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A Modified frame difference method using correlation coefficient for background subtraction

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Abstract

Background subtraction is one of the most important step in video surveillance which is used in a number of real life applications such as surveillance, human machine interaction, optical motion capture and intelligent visual observation of animals, insects. Background subtraction is one of the preliminary stages which are used to differentiate the foreground objects from the relatively stationary background. Normally a pixel is considered as foreground if its value is greater than its value in the reference image. Hence, every pixel has to be compared to find the foreground and background pixel. This paper presents a technique which improves the frame difference method by first classifying the blocks in the frame as background and others using correlation coefficient. Further refinement is performed by performing pixel-level classification on blocks which are not considered as background. Experiments are conducted on standard data-sets and the performance measures shows good results in some critical conditions.

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Keywords: Background Subtraction; Frame Difference; Correlation Coefficient;

1. Introduction

In the field of computer vision, background subtraction is a crucial task. It provides essential real-time information for many different applications such as video surveillance[1, 2, 3] human computer interactions and video indexing and retrieval, optical motion capture, and intelligent visual observation of animals, insects[4]. Object detection, tracking, human action and activity recognition are the steps involved in video surveillance system. For object detection, the first step is to locate the objects in the video sequences which are acquired through static

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cameras with a fixed background. To identify the object of interest, a popular and efficient approach is called background subtraction is necessary. Most of the background subtraction methods are very challenging in detection of accurate foreground objects and background subtraction at various critical conditions. Thus, they require high detection rate and low computational time for background subtraction.

In recent years, many background subtraction models are proposed and a recent survey is found in[4]. Some of the traditional basic background models based on Mean[5], Median[6], Histogram[7], Pixel intensity classification[8, 9, 10] and pixel change classification[11], MoG model[12], Codebook model[13], SACON[14] and texture model[15] are used in recent years. Most commonly used method for moving foreground objects is frame difference method[16]. In frame difference method, the background image is assumed to be the frame at time t. Pixels are labeled as foreground or background based on thresholding the absolute intensity difference between frames at time $t+1$ and the background image. This method works well if the foreground intensity is sufficiently different than the background. Moreover, this approach detects foreground objects based on decision made at the pixel level.

In this work, a modified frame difference method is proposed which uses the information available in the regions of the images and in individual pixels in order to categorize the pixels as foreground or background. The similarity between block from a frame and the background is measured using correlation coefficient. The blocks which are highly correlated are considered as background blocks. For the remaining blocks, pixel wise comparison is made to classify them as foreground and background. On the one hand, using block-wise categorization accelerates the background subtraction and on the other hand the accuracy of detecting foreground and background is improved by correlation analysis. The performance of the proposed method is evaluated by applying the method on standard datasets. The rest of this paper is organized as follows. In section 2, proposed methodology is described in detail. In section 3, experimental results and performance analysis are presented. Finally, section 4 concludes the work with possible extensions.

2. Proposed Methodology

2.1. Correlation Coefficient Analysis

In general, correlation coefficient is a measure of relationship between two variables and gives the result in single value r [17]. It gives a measure of the strength of association between two variables. The correlation coefficient r ranges from +1 to -1. A positive value of r indicates that either variables increase or decrease together, whereas a negative value of r indicates that as one variable increases, the other decreases and vice versa. If the value of r is 0, it means that there is no linear relationship between both the variables. In the proposed method the correlation coefficient between a block in the current frame and the corresponding block in the background image is computed. The correlation coefficient, is given by[17]

$$\rho(X,B) = \frac{\sum_m \sum_n (A_{mn}-\overline{A})(B_{mn}-\overline{B})}{\sqrt{\sum_m \sum_n (A_{mn}-\overline{A})^2 \sum_m \sum_n (B_{mn}-\overline{B})^2}} \quad (1)$$

When m, n represents the width and height of the block.

- A is the current image block
- B is the background image block
- $\overline{A}$ is the mean of pixels in current image block
- $\overline{B}$ is the mean of pixels in the background image block
- The value of the correlation coefficient between a block in the current image and the corresponding block in the background image can be used to measure the degree of correlation between these two blocks.

2.2. Background subtraction using correlation coefficient

In this research work, the frame difference method is slightly modified to improve its performance. The first image in the video sequence is set as the background image. The current frame is divided into 8x8 non-overlapping blocks. The correlation coefficient between a block in the current frame and the corresponding block in the background image is computed using equation 1. If the value of correlation coefficient r is greater than a particular threshold T, the entire block is classified as background. The value of threshold T is set as 0.5 for all the experiments in this research work. For the remaining blocks, the absolute intensity difference between pixel in the current frame and the corresponding pixel in the background image is computed. If this value is greater than a particular threshold, the pixel is categorized as foreground; otherwise it is categorized as background. This is given by[4].

$$f_t(x,y) = \begin{cases} 1 \text{ if } |I_t(x,y) - B(x,y)| \geq \lambda \\ 0 \quad\quad\quad\quad\quad\quad \text{otherwise} \end{cases} \tag{2}$$

Where $I_t(x,y)$ is the pixel at location $(x,y)$is current frame, $B(x,y)$is the pixel at location (x,y) is the background image and λ is the threshold. The categorization of a block as background based on the correlation coefficient improves the accuracy and accelerates the process of background subtraction. The complete steps involved in background subtraction using the proposed correlation coefficient based method are given in figure 1. The steps of the proposed method are also summarized as given below:

2.3. Proposed Algorithm

Step 1: Set the first frame as the background image
Step 2: Divide the background image into 8x8 non-overlapping blocks
Step 3: Read the current image
Step 4: Divide the image into 8x8 non-overlapping blocks
  4.1 Repeat the following steps for every 8x8 block
  4.2 Calculate correlation coefficient of a block in current image and the corresponding block in background image
  4.3 If correlation coefficient is greater than a threshold T, then the block is in the current image belongs to foreground
  4.4 Otherwise the following steps are performed for every pixel in the block.
    4.4.1Calculate the absolute difference between the pixel in current image and background image
    4.4.2 If the difference is greater than a threshold λ, then the pixels belongs to foreground otherwise it belongs to background.

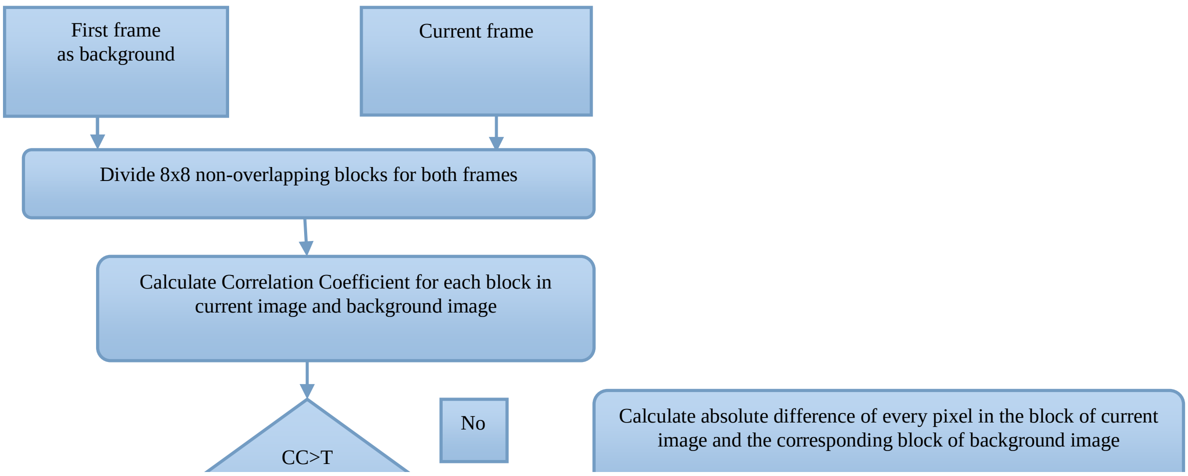
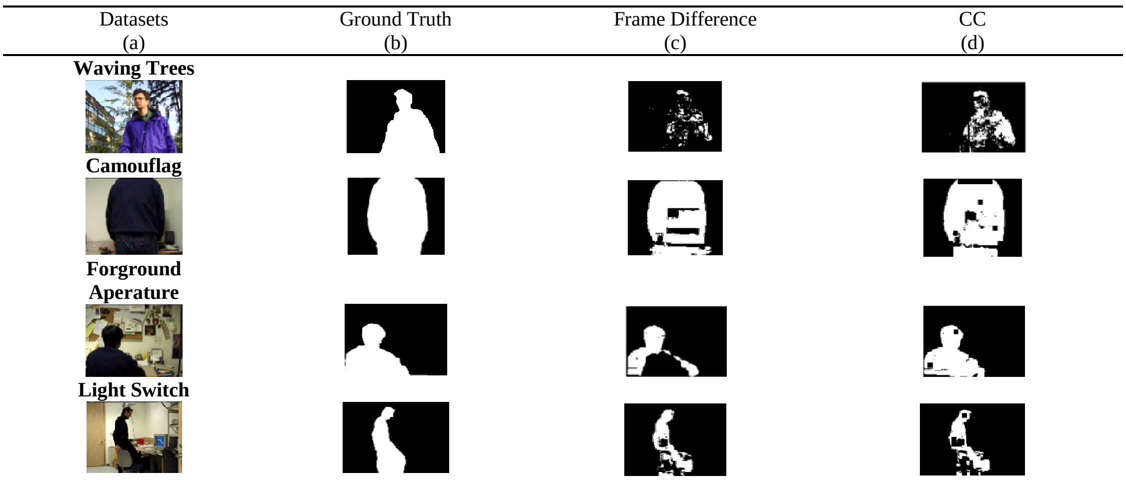


Fig.1. (a) block diagram of proposed method

3. Experimental Results

In this section, we compare the performance of the proposed background subtraction method with frame difference method. We tested the proposed method using image sequences from the wallflower dataset[18] and I2R dataset[19]. Fourteen challenging video sequences have been used in our experiments. These video sequences consist of a wide variety of complex dynamic scenes including Hall (176x144), Campus (160x128), Curtain (160 x128), Escalator (160x130), Fountain (160 x 128), Lobby (160x128), Shopping mall (320x256) and Water Surface (160x128), Camouflage(160x120), Time of the day (160x120), Light Switch (160x120), Foreground Aperture (160x120), Waving Trees (160x120) and Moved Object (160x120). Ground truth images are provided in the form of binary masks segmenting the background and foreground pixels in the datasets. Each of the video is represents a specific challenge such as illumination change and background motion. The results of the proposed background subtraction method using the two datasets are given in figure 2. In the figure, only one sample frame per video has been given.



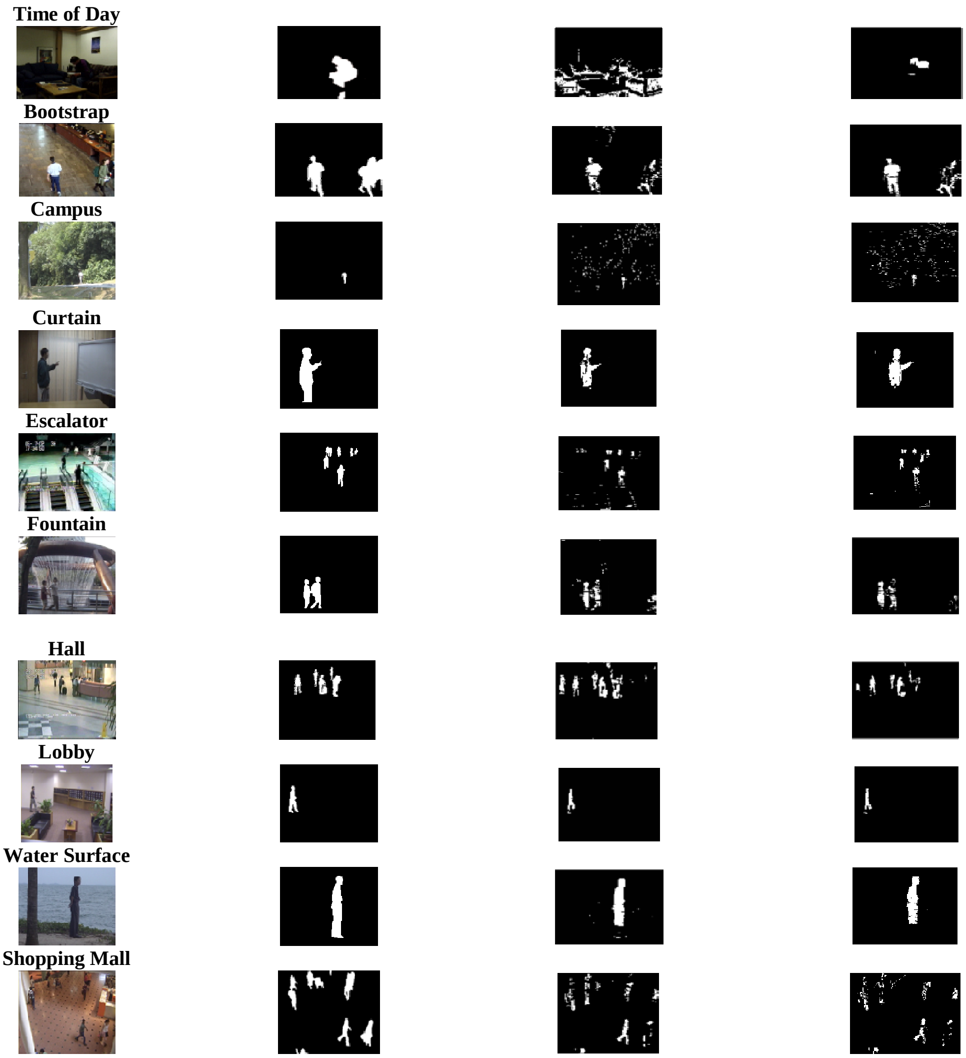


Fig.2. Results obtained using the proposed method a) original image b) ground truth image c) detected foreground using frame difference method and d) detected foreground using proposed method.

The Experimental validation of the proposed method is also performed on these video sequences using recall, precision and F-measure.

- Recall or detection rate which focuses on false negative is given by

$$Recall = TP/((TP+FN)) \quad (3)$$

Where TP (True Positive) is the number of foreground pixels that are classified as foreground, FP (False Positive) is the number of background pixels that are classified as foreground and FN (False Negative) is the number of foreground pixels that are classified as background.

- Precision or Positive Prediction is given by

$$Precision = TP/((TP+FP)) \quad (4)$$

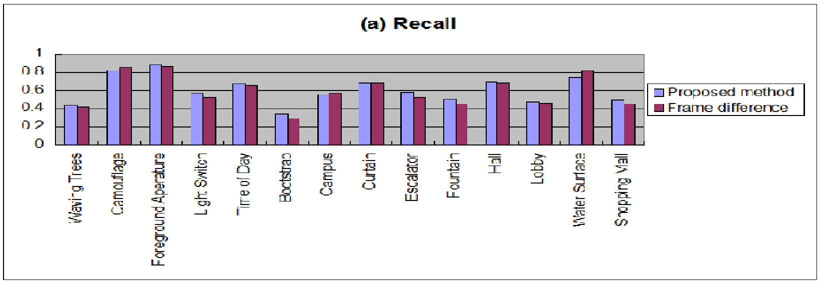
- F-measure is a weighted harmonic mean of Precision and Recall which is defined as

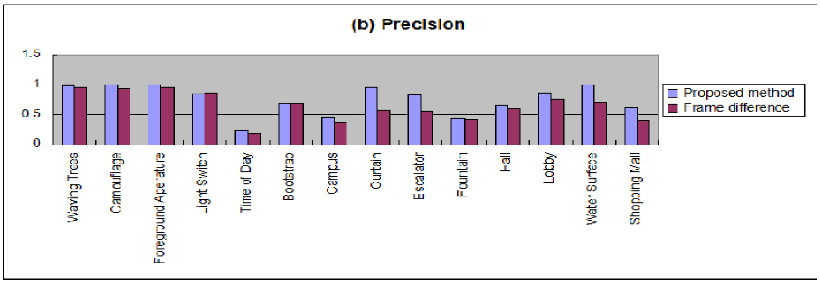
$$F\text{-}measure = (2\,TP)/((2\,TP+FP+FN)) \quad (5)$$

Table 1. gives the recall, precision and F-measure for the 14 image sequences. The same results are plotted as graphs in figure 3. The proposed method is implemented using MATLAB. The results of the proposed method obtained on a single frame for all video sequences given in figure 2 show that the proposed method accurately detects the background compared to the frame difference method. It can also be inferred from table 1 and graphs in figure 3 that the proposed method outperforms the frame difference method for almost all sequences in terms of precision, recall and f-measure.

Table 1. recall, precision and F-measure for the 14 image sequences.

	Recall		Precision		F-Measure	
Original Images	Proposed method	Frame difference	Proposed method	Frame difference	Proposed method	Frame difference
Waving Trees	0.4328	0.4187	0.9803	0.9648	0.6505	0.6032
Camouflage	0.8198	0.8529	0.9984	0.9388	0.9003	0.8938
Foreground Aperature	0.8825	0.8606	0.9956	0.9542	0.9356	0.9241
Light Switch	0.5749	0.5245	0.8467	0.8669	0.8848	0.7268
Time of Day	0.6741	0.6557	0.2456	0.1691	0.2966	0.2688
Bootstrap	0.3446	0.2895	0.6857	0.6831	0.4284	0.3972
Campus	0.5559	0.5738	0.4458	0.3689	0.6587	0.6949
Curtain	0.6885	0.6849	0.9583	0.5736	0.4824	0.4496
Escalator	0.5825	0.5225	0.8349	0.5612	0.6559	0.6053
Fountain	0.5106	0.4519	0.4331	0.4082	0.5416	0.5061
Hall	0.6945	0.6846	0.6591	0.6058	0.7989	0.7869
Lobby	0.4748	0.4563	0.8642	0.7692	0.3994	0.3243
Water Surface	0.7403	0.8158	0.9962	0.6936	0.7893	0.6904
Shopping Mall	0.4912	0.4543	0.6175	0.3973	0.6999	0.6537





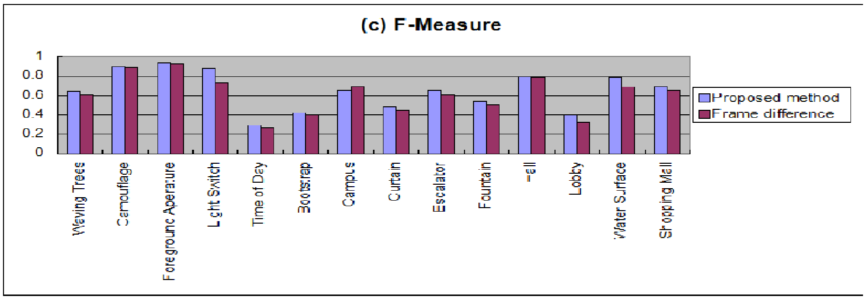


Fig. 3. (a) Recall; (b) Precision; (c) F-Measure obtained from proposed scheme and frame difference method for I2R and wallflower dataset are plotted as graphs.

4. Conclusion

In this paper, a modified frame difference method is proposed which uses correlation between blocks of current image and background image to categorize the pixels as foreground and background. The blocks in the current image which are highly correlated with the background image are considered as background. For the other block pixel wise comparison is made to categorize it as foreground or background. The experiments conducted prove that the proposed method improves the frame difference method in terms of speed and detection accuracy. In future, other information available in the blocks such as shape and edge can be used to improve the detection accuracy.

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