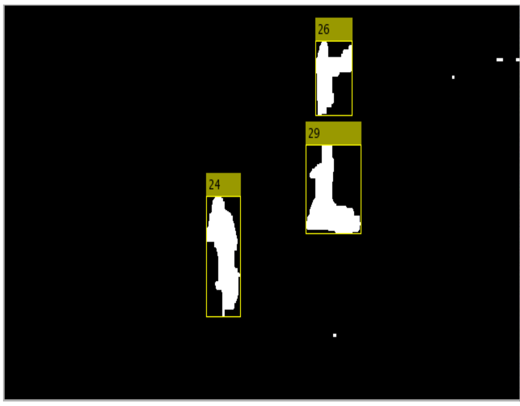

Fig 2(a) Binary image

Fig 2(b) object detection

Fig 3(a) Original frame

Fig 3(b) Optical flow vectors

Fig 4(a) Binary image Fig 4(b) object detection

V. Conclusion and Future Work

In this paper we presented a set of methods and tools for object detection and tracking in videos. We considered the five different scenario to test our implementation and we are able to detect the multiple objects in the videos. In some of the videos, accuracy of object detection were less and we are trying to overcome the accuracy problem, and also we are unable to perform clear occluded multiple object detection in a video.

We implemented three different object detection algorithms and compared their detection quality and time-performance. The adaptive background subtraction scheme gives the most promising results in terms of detection quality. The proposed object tracking algorithm successfully tracks objects in consecutive frames. Our tests in sample applications show that a combination of Kalman filter and Optical flow method gives significant results. The method is generic and can be applied to different classification problems as well. Although this algorithm gives promising results the system needs to be improved for object detection in multiple background and detection of occluded objects. Improvement in the current system's segmentation and tracking algorithms, and Extension of the system towards building higher-level intelligence applications based on motion tracks are the challenges that needs to be answered.

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