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# Moving Object Detection against Sudden Illumination Change Using Improved Background Modeling

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***Abstract*—This paper presents a moving object detection method against sudden illumination change using improved background modeling. Initially, background model is created for every pixel from the first frame. The sample values for the model of a pixel are collected from the neighborhood of that pixel. Then the new pixel values from the new frames are compared to make background foreground decision. Conventional background modeling faces problem with change in the illumination of the scene. The proposed method frequently checks whether abrupt change of illumination take place or not and then initialize the background model from the frame that is detected with changed illumination. The illumination change is detected by obtaining the images of two frames that are taken at a suitable interval in HSV color space. Then the mean change value of each channel is calculated to make a decision. This enables the background model to start over with new sample values that are obtained in the current illumination condition and the background subtraction process can successfully detect moving object with greater accuracy even in changing illumination condition. Simulation results indicate that the proposed method gives excellent results in illumination changing condition to detect moving object whereas the conventional background modeling can not detect accurately. Comparison analysis shows that our proposed method outperforms recent methods in terms of detection accuracy.**

***Keywords—Background modeling, Illumination change, HSV color model.***

## I. Introduction

The exponential prosperity of technology has resulted into the emergence of many automatic video processing applications. Moving object detection has been a widely researched topic in the area of artificial intelligence, vision understanding and surveillance system. It has immense importance due to the fact that it serves as a prerequisite state for many higher level video processing applications like object counting, behavior analysis, appearance recognition and so on. Even after so many years of research work in this field, moving object detection faces some major challenges like cavity inside foreground object, dynamic background scene, illumination change etc. For this reason, there is still very good opportunity for improvements and new methods are being proposed with the goal of solving these problems. A significant number of methods have been proposed to solve the challenges of motion detection consisting of different strategies. A few of the most widely used techniques are optic flow calculation, frame differencing and background subtraction. In [1], the author provides a brief classification of the classical approaches for moving object detection with their respective advantages and disadvantages. In [2] the optical flow information is calculated and some morphological operations are combined to detect moving objects. The main disadvantage of this method is the computational complexity. Frames differencing method concentrates on extracting the difference between frames of a video scene proposed in [3]. But this method fails to obtain the complete contour of the foreground object. In [4], authors present a novel and efficient texture-based method for modeling the background and detecting moving objects from a video sequence. The authors of [5] and [6] propose a block based background modeling method using texture description. But texture based methods face problems while it comes to smooth parts of the scene such as windshield of a car, which is a major drawback of these methods. In this paper [7], they propose a robust background subtraction approach via multiple features based shared models. Background subtraction is also used in [8]. In [9]-[11], recursive equations are utilized to update the parameters used in these methods. In [12], the authors suggest a universal background modeling approach ViBE that is simple but efficient. It gives very good results but the background model needs to be restarted in case of illumination change in the scene. The authors of [13]-[15] also use background subtraction and modeling for detection of moving object. The evaluation of this method in different challenging conditions is given in [16]. Combination of color and texture feature is used in [17], where this method combines the advantage of these two features, but this method is modified from its actual version to produce a result that discards its disadvantages. The methods proposed in [18] and [19] work on specially detecting camouflaged object, which is very hard to detect for conventional methods. In the methods[20] and [21], the authors follow a nonparametric background modeling paradigm, similar to the prior work of [12], with some new modifications. In [22], illumination invariant property is used to show robust result against illumination change with the same target as

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in [23]. Another type of research work is in vogue which focuses on particular problems instead of working for a universal method like [12]. Such a particular challenge is dynamic background problem reported in [25] and [26]. In [27], the author discusses about detection of aerial moving objects. Non stationary background problem is aimed to be solved in [28]. Apart from these methods there are also various methods that are used to detect moving object from a video scene such as saliency map. But the challenge is that these different techniques can not stop at just getting good results in normal conditions they also have to focus on challenging conditions and computational costs. As much work is being done on this topic, more new challenges are being discovered, which are leading to more research in this area. To overcome these limitations, in this paper we propose a moving object detection method against sudden illumination change using improved background modeling. Simulation results indicate that the proposed method gives excellent results in illumination changing condition to detect moving object whereas the conventional background modeling can't detect accurately.

The rest of the paper is organized as follows. Section II gives background information. Section III demonstrates the proposed moving object detection method step by step. Section IV discusses the experimental results of the proposed method. Finally, Section V concludes the paper.

## II. Background Information

### A. Cavity

Cavity is one of the challenges faced while moving object detection takes place. Cavity is actually a hole inside the contour of a foreground object. When there remains undetected foreground pixels inside the contour of a moving object then we call this phenomena a cavity. It decreases the efficiency of moving object detection process and gives bad result which causes problems for later higher level processing of that segmentation map. It can be caused by various reasons like smooth part of moving object for example, the windshield of a car or resemblance of color of cloth of a person with the background etc.

Fig. 1. Cavity inside detected foreground object

### B. Ghost

The term **"**Ghost**"** is very important in the moving object detection process. A ghost is basically nothing but some false detected foreground pixels. But it's the situation in which the ghost emerges is more important because it is one of the challenges of moving object detection. This specifically happens in background modeling cases where the first frame or the frames that are responsible for initialization or the frames from where the sample values for a background model are taken, contains an object that is moved in the next coming frames. In that case, the vacant place it leaves behind is detected as foreground and continues to do so until it is suppressed into the background by the update process. The wrongly detected part of the scene is called **'**ghost**'** in the sense that the movement detected is not distinguishable in our eye.

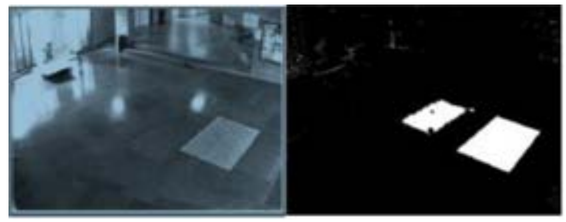

Fig. 2.Emergence of **"**ghost**"** for moving an object from the first frame

### C. ViBE

ViBE is a universal background subtraction algorithm used for detecting moving objects from video sequence. This method approaches the problem of moving object detection using background modeling. A background model for each pixel is created beforehand with samples taken randomly from the neighborhood of the pixel. Then the new value of a pixel in the next frame is checked to see if it is closed to a least number of samples of its background model. If yes, then the new pixel is detected as background. Otherwise, it is detected as foreground pixel. The background models are updated from time to time. This method is simple but efficient in detecting moving object. The parameters do n**o**t need to be updated for different conditions. But this method gives bad result when the illumination of the scene changes abruptly.

## III. Proposed Method

The proposed moving object detection method can be divided into three main parts. The first part is background modeling and detecting moving objects by comparing the current frames with that model. The second part is the detection of illumination change to see if the illumination condition of the scene has changed and take necessary steps to prevent the background modeling from giving bad results. Finally, the last part is to integrate the initial processes together to complete the proposed algorithm, which are described in details below:

### A. Background Modeling Technique

In our proposed method, we used a similar method for background modeling reported in [12]. It has some very good properties with which it is able to detect moving object properly in normal conditions. But it has a problem when it comes to illumination change. The method shows inaccuracy in such conditions. To overcome this limitation, in this paper we propose an illumination detection process which is used to detect abrupt illumination change in the scene and it is illustrated in

Fig. 3. The proposed background modeling technique used to detect moving object is discussed step by step.

Step 1: In background modeling initialization process, we create a model for each pixel of the background. The model consists of N sample values collected randomly from the eight-connected neighborhood of that pixel. If NG(x) is a spatial neighborhood of a pixel location x, then the model consists of

$$M(x) = \{v(y \mid y \in NG(x))\} \quad (1)$$

Suppose we take a pixel in a Euclidean color space. The model M(x) is created for x with sample values v.

$$M(x) = \{v_1, v_2, v_3, \ldots, v_N\} \quad (2)$$

Here, M(x) is the background model for the pixel at position x. N is taken to be 10 in our method as it shows good results.

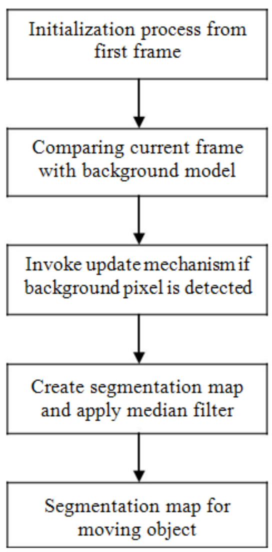


Fig. 3. Block diagram of background modeling technique

Step 2: To classify a pixel v(x), it is compared with values of M(x) by defining a sphere $S_R(v(x))$ of radius R centered on v(x), where R is the matching threshold and is taken to be 20 as suggested in [12]. The new pixel is considered to be a background pixel if the cardinality of the intersection of the sphere and the model samples M(x) is larger than or equal to a given threshold #min, which is taken as 2, because all of the samples are really good candidate for background.

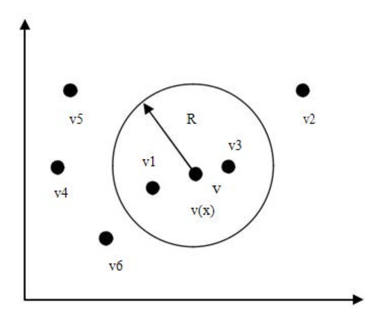


Fig. 4. Comparison of a pixel value with a set of background sample

More formally, we compare #min to

$$\#\{ S_R(v(x)) \cap \{v_1, v_2, v_3, \ldots, \}\} \quad (3)$$

The comparison is carried on until #min matches are found. The sensitivity of the model depends on the ratio of #min and N.

Step 3: If a background pixel is detected then the model of that pixel is updated with the new value. The value to be replaced is chosen randomly. It is also used to update the background model of one of its neighboring pixels, which is also chosen randomly.

Step 4: Now, the detected background and foreground pixels are assigned the value of 0 and 255 respectively. Median filtering is also used in this step to remove noise.

Step 5: Finally we get the moving object detection result for each frame in the form of binary image, in which the moving object is covered with white color while the background is black. Fig. 4 shows a comparison of a pixel value with a set of background sample.

### *B. Illumination Change Detection*

Illumination change detection is a significant step in this process. The change of illumination causes the existing background model to fail as it does not consist of any value that will match the current pixel value. All the pixels of the scene affected by illumination change will be wrongly detected as the foreground pixel while they are not. For this reason, detection of the change in illumination is very important.

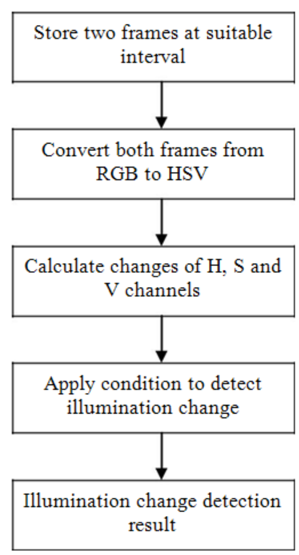


Fig. 5. Block diagram of illumination change detection technique

Fig. 5 shows the block diagram of illumination change detection technique and the detection process is described in the following steps.

Step 1: At first the two frames that are to be checked for illumination change have to be stored in their original RGB color space.

Step 2: Then they are converted to HSV color space from RGB color space, because it helps to determine the change of illumination between the saved frames.

Step 3: In this step, the mean change value of H, S and V channels between the two frames are calculated.

Step 4: Then we apply the following condition to decide if there is a significant change in the illumination.

((Change of V> Change of H) or (Change of V>Change of S)) and (Change of V>0.05)and (Change of H>0.001) and (Change of S>0.001)

Step 5: Finally if the condition is satisfied then illumination change is detected and necessary actions are taken to restart the initialization process.

### *C. Integration of Background Modeling and Illumination Change Detection Technique*

In this section, we integrate the two previously described modules in a way that the process is enabled to continuously check for illumination change in a scene along with background subtraction. Background model is created from the first frame. The background subtraction process continues all along. The illumination change detection process works with two frames in every six frame interval to see if significant change of illumination takes place or not. If illumination change is detected by this process then the background model initialization process is recalled using the current frame. In this way new background model is created consisting of sample values of the new illuminating condition. Fig. 6 shows the integration of background modeling and illumination change detection process.

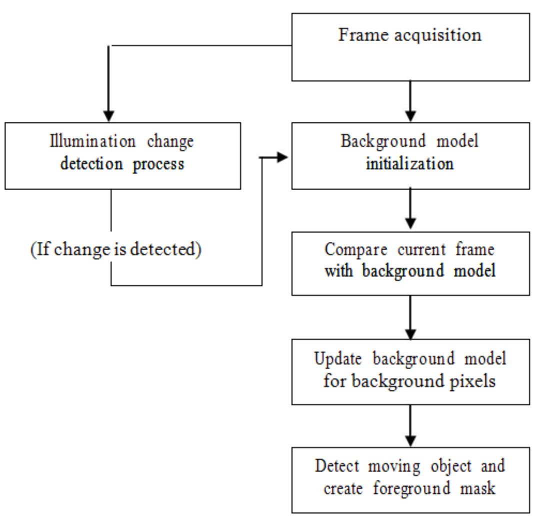


Fig. 6. Integration of background modeling and illumination change detection process

## IV. Experimental Results and Discussion

In this section, we have discussed the experimental results of our proposed method. We have used various videos with different illumination conditions. The illumination detection process takes two frames at the interval of six frames to check if the illumination condition changed significantly. The interval can not be too long because if illumination change takes place just after a frame is taken for checking then the detection result is inaccurate for the rest of the interval time. From experiment results, we observed that taking five to ten frames as interval provides good result. In this case even if illumination changes at the beginning of an interval the inaccurate results disappear quickly as model is initialized very soon after the interval. We will also have to be aware of the fact that taking a small interval increases computational cost. In our method we conducted the experiments with a frame interval of 6.Fig. 7 shows the storing two frames at a interval of six frames. The condition that is used in the method for detection of illumination change is also achieved by some empirical data, they are given in Table I.

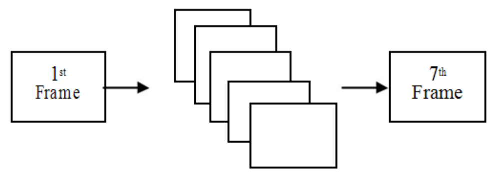


Fig. 7. Storing two frames at a interval of six frames

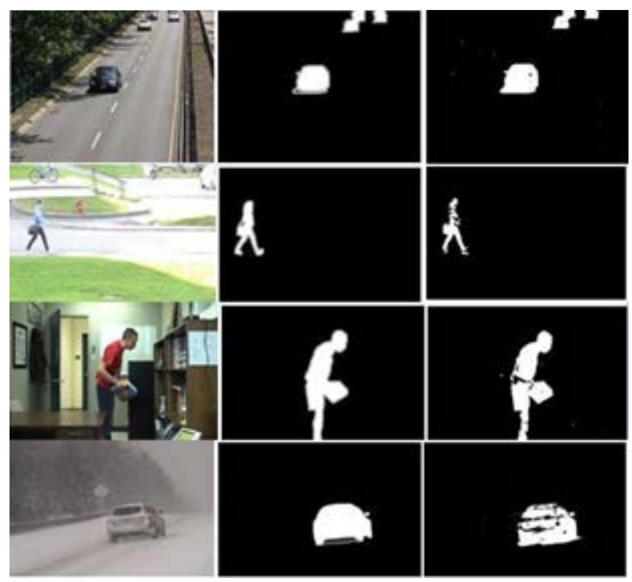

Fig. 8. Moving object detection results
(a) Input frame (b) Ground truth (c) Segmentation map

As we can see from Fig. 8, moving object in different conditions is detected almost completely. Some cavities can be noticed in the segmentation of the moving car in the last example (car in blizzard), that is caused by the snow covering the car and giving it almost the same color as the road. The Precision, Recall and F-measure of some tested videos are also given later to show the performance of our method.

From TABLE I, we observed that the illumination change takes place when mean change in V channel is greater than that of H or S channel.

TABLE I. Required VALUE CHANGE FOR H, S AND V CHANNEL

| Initialization required? | Mean change of H channel value | Mean change of S channel value | Mean change of V channel value |
|---|---|---|---|
| Yes | 0.1260 | 0.2160 | 0.6594 |
| Yes | 0.0232 | 0.0762 | 0.0433 |
| Yes | 0.1713 | 0.1334 | 0.5388 |
| Yes | 0.0127 | 0.0321 | 0.0872 |
| No | 0.000857 | 0.0185 | 0.0494 |
| No | 0.0021 | 0.000644 | 0.0010 |
| No | 0.0002961 | 0.0030 | 0.0011 |

But we also noticed that in some cases the condition is triggered even if the restart of the model is unnecessary. These cases cause emergence of ghost due to initialization without any reasonable benefit. So to stop these unnecessary initializations we augmented the condition observing the data, that the change in the V channel must be above 0.05 and the change in H and S channel must be above 0.001. This condition proves to be very efficient in triggering re-initialization when necessary and avoiding them when not required. The proposed method was tested using the changedetection.net 2014 dataset for different conditions. It shows very good results for those videos.

From the Table II, we can see that our method performs strongly in baseline videos such as pedestrians, office, and highway. It also shows very good results in snowfall video which features bad weather. The canoe and overpass video have comparatively lower precision and recall because of the dynamic background that is caused by the water of the lake and the shaking tree in those videos. But comparing our method with some existing methods we observed that it performs better.

TABLE II. PRECISION AND RECALL VALUE

| Video Name | Precision TP/(TP+FP) | Recall TP/(TP+FN) | F-measure (2.Pre.Re)/(Pre+Re) |
|---|---|---|---|
| Pedestrians | 0.96 | 0.85 | 0.9 |
| Highway | 0.87 | 0.85 | 0.86 |
| Office | 0.96 | 0.81 | 0.88 |
| Snowfall | 0.87 | 0.72 | 0.79 |
| Overpass | 0.77 | 0.72 | 0.74 |
| Canoe | 0.49 | 0.80 | 0.60 |

TABLE III. DETECTION PERFORMANCE COMPARISON

| Method | Average Precision | Average Recall | Average F-measure |
|---|---|---|---|
| Moving Average | 0.33 | 0.571 | 0.42 |
| Recursive Median | 0.371 | 0.642 | 0.47 |
| GMM | 0.532 | 0.47 | 0.5 |
| BGFG | 0.645 | 0.614 | 0.63 |
| Proposed Method | 0.63 | 0.76 | 0.69 |

We compared our proposed method with moving average [29], recursive median [30], GMM [31] and BGFG methods. All results were achieved for the Overpass and Canoe video of the changedetection.net 2014 dataset. The average Precision, Recall and F-measure value for the two videos are given for the sake of comparison. From the table III we can see that our proposed method has the highest value of average recall and f-measure among other methods. It also has a good value of average precision. This comparison shows that our method performs well in case of dynamic background. Another comparison is shown with the temporal information technique proposed in [32]. This was also done on the average value of Precision, Recall and F-measure. The following comparison shows that our proposed method performs well in comparison with recent methods.

From the results and comparisons with the existing method we can clearly see that our method shows good result in normal condition and challenging conditions like snow, tree shaking etc. The novelty of this method was the illumination change detection process which comes into play in case of illumination change in the video scene. Fig. 9 shows the moving object detection by fixed illumination condition and changed illumination condition. Fig. 10 shows the moving object detection by the proposed method. We also observed that the moving person is detected without any problem by the conventional background modeling technique but it fails to detect in a changed illumination condition. Table IV shows the detection performance accuracy. It is seen that the proposed method detects moving object with better accuracy than the conventional background modeling.

Fig. 9. Moving object detection by background modeling in
(a) Fixed illumination condition (b) Changed illumination condition

The figure above shows that the conventional background modeling method fails to show accuracy when the initial illuminating condition changes. In 9(a) it detects the object pretty well but in 9(b) when the lighting condition is slightly changed inaccurate detection takes place.

Fig. 10. Moving object detection result by proposed method in changed illumination condition

From these figures 9 & 10, we observed that our method detects moving object accurately when the background modeling technique [12] fails.

TABLE IV. DETECTION PERFORMANCE COMPARISON

| Method | Average Precision | Average Recall | Average F-measure |
|---|---|---|---|
| Temporal Information | 0.743 | 0.91 | 0.818 |
| Proposed Method | 0.75 | 0.88 | 0.809 |

## V. CONCLUSIONS

In this paper, a moving object detection method has been introduced against sudden illumination change using improved background modeling. We have simulated our proposed method with different videos in various illuminating conditions. The main contribution of our work is the integration of illumination detection process with the conventional background modeling method. In our proposed method, it is not needed to restart the initialization process manually when the illumination change occurs. We observed that the proposed method gives excellent results in illumination changing condition to detect moving object whereas the conventional background modeling fails to detect moving object accurately. We also observed that the proposed method performs very well with dynamic background. Comparison analysis shows that our proposed method outperforms recent methods in terms of detection accuracy. The main limitation of our proposed method is that it faces some problems when the moving object is of the same color as the background. In future, we will improve our proposed method to overcome this limitation.

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