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Innovative approach on novel open-close sequence filters to remove impulse noise in highly corrupted images

Rajeev Thakur[1] and Kashmira Sharma[1*]
[1]Assistant professor, Department of Electronics Engineering NRI College of Engineering Bhopal, M.P.-India
[1*]M.Tech Scholar Department of Electronics Engineering NRI College of Engineering Bhopal, M.P.-India

ABSTRACT
In this research paper, various impulse noise filters are studied. These are median filter, center weighted median filter, pixel-wise MAD (mean of the absolute deviations from the median) filter and. Here a novel, effective and simple approach is implementing using powerful open-close sequence (OCS) filter to restore images that are corrupted by 40%–80% probability impulse noise. Extensive simulation results show that proposed method substantially outperforms all other existing method, in terms of suppressing impulse noise while preserving image details. Since proposed method is algorithmically simple and requires low computational complexity, it is suitable to be implemented by hardware and applied to many real-time applications.

INTRODUCTION

Image Processing is a promising area of research in the fields of electronics and communication engineering, consumer and entertainment electronics, control and instrumentation, biomedical instrumentation, remote sensing, robotics and computer vision and computer aided manufacturing (CAM). For a meaningful and useful processing such as image segmentation and object recognition, and to have very good visual display in applications like television, photo-phone, etc., the acquired image signal must be deblurred and made noise free. The deblurring and noise suppression (filtering) come under a common class of image processing tasks known as image restoration.

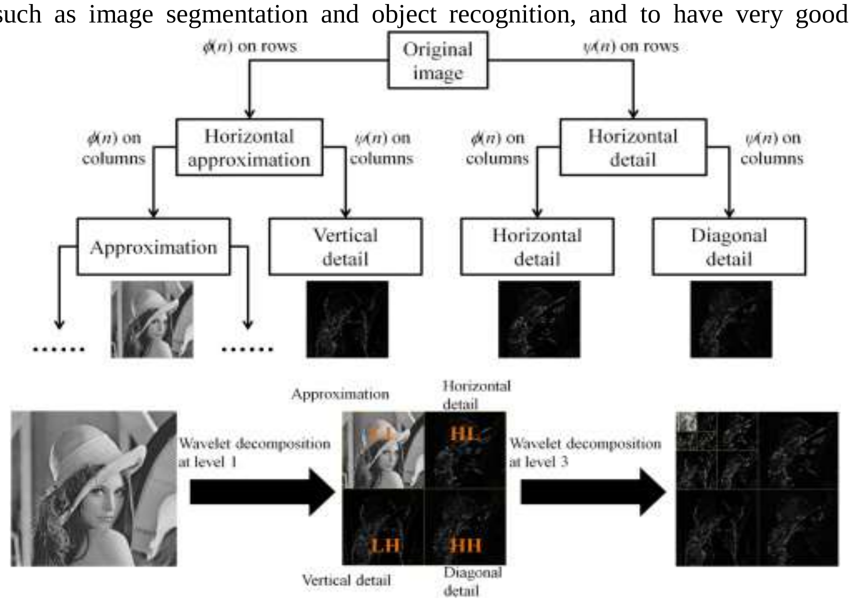

Fig.1 A typical processing of digital image processing system

The term digital image processing refers to processing of a two dimensional picture by a digital computer. In other words, it implies digital processing of any two dimensional data. A digital image is an array of real or complex numbers represented by a finite number of bits. An image is a 2-D function (signal), X (m, n); where m and n are the spatial (plane) coordinates. The magnitude of X at any pair of coordinates (m, n) is the intensity or gray level of the image at that point. In a digital image, X (m, n), and the magnitude of X are all finite and discrete quantities. Each element of this matrix (2-D array) is called a picture element or pixel. An image given in the form of a transparency, slide, photograph, and chart is first digitized and stored as a matrix of binary digits in computer memory. The digitized image can then be processed on a high resolution television monitor. For display, the image is stored in a rapid access buffer memory which refreshes the monitor at 30 frames per second to produce a visibly continuous display.

Image processing may be performed in the spatial domain or in a transform domain. To perform a meaningful and useful task, a suitable transformer, e.g. discrete Fourier transform (DFT), discrete cosine transform (DCT), discrete wavelet transform (DWT), etc., may be employed. Depending on the application, a suitable transform is used.

Digital image processing has a broad spectrum of applications, such as digital television, photo-phone, remote sensing, image transmission, and storage for business applications, medical processing, radar, sonar, and acoustic image processing, robotics, and computer aided manufacturing (CAM) and automated quality control in industries. Similarly successful application of image processing concept can be found in astronomy, biology, nuclear medicine, law enforcement, defense and industry. Fig. 1.1 depicts a typical image processing system [1, 2].

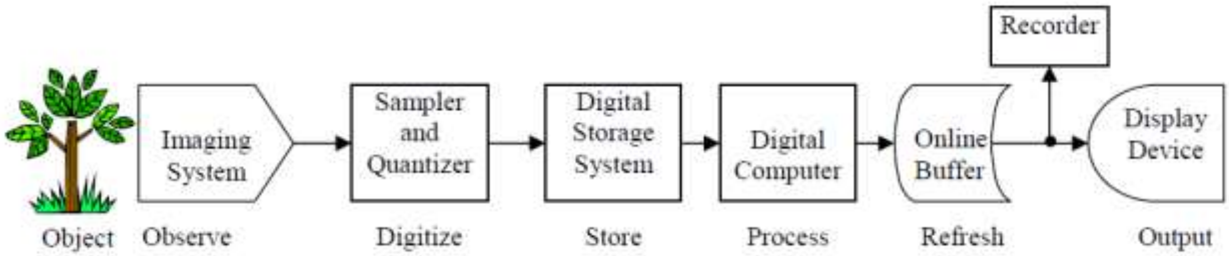

Fig.2 A typical digital image processing system

RESERCH METHODOLOGY

Open-close sequence filter:

we implement a powerful open-close sequence (OCS) filter to restore images that are corrupted by 40%–80% probability impulse noise.

The scheme of the proposed filter is shown in Fig. 3.

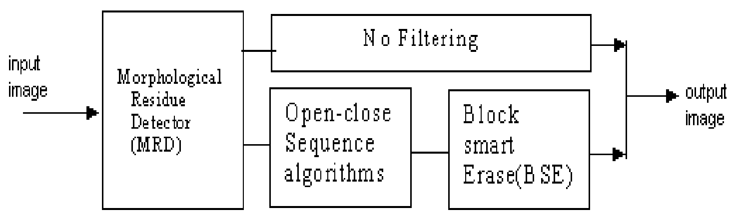

Fig.2. Open – Close sequence (OCS) filter

Main components of the open close sequence (OCS) filter are as follows:-

- Morphological Residue Detector (MRD)
- Open-close sequence algorithms
- Block Smart Erase (BSE)

In this section, we start by describing the noise detector based on morphological residues. Then we introduce the open-close sequence algorithms and block smart erase method. Finally, the open-close sequence filter is proposed.

Morphological Residue Detector (MRD)

In this method, we detect noisy pixels using mathematical morphology. As usual, erosion outputs the minimum value in the structuring element domain, and dilation outputs the maximum value in the structuring element domain. Therefore, the opening removes salt impulse noise, and the closing removes pepper impulse noise. The determination of the salt or pepper noises is easily done by comparing the difference between the value of the pixel and the result of opening and closing with a flat structuring element Let Do and Dc be the opening and closing absolute distance from input signal respectively

$$D_o = f - f \circ b$$

$$D_c = f \bullet b - f$$

Here D_o and D_c are nonnegative. Noise pixels are detected by comparing D_o and D_c with a threshold T .

$$r(i,j)=\begin{cases}1, & D_o \geq T \text{ and } D_c = 0 \\ -1, & D_o = 0 \text{ and } D_c \geq T \\ 0, & \text{otherwise}\end{cases}$$

If $r(i,j)$ is 1, then is regarded as salt noise; if $r(i,j)$ is -1 , then is regarded as a pepper noise; otherwise, if $r(i,j)$ is 0, then $f(i,j)$ is regarded as an original pixel. This detector uses two parameters: the threshold T and the size of the structuring element b . It is easy to optimize the parameters by means of experiment. Whenever these noises are not or cannot be detected, the pixel value is considered noiseless, and it is passed thorough. When a certain noise is detected, the corresponding generalized open-close sequence algorithm is selected; otherwise, the input signal is put forward.

Open-Close Sequence Algorithm

Two filters using open-close sequences are employed to the detected impulse noise. The first one called open-close filter (OCF) is defined as follows:

$$OCF(f)=(f \circ b_1) \bullet b_2$$

Multiscale structure elements are introduced to the open-close sequence algorithm. The size b_1 must be small enough to preserve more details of the image, and the size of b_2 is larger than that of b_1 . The opening efficiently eliminates the detected salt noises, but at the same time, the pepper noises are magnified by the first erosion. So it is necessary to use closing to remove the additional pepper noises. However, infected pepper noises whose sizes exceed that of b_1 cannot be eliminated. To achieve better performance, the scale of b_2 must be much larger than that of b_1. It is appropriate that the size b_2 of is 5x 5 (or 7x 7), which is not so large as to remove lots of image details. Then the pepper noise can be eliminated powerfully by the following closing while more image details can be preserved. The second sequence called close-open filter (COF) is defined as follows

$$COF(f)=(f \bullet b_1) \circ b_2$$

Corresponding to the first filter, the second one applied to remove the detected pepper noises consists of one closing and one opening**.** Both OCF and COF filters are combinations of opening and closing operators and perform efficiently to remove the corresponding impulse noise. However, the noises whose size is larger than the size of b_1 will not be eliminated and propagated in the image. The filtered image appears to have some uncomfortable characteristics: undesirable white (or black) blocks are generated during the OCF (or COF) procedure and reserved in the filtered result. Their sizes are large enough and cannot be eliminated by above two sequence filters

Block Smart Erase Algorithm

The existence of white and black blocks degrades the filtered image significantly and makes the filtered image look uncomfortable. A simple and efficient algorithm called block smart erase (BSE) algorithm is proposed to eliminate their effects. The BSE algorithm is based on median technology and takes the place of the extreme value (black or white) pixel by the median value of their surrounding pixels. The details of the proposed scheme are shown as follows.

1) For an NxN window centered at the test pixel, where N would normally be 5,7,9,…… and larger value should be suggested.

2) If $f(i,j)$=0or $f(i,j)$=255, $f(i,j)$is an absolute extreme value pixel that must be estimated; go to step 3. Otherwise, the value of $f(i,j)$is not altered; go to step 4.

3) When an extreme value pixel is detected, its gray level is substituted by the median value of the window.

4) The procedure is repeated for the next window.

It can be seen that the white and black blocks are efficiently removed.

The OCS filter can be defined as

$$OCS(f)=\frac{BSE_w(OCF(f))+BSE_b(COF(f))}{2}$$

VISUAL RESULT FOR LENNA IMAGE

Fig.3.1. simulation result for lenna image:(a)origanal image (b) corrupted with 30% noise (c)output from median filter (d)output from cwm filter(e)output from pwmad filter(f) output from ocs filter

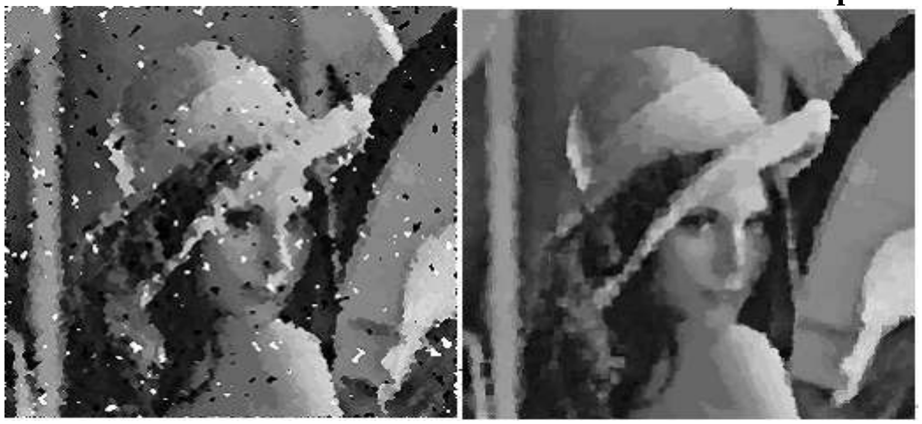

Fig.3.2. simulation result for lenna image: (a)origanal image (b) corrupted with 60% noise (c)output from median filter (d)output from cwm filter (e)output from pwmad filter (f) output from ocs filter

VISUAL RESULT FOR GIRL IMAGE

Fig.3.3. simulation result for girl image: (a)origanal image (b) corrupted with 30% noise (c)output from median filter (d)output from cwm filter (e)output from pwmad filter (f) output from ocs filter

Fig.3.4. simulation result for girl image: (a)origanal image (b) corrupted with 60% noise (c)output from median filter (d)output from cwm filter (e)output from pwmad filter (f) output from ocs filter

In this section, simulation experiments were undertaken to demonstrate the performance of the proposed open-close sequence filter. Comparisons are made with other nonlinear filtering techniques, a standard 3x3 median filter, CWM filter, PWMAD filter. The performance of these filters was tested on the well-known standard image corrupted by salt and pepper noise with equal probabilities.

The MAD detector contains too much false detection error in lowly corrupted images and too much missed detection error in highly corrupted images. It performances badly when the noise ratio is high. The main error of our proposed detector is false detection, and there is almost no missed detection error. The false detection probability descends rapidly when the noise level increases, and it is less than 1% when the noise ratio is above 50%. The efficiency of MRD is also greater than 99% and almost 100% when the noise ratio keeps increasing. It is obvious that the proposed MRD algorithm absolutely performs much better than the MAD detector and is appreciated for the images corrupted by high probability impulse noise.

To exhibit the generalization of the proposed algorithm, experiments with other images are shown.

To quantitatively measure the performance of our filtering scheme versus other filters, the results, measured with PSNR (dB), for the cases of 10% to 80% impulse noise . It is seen that the performance of our proposed algorithm definitely is better than other filters when the noise ratio is higher than about 45%. Also our filter performs robustly over all the noise range and represents a slowly decreasing curve as the noise ratio increases. Other filters fall down abruptly and generate a worse result when the noise ratio is high. figure shows the subjective visual qualities of the filtered images using various filters for the standard images as examples.

It can be seen that the simple median filter suppresses little noise and gets the worst result. The CWM and PWMAD filters perform much better than the median filter, but also many noises remain .However, the proposed filter can remove most of the noises effectively while preserving image details very well.

The PSNR of restored images 'Lenna', 'Girl', corrupted by 60% impulse noise is 21.17, 23.67dB, respectively.

CONCLUSION AND FUTURE SCOPE

We have proposed a novel open-close sequence filter to remove impulse noise in highly corrupted images. The proposed open-close sequence filter is based on mathematical morphology and uses an impulse noise detector. The morphological residue detector powerfully determinates the impulse noise with a low percentage error.

The OCS filters effectively remove high probability impulse noises. The block smart erase algorithm briefly eliminates the black and white blocks in the filtered image. The simulation results indicate that the proposed filter performances better than other nonlinear filtering techniques and represents robust ability of impulse noise removal.

In the future, various techniques can be considered to incorporate in our scheme to further improve the performance and preserve more details in both highly and lowly corrupted images.

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