Improved Background Subtraction Techniques for Security in Video Applications

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***Abstract*—This paper attempts to find moving objects by subtracting the background images from static single camera video sequences in security systems. It aims to improve the background subtraction techniques for indoor video surveillance applications. For dynamic video sequences, the object focus and object tracking are very difficult due to changing of various parameters such as camera noise, illumination changes, motion changes, and geometry of background changes. The background subtraction algorithm provides the solution to detect moving objects in the static scene. The recursive and non-recursive algorithms are discussed in an improved way. The novel automatic threshold updating (ATU) algorithm is also developed and tested for various indoor video sequences which gives better efficiency. The statistical and temporal differencing methods are also presented. Finally, our novel approach is compared with the existing methods.**

Keywords- Background subtraction algorithm, Background modeling, Motion detection, Recursive and non recursive algorithms, Video security systems.

I. INTRODUCTION

In recent years, the video surveillance system has been a very important research area in monitoring humans and their behaviors to analyze the habitual and unauthorized activities [1],[2],[3]. This can be applied in various areas such as security systems, sports, medical field, air port terminal check-in and robotics etc. The problem here is that the background has illumination changes, camera noise, reflections and motion changes. The segmentation of object is an important because in the indoor as well as outdoor surveillance video data, there are many numbers of static and dynamic objects and may have their movement. The existing algorithms are implemented with the use of manual updation according to the scene. But we develop an algorithm for continuously moving video frames and update the threshold of each frame in a suitable manner using ATU algorithm in an automatic way.

II. RELATED WORK

In computer vision systems, the segmentation of moving objects is a very important research problem in surveillance applications [4]. Ariel Amato *et al.* [5] propose a method for Background subtraction technique based on Chromaticity and Intensity Patterns for indoor surveillance applications. Sometimes shadings and shadows are introduced due to local and global illumination changes.

III. BACKGROUND SUBTRACTION ALGORITHM

The background subtraction technique is the first process for analyzing the video sequences for visual surveillance applications. Figure.1 shows the Overview of the background subtraction system. First, the Video is acquired by using high resolution Nikon COOLPIX S210 digital camera which is capable of producing 8.0 million effective pixels at the rate of 30 frames per second. In the second step, the video data is converted into frames by using an algorithm. The preprocessing is an important step to improve the image so that it increases the quality for further processing. After preprocessing stage, the background modeling creates an ideal background which should be static for all environment changes.

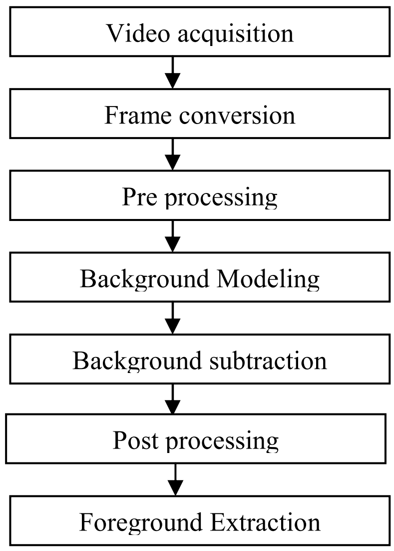


Figure1. Overview of the Background Subtraction System

This is a very important part of the system which includes image subtraction operation. Finally, the post-processing has to done to improve the results with the help suitable morphological operations like dilation, erosion, opening and closing.

IV. BASIC IMSUBTRACTION METHOD

This is the basic method to segment an image from the background one which is achieved by frame to frame subtraction. Initially, the first frame is considered as a reference image and the next forthcoming frames are subtracted from the first one and stored it in the corresponding pixel coordinates. This method is described in (1).

$$\text{Foreground= imsubtract}\left(\text{foreground, background}\right) \quad (1)$$

The disadvantage of this basic method is that it can not be applied to all the applications. Because, due to various conditions the pixel levels may get changed and threshold need to be included.

V. RECURSIVE ALGORITHMS

A. Approximate median method

In the existing technique prescribed by [8], the running estimate of the median is incremented by one if the input pixel is larger than the estimate, and decreased by one if it is smaller as in (2)-(3).

$$Fr>bg \rightarrow \sum_{i-1,1}^{k,j} bg(k,j)+1 \quad (2)$$

$$Fr<bg \rightarrow \sum_{i-1,1}^{k,j} bg(k,j)-1 \quad (3)$$

The disadvantage of this method is that it does not provide smoother results in all conditions. Here we update the threshold automatically for each frame to segment foreground images by (4).

$$Th= \text{graythreshold X } 75 \quad (4)$$

and followed by the expression:

frameno(i) = i;
level(i) = graythresh(fr_bw);
threshold(i) = level(i)*75;

This equation has been developed after testing for various indoor video sequences. In our approach, multiplication factor can be varied from 75-90 for indoor surveillance applications.

B. Adaptive background method

In the existing algorithm, there is no updating of the gain values which can be improved by our new approach. A gain value for the proper updating is done with the help of the alpha values and the weight value. Typical value of α = 0.1 to 0.9 only. The main advantage of this algorithm is that the increased efficiency of the segmented results by the gain values. Also auto threshold is included in this method.

C. Mixture of Gaussians

Here, the background model is parametric. Each pixel location is represented by a number (or mixture) of Gaussian functions that sum together to form a probability distribution function *F* as in (5).

$$F= \sum_{i=1}^{k} Wi,j,k,\eta(\mu,\sigma) \quad (5)$$

We select the number of Gaussian components are C=3, Number of background components are M=3, Positive deviation threshold D=2.5, α=0.15 and threshold=0.25. The weights, gain, mean, and standard deviation are updated by using (6)-(9).

$$W_{i,j,k} = \left(1-\alpha\right) W_{i,j,k} + \alpha \quad (6)$$

$$P= \alpha / W_{i,j,k} \quad (7)$$

$$\mu_{i,j,k} = \left(1-P\right)\mu_{i,j,k} + P.Ic \quad (8)$$

$$\sigma_{i,j,k} = \text{sqrt}\left[\left(1-P\right)\sigma^2_{i,j,k} + P\left(Ic- \mu_{i,j,k}\right)^2\right] \quad (9)$$

Even though the mixture of Gaussian method is complex and tedious, it provides better results by our modified parameters.

VI. NON-RECURSIVE ALGORITHMS

A. Frame difference method

Frame difference method constitutes pixel to pixel subtraction of the current frame from the background. The foreground image is segmented by the following equation:

$$\left|\text{frame Ic} - \text{frame Ib}\right| > T \quad (10)$$

where, frame Ic – Current image.
frame Ib – Background image.
T – Threshold value

When the pixel difference is above the threshold value T, it is considered as foreground image. In our novel approach, we update the threshold value using (10).

For this method, the algorithm is as follows:

i. Determine the background frame and current frame from video sequences.
ii. Determine the gray scale image of those frames.
iii. Set the frame size for further computation of pixels.
iv. Find the difference between pixels of two frames and compare with threshold value.
v. Update the threshold value.

B. Median filtering

Median filtering is the commonly used technique to find foreground images. In the existing algorithms [8], the pixel parameters M, N, and D represent minimum, maximum, and largest inter-frame absolute difference are used. Here the new approach is designing the mediod with the help of covariance matrices and auto-threshold. A covariance matrix is shown in (11)-(12).

$$CM= \sum_{i-1,j-1}^{M,N} (xi,yj) \quad (11)$$

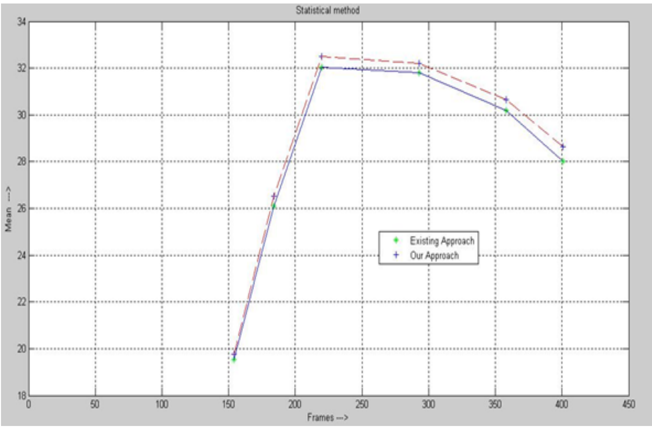
or

$$CM= \sum_{i-1}^{M} x_i \sum_{j-1}^{N} y_j \quad (12)$$

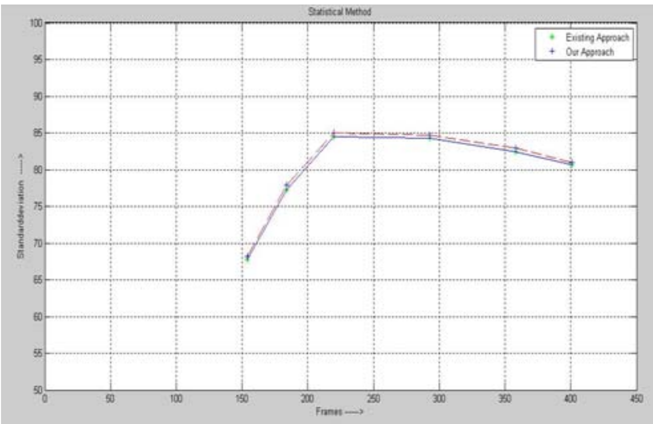
The covariance matrix is formed for the first 5 frames. All the first 5 frames are converted to the gray scale images and stored. The storing of this matrix involves the gray level value of each pixel to be stored in the huge matrix size of the image resolution. The main advantage of this method is that, the computation speed is high when compared to the existing approach.

VII. STATISTICAL BACKGROUND APPROACH

The statistical background subtraction is the process of finding the moving objects present in the foreground images by removing the background details. It is based on the statistical parameters available in the scene.



(a)



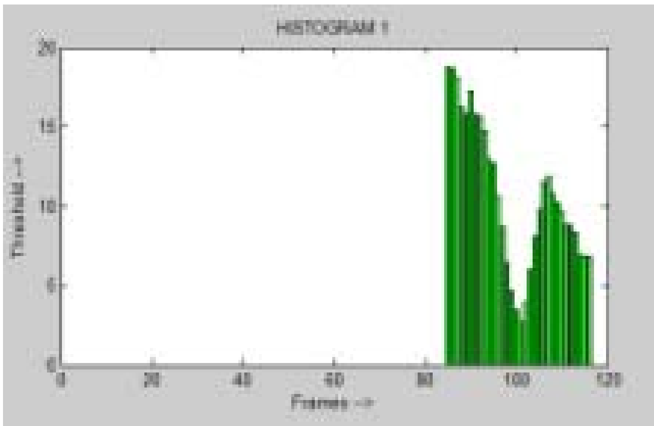
(b)

Figure 2. (a) Mean of Existing and our approach (b) Standard deviation of Existing and our approach

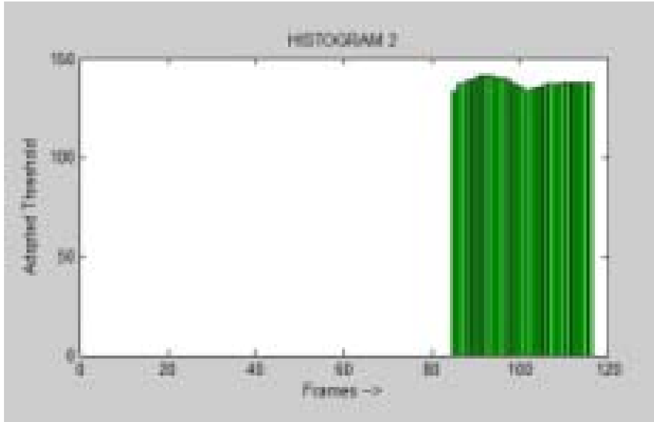
The statistical functions are calculated for comparing the results with the previous background subtraction method [6]. In this paper, we consider mean and variance of pixels which is described in Figure.2.

VIII. TEMPORAL DIFFERENCING METHOD

In our approach, instead of using the normal background subtraction as suggested in the previous work[7], we have adopted background subtraction using frame differencing for better efficiency and automatic threshold is implemented.



(a)



(b)

Figure3. (a) Normal threshold (b) Automatic updated Thresholding.

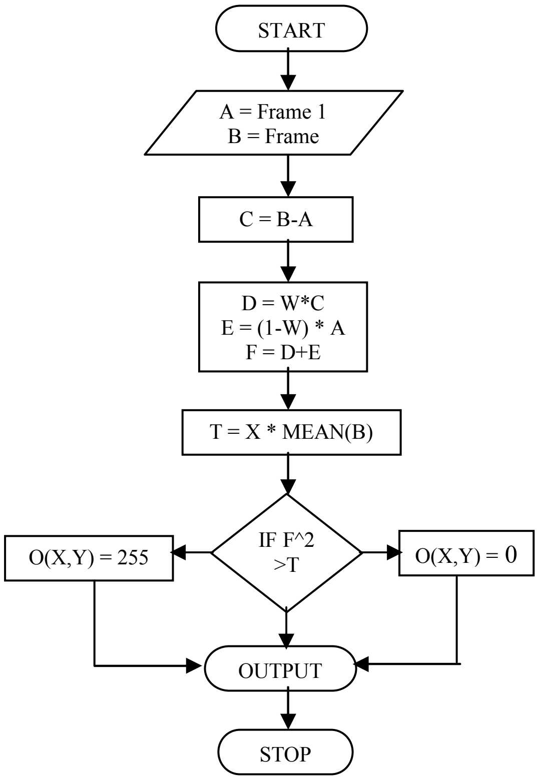


Figure. 4. Flowchart of Temporal differencing

Figure 3-4 explains normal threshold, automatic threshold and flow chart of Temporal differencing. Here X is varied between 2-3 in (13) for indoor applications.

$$T = X \times mean[I(x,y,t+1)] \qquad (13)$$

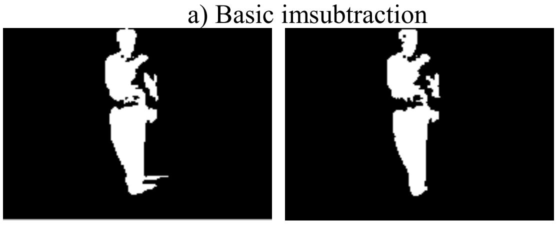
Our approach provides more prominent silhouette of a video data with considerable noise reduction. The algorithm adapts itself accordingly with respect to change in background. It gives more immunity to external disturbances like illumination changes, reflections etc. and shadow is also eliminated.

IX. SIMULATION RESULTS

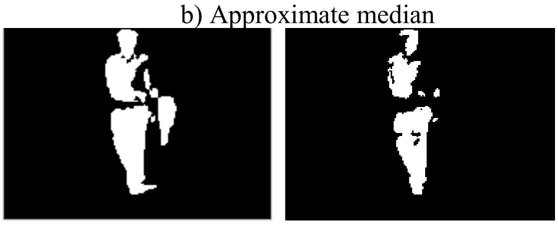
The proposed methodology is demonstrated using MATLAB 7.6(2008a) on Intel dual core processor, 2 GB RAM and Windows XP SP2. We have taken more than 100 videos for implementing our novel algorithm.

Original Video image

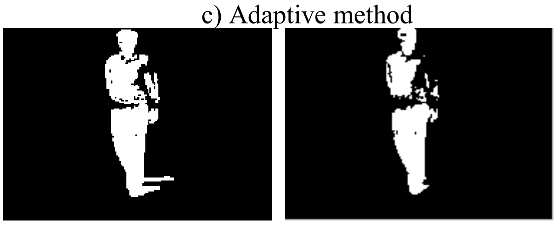
a) Basic imsubtraction



b) Approximate median

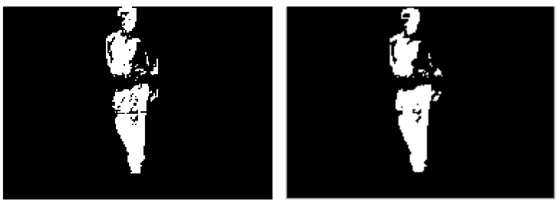


c) Adaptive method

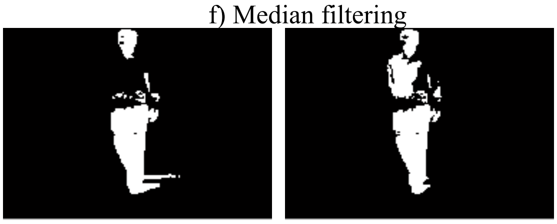


d) Mixture of Gaussians

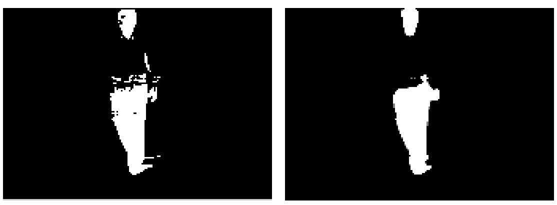
e) Frame differencing



f) Median filtering



g) Statistical Approach



h) Temporal Differencing

Figure. 5. Simulation results of Existing and Our approach of Background subtraction methods

X. CONCLUSION AND FUTURE WORK

In this paper, we have proposed the improved background subtraction methods for recursive and non-recursive situations in video security applications. Our experimental results in Figure 5 show that our method works well and provides better foreground images. The automatic threshold updating (ATU) is also developed to improve the system's performance and to reduce complexity. We have also showed the comparative results with the existing algorithms. In the future, this work can be extended to outdoor video surveillance applications in which lighting conditions have to be considered and suitable algorithms have to be developed.

XI. ACKNOWLEDGEMENTS

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XII. REFERENCES

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