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Detection and Tracking of Moving Objects in Surveillance System

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Abstract

A video is a collection of sequential images with a constant time interval. Videos can provide more information about real world objects where scenario changes with respect to time. Because of complicated occlusions, and disordered background, Identifying moving objects and their tracking is a challenging problem for many computer vision applications, especially in complex real world scenes that commonly involves multiple objects. Therefore, we need some automated devices to handle the video for monitoring the moving objects. Many algorithms have already been developed to automate the monitoring of the moving objects. In this paper, we propose a novel approach for tracking multiple objects via using background subtraction based on Gaussian Mixture Model (GMM). The proposed model in this paper is effectively working for dynamic background, fast light change environment, repeated motion. For tracking the objects we used Kalman filter. This filter successfully tracks moving objects even in full occlusion cases. Hence lower processing time while maintaining competitive performance in terms of recall and precession is the main feature of the proposed approach in this paper.

Keywords

Object detection, Background subtraction, Gaussian mixture Model, Tracking, Kalman filter, Shadow Detection.

Introduction

Detection and Tracking of moving objects for video surveillance system is an important research area of image processing. The essential work of Surveillance System to detect the moving object and track the detected objects through the sequence of frames. So, we need a robust video surveillance system. It should be capable to monitor security sensitive areas such as banks, storage department, highways, crowed public places and borders areas etc. It also handles the problems related to moving objects in indoor as well as outdoor environments, varying illumination condition along with shadow removal.

Object can be defined as thing of interest which can be used for further analysis and tracking means to follow the motion of an object moving under the action of given moment[7]. For example, In traffic surveillance application interested object may be human or car, where as for satellite application interested object may be a planet or for gaming application it may be face of particular person. The main idea of moving object system is to separate the moving foreground objects and background pixels. For detecting the moving objects, object segmentation is very difficult task from static background and dynamic environments [4]. To words this cause we require an adaptive background subtraction method. In this method a reference background is initialized at the start of the system with the first few frames of video and updated to adapt to short and long term dynamic scheme changes during the operational period. It gives the higher accuracy.

The main objective in this paper is to discuss background subtraction technique and analysing the proposed tracking algorithm successfully tracks video objects even in full occlusion cases along with removing shadow problem. The remaining work of this paper is organised as follows. Section 2 describes the related works. Section 3 gives an overview of our approach and introduced the object detection and motion tracking method. Section 4 and 5 evaluated the experimental result and gives the conclusion.

Related work

The main goal of object tracking is to segment the detected the moving objects, keep track of them and analysis of object tracks to understand their behavior. In general to detect the suspicious object is a very difficult task. Especially since objects can have rather complicated structures and many change in shape, size location and orientation over subsequent video frames [5].

Currently, there are many algorithms such as frame difference method, background subtraction method, optical flow method and statistical learning method etc, to detect the objects in a particular video sequences and each algorithms has their own advantages and drawbacks, In object detection and tracking, the main challenge that has to consider while the operating a video tracker are when the background is appear which is similar to interested object or another object which are present in the scene. In frame difference method we calculate the pixel-wise difference between two consecutive images and detect regions corresponding to moving object such as human and vehicles etc[6]. This method is easy to implement and gives the high detected speed. But difficult to remove the noise in a given frame. That why difficult to obtain the correct result. Optical flow and statistical learning method are not suitable for real image processing technique. Its expend more time and needed many training samples. In the framing difference method threshold selection is also main key problem.

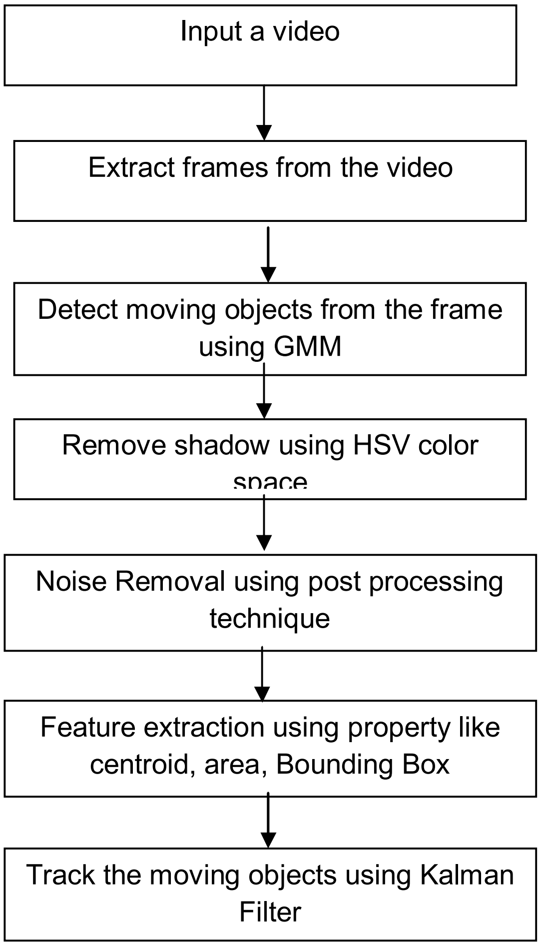
To overcome this problem ZHAN Chaohui DUAN Xiaohui[5] proposed an improved moving object detection algorithm based on frame difference and edge detection. It gives high recognition rate and a high detection speed. This method not only retains the small calculation from frame difference method and the impregnability of light from edge detection method, but also improved in noise restraining and objects segmentation method. But this method is not suitable for dynamic background. Then new method proposed by Soumya Varma[3],that is use background subtraction method, in this method for foreground detection we take the difference between the current image and background image in the given video sequence. Due to change environment continuously background image change, which gives the disturbance to detect foreground pixels. To remove this Dina M. Rashed implemented a new approach, improved moving object detection algorithm based on adaptive background subtraction[2]. This algorithm construct background model and compares its pixels with current images to identify foreground/background pixels and minimize the number of updated pixels in background model to reduce the processing time.

Detection of moving objects and motion-based tracking are important components of many computer vision applications, including activity recognition, traffic monitoring, and automotive safety. In this paper we detection of moving objects uses a background subtraction algorithm based on Gaussian mixture models. Apply HSV colour model to remove shadows problem, and then apply Morphological operations to the resulting foreground mask to eliminate noise. Finally, blob analysis detects groups of connected pixels, which are likely to correspond to moving objects. The association of detections to the same object is based solely on motion. The motion of each track is estimated by a Kalman filter. This filter is used to estimate the track’s location in each frame based on use of state space techniques and determine the likelihood of each detection being assigned to each track. Using this method we reduced computational complexity. Hence lower processing time while maintaining competitive performance in terms of recall and precision parameters.

Proposed Approach

Fig. 1 show the flow diagram of our proposed method. In the proposed method first of all we generate video frames. Then we apply Background subtraction algorithm based on Gaussian mixture models to detect Foreground object and Background pixel. Then We see some problem like Shadow detection, so to remove this problem we can use HSV colour space model. After this apply pre-processing steps to reduce the image noise in order to achieve a higher accuracy of the tracking. After this detecting moving object we extract the feature of object and store it in a Feature extraction queue and we compare to the new moving object. Now we track the moving object by using the Kalman Filter approach. Each of modules describe as follow.

Figure 1: Proposed Method



Video Frame

Video is nothing but a sequence of images, each of which is called a frame. In this scenario we take video as input and generated a number of frames determined by the frames per second property of video. Then detect moving objects.

Object detection

Moving object detection is the basic step for further analysis of video. It handles segmentation of moving objects from stationary background objects. This not only creates a focus of attention for higher level processing but also decreases computation time considerably. One reliable method of object detection involves building a representation of the scene known as the background model and finding deviations from the model for each incoming frame in the video imagery. Any significant change in an image region from the background model is noted down as a moving object. The pixels in the regions of the undergoing change are marked as moving objects and reserved for further processing. This process is referred to as the background subtraction. There are various methods of background subtraction. We use Gaussian Mixture Model for background subtraction proposed by Stauffer and Grimson[1]. In this algorithm each pixel in the image is modelled as a mixture of k Gaussian(k=3).

Let Xt denote the pixel intensity at time t of a pixel, then the history {X1.............Xt} of the pixel is modeled using a mixture of K distributions of Gaussian. The probability of observing the pixel intensity at time t is expressed using

$$P(Xt)=\sum_{i=1}^{K} \omega i, tn(Xt, \mu i, t, \sum i, t)$$

Where,

- K denotes the number of Gaussian clusters for modeling pixel history
- ωi, t is the weight factor associated with cluster i at time t.
- n is the Gaussian pdf
- i, t and $\sum$ i. t are the mean and covariance matrix of ith Gaussian cluster

Each Gaussian are then ranked based on the value $\frac{\omega}{\sigma}$. The parameter P is estimated dynamically by summation of weights for sorted order of Gaussians until threshold Th is reached (Th=0.25). Each of the new pixel is checked against the K distributions to find a match, which is defined as pixel value ranging within 2.5 times the standard deviation. If match is found, appropriate class label is assigned, and if no match, the pixel is treated as foreground.

Shadow detection and removal

Shadow detection and removal is an important step for foreground detection. To remove shadow problem we used HSV color space model[4]. In this method the values of the HSV components are obtained from both the current frame I(x.y) and the background frame B(x,y). The component is given below.

$V=\frac{Iv(x,y)}{Bv(x,y)}$

S= Is(x,y) – Bs(x,y)

H= $|Ih(x, y - Bh(x, y))|$

$$S(x,y)= \begin{cases} 0, \text{if } (\alpha < v < \beta) \wedge \quad (s < Ts) \wedge (h < Th) \\ 1, \text{otherwise} \end{cases}$$

Where,

$v =$ value components
s = saturation components
h= hue components
$\alpha, \beta =$ value threshold ($0 < \alpha < \beta < 1$)
Ts= saturation threshold
Th= hue thresold

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Post processing

After applying background subtraction method, image may be consist of noise, incompleteness in shapes, etc. Post processing module[2] solve such a problem using morphological filtering. This filter helps in maintaining by passing a rectangular structuring element of 2x2 size over the image. Pixels can be added to (dilation) or subtract (erosion) from the object boundaries. Then we find the correct segmented images. The size of structuring element determines the number of pixels added or removed.

Feature extraction

For any algorithm extraction feature is the important step. It is allowing us to highlight the information of the interested object from the video frames or target image. For feature extraction we measure different parameter of object like centroid, area, Bounding Box, etc. The detected object is represented by its centroid and the regular shape around the object boundary.

Kalman filter

Tracking is the process to locating the interested object within a given sequence of frames, from its first appearence to its last. A tracking system should be able to predict the position of any occluded objects. The motion of each track is estimated by a Kalman filter. This filter is used to predict the track's location in each frame, and determine the likelihood of each detection being assigned to each track. Using this method we reduced computational complexity.

Experimental result

Here experimental set up used consists an Intel core i4 processor with 2 GB RAM and with window 7 operating system. Programming environment is Matlab 2010. Size of sequence image is 640x360. We have tested our proposed method using various video sets [7] of within indoor as well as outdoor environment. In table 1 shows the properties of different video sets.

Table 1.Video Properties

Video Set	Sample Frame	Sequence Type	Image Size	Background Property	Processing Time (sec)	Frame per sec	Total frames
1		Outdoor	360x640	Static	69	30	531

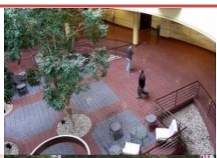
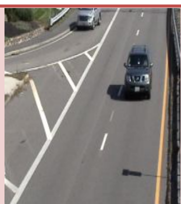
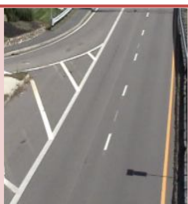
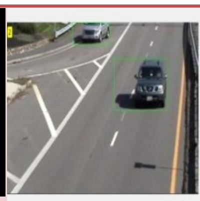
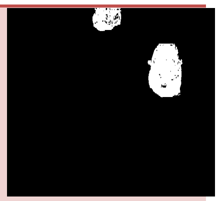
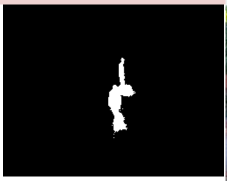
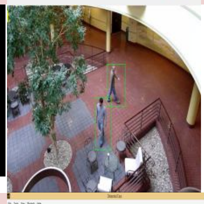
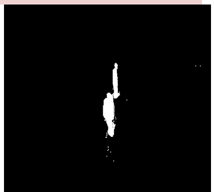
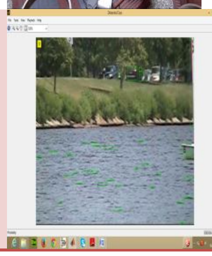
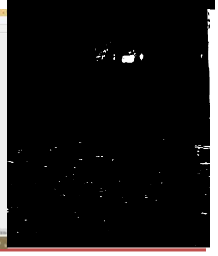
2		Outdoor	360x640	Static	55	30	431
3		Outdoor	240x320	Dynamic	23	25	152
4		Indoor	240x360	Static	47	25	695
5		Outdoor	120x160	Static	8	15	120

Table 2 shows the result of our proposed method. In this, It tracks 1 to 6 moving objects in given video sets using Kalman filter.

Table 2. Result for Proposed Method

Video Set	**Input Image**	**Background Image**	**Foreground object**	**Result of Detection**	**Output with shadow removal**
1					
2					
3					

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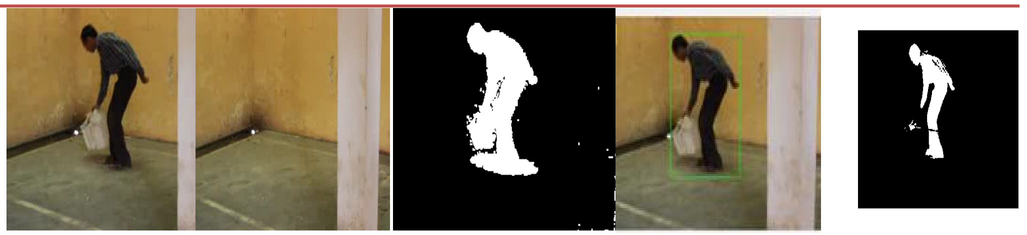
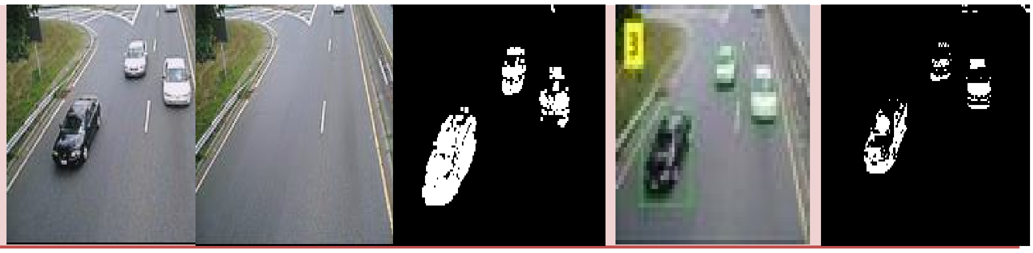


5



The output will be evaluated based on accuracy of detection[6], True Positive (TP), True Negative(TN), False Positive(FP), False Negative(FN), Recall, Precision values. All these measurement are shows below in table 3. It can be observed that using our approach accuracy for finding of recall and specify value is better than the exiting methods. The method is given below.

Recall=$\frac{TP}{TP+FN}$,
Specify=$\frac{TN}{TN+FP}$

Table 3. Objective Measures for Evaluation of Video

Video Set	TP	TN	FN	FP	Recall	Specify
1	419	64646	297	174	0.59	0.99
2	8	64209	1	880	0.88	0.98
3	13	60619	16	3792	0.49	0.94
4	16	63208	10	992	0.61	0.98
5	316	65678	308	216	0.51	0.99

Conclusion

Detection of moving objects and motion-based tracking are important components of many computer vision applications, including activity recognition, traffic monitoring, and automotive safety. In this paper we used probabilistic method (GMM) for background subtraction. Our algorithm, provides faster detection of objects in a video. We tested our algorithm for different video sets[7] with fixed camera. The experimental result shows the feasibility, usefulness of the proposed method and increase accuracy rate.

The proposed model has been proved to be robust in various environments (including indoor and outdoor scenes), different type of background scenes. It successfully segments and tracks occlusion of moving objects in video sequences. Our method has lesser computation complexity. Hence lower processing time while maintaining competitive performance in terms of recall and precession is the main feature of the proposed approach in this paper.
In future, this work can be extended for a robust tracking algorithm which can classify the objects with respect to status and other characteristics.

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