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Detection of Moving Object using Continuous Background Estimation Based on Probability of Pixel Intensity Occurrences

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***Abstract*—Video object segmentation is an important part of real time surveillance system. For any video segmentation algorithm to be suitable in real time, must require less computational load. This paper addresses the problem of maintaining the background with the changes in the scene. The algorithm proposed in this paper enables to update the background image timely without compromising the time taken for object detection by executing the algorithm in parallel with the object detection process. Background maintenance is done by evaluating the probability of occurrence of the intensity value at each pixel coordinate. Algorithm has been implemented on videos with various changes in the scene in which the results are quite encouraging. Results obtained with the proposed algorithm are compared with the traditional background subtraction method.**

***Index Terms*— Smart Surveillance System, Video Object Segmentation, Static Background, Background Subtraction, Background Image Generation and Background Updation**

I. RESEARCH OBJECTIVE

SURVEILLANCE system is not a new name. Earlier the surveillance system was used just to capture videos. But with the advent in the field of image and video processing, the surveillance system [1],[2] has extended its functionality from providing videos to be observed by a human operator, to taking an action on events which are identified as a consequence of image processing. Such type of surveillance system is known as Smart Surveillance System. Smart Surveillance Systems needs the system to be responding to the action in real time [3]. To process something in real time, very fast and robust analysis is required. The process of analysis can be divided into segmenting the moving object from the video followed by its identification and finally generating an action based on the event. The block diagram of a general smart surveillance system is shown in Fig 1.

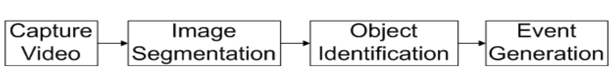


Fig. 1. Block diagram of a general surveillance system

Segmentation of video object must be done in order to effectively detect a moving object. Segmentation is considered to be the most important yet the most difficult part of any video based application. Many researches have been carried out to develop various methods for segmenting a video object [6], [7], [8]. Most widely used method for object segmentation is the background subtraction method. In this method a moving object is separated from its background by taking the difference of the image frame with a background frame void of any moving object. The background subtraction methods can give accurate result only when the reference frame which is the background image is selected properly. Therefore, having appropriate background image constitutes the key aspect in object detection. This paper addresses the method of constructing an optimal background image from a video sequence by evaluating the initial few frames of the video.

II. INTRODUCTION

A background image can be considered as an image containing objects which remain inactive in the frame. In an indoor environment, it may consist of the furniture, television, telephone etc. which are non-living things and are not capable of changing their position on their own. In an outdoor environment, it may consist of buildings, electric poles and hoardings which are also non-living objects. These can be considered as static object in the background image. But the appearance of background image may change with time. Following can be the situation where background can change:

i) An object remains stationary for a long duration of time.
ii) An object initially moving but then becomes stationary for a long time.
iii) An object which was stationary, starts moving after sometime.

In both of these situations, the background image changes. If it is not updated with the changes in the scene then object might not be detected appropriately. To handle both the above mentioned situations a new approach for generating the background image has been proposed. A modified background subtraction method is introduced which has the ability to generate a new reference image with the changing scene. The proposed algorithm runs in parallel with the actual background subtraction method without interrupting the process of moving object detection. The algorithm can generate an image consisting of all the static objects in the scene. At regular interval the algorithm can be repeated to generate a new image and this newly generated image can be used as the background image for carrying out background subtraction method to detect moving objects. When a new background image is generated, it is made available to the object detection process (as shown in Fig. 2) and further subtraction is carried out considering the newly generated image as the background image. As a result the execution time is not affected. The proposed algorithm is able to handle the situations mentioned which cannot be handled by the traditional background subtraction method where the reference background image does not adapt with the changes is the background scene. Implementation of the algorithm considers two cases: 1) image with static background and, 2) image with dynamic background. The results which are obtained are compared with the results of applying traditional background subtraction method.

The remaining part of the paper is organized in the following manner. Overview of the proposed method is shown in Section III. In Section IV experimental results of the proposed algorithm are shown, and finally the conclusion of the paper is given in Section V.

III. METHODOLOGY

Different video object segmentation methods are used for separating the moving objects from their background. In order to achieve this separation the first and foremost step is to extract the background from the video. Various changes in the background such as leaves of a tree waving due to wind can affect the efficiency of object detection. In order to obtain a good object profile, some processing needs to be done to generate an accurate background image.

In this paper, frames of the first t seconds of the video are evaluated to generate an appropriate background image. The algorithm is repeated after certain time duration to get a new background image. The advantage of executing both the processes in parallel is that when a new image is being generated, object detection process does not stop executing and continues the subtraction using previously generated background image. When a new image is generated, image subtraction can be carried out using the new image. Executing the algorithm in parallel do not interfere with the execution time which is required for real time processing. The block diagram of the algorithm is shown in Fig. 2.

Algorithm of the method is as below:

i) Read the first N frames from the video.

ii) Store all the intensity values of the respective coordinates from all the N frames.

iii) Calculate the probability distribution PD for each coordinate point showing the probability of occurrence of the intensity values at that coordinate.

iv) From the PD find out the intensity value with the maximum probability.

v) Generate a new background image by placing the maximum intensity values at the respective coordinate point.

vi) Use the newly generated background image for performing image subtraction.

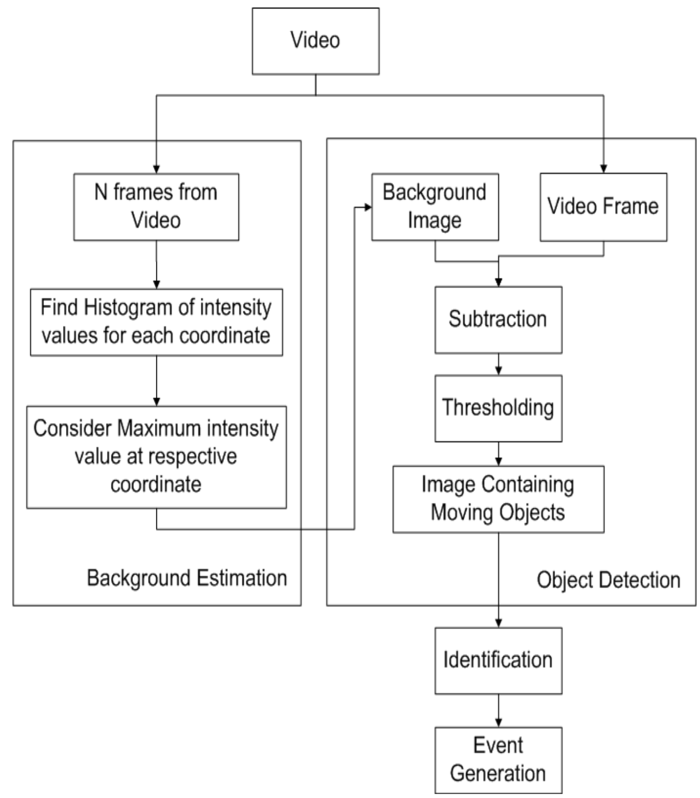


Fig. 2. Block diagram of the proposed algorithm for generating the background image

The above mentioned algorithm can be repeated at regular interval in order to obtain a new reference image. The algorithm has to be repeated periodically in order to change the background image which is used for image subtraction when an object which was stationary in the scene has now moved out of the scene.

Implementation of the modified background subtraction method can be subdivided into three main parts: *background image generation, background subtraction, background updation*.

A. Background Image Generation

The first and important step for performing background subtraction is to obtain an appropriate background image which does not contain any moving objects.

Consider that a video sequence has N frames. Out of that first T frames are considered for generating a background image. Let $F_t(i,j)$ be a frames from a video where, $t=1,2,3,\ldots,T$ and i & j represents the resolution of the frame. The following equation is used to generate a background image:

$$PD(i,j,k) = \frac{1}{t}\sum_{t=1}^{N} Ft(i,j) \quad (1)$$

where k is the intensity value.

$$BGI(i,j) = max[PD(i,j,k)] \quad (2)$$

BGI(i,j) is the generated background image.

B. Background Subtraction

Having got the background image, background subtraction can be applied to detect the moving objects from different video frames. Let N be the total number of frames in the video. BGI(i,j) is the background image. Each new frame of the video is subtracted from BGI(i,j).

$$FD_n(i,j) = |BGI(i,j) - I_n(i,j)| \quad (3)$$

where n=1,2,3,…,N and $FD_n(x,y)$ is the frame difference of each frame from the background image.
Thresholding is to be performed for each difference image.

$$THI_n(i,j) = \begin{matrix} 1 & ,if\ FD \geq Th \\ 0 & ,if\ FD < Th \end{matrix} \quad (4)$$

where Th is the threshold value and $THI_n(x,y)$ is the thresholded image.

C. Background Updation

Updating the background image is required to adapt the reference image with the changes in the background scene. To detect a moving object accurately it is required to again generate a new background image. For that the procedure given in Equations (1),(2),(3) are again repeated. This is done parallel to the background subtraction process.
Let BGI(x,y) is the newly generated background image. Now this image is used for further processing.
Next Section shows the results obtained by applying the algorithm on different video sequences.

IV. EXPERIMENTAL RESULTS

The proposed algorithm has been applied on video in which background image changes with the changes in position of different object. It is considered that the cameras are stationary. Videos have been recorded using a single camera.

A. Results obtained by applying proposed algorithm

Three different scenarios have been considered on which the algorithm has been applied. Fig. 3 shows the frames of a video in which a car is stationary for a while and then it moves out of the frame.

The algorithm generates a background image by analyzing the initial few frames of the video. Fig. 4 shows the generated background image.

The background image thus generated is used as the reference image for performing background subtraction. Fig. 5 shows the frame having moving object and the image obtained after doing subtraction and thresholding.

(a) (b) (c) (d)

Fig. 3. Frames from a video (a) a car is stationary, (b) car started moving, and (c) car moving farther, (d) car moved out of the frame

Fig . 4. Background image generated by implementing the proposed algorithm

(a) (b)

Fig. 5. Result of background subtraction (a) video frame in which car has moved out, (b) thresholded image

As the background image does not contain the temporary static object, moving object can be detected accurately. Fig6 shows the scenario in which a car remains stationary for a long duration of time.

(a) (b)

Fig. 6. Frames from a video in which car is stationary

The background image generated from the video must contain the stationary object as it does not move for a long duration of time. Fig. 7 shows the generated background image.

Fig. 7. Background image generated for the above video sequence

(a) (b)

Fig. 8. Result of background subtraction: (a) video frame containing stationary and moving object both, (b) thresholded image

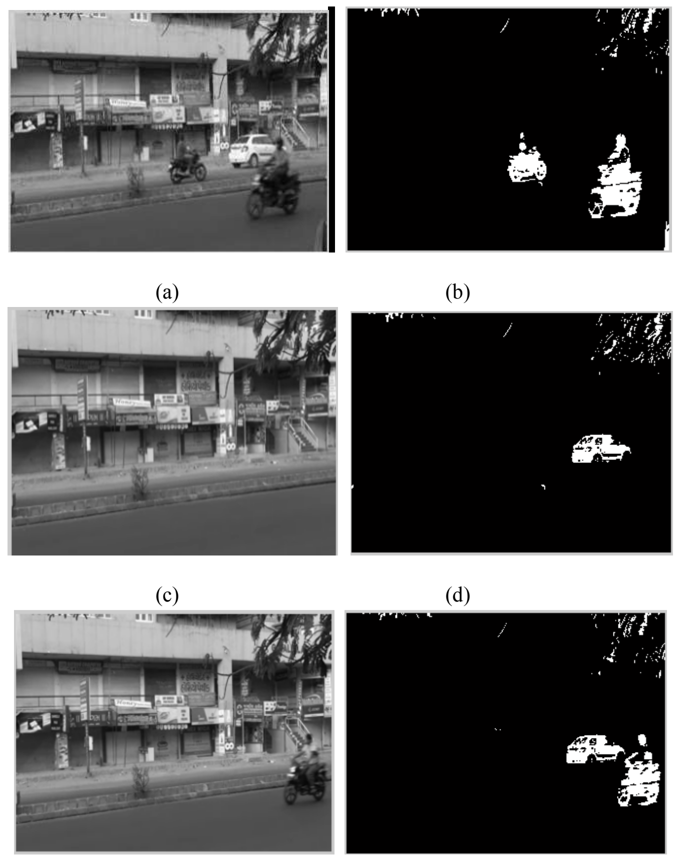
Fig. 8 shows the result of background subtraction using the background image generated by the algorithm. As the car in Fig. 8(a) remains stationary and the background image generated also contains the stationary object, resultant image obtained after background subtraction detects only the moving object.

A. Results of traditional background subtraction method

Applying traditional background subtraction technique requires having a background image which is used during subtraction. In order to adapt to the changes in the scene, background image must also change. It would be required to constantly monitor the video in order to check whether there is any change in the scene due to change in position of stationary object. Fig. 9 shows the background image for a video sequence. In the video when the background image is captured, there is a stationary object.

Fig. 9. Background image

Fig. 10 shows changes in the resultant image obtained after background subtraction as the scene changes.



(a) (b)

(c) (d)

(e) (f)

Fig. 10. Result of background subtraction: (a) video frame containing stationary and moving object both, (b) its thresholded image, (c) frame which does not have stationary object, (d) its thresholded image, (e) frame containing only the moving object, (f) its thresholded image

Fig. 10(b) detects the moving objects appropriately. But Fig. 10(d) and Fig. 10(f) detect the moving object incorrectly. In Fig. 10(c) and Fig. 10(e) there is no stationary object but still its thresholded image detects a moving object as this frame is subtracted from the background image containing the stationary object. In such cases if the background image does not adapt to the changes in the scene it will not detect moving objects correctly.

V. CONCLUSION

In this paper, a new approach for generating a background image from a real time video sequence using a single static camera has been proposed. The algorithm can efficiently generate a background image from a video which contains a stationary object for a long time. This algorithm when repeated again after certain interval can handle the scenario when the stationary object moves away.

It is considered that the initially generated background image has to be used for image subtraction till a new background image is generated. If the scene changes during that period then image subtraction will be carried out with the previously generated background image. As background estimation and object detection always run in parallel, the frequency of background updation can be increased without affecting the real time response time.

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