Moving Object Detection and Tracking Using Stationary Camera

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Abstract
Video surveillance is a widely used process of monitoring secured areas like bank vaults, traffic signals, and Jewellery stores, etc. In the modern world with the help of advance technologies in hardware and software systems it has become viable to store large amount of data and process it adequately with high speed. Before the advance in technology video surveillance was done manually by human operators and were saved in tapes to examine later. But with the increase in the number of cameras in surveillance systems it is no longer feasible to ensure proper monitoring of each and every video manually by the human operators. In order to reduce the manual work and increase accuracy and efficiency and response time in surveillance systems to detect and track specific events from live or a recorded video stream object detection has become a very critical requirement.
In this paper, we implement a video surveyance system with real time moving object detection and tracking features. The system uses a stationary camera to record the live video stream and process it to detect foreground objects from any video i.e. color or gray scale. A tracking algorithm is used to track the object once it is detected.

Keywords
Moving Object Detection, Background Subtraction, Blob Analysis, Foreground Detection, Gaussian Mixture Model, Object Tracking.

I. Introduction

Video analysis is used in many real time monitoring applications. It is used for security purposes and video surveillance in banks, highly secure militarized zones, and other sensitive regions. Before the advancement in image processing technologies there were a lot of limitations to perform complex real-time video processing. With the recent advancement such as rapid computation, high quality cameras and development of some advanced algorithms has helped scholars to overcome the shortcomings of traditional technologies. Video analysis consists of two main processes (1) object detection and (2) object tracking. In object detection we identify the segment or region of interest that is the foreground object. In our paper we use GMM and blob analysis for detection purpose. The background subtraction method is used to differentiate between the reference model and the region of interest.

Here the result of blob analysis is supplied as an input to the Gaussian mixture model. This gives accuracy in the detection process. After this we can track the detected objects from one video frame to another frame using KLT (Kanade-Lucas-Tomasi) Feature Tracking Algorithm. The system also maintains the count of number of objects detected and the same is shown on the screen. This technique gives us the complete trajectory information of the object. We use mobile camera, recorded video, webcam or cctv camera for fetching the input video frames. In this system we can detect the object as well as save it in database.

Abbreviations and Acronyms

GMM: Gaussian Mixture Model
KLT: Kanade-Lucas-Tomasi

I. The Method

A. Object Detection

Object detection involves differentiating foreground objects from stationary background. The initial step in all of the surveillance systems is to detect a foreground object. This then makes a base for further operations such as tracking, classification. We first perform background scene initialization. In our system we are using the GMM to differentiate the background. Further we detect the foreground pixel from the background model and current input frame from the video. Before the further processing, some pixel level post processing is done to remove the noise in foreground pixel. We use the mixture of background detection and the pixel post processing to create a map of pixels of objects in the foreground and obtain the objects in the video frame.

B. Object Tracking

Object Tracking being a complex method has always aroused interest, and gained attention of the researchers worldwide. The main objective in our research of object tracking is to create a correlation of objects and different segments of object within the consecutive video frames. Object tracking is an important aspect in the process of moving object detection. Object tracking is used in surveillance applications as it gives temporal information about moving elements in the frames. The object tracking algorithm uses the aspects of the extracted object together with a corresponding matching scheme to track objects from one frame to another.

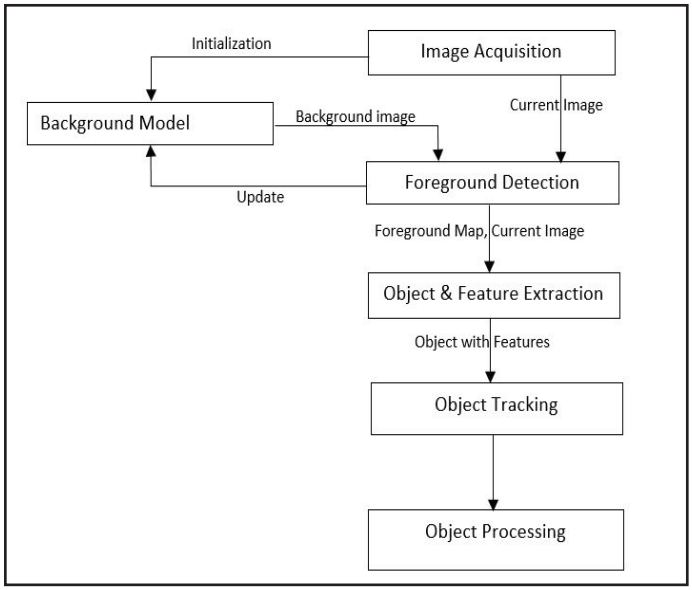

Fig. 1: Flow Chart

It is challenging to use object tracking in a congested environment, because of segmentation problems such as wide shadows of object,

full or Sectional obstruction of objects with each other as well as with stationary elements in the environment. The main intent of object tracking is to obtain temporal information of the objects such as its path trajectory, the position of the object, speed of the object as well the direction in which it is moving. There are two methods used in tracking the moving objects (a) to track the object as a whole, which uses motion prediction or position estimation and (b) to track the parts of objects differently. In this paper we are adopting object level tracking. Object level Tracking tracks the object as a whole from one frame to another.

C. Background Subtraction

Background subtraction is one of the many popular techniques that is used for detection of objects. It is considered as the efficient technique among others used. The process of background subtraction is to leave only the foreground pixels of interest by eliminating the background pixels. The comparison for background subtraction technique is made between the ith and i-1th frame. Background subtraction methodology matches the reference model with the initial frames of input video. The intensity values of the pixels in one frame are then subtracted with the pixels of reference model. Further the difference in the pixel is filtered using threshold per pixel [1].

$$D(x,y)=|It(x,y)-Bt(x,y)|$$

$$D(x,y)>th=1$$

$$=0, \text{otherwise}$$

Here It(x,y) is the intensity value of a pixel at point (x,y), video sequence I and time frame t . Bt(x,y) is the corresponding background intensity pixel value. Th is the threshold value approximated through the image sequence. The reference model Bt(x,y) is initialized with the first video image I0, B0 = I0. The threshold is defined using some pre-determined value. A pixel is set as background pixel if D(x,y) < Th.

D. Frame Difference

The Background image is obtained from frame (f) which is before the current video frame (ft-1). [3]

$$B = f_{t-1}$$

E. Weighted Moving Mean

Mean of each frame is computed by the algorithm. [3]

$$B = (f_t * w_1) + (f_{t-1} * w_2) + (f_{t-2} * w_3)$$

$$B = ((1/t)\Sigma_{i=1}^{t}(f_i-(f_i * w_1) + (f_{i-1} * w_2) + (f_{i-2} * w_3)))^{1/2}$$

F. Weighted Moving Variance

Variance of each frame of the video is calculated. Following is the formula for calculating the variance [3]:
The Frame Difference, the Weighted Moving Mean algorithm and the Weighted Moving Variance algorithm are used for creating the reference model of the background. For detecting the objects from the foreground model, for this we have to calculate the difference between the reference model and the current image frame.

$$F = |f_t-B|$$

G. Single Gaussian

We are using a Gaussian model for calculating values of each pixels from mean (μ) and variance (σ) of the sample pixels. Then a lower and upper bound value is set that will be used for the purpose of eliminating the pixels which doesn't follow these constraints. For adapting the model over a period of time at new frame, the mean and variance are needed to be updated by taking average of the pixel values. [3]

$$\sigma(x,y,t) = (\Sigma i=1\ t\ p2(x,y,i)/t - \mu 2(\ x,y,t\ ))1/2$$

$$\mu(\ x,y,t\ ) = \Sigma i=1\ t\ p(x,y,i)/t$$

Detection of the foreground object is done by the following formula:

$$|\ \mu(t+1)- \sigma(t+1)| < k\ \sigma(t+1)$$

The pixel is then classified under the category of background or foreground pixel.

H. Gaussian Mixture Model

Gaussian Mixture Model works on the basis of parametric probability density function. This function is expressed as the weighted sum of component densities of Gaussian. GMMs are commonly used as a parametric model of the probability distribution of continuous measurements or features [7].

I. Morphological Operation

After the completion of background subtraction, we obtain the foreground mask which represents moving pixels in the video frame. But there is still noise in the foreground image. We can overcome this by applying morphological operation on the foreground mask. [3]

J. Blob Analysis

Blob detection method is basically used to distinguish particular regions in an image that vary in several properties such as illumination, color as compared to the surrounding region. Blob is considered as a part of image in which some aspects are partially constant. We are using blob analysis in our system because of its high flexibility and better performance. Initially in our system we GMM to detect the foreground object, but to increase the efficiency of the detected region we further use blob detection. Blob analysis uses the three step method of Extraction, Processing and Analysis. In the initial step the thresholding technique is applied and region of object or objects are detected. Many a time the detected or extracted region contain noise, in the second step the objects or region is updated using some transformation method. In the analysis step the detected objects are processed and split into multiple blobs so that they can be recognized separately. In our system we pass the result of the blob analysis to the Gaussian mixture model. [2]

K. KLT

The KLT tracking algorithm i.e. Kanade-Lucas-Tomasi is a feature tracking approach.

KLT uses spatial intensity information and directs its search for the location which has the best match. It is considerably faster than primitive techniques used.

III. Results

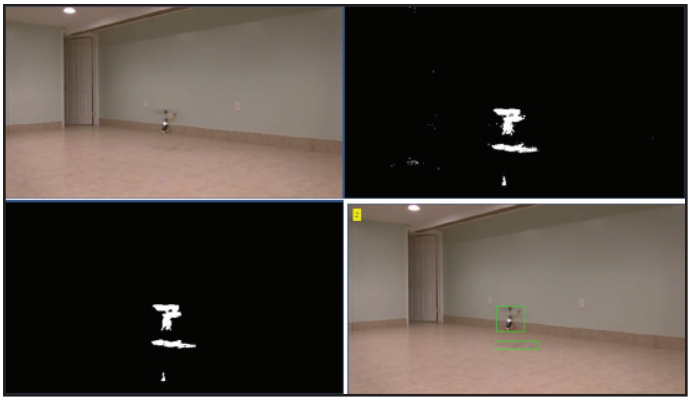

Fig. 2: Detection Process

IV. Conclusion

Due to noise inherited from camera while capturing the video and several background disturbances and irregularities, it gets tough to detect moving object. In this research we use blob detection along with Gaussian mixture model to achieve moving object detection. Using both the models together lets us achieve higher efficiency and flexibility in detection of the object. We have used KLT algorithm for tracking, it is fast and efficient compared to other tracking methods. Which helps in speeding up of tracking process.

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