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Moving Object Detection using Recursive Difference of Gradientand sliding window for frame selection

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Abstract: Moving object detection is very important in the perspective of security nowadays. It can be used to monitor the suspicious and doubtful activities in that areas where human monitoring is not possible. In this paper, a novel moving object detection techniques are used which is based on recursive difference of gradients of the frames. Here we are using the concept of sliding windows for taking the frame difference. This technique is useful when we need to distinguish between slight movement and significant movements. There are various natural effects also called ghost effect which must be excluded before providing the final result. Our approach has flexibility to monitor variety of movements from slight to significant. Experimental results show the effectiveness of the proposed approach.

Key words: Moving object detection, Difference of gradient, sliding window, Ghost effect, Frame difference.

Introduction

Surveillance Systems is vital in the perspective of security. It is designed to monitor the movements in an area, spot the moving objects and report any doubtful situation [9]. This system needs to discriminate between natural entities and humans, which need a good object tracking system. Automation of the detection and tracking of moving objects in any surveillance video requires high level of artificial intelligence and also it's very challenging in various critical scenario. Many application have different event of interest to track so need a generalized approach for all type of requirements. Moving object detection is the basic step for Surveillance system. In this approach foreground objects are differentiated with background objects with various ways. The development of moving object detection approach for video surveillance systems requires less complex, fast, reliable and robust algorithms. A video may contains considerable amount of frames per second hence the algorithm must not only be less complex but also it must be less time consuming so that it can be used for real time processing. A generalized approach is required which can work for any type of videos either gray or color, or indoor or outdoor or in any light illumination condition.

There are many algorithms such as based on various techniques such as frame difference method, background subtraction method, optical flow method and statistical learning method etc, ar available to detect the moving objects in a given frame [1-7] of a particular video sequences.Each algorithm has its own pros and cons. In object detection and tracking, it is challenge to detect the moving objects with the subtraction of other ghost effects simultaneously.Xiaohui [8] has proposed an improved moving object detection algorithm which is based on the difference of successive frames as well as edge detection technique. The advantage of this approach is high detection and object recognition rate. It also improves noise restraining and objects segmentation method. But it is unsuitable for dynamic background. Another method is proposed by Soumya Varma[16] i.e. background subtraction method. Here the difference between the current image and background image in the given video sequence is taken. But due to changing environment background image changescontinuously, which may disturb the detected sequence of foreground pixels. To remove the aforesaid problem, Dina M. Rashed proposed a novel approach in [14] that is improved moving object detection algorithm based on adaptive background subtraction. Here background model is constructed and it is compared with the current images to identify foreground/background pixels and alsoreduces the processing time by minimizing the number of updated pixels in background model.

Wang and Zhao[17] presented a new motion detection technique by using background subtraction method. In this approach, a video is composed of number of video images which contains geometry feature of the target. It extractsappropriate information to validate the movement of targets and then detection results are finalized.

Rakibe and Patil[18] also proposed a different motion detection technique by using background subtraction algorithm. In this approach, a reliable background model is used which is based upon statistical data. A threshold is used in order to subtract the current image and background image. This subtraction leads the result of moving object detection. But this result may be not good enough due to noise issues hence some morphological filtering is applied to remove the noise and solve the background interruption problem. There are few disadvantages of moving object detection approaches which are based on background subtraction method. Kavitha and Tejaswini[19] presented an approach to overcome these type of problems. He has used a robust and efficiently computed background subtraction method. Shafie et al. [20] proposed a motion detection approach which is based on optical flow method. Optical flow can come up from the relative motion of viewers and objects hence by this way we can know the spatial arrangement of objects in space and also the rate of change of the spatial arrangement. We can segment the different objects by the discontinuities in the optical flow. Temporal difference and optical flow field are used to detect the motion in a technique which is developed by Shuigen et al. [21]. This approach is good for dynamic background. First of all, using two consecutive gray scale images an absolute differential image is calculated. Then low pass filter is used to filter out this absolute differential image and then it is converted into binary image. After that optical flow field is designed from image sequences using Hron's algorithm. At last, one can detect the moving object byusing indexed edge and optical flow field.Devi et al. [22] proposeda technique of comparing intensity values of image in subsequent stationary frames which is captured after the interval of every two seconds from the camera. In order to detect the movements at least two frames are required which are called refrence frame and input frame respectively. These two frames are compared and pixel values are determined based on the differences. A real time moving object detection algorithm is proposed by Lu et al.[23]. There are four techniques used to achieve this goal namely, the temporal differencing method, optical flow method and double background filtering (DBF) method and morphological processing methods.

Rest of the paper is organized as:

Section 2 describes the proposed approach. Section 3 demonstrates the experimental results and it analysis. Paper is concluded in section 4 followed by references.

II. Proposed Approach

Proposed approach is divided into six steps as shown in figure 1. Our assumption for this approach is that the objects are moving and camera is still. We will understand each steps in sequence.

2.1 Video Frame Extraction

First of all our objective is to extract the each and every frame from the video. This process will consume time as per the frame rate of the given system. Frames can be treated as the image. Hence we can apply all image processing techniques on the frames after extracting it.

If the video is in color format then each frame will have three dimensions for each image plane that is Red, Green and blue. If the Dimension of the given frame is of M x Nthen there will be total M x N x 3Processing planes in case of color video.

2.2Sliding Window Generation

In this proposal, we are using the concept of sliding window to obtain the desired amount of motion in given video. Here after frame extraction, we decide the number of frames which will be in a window. If we want to detect the significant motion in a given video then we need to take more number of frames in sliding window whereas if we want to get slight movement detection then we can reduce the window size. One can remove the ghost effect after deciding the slight movements using less window size. The number of frames per window must be odd, so that we can easily point out the center frame.

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Let us consider that the window size is n, it means n number of frames will be at a time in sliding window. The processing frame will be $\left\lceil\frac{n}{2}\right\rceil$ th number of frame. In figure 2 one can see the sliding window with five number of frames. Here colored frame is processing frame. It means that at the end of the processthis frame will be updated for black and white images. Where white pixels show the moving objects whereas black pixels show the stationary objects. Sliding window consider the overlapping frames, it means in each iteration $\frac{n}{2}$frames will always be repeated.

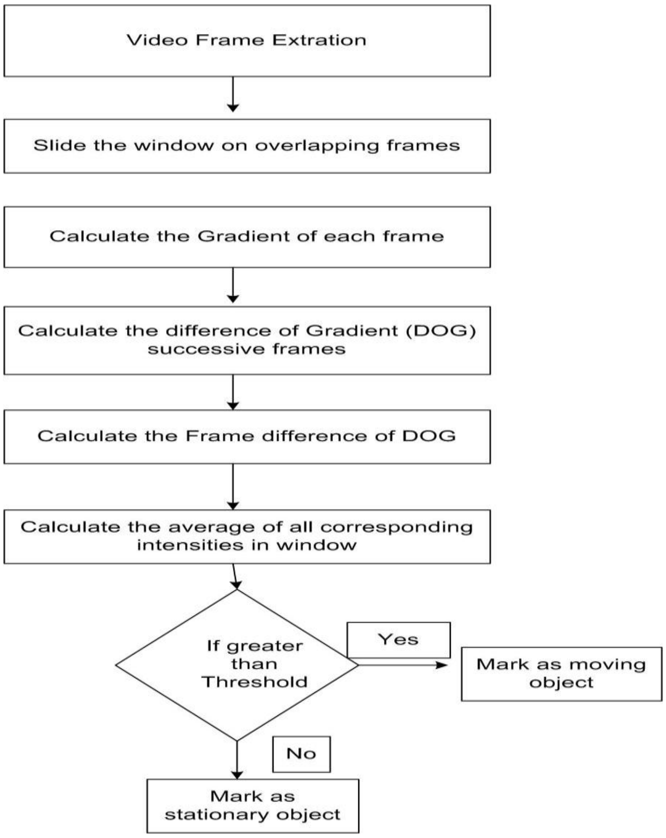

Figure 1- Flow Diagram of Proposed approach

2.2Gradient calculation for each frame

Once we identify the frames in window, we apply gradient on each frame to detect the information of edges. In order to apply the gradient we need to calculate the first order derivatives for each pixel in the given frame. Gradient can be calculated as

$$\frac{df}{dx} = f(x+1, y) - f(x, y)$$

$$\frac{df}{dy} = f(x, y+1) - f(x, y)$$

$$\nabla = \sqrt{\left(\frac{df}{dx}\right)^2 - \left(\frac{df}{dy}\right)^2}$$

For each frame there will be a corresponding gradient image hence total number of gradient frames will be n. By this way we can keep the track of all the structural information of the image which may be more important for moving object detection. After getting the information of edges we need to pre process the image for next steps. These preprocessing may include following steps.

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2.2.1 Morphological Operations

To enhance the quality of gradient we use some morphological operations. Here we process the images based on their shapes. In this process, we need two inputs first one is structuring element of different shape and another one is input image itself. After the morphological operation we get the output image of same size.Basically for morphological operations, black and white images are best option. There are many morphological operators, few of them are:

Erosion and Dilation: The most basic morphological operations are dilation and erosion. In dilation, we expand the width of edges or boundaries, while in erosion we shrink the edges or boundaries of object. Structuring element is responsible to decide the number of pixels to be added or removed.

Opening and closing: An opening operation is nothing but the erosion followed by a dilation using the same structuring element for both operations. Whereas closing is dilation followed by erosion with the same structuring element.

2.2.2 Edge Linking

Some times after edge detection, we may get the broken edges, which may cause the wrong and misleading results. Hence we need to link all the edges before next processing. Fo this we can Hough transformation. By we can know that the given three or more points are collinear or not. If they are collinear then we can draw an edge to join them.

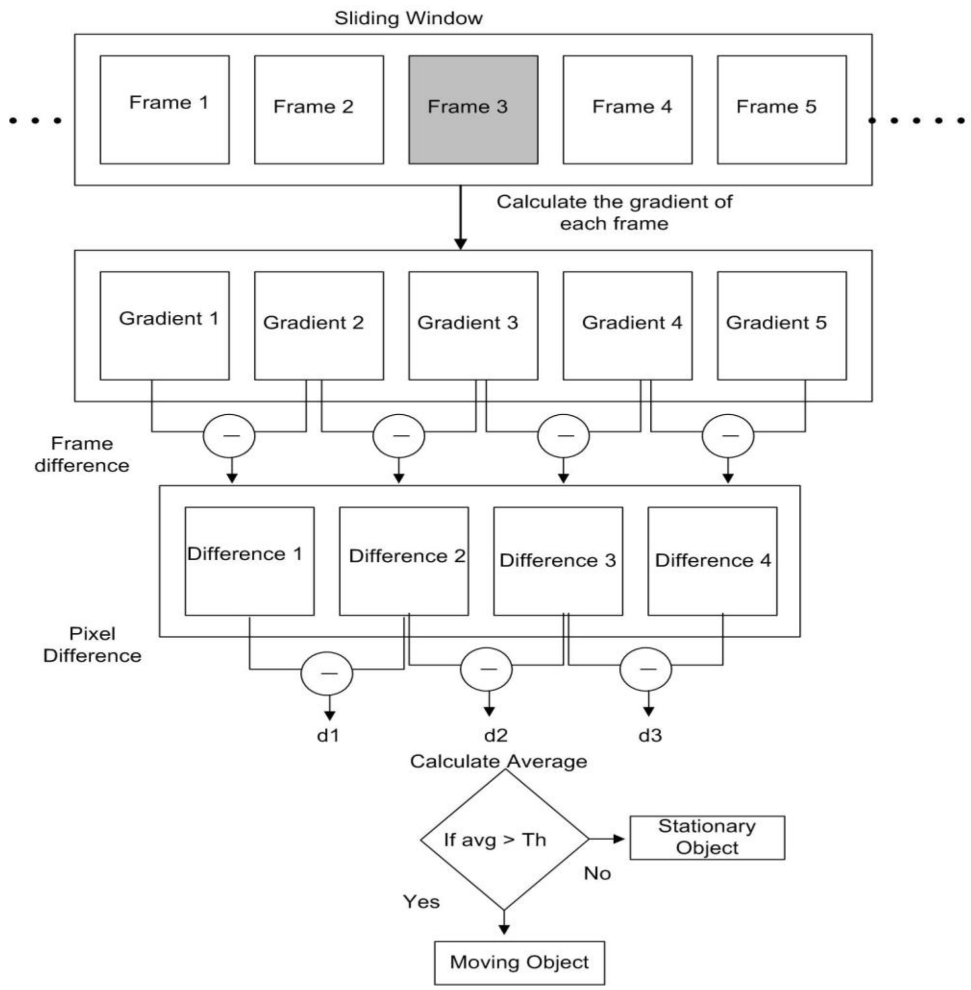

Figure 2- Working model of the proposed approach

2.3Difference of Gradient (DOG)

After getting the pre-processed gradient images we need to take the difference of gradient with its successive gradient of frame. S we can see in figure 2 that gradient 1 and gradient 2 are used to create difference 1 image. Similarly Gradient 2 and gradient 3 are used to create difference image 2 and so on.

$$\mathrm{Diff}_1 = \nabla_1 - \nabla_2$$

If there are n number of frames in a sliding window then total n-1 number of difference images will be generated. These difference image will keep the record of moving pixels or those pixels which are not similar with its corresponding successive frame's pixels. Since we are using gradient images for taking the frame difference hence we will have only those pixels in our account which have significant movement with respect to its successive frames.

2.3 Difference of DOG

Once we get the difference of gradient (DOG) after that we again calculate the difference of DOG. By this way we can eliminate very small movements of the objects which may be because of improper focus of camera or any signal fluctuation. These types of small movements are called ghost effect which must be filtered out before declaration of final results.

$$d_1 = \mathrm{Diff}_1 - \mathrm{Diff}_2$$

Hence if we have total nnumber of frames then we will get n-2number of difference of difference of gradient (DDOG). After calculating the DDOG we need to calculate the average of the all corresponding DDOG pixels.

$$\mathrm{Avg} = \frac{\sum_{i=1}^{n-2} d_i^{m,n}}{n-2}$$

In above equation we can see that we are taking each DDOG frame and calculating the average for all the corresponding intensities from each DDOG frame. If this Avgvalue is greater than a particular threshold then we will assign that pixel to white colour otherwise we will assign that pixel to black colour.

$$P_i^{m\times n} = \begin{cases} 0, & d_i^{m\times n} < th \\ 1, & d_i^{m\times n} \geq th \end{cases}$$

Here white pixels show the moving objects in the given frame whereas black pixels show the stationary objects.

III Experimental Results and Analysis

Proposed approach has been implemented in MATLAB 2015, window 7 (operating system) with processor Intel corei3. We have taken the videos of .AVI format. Figure 3 shows the result of our proposed approach when no movement is occurred. Here we can see that the output image is completely black. It means all objects are in stationary condition during that moment. Similarly figure 4 shows the just next frame of that video, where we can see that some white portions in output image. These white pixels are nothing but the moving objects in that particular frame. These two results are validated to ensure that the effectiveness of the proposed approach for gray scale and indoor videos. Figure 5 shows the list of few sample videos which are taken in our account to demonstrate the experimental results. Here we can see that we have checked our videos for outdoor scene also. For the experiments, our assumption is, we assume that static camera position. All videos are having good resolution and having good frame rate.

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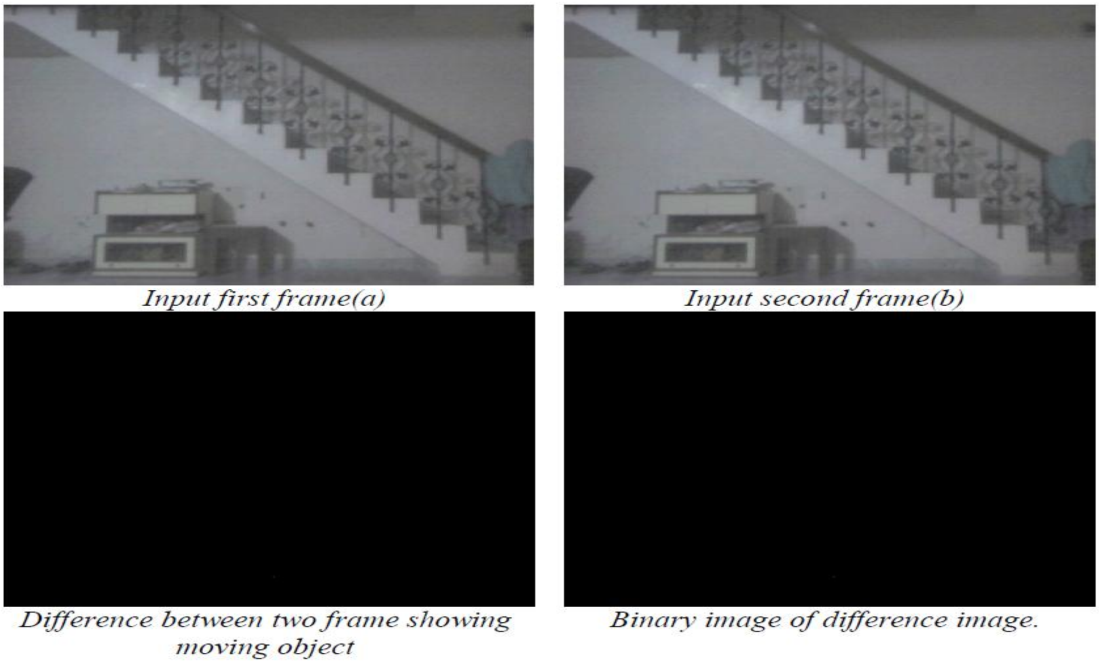


Figure 3- Frame difference without any movement.

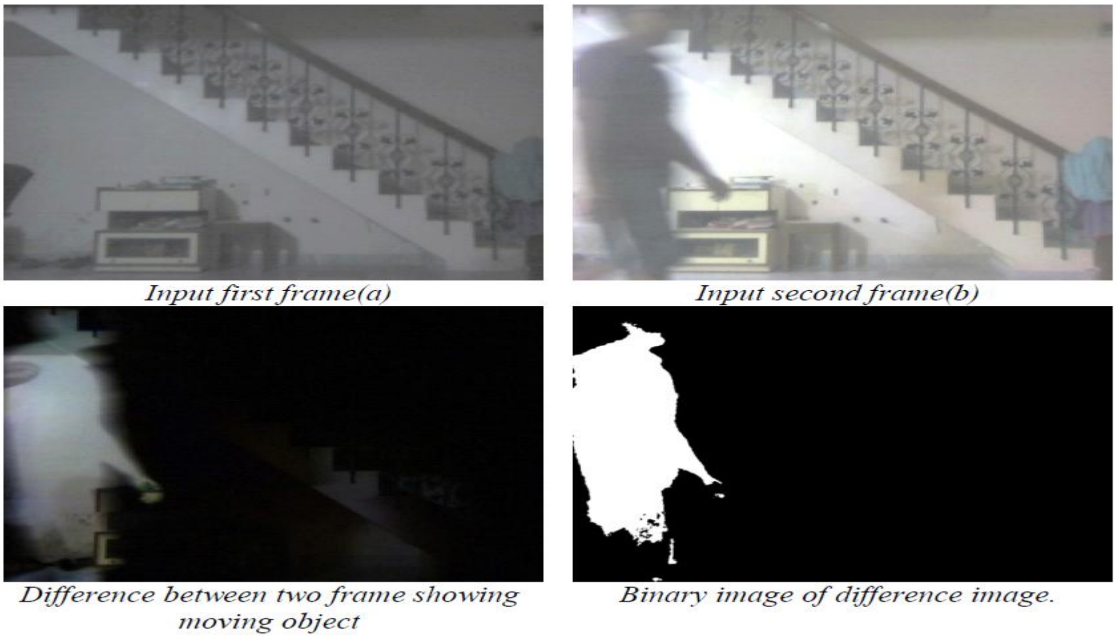


Figure 4- Frame difference with movement.

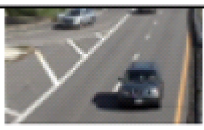
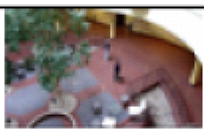
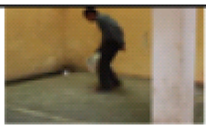
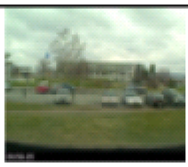
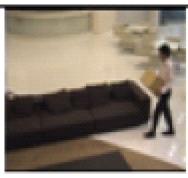
Video Set	Sample Frame	Sequence Type	Image Size	Background Property	Processing Time(sec)	Frameper sec	Total frames
1		Outdoor	360x640	Static	69	30	531
2		Outdoor	360x640	Static	55	30	431
3		Outdoor	240x320	Dynamic	23	25	152
4		Indoor	240x360	Static	47	25	695
5		Outdoor	120x160	Static	8	15	120
6		Outdoor	600x1000	Static	300	20	1350
7		indoor	600x1000	Static	228	15	875
8		outdoor	600x1000	Dynamic	168	20	612

Figure 5- Sample videos with their properties

Figure-6 shows the experimental results of our proposed approach. Here we can see that we are effectively detecting the moving objects.

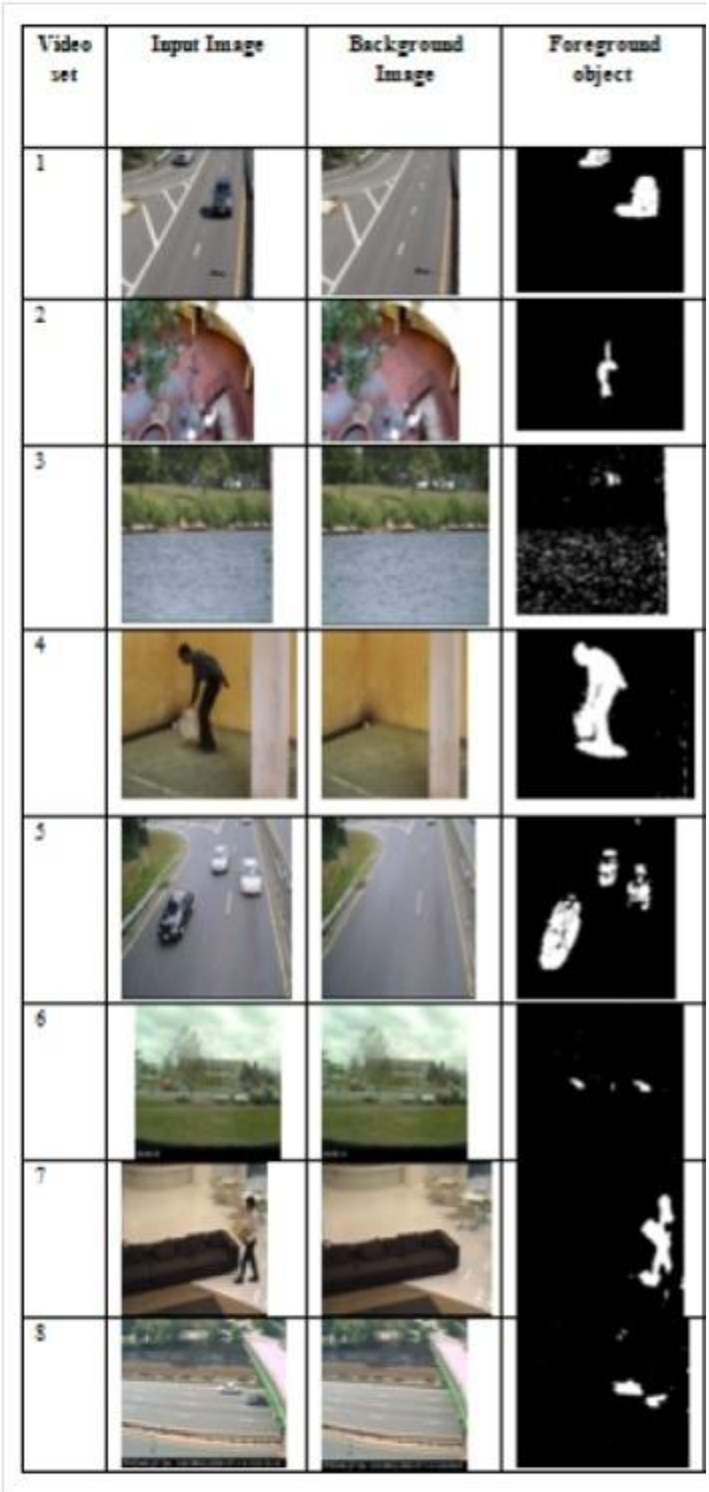


Figure 6- Experimental results forMoving object detection

Experimental results are also verified and validated with some objective evaluation parameters. There are various metrics like Precision, Recall, specificity, false positive rate, false negative rate and F-measure etc. which are used to check the effectiveness of the proposed approach.

$$\text{Precision (Pr)} = \frac{TP}{TP + FP}$$

$$\text{F-Measure} = 2\frac{Pr.Re}{Pr + Re}$$

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$$\text{Recall (Re)} = \frac{TP}{TP+FN}$$

$$\text{Specificity (Sp)} = \frac{TN}{TN+FP}$$

$$\text{False Positive Rate (FPR)} = \frac{FP}{FP+TN}$$

$$\text{False Negative Rate (FNR)} = \frac{FN}{TN+FP}$$

Here we can see that there are four parameters denoted as True Positive (TP), False Positive (FP), True Negative (TN) and True Positive (TP)

TruePositives (TP) = Number of pixels correctly identified as foreground

False Negatives (FN) = Number of actual foreground pixels incorrectly identified as back-ground

False Positions (FP) = Number of background pixels incorrectly identified as foreground.

True Negatives (TN) = Number of pixels correctly identified as background

IV Conclusion

In this paper, a novel moving object detection technique is proposed which is based on recursive difference of gradients of the frames. Here, the concept of sliding windows is used for taking the frame difference. This technique is useful when we need to distinguish between slight movement and significant movements by just varying the size of sliding window. There are various natural effects also called ghost effect which must be excluded before providing the final result. Proposed approach has very less complexity hence it can be used in runtime without any frame delay. This approach has flexibility to monitor variety of movements from slight to significant. Experimental results show that the proposed approach is effectiveenough to detect the moving objects in indoor as well as outdoor videos.

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