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DETECTION OF MOVING OBJECT USING MORPHOLOGICAL FILTERS

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Abstract : In this paper, novel morphological filters are developed under the scope of traffic system in India is proposed. The algorithms of three filters are developed and implemented with their proper coding using Matlab (R2017a) software to detect the moving objects from CCTV video signal. For this aim, three filters are designed with gaining concepts of linear filters and also non-linear operators i.e., morphological operators. Noise reducing is also important to identify or detect a moving object. As the most of traffic videos contain background images and also different noise signals, it is necessary to minimize or to eliminate noise by subtracting background images from the images of traffic video. After detecting moving object using three morphological filters developed, PSNR and SNR values are also calculated for identified object to get the best filter designed. It is seen from the result, that moving object i.e., only white car detected after removing noise and applying median filter followed by morphological filter on background subtracted image, gives highest PSNR and SNR values.

Keywords: Morphological filters; Binary erosion and dilation; Median Filter; Mean filter; MATLAB simulation

1. INTRODUCTION

For extracting information and also to detect objects from any video signal, most of the widely used operations are developed, designed with the key knowledge acquired from Computer vision concept. The noise removal is a very critical job. So many algorithms are developed and implemented on noisy signal to reduce and also to remove noise from the signals [1-13]. Highest Peak signal to noise ratio (PSNR) and Signal to noise ratio (SNR) values denote a good result for noise elimination from an image. For detection of moving object from a video, image frames are generated from input video. Different mathematical techniques are introduced and those are applied on

image frames of video signals to remove noise and to detect the moving objects present in those frames. The linear and non linear filters are developed to remove the noise present in images. On the other way, so many operators are used to detect geometrical structures and feature of objects. Image picture element in short pixels are the gray level intensity of a particular point. When linear filters such as mean filter applied on an image results a smooth or blurred image and also may be a sharp image. Non linear filter

like median filter are used to detect the edges of object present in an image. This filtering process is also considered as a preprocessing method for further operations to be applied on a test image [1]. Morphological filters are such type of nonlinear filters which are developed to obtain the geometrical features of all objects present in an image or image frames. These type of filters use a mask function or window called structuring element. The 2D shape of this element is like a rectangle/ ellipse/ cross or may be circle. For the betterment of results of detection, the size of structuring element (SE) is adjusted [2].

2. RELATED WORK

Maragos et al., have developed concept on set theory of morphological system with Filter set theory and their relations with other filters [6,7,8]. Loce et al. had designed optimal binary Morphological Filter via structuring Element [5]. Algorithms for Object tracking from video and analysis of their performance were done in literature [9,11,14-22]. Researchers have developed algorithm to identify moving objects simultaneously in turbulence [18] and Kumar et al. have detected moving object using GPUs [13]. Researches were done to detect abandoned object and also to detect objects in video frames or in sequences [10,12,20]. Researchers have detected moving objects under video surveillance in literature [22,17]. Foreground detector with morphological filters are designed by Olugboja et al. and other scientists have generated algorithms for detection, tracking and classification of moving objects from video [14,15,16]. Yang et al. have detected moving object in dynamic background [21].

3. CONCEPT ON MORPHOLOGICAL FILTERS

These filters are such type of non linear filter which relates the shape or morphology of features in an image.

The algorithm is designed based on an image template/ window of 2D shape. This is called structuring element (SE) and it defines region of interest (ROI). The shape of filter window may be a square, a rectangle, an ellipse, cross shape or may be a circle. But in this paper, a square window is taken as structuring element (SE). The size of window or SE is resizable for improving filter result.

3.1. Common Morphological Operations

The list of morphological operation [7] is given:

a) Dilation: Expanding the foreground
b) Erosion: Shrinking the foreground

c) Closing: Removal of holes in foreground

d) Opening: Removal of stray foreground pixels in background

e) Hit and Miss Transform: Matching and marking of image pattern

There are other morphological operations which are used in image processing:

I Structured erosion (Thinning)
ii. Structured dilation (Thickening)

The aforesaid two operations are done using image pattern matching. The other operation is to find skeletons of binary regions (Skeletonization / Medial Axis Transform) from image.

In proposed algorithm to find moving object, the operations mentioned in "a to d" are used. So mathematical concepts of those operations are stated in the following sections.

3.1.1. Expanding the foreground ("dilation")

In mathematical morphology, binary images are denoted by sets and binary image transformations are expressed by different set operations. Let, a binary image object is denoted by B and Bc is its background i.e., a set complement. S is Structuring Element (SE). Boolean OR operation between set B and S is equivalent to the Minkowski set addition $\oplus$. This is the dilation of B by S. Dilation is defined by Eq

$$\mathbf{B} \oplus \mathbf{S} = \{b + a : b \in B, a \in A\} = \bigcup_{a \in S} B_{+a} \quad (1)$$

Where $B_{+a} \equiv \{b + a : b \in B\}$ is the *translation* of B along vector a.

3.1.2. Shrinking the foreground ("erosion")

If $S^r \equiv \{b: -b \in S\}$ is reflection of S w. r. t. origin, then erosion of B by S is the Boolean AND operation of B by S^r. This is same as the Minkowski set subtraction, $\ominus$. Erosion is defined by Eq. (1)

$$B \ominus S \equiv \{b: S_{+b} \subseteq B\} = \bigcap_{a \in S} B_{-A} \quad (2)$$

3.1.3. Removing stray foreground pixels in background ("Opening")

If erosion is done at first between B and S followed by dilation, then it creates operation, opening. So, Eq. (3). defines Opening. Using this method, external noises present in image and its background are removed.

$$B \circ S \equiv (B \ominus S) \oplus S \text{ of B by S} \quad (3)$$

3.1.4. Removing holes in the foreground ("Closing")

When Dilation operation is done at first followed by erosion between B and S, the closing operation is performed. It is mentioned$\oplus$in Eq. (4).

$$B \bullet S \equiv (B \oplus S) \ominus S \text{ of B by S} \quad (4)$$

Size of S is smaller than B. When shape of S is regular, working of opening and closing operations will be like nonlinear filters and those smooth the contours of B. If feature of S is like flat in land, then opening operation suppresses sharp caps. It also cuts narrow sides of B. For the flat shape of S, closing operation fills thin and small templates present in B.

In next section, discussion is made on mean and median filters, PSNR and SNR as comparison of proposed filter is done with mean and median filter based on PSNR and SNR values.

3.2. Mean and Median Filters

Mean filter is a linear filter and its working

principle is like a simple sliding window spatial filter. This filter replaces center value in window i.e., image matrix (kernel) by calculating average or mean of all pixel values present in it. Here, kernel is basically square in shape but it may be in any other shape. In filtered image window center pixel value is replaced by mean of all pixel values.

Median filter is nonlinear filter based on working principle of sliding window spatial filter. This filter replaces center value of image pixel window with median value of all the pixel values present in image window matrix (kernel). Here center pixel value will be replaced by median of all pixel values present in kernel. Median filter ables to remove impulse noise and it can claim edge preserving as it preserves step edges without blurring. It also blur image edges slightly in presence of noises.

3.3 Concepts of PSNR and SNR

The ratio between maximum possible power of a signal and power of corrupting noise that affects fidelity of its representation is called Peak signal to noise ratio (PSNR). As a signal has very wide dynamic range, PSNR is expressed by logarithmic decibel (dB) scale. This is used to measure quality of reconstruction of lossy compression codec "Higher PSNR value indicates reconstruction of higher quality": may be true or not. PSNR is valid when this parameter is used for comparing results with same type of codec and content. Mean Square Error (MSE) and PSNR are defined in Eq.(5) and (6), respectively.

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2 \quad (5)$$

$$PSNR = 20\log_{10}(MAX_i) - 10\log_{10}(MSE) \quad (6)$$

MAXi = max (possible pixel value in 8 bit image).

For RGB colour images, the PSNR is defined as same in Eq. (6) and MSE is summation over all squared value differences divided by image size multiplied by three.

Next, proposed method with its algorithm and flowchart are described.

4. PROPOSED METHOD TO DETECT MOVING OBJECT FROM A VIDEO

In the proposed method, three morphological filter architectures are

designed. Each has performed binary erosion or dilation, with low complexity and low memory requirement. Among three filters, one supports static, and other support locally adaptive flat rectangular structuring elements of arbitrary size.

To develop algorithms of filter, a CCTV video signal of .mp4 format is collected from freely available website (https://www.youtube.com/watch?v=v2 u8wFR1rrc). This is a HIKVISION 2MP Camera Demo video of road traffic with moving cars. The time duration of this video is 31secs. Two snapshots are taken from the video at time t^1 and another at time t^2.

Then snapshot is cropped with a single car for algorithm implementation purpose.

4.1. Algorithmic Steps of Proposed Method

Inputs ► Two cropped snapshots from a traffic video in .mp4 format in which a car is running

Output ►Moving object i.e. car (in any image format)

Step 1: Two snapshots at time t_1 and (a = image1.png and b = image2.png) are taken respectively. a and b are RGB images.

Step 2: convert two RGB images of .png format into their corresponding gray scale images, i.e., A and B respectively from a and b.

Step 3: To scaling of two snapshots in same size are performed and resulting images are C and D.

Step 4: To subtract image C from image D for background subtraction

Subtracted image, E = D – C

Step 5: To plot image A, B, C and D

Step 6: To apply filters: both linear (mean filter) and non linear (median filters).

To get filtered image F and X respectively. find PSNR and SNR of filtered images with respect to E.

Step 7: To construct structuring element, SE of square shape with size 35*35; i.e., it is a matrix of all values 1.

Step 8: Apply morphological operations using SE on image E to get output image.

Step8.1: To construct morphological filter 1: First to do dilation on E with SE, followed by erosion with SE and again to apply opening operation on output image. To find PSNR and SNR of filtered image with respect to E.

Step 8.2: To construct morphological filter 2: To do all steps of Step 8.1 on F.

Step 8.3: Construct morphological filter 3: Do all steps of Step 8.1 on X

Step 9: Moving object detected by morphological filters 1, 2 and 3.

4.2. Flowchart of the work

The flowchart corresponding proposed algorithm is given in Fig. 1.

5. RESULTS

The entire algorithm is coded and implemented using MatlabR2017a. The results are shown in figures 3 to . Also comparisons are performed between all PSNR and SNR values obtained for all filtered outputs. Fig. 2, shows two snapshots with their scaled images. It is seen from that a white colored car is there and the road also contains zebra crossing white marks. The goal is to detect the moving car (i.e., only the white pixels of the moving car).

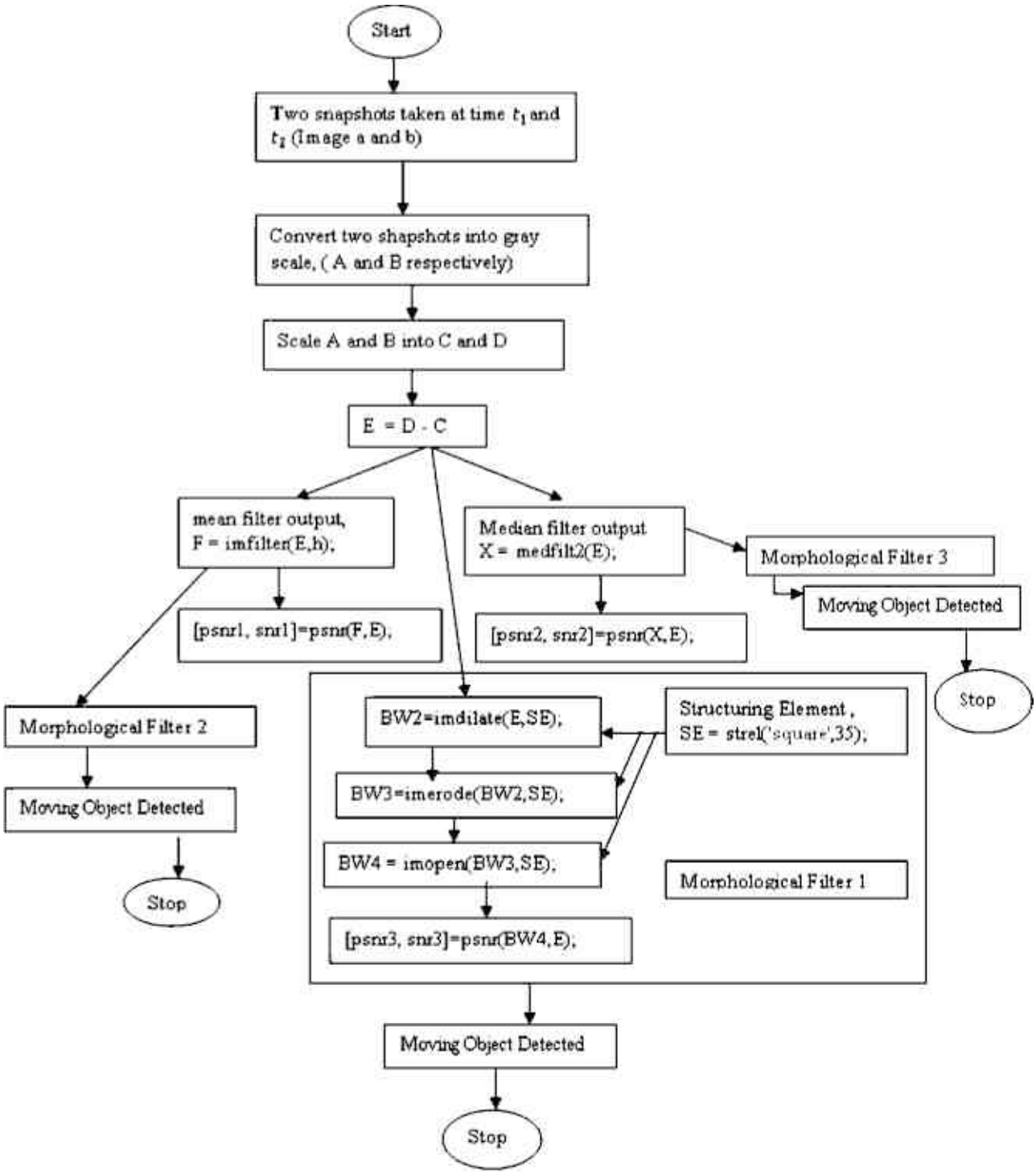

Fig. 1: Flowchart of proposed method

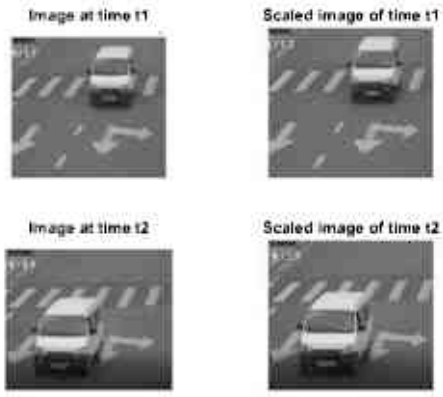

Fig. 2. Snapshots (at time t_1 (4.17) and t_2 (4.19) and scaled image snapshots with a running car are shown in a frame

In Fig.3, subtracted image, E = D - C (Output of image t1 - image t2), filtered images after implementing Mean filter, Median filter and morphological filter 1 on image E are shown. In the subtracted image E, some part of white pixels of car are overlapped. It is seen that white pixels of moving car with its overlapping area of two positions are shown in filtered images of mean and median filter outputs. In these two outputs, the zebra crossing white pixels are also present. But in the Morphological filter 1output which is implemented on E, the car pixels with its overlapped area is clearly detected but a small part of zebra crossing white pixels are also present. As the goal of this paper is to detect only the moving object i.e., car, the Morphological filters are applied on the mean and median filter outputs.

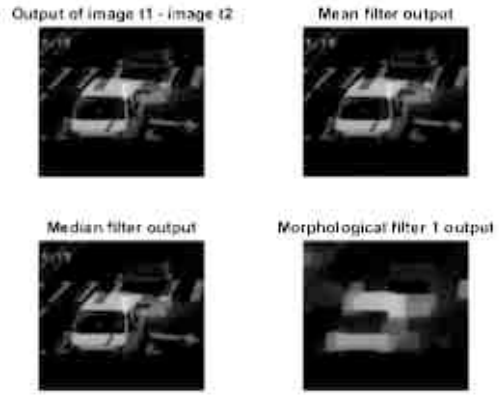

Fig. 3. Subtracted image, E, Mean filter output, Median filter output, and Morphological filter 1 output are shown here

In Fig. 4. Morphological filter 2 and Morphological filter 3 outputs are shown. The Morphological filter 2 is applied on mean filter output image to eliminate white pixels of zebra crossing and Morphological filter 3 is applied on median filter output imaged.

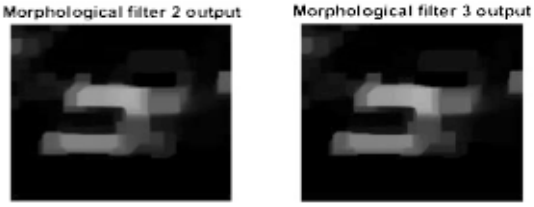

Fig. 4. Morphological filter 2 and 3 outputs are shown here

It is seen from the resulting filtered output that most of the zebra crossing white pixels are removed and only pixels of moving car are present. A comparative analysis is done by calculating PSNR and SNR values of these three morphological filter outputs. The values are stated in the Table. 1.

Table.1: Comparison between PSNR and SNR values of three morphological filters

SL. NO.	FILTERS. NAME	PSNR in dB	SNR in dB
1.	Morphological filter 1	22.59	5.28
2.	Morphological filter 3	23.16	5.85
3.	Morphological filter 2	23.10	5.78

It seen from Table 1, that highest PSNR and SNR values of image filter outputs which detect the moving car are 23.16dB and 5.85dB respectively. As it is known that highest PSNR and SNR values for a filtered image mean a better filtration. So morphological filter 3 which is implemented after filtration with median filter is a better solution of detecting a moving object from a video.

6. CONCLUSION

In this paper, Morphological filters are constructed and implemented on image to detect a moving object from a video. Different image processing operations such as; RGB to Gray conversion, image subtraction, mean and median filter operation, Morphological filtration (dilation, erosion, opening) are applied to get the best result i.e. detection of moving object. PSNR and SNR values are also calculated for three morphological filtered outputs. It is noticed that these said two values are highest for morphological filter 3 (applied on median filtered image) output. So it is concluded that this filter gives the best result for sample video clip.

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