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Detection Of Moving Object Based On Background Subtraction

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Abstract: ***Visual surveillance has been a very active research topic in the last few years due to its growing importance in security, law enforcement, and military applications. The making of video surveillance systems smart requires fast and reliable algorithm for moving object detection. In this work we propose the implementation of an efficient object detection algorithm that can be employed in real time embedded systems due to its fast processing. This paper proposes a new method to detect moving object based on background subtraction. Morphological method is used for further processing to remove noise and to preserve the shape of moving object. We compare our method with other modeling techniques and report experimental results, both in terms of detection accuracy and in terms of processing speed.***

Keywords: Background subtraction, moving object detection, morphological operation, visual surveillance.

1. INTRODUCTION

Visual surveillance has been a very active research topic in the last few years due to its growing importance in security, law enforcement and military applications. More and more surveillance cameras are installed in security sensitive areas such as banks, train stations, highways, and borders. Object detection is used for identifying the trajectory of moving objects in video frame sequences.

Graphic Processor Units (GPUs) are used for graphics applications taking advantage of the parallel floating-point units and increasing the throughput of the algorithm. Although, the GPU-based implementations achieve a noticeable speed-up but these integrated circuits operate at high frequencies leading to large power consumption [2]. This aspect represents a drawback for embedded system applications. Computationally, real-time computer vision is an expensive task due to the fact that even small images need to be submitted to many processes. So that large quantities of calculations are need to be avoided. We have design a new algorithm which is based on background subtraction due to the fact that it is not a computationally expensive algorithm and also presents high performance in terms of accuracy.

2. LITERATURE SURVEY

There are three ways for detecting motion in image sequences: (a) temporal difference, (b) Optical flow and (c) background subtraction.

a) Temporal difference:- The Frame difference is arguably the simplest form of background subtraction. The current frame is simply subtracted from the previous frame, and if the difference in pixel values for a given pixel is greater than a threshold (Th), the pixel is considered part of the foreground [1]. For a variety of dynamic environments, it has strong adaptability, but it is generally difficult to obtain a complete outline of moving object, liable to appear the empty phenomenon, as a result the detection of moving object is not accurate.

b) Optical Flow:- Optical flow method is to calculate the image optical flow field, and do clustering processing according to the optical flow distribution characteristics of image [9]. This method can get the complete movement information and detect the moving object from the background better, however, a large quantity of calculation, sensitivity to noise, poor anti-noise performance, make it not suitable for real-time demanding occasions [8].

c) Background subtraction:- The background subtraction method is to use the difference method of the current image and background image to detect moving objects. After background image B(X, Y) is obtained, subtract the background image B(X, Y) from the current frame F_K(X, Y). If the pixel difference is greater than the set threshold T, then determines that the pixels appear in the moving object, otherwise, as the background pixels [5]. The moving object can be detected after threshold operation. Its expression is as follows:

$$D_K(X, Y) = 1 \quad \text{if } (|F_K(X, Y) - B(X, Y)| > T) \quad (1)$$
$$= 0 \quad \text{others}$$

But only background subtraction method is very sensitive to the changes in the external environment. The methods with a background model based on a single scalar value can guarantee adaptation to slow illumination changes, but cannot cope with multi-valued background distributions. As such, they will be prone to errors whenever those situations arise. However, if such errors connect into relatively small blobs, they can be removed from the classified image by a special filter. Where D(X, Y) is a binary image of differential results.

After median filtering operations, some accurate edge regions may be obtained. Median filtering is one kind of smoothing technique [6]. All smoothing techniques are effective at removing noise in smooth patches or smooth regions of a signal, but adversely affect edges. Same time it is important to preserve the edges. Edges are of critical importance to the visual appearance of images. So that

performance may not up to the mark. To find the median value it is necessary to sort all the values in the neighborhood into numerical order that leads process becomes relatively slower.
Morphological closing operation tends to fuse narrow break and also eliminate small holes. After applying morphological closing operation some accurate edge may be obtained and moving object will be detected [11]. Processing time required to detect the object using this technique is low but accuracy may not be good enough.

3. PROPOSED METHOD

Proposed technique reliable as well as it requires less processing time. The algorithm employed in this work is based on the background subtraction object tracking algorithm. The background subtraction method is the common method of motion detection. It is a technology that uses the difference of the current image and the background image to detect the motion region and it is generally able to provide data included object information. Output of subtraction stage is binary image. As the complexity of the background, the difference image obtained contains the motion region along with noise. Therefore, noise needs to be removed.
This paper adopts special type of filter mask w(x, y) with the 3x3 window to filters out noise. All coefficients of this mask are 1. Correlation of filter w(x, y) with image f(x, y) denotes as w(x, y)*f(x, y).

$$w(x, y)*f(x, y) = 1 \quad \text{if } \sum_{s=-1}^{1}\sum_{t=-1}^{1} f(x+s, y+t) > 4$$
$$= 0 \quad \text{Otherwise} \qquad (2)$$

Eq. (2) shows that proposed 3x3 mask counts number of non-zero elements in original binary image. If count is more than 4 then center value is replaced by 1 otherwise center value is replaced by 0. As this mask is working on binary numbers, it requires least calculation time, it also fuse narrow break and eliminate small holes. It combines advantages of median filter mask and morphological closing operation.
In figure 3.1 (a) binary 1 represents hole. Suppose a hole is located at center. As number of 1's is only one so that center pixel is replaced by 0 Figure 3.1. (b) Shows that it eliminates small holes.

0	0	0
0	1	0
0	0	0

(a

0	0	0
0	0	0
0	0	0

(b)

Figure 3.1: (a) input matrix with hole at center (b) Elimination of center hole

Another case about image is that generally edges in the image don't have sharp bending structure but they have smooth structure. Using above proposed mask, sharp bending structure will be made smoother. In figure 3.2(a) there is sharp structure of the edge. Figure 3.2 (b), shows that edge is made smoother using this filter.

1	1	1
0	0	1
0	0	1

(a

1	1	1
0	1	1
0	0	1

(b)

Figure 3.2: (a) Input matrix with sharp bend (b) Sharp bend is removed.

Proposed algorithm can be explained as follows:

1. Input a video
2. Extract the frame
3. Take absolute difference of the current image and a background image
4. Select proper threshold level to convert subtracted image into binary image
5. Convolve proposed 3x3 masks with binary image to filter out noise.
6. B(x, y)=1 represent foreground
7. B(x, y)=0 represent background

Proposed method can be explain diagrammatically as shown in figure 3.3

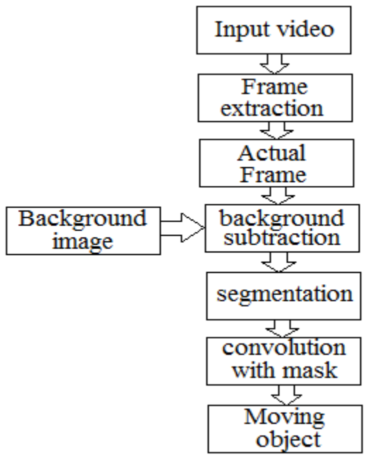


Figure 3.3: Flow chart for Moving Object detection

4. PERFORMANCE EVALUATION

The proposed system can be experimented with different settings of adjustable parameters which can be used for performance evaluation.
a) **Processing time**:- Processing time of single image is calculated by using tic and toc functions of MATLAB. Based on the processing time, we would determine which system is fastest [3].
For measuring accuracy we adopted different metrics, namely Precision, Recall, F1-matrix and similarity [4]-[9].
b) **Recall**:- Recall, also known as detection rate, gives the percentage of detected true positives as compared to the total number of true positives in the ground truth.

$$\text{Recall} = \frac{tp}{tp+fn} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where *tp* is the total number of true positives, *fn* is the total number of false negatives, and *(tp + fn)* indicates the total number of items present in the ground truth.
c) **Precision**:- Recall alone is not enough to compare different methods, and is generally used in conjunction

with Precision, that gives the percentage of detected true positives as compared to the total number of items detected by the method.

Precision = $\frac{tp}{tp+fp}$……………………(3)

Where *fp* is total number of false positive and *(tp + fp)* indicates the total number of detected items.

d) **Figure of merit**:- We considered the F1 metric, also known as Figure of Merit or M-measure that is the weighted harmonic mean of Precision and Recall.

Figure of merit = $\frac{2*recall*precision}{recall+precision}$…………..........(4)

e) **Similarity:-** We considered the pixel-based *Similarity* measure

Similarity = $\frac{tp}{tp+fn+fp}$……………………..….(5)

Greatest value of similarity shows accurate detection of moving object.

5. EXPERIMENTAL RESULT

Experimental results for moving object detection using the proposed approach have been produced for several image sequences. Here, we describe three different sequences, that represent typical situations critical for video surveillance systems, and present qualitative results obtained with the proposed method.

5.1 Sequence Hall monitor

Sequence Hall monitor is an indoor sequence consisting of 287 frames of 320 x 240 spatial resolutions, acquired at a frequency of 30 fps (frames per second). The scene consist hall, where a man comes out, leaves a bag on the floor, and then goes in the room. While the first man passes, the another man comes into the hall and moves towards the room. It represents an example of easy sequence, in that lighting conditions are quite stable and moving objects are well contrasted with the background (there is no camouflage); however, strong shadows cast by moving objects can be observed in the entire sequence.

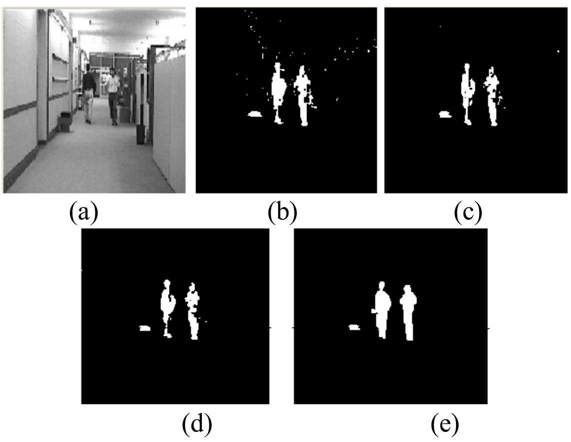


Figure 5.1:(a) Frame to be tested (Frame No. 185) (b)Image after morphological closing operation (c) Median filtered Image (d) Proposed method result (d)Ground Truth Image

Results for accuracy of sequence Hall Monitor is given in table no. 1. Accuracy of proposed method is more than remaining images. Median filtered method is not good in terms of accuracy as well as processing time is 5 times greater than proposed method. Processing time of morphological closing operation is half of proposed method but accuracy is not good enough.

Table 1: Result of sequence Hall Monitor

Parameter	Median Filtered	Morphological Closing	Proposed Method
Recall	0.7135	0.7881	0.7273
Precision	0.8882	0.8041	0.9123
F1	0.7913	0.7960	0.8094
Similarity	0.6547	0.6612	0.6798
Processing time	0.5502 s	0.0519s	*0.1102s*

5.2 Sequence water surface

Sequence water surface consisting 60 frames of 160 x 120 spatial resolutions, captured at a frequency of 15 fps. Here, it has been chosen in order to test our method ability to cope with moving background. The outdoor scene includes (moving) waves of water in the background and, finally, a man passing in front of the camera; here we are not interested in the waving water, but only in extraneous moving objects (the man).

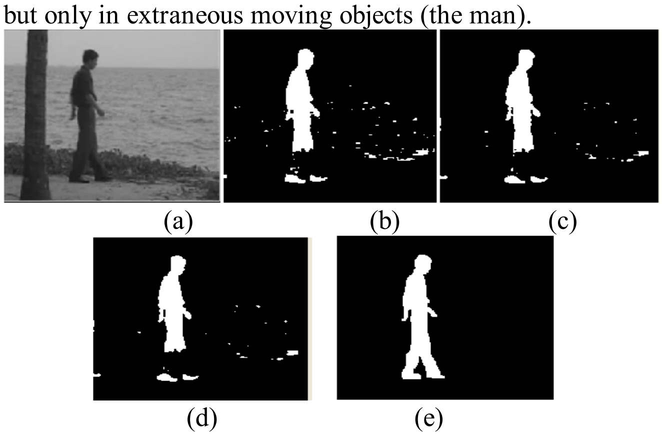


Figure 5.2:(a) Frame to be tested (Frame No. 25) (b)Image after morphological closing operation (c) Median filtered Image (d) Proposed method result (d)Ground Truth Image

Results for accuracy of sequence Water surface is given in table no. 2.

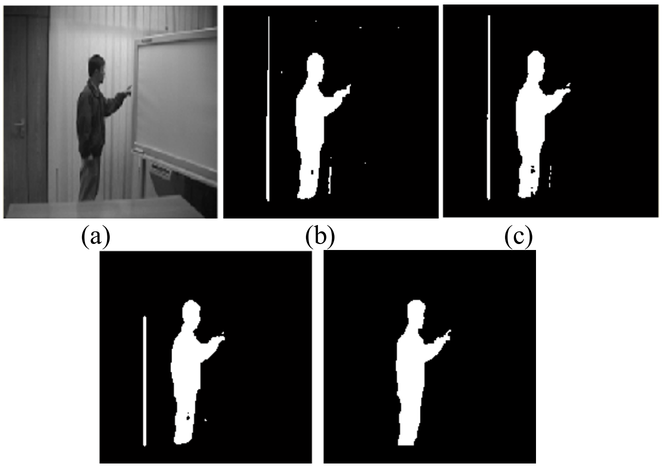
Table No. 2 Result of sequence Water Surface

Parameters	Median filtered	Morphological Closing	Proposed Method
Recall	0.7415	0.7522	0.7413
Precision	0.8908	0.8394	0.9009
F1	0.8093	0.7934	0.8133
Similarity	0.6797	0.6576	0.6854
Processing time	0.5518s	0.0522s	*0.1117s*

5.3 Sequence Moving Curtains

Sequence Moving Curtains consisting 189 frames of 161 * 129 spatial resolutions, captured at a frequency of 15 fps. The scene consists of close room where curtains are moving slowly. Meanwhile a person is pointing toward white board.

In this sequence back ground is not steady but it is complex. We check whether our algorithm can cope up with such sequence.



(e) (f)

Figure 5.3:(a) Frame to be tested (Frame No. 120) (b)Image after morphological closing operation (c) Median filtered Image (d) Proposed method result (d)Ground Truth Image

Table No. 3 Result of sequence moving curtains

Parameter	Median Filtered	Morphological Closing	Proposed Method
Recall	0.9559	0.9644	0.9604
Precision	0.8591	0.8502	0.8844
F1	0.9049	0.9037	0.9208
Similarity	0.8264	0.8243	0.8533
Processing time	0.5562s	0.04863s	*0.1263s*

Efficiency in terms of accuracy is better than others methods.

6. CONCLUSION

In this work a moving object motion detection system based on background subtraction algorithm was developed. In proposed algorithm complexity of calculation is avoided. Convolution operation is applied to the binary image so that parallel architecture of embedded system will produce result very quickly. Binary image is convolved with binary numbered mask, causes limited memory requirement which is allowing the implementation of this system over low-cost FPGAs.. Experimental results, using different sets of data and comparing different methods, have demonstrated the effectiveness of the proposed method, Accuracy produced by this method is better as compared to other methods.

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