Implementation of the Gaussian Mixture Model Algorithm for Real-Time Segmentation of High Definition video: A review

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Abstract— The detection of moving object is important and critical task in Real-Time video signal. This becomes more critical under this circumstances such as luminance changed, weaving leaves, rainy weather, under heavy snow fall weather. In this paper we studies background subtraction algorithm for foreground detection. Foreground detection is mainly with help of these two approaches, pixel to pixel and frame to frame comparison. But in real-time video sequence pixel to pixel foreground detection is complex because it has more time for processing because in this method compares pixel value. And in frame to frame comparison method compares two consecutive frames. In this paper by using GMM Algorithm improves result in case of less illumination as well as the images having moving objet of the background. In this paper, many soft computing techniques is used such as filtering, mean square error, recall, precision etc. will used for identifying foreground.

Index Terms— soft computing, filtering, recall, precision, MSE, GMM, BG, FG.

I. INTRODUCTION

Identifying of moving objects from a video sequence is a fundamental and critical task in video surveillance. For security purpose motion detection is very essential. Basically motion detection is the process of detecting change in position of an object relative to stationary part. Normally background subtraction based on static background but this is not applicable Real-Time video signal. In previous work mostly algorithm assumes that illumination in scene remains constant [1-2]. Grievously in indoor environment reflection or animated images on screens lead to background images and in outdoor environment illumination is changed due whether problem identification of moving becomes more critical when luminance is changed. In background subtraction technique, set the background and then see what changes occur in background. In defining the background is assumed that stationary objects that can be variations in color and intensity versus time. Foreground detection process is detection of moving object. Foreground detection can be achieved by both mechanical and electronic system. When apply electronics system, for detecting a moving object a simple algorithm is used for motion detection. In this algorithm compares the current image with a reference image. Generally in video processing video signal is segmented into image frame [3]. A common method for real-time segmentation of moving regions in image sequences involves “background subtraction,” [4].

The methods are available for moving object detection are Background subtraction and Feature comparison [2]. Background subtraction is very common technique for foreground detection. Background subtraction divides in two categories [5].

1. Frame To Frame Comparison
2. Pixel To Pixel Comparison.

In frame to frame comparison techniques two consecutive frames are compared. And in pixel to pixel comparison method two consecutive pixel value of video signal are compared. First method is better because in this method whole frame is compared but in second method each pixel value is compared. So pixel to pixel comparison algorithm is more complex and processing speed also reduces in pixel to pixel comparison. So first method, is suitable and faster.

Real-Time video processing, demands simple and fast algorithm. For achieving best result in Real-Time video sequence update the background properly. Efficiency and accuracy of Real-Time video signal depends upon the background updating technique and value of threshold value in background subtraction technique [1]. For outdoor environment new illumination independent algorithm, is used for background subtraction this is background subtraction algorithm using GMM.

II. RELATED WORK AND CONTRIBUTION

In most algorithms in foreground detection is assumed that illumination is constant. This is very vast area for research many researchers works on this area. We summarized some works in below table.
<table>
<thead>
<tr>
<th>S. N.</th>
<th>Title</th>
<th>Technique</th>
<th>Outcome</th>
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<tr>
<td>1.</td>
<td>A statistical approach for real-time robust background subtraction and shadow detection</td>
<td>Clustering detection elimination</td>
<td>Detection rate =0.99 Brightness distortion=0.4</td>
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<td>2.</td>
<td>An Improved Adaptive Background Mixture Model for Real time Tracking with Shadow Detection</td>
<td>Adaptive background mixture model</td>
<td>Shadow detection reduces the effect of small repetitive motions in the background scene.</td>
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<td>3.</td>
<td>Multi valued Background/Foreground Separation for Moving Object Detection</td>
<td>fuzzy approach to the background model update procedure</td>
<td>For WS Recall=0.8606 Precision=0.9684 For MR Recall=0.8751 Precision=0.9108</td>
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<td>4.</td>
<td>Robust techniques for background subtraction in urban traffic video</td>
<td>Frame differencing and adaptive median filtering</td>
<td>This technique gives better result under fog, snow and heavy traffic</td>
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<td>5.</td>
<td>GPU implementation of Extended Gaussian mixture model for Background subtraction</td>
<td>Extended Gaussian mixture model</td>
<td>Frame rate and speedup decreases.</td>
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<tr>
<td>6.</td>
<td>Moving object detection using Matlab</td>
<td>Thresholds at various Phases.</td>
<td>This algorithm detects background dynamically and gives effectively foreground and also removes the shadow.</td>
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<td>7.</td>
<td>Real-time background generation and foreground object segmentation for high-definition color video stream in FPGA device</td>
<td>Methods based on optical flow and background generation followed by background subtraction.</td>
<td>The foreground object segmentation method gives three pieces of information: lightness, color and texture in order to obtain better results and removes the shadows.</td>
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<tr>
<td>8.</td>
<td>ASIC and FPGA Implementation of the Gaussian Mixture Model Algorithm for Real-Time Segmentation of High Definition video</td>
<td>Open CV version of the Gaussian mixture model (GMM), a background identification Algorithm.</td>
<td>The FPGA implementation when compared with previously proposed background identification circuits provides Improved speed and logic utilization.</td>
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### III. ALGORITHM USED FOR MOVING OBJECT DETECTION

Motion detection in consequent images is nothing but the detection of the moving object in the scene. In video surveillance, motion detection refers to the capability of the surveillance system to detect motion and capture the events [6]. Motion detection is usually a software-based monitoring algorithm which will signal the surveillance camera to begin capturing the event when it detects motions. This is also called activity detection.

Let us consider that a video frame in which background is highway image as shown in fig 1. Let us assume that this is first frame. A moving object is entered on highway as shown in fig 2. Let us assume that this is second frame. When we compare this two consecutive frame then pixel of same value is subtract. As shown in fig 3(detection of moving object) same pixel which is in background is subtracted and pixel value of car is changed frame to frame is detected. GMM algorithm is used for improving result as shown in fig 4. This output is proposed output.
1. **Preprocessing**: Preprocessing consists of simple image processing tasks. In image processing, mostly images are available in either RGB or HSV color space. In video signals, one scalar value per pixel. In preprocessing, reduce camera noise which produces under such circumstances like rainy, fog whether of outdoor images. In preprocessing, smoothing can also be used to reduce camera noise.

2. **Background modeling**: Background modeling plays a very vital role in the background subtraction algorithm. Background modeling divides into two parts [2, 7].
   
   A. **Non Recursive**: In non-recursive method, stores previous video frame of video signal. Non-recursive techniques are used in a sliding window approach for background estimation. Some common techniques used in non-recursive methods. This method is frame differencing, median filtering, linear predictive filter, and non-parametric model.
   
   B. **Recursive**: In recursive methods, do not store previous video frame. Recursive techniques commonly use approximated median filtering, Kalman filter, and mixture of Gaussian. In comparison of non-recursive techniques, recursive techniques require less storage of memory.

*Background estimation*: The absolute background subtracting estimation by the help of this equation [4].
Threshold error is produced between current pixel and background pixel [4].

3. **Foreground detection**: foreground detection compares the video frame with the background model and identifies candidate foreground pixel from the input frame. The most commonly used approach for foreground detection is to check whether the input pixel is significantly different from the corresponding background estimates [2]. Generally threshold value is taken lower value (small number 3 to 5) [6] in this paper take threshold value 2.5.

\[
|I_t(x, y) - B_t(x, y)| > T
\]

Another popular foreground detection scheme to threshold based on normalized statics [4]:

\[
\frac{|I_t(x, y) - B_t(x, y)|}{\sigma_d} > T_s
\]

Where \(\mu_d = \text{mean of } |I_t(x, y) - B_t(x, y)|\)

\(\sigma_d = \text{standard deviation of } |I_t(x, y) - B_t(x, y)|\)

For all spatial location of \((x,y)\)

4. **Data validation**: Data validation is improving the result of foreground detection. In background detection arises the three limitation first, they ignore any correlation between neighboring pixels; second, the rate of adaption may not match the moving speed of the foreground objects; and third, non-stationary pixels from moving leaves or shadow cast by moving objects are easily mistaken as true foreground objects. After data validation evaluate result by the help of two formulae. These formulae are recall and precision. These formulae compare various backgrounds modeling technique. These formulae are mentioned below

Recall: in image processing recall is the common parameter which is used to improving result of two consecutive frames. Recall is ratio of number of retrieved images that are also relevant and total number of relevant images. In this paper number of number of retrieved images that are also relevant is number of foreground pixel which is correctly identified and total number of relevant images is number of foreground pixel in ground truth [1].

\[
\text{recall} = \frac{\text{number of foreground pixel correctly identified by algorithm}}{\text{number of foreground pixel in ground truth}}
\]

Precision: precision is ratio of number of retrieved images that are also relevant and total number of retrieved in this number of retrieved images is number of foreground pixel detected [1].

\[
\text{precision} = \frac{\text{number of foreground pixel correctly identified by algorithm}}{\text{number of foreground pixel detected by the algorithm}}
\]

**Mean Square Error**: The mean square error is used as part of the digital image processing method to check for errors. Two MSEs are calculated and then compared to determine the accuracy of an image.

Now we calculate the mean square error by the formula [8]

\[
MSE = \frac{1}{MN} \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} (I(m, n) - I_{ref}(m, n))^2
\]

IV. CONCLUSION

We have studied a few of the papers in the field of detection of moving object in the background subtraction algorithm. The detection of moving object is very essential for security purpose. For correct and efficient detection of moving object to reduce the load on the human observer and traffic monitoring, an automatic method for detection of moving object is highly desirable. In this paper automated moving object detection methods through background subtraction has been surveyed. After surveying we can conclude that the automatic detection method for the moving object in the background subtraction algorithm can be broadly classified into following category: pre-processing, background modeling, foreground detection, and data validation. Various algorithms have been
proposed in the literature. For example, for feature extraction background subtraction and foreground detection are used. Background subtraction subtracts same pixel value whereas foreground detection is used to extract moving object. We analyze them based on how they differ in preprocessing, background modeling, foreground detection, and data validation. In background modeling we used recursive and non recursive method. The advantage of recursive technique is that it does not require the prior knowledge of the system under consideration and are very well suited for modeling the dynamic systems on a real-time basis. The results of methods proposed by different people in traffic video processing are used to focus on the various combinations of techniques and their performances. The results of various algorithms are discussed.

V. FUTURE SCOPE

The detection of the moving object in the traffic monitoring is a difficult task. After studying the previous research papers in the field of detection of moving object, it is found that a lot of work has been done in the field of detection of moving object. But very little research work has been done in the field of moving object detection by the help of background subtraction. Further, the development of automated analysis of background subtraction using GMM has been hindered by the subtle nature of moving object abnormalities which appear as under some critical weather like heavy rain, fog. Hence there are very large scope of research in this field exists.

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