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ANALYSIS OF NOISE REDUCTION USING ADAPTIVE FUZZY SWITCHING MEDIAN FILTER

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ABSTRACT
The pictures in the advanced arrangement are generally corrupted by drive commotion which is because of the unexpected blunders in correspondence channels or electronic sensors. Most existing strategies fall flat at high clamor thickness. Here another versatile insertion procedure is foreseen for reclamation of exceptionally corrupted pictures by arbitrary esteemed drive clamor. This new method gives a more corrected preferred picture quality over the standard Versatile Middle Channel, Standard Middle Channel, Choice Based Calculation, Dynamic Exchanged middle Channel, Choice Based Un-symmetric Trimmed Middle Channel and altered Choice Based Un-symmetric Trimmed Middle Channel. The strategy anticipated is confirmed for its proficiency against various pictures and is found to give enhanced Pinnacle Motion to-Commotion Proportion. These detected “noise pixels” will then be subjected to the second stage of the filtering action, while “noise-free pixels” are retained and left unprocessed. Then, the NAFSM filtering mechanism employs fuzzy reasoning to handle uncertainty present in the extracted local information as introduced by noise. Simulation results indicate that the NAFSM is able to outperform some of the salt-and-pepper noise filters existing in literature.

1. INTRODUCTION

The idea of Computerized Picture Preparing assumes an imperative job in numerous territories, for example, therapeutic imaging, remote detecting, printing, media transmission, security and resistance applications [9,15]. The advanced pictures acquired through imaging gadgets are frequently undermined by drive clamor which is because of the startling blunders in correspondence channels or electronic sensors. Motivation clamor can be gathered into two kinds: settled esteemed drive commotion (FVIN) and arbitrary esteemed drive commotion (RVIN). In FVIN, the tainted pixel goes up against an esteem which is equivalent to either 0 or 255. Be that as it may, in RVIN, the defiled pixel goes up against any incentive between the base 0 and greatest 255. So evacuating RVIN is a confounded procedure in contrast with expulsion of FVIN.

In the strategy where Best in class Exchanging Middle Channel (PSMF) [5] is utilized, the change between the present pixel esteem and the middle an incentive in the sifting outline is coordinated with a limit esteem which has been pre-characterized, picks whether a motivation is accessible. The key hindrance of this technique is in touching base at a strong choice. This burden is overwhelmed by the Versatile Rank-requested Exchanging Middle Channel (ARSMF). This strategy painstakingly channels those pixels which are corrupted by motivation commotion and leaves the remaining estimations of the simple pixels whole. Additionally Choice Based Unsymmetrical Trimmed Middle Channel is anticipated in [1]where if the dealt with pixel in the casing has an estimation of either 0 or 255, at that point that esteem is changed by the middle of the lingering esteems in the edge. In the event that the picture has high commotion densities, at that point the sheared middle esteem [7] additionally will be like handled pixel. Therefore this strategy creates in able for pictures with high commotion densities. Roy et al. in anticipated a versatile channel for the end of high commotion thickness in shading pictures yet at the same time not futile against irregular esteem drive clamor.

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SALT-AND-PEPPER noise is a special case of impulse noise, where a certain percentage of individual pixels in digital image are randomly digitized into two extreme intensities. Normally, these intensities being the maximum and minimum intensities. The contamination of digital image by salt-and-pepper noise is largely caused by error in image acquisition and/or recording. For example, faulty memory locations or impaired pixel sensors can result in digital image being corrupted with salt-and-pepper noise [1]. The need to remove salt-and-pepper noise is imperative before subsequent image processing tasks such as edge detection or segmentation is carried out. This is because the occurrence of salt-and-pepper noise can severely damage the information or data embedded in the original image. One of the simplest ways to remove salt-and-pepper noise is by windowing the noisy image with a conventional median filter [2]. However, the conventional median filter, which restores each pixel with the median pixel in the filtering window regardless whether it is a noise or noise-free pixel, exhibits blurring of filtered images. Recently, Luo in [3] proposed an efficient detail-preserving approach (EDPA) based on alpha-trimmed mean statistical estimator. Similarly, an efficient edge-preserving algorithm (EEPA) is introduced in [4] for the removal of salt-and-pepper noise without degrading image fine details. Then, Chen and Wu [5] proposed the adaptive impulse detector with center-weighted median (ACWM) filter to effectively remove salt-and-pepper noise. These methods only perform well when an image is corrupted with 50% of salt-and-pepper noise or lower. On the other hand, the decision-based algorithm (DBA) filter in [6] and the open-close sequence (OCS) filter based on mathematical morphology [7] are shown to be able to filter high-density of saltand- pepper noise corruption, but at the expense of fine image details or high computational time [8]. In this letter, we proposed a new type of salt-and-pepper noise filter called the noise adaptive fuzzy switching median (NAFSM) filter. The NAFSM filter is a hybrid between the
simple adaptive median filter in [9] and the fuzzy switching median filter in [1]. The adaptive behavior enables the NAFSM filter to expand the size of its filtering window according to the local noise density, making it possible to filter high-density of salt-and-pepper noise. Meanwhile, the inherited switching median behavior will speed up the filtering process at the same time preserving image details by selecting only "noise pixels" for processing. In addition, the resorted fuzzy reasoning deals with the uncertainty presence in the local information and helps to produce an accurate correction term when restoring detected "noise pixels".

Contribution in this paper

• This paper introduces interpolation based detection and Filtering for Random valued Impulse noise.

• Both the detection and Filtering is done in a single process, which reduces the time complexity.

• Adaptive interpolation algorithm makes it to achieve high accuracy during filtering.

2. PREVAILING DETECTION METHODS

2.1. Four Phase Detector (FPD)

This method [6] of removal of RVIN operates in maximum four detection phases with some advancement in two phase detector. The detection process in this method operates using similar valued neighbour criterion. After each of the detection phase, the median of the luminance values of the non-corrupted pixel is computed and the corrupted pixel is replaced with this value.

Considering a pixel x=xi,j, with xx representing the pixels in a 3x3 window centered at x. The most similar pixels to the tested pixel in the window are determined. The mean of the absolute difference of the three pixels and the tested pixel is computed by the equation

$$\mathrm{STAT}_1 = \frac{1}{3}\sum_{r=1}^{3} S_{x,y}^{r}$$

The value of STAT1 is compared with the threshold values which have been predetermined based on earlier experiments. The best suitable threshold values for this phase is T1=[8,15,45]. If the STAT1 is greater than the threshold value

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selected, then the pixel of interest is considered to be a noisy pixel. The filtering step is used to suppress the noisy pixel. The median of luminance value of the uncorrupted pixels within the window is computed and the corrupted pixel is replaced with the computed value. If it is found that all the pixels within the selected window are corrupted by Impulse Noise, then the window sixe is increased till we obtain a window where at-least one pixel remained uncorrupted.

The above procedure is repeated for all the three threshold values. The PSNR value of the filtered images is obtained and the image with the best PSNR is selected as the noise image for the second phase.

In the second phase the image with best PSNR value at the end of first phase is selected as IN corrupted image. Similar to first phase three threshold values are selected. Here let yxbe the pixels in a 5x5 window centred at x. The most similar three pixels with respect to the tested pixel in the neighbourhood with e chessboard distance 1 and the most similar three pixels with respect to the tested pixel in the neighbourhood with chessboard distance 2 are selected.

The mean of the absolute difference of the three similar pixels at chessboard distance 1 and the tested pixel and the mean of the absolute difference of the three similar pixels at chessboard distance 2 and the tested pixel are computed by the equation

$$\mathrm{STAT}_2 = \frac{1}{6}\left(\sum_{r=1}^{3} S^{r}_{1x,y} + \sum_{r=1}^{3} S^{r}_{2x,y}\right)$$

As the case with phase 1, the mean is compared with the threshold value of T2. If STAT2 is greater than the threshold value selected the pixel of interest is said to be a noisy pixel and this pixel is suppressed through filtering.

Similar to phase 1, the above procedure is repeated for all three threshold values and three images are obtained. The PSNR value of the three images is computed.

The best PSNR value from phase 2 is selected and this is compared with the best PSNR obtained in phase 1. The best PSNR selected from phase 2 if is found smaller than the best PSNR selected from phase 1, the detection process is terminated and the resultant image obtained of the best PSNR in phase 1 is accepted as the best result. Else the third phase is proceeded with the best image of phase 2.

In the third phase the best restored image of phase 2 is taken as the corrupted image. As the usual procedure of previous phase the threshold values is selected. The steps followed in phase 1 are repeated.

The best PSNR selected from phase 3 if is found smaller than the best PSNR selected from phase 2, the detection process is terminated and the resultant image obtained of the best PSNR in phase 2 is accepted as the best result. Else the fourth phase is proceeded with the best image of phase 3.

In the fourth phase the image with best PSNR obtained from phase 3 is taken as the corrupted image. As the usual procedure of previous phase the threshold values is selected. The steps followed in phase 2 are repeated.

The best PSNR selected from phase 4, if is found smaller than the best PSNR selected from phase 3, the detection process is terminated and the resultant image obtained of the best PSNR in phase 3 is accepted as the best result. Else the image with best PSNR obtained from fourth phase is accepted as the best restored image3.

2. RANK ORDER ABSOLUTE DIFFERENCE (ROAD)

In ROAD [4,14] generally the neighbourhood size is selected as odd number, this is so because it gives a definite centre pixel value. If the size of neighbourhood is selected to be even, then a median is obtained which is nothing but the arithmetic mean of the two center pixels in the window.

Having a corrupted image B, with the window size to be (2N+1)X(2N+1) the absolute difference is obtained by the relation

$dk = |(i,j) - B(i+s, j+t)|$,where $-N \leq s,t \leq N$

$(s,t) \neq (0,0)$ and k varies from 1 to (n-1), where n represents number of pixels in the sliding window.

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Here we consider s=4 where s represents the minimum number of absolute differences m1, m2, m3,m4…..ms in the selected frame which are to be used for obtaining the ROAD value.
The selected minimum absolute difference values are added as shown by the formula to obtain the ROAD value.

3.1 . Rank Order Logarithmic Difference (ROLD)

In case of RVIN, some noise pixels at the center of window may at times be close in value to their uncorrupted neighbours. In such a situation, the ROAD value may not take a large value, there by not able to distinguish the pixel of interest as noise. So one way to deal with such an image, is to find a means to increase these ROAD values, at the same time maintaining small the ROAD values of uncorrupted pixels. Hence we use the logarithmic function of ROAD to obtain ROLD value [20].
Having a corrupted image B, with window size (2N+1)x(2N+1) the absolute difference is obtained by the formula
$adn = |(i,j) - B(i+s,j+t)|$, where -N≤(s,t)≤N.
(s,t)≠(0,0) and k the number of pixels in window.

4. NOISE ADAPTIVE FUZZY SWITCHING MEDIAN FILTER

The proposed NAFSM filter is a recursive double-stage filter, where initially it will perform the salt-and-pepper noise intensities detection before identifying the locations of possible noise pixels. When a "noise pixel" is detected, it is subjected to the next filtering stage. Otherwise, when a pixel is classified as "noise-free," it will be retained and the filtering action is spared to avoid altering any fine details and textures that are contained in the original image.

A. Detection Stage

The proposed NAFSM filter will utilize the noisy image histogram as to estimate the two salt-and-pepper noise intensities. Based on the assumption that an image corrupted with salt-and-pepper noise will produce two peaks at the noisy image histogram [10], the detection stage begins by searching for these two peak intensities. However, this assumption does not always hold true, especially when an image is corrupted with extremely low-density of salt-and-pepper noise. In this case, other noisefree intensities will peak in the noisy image histogram instead of the salt-and-pepper noise intensities. As a result, when the noise intensities are wrongly detected, the salt-and-pepper noise will be left unfiltered in the noisy image.

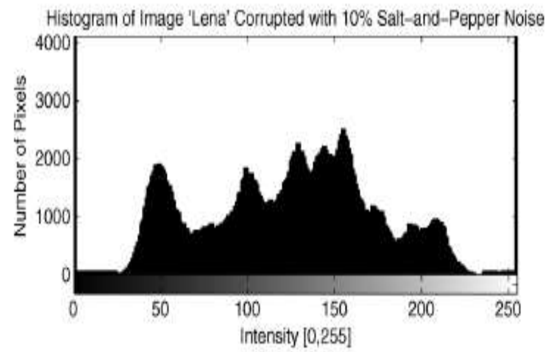

Fig. 1. Histogram of "Lena" image corrupted with 10% of salt-and-pepper noise.

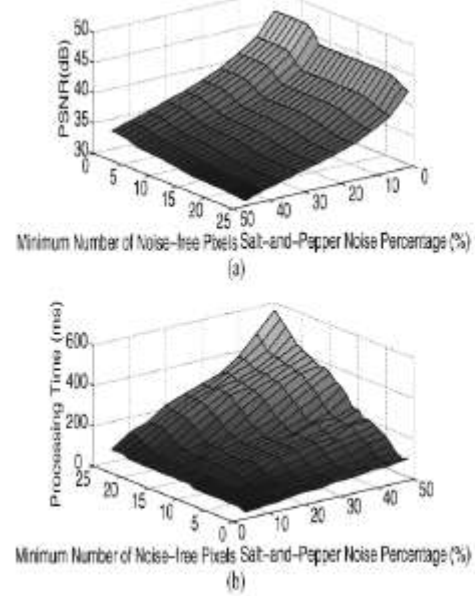

Fig. 2. Minimum number of "noise-free pixels" required in the sample for selecting median pixel based on (a) PSNR and (b) processing time, simulated using noisy "Lena" images.

5. PROPOSED METHOD

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The overall architecture for the removal of Random-valued impulse noise is shown in Figure 3. Here, the noisy image is read as input and Interpolation [10] is used to detect the noisy pixel present in an input image and in the filtering stage Interpolation technique is used to substitute the detected noisy pixel. Therefore, it produces a noise-free image as an output image.

The working Principle of proposed architecture is:

1. Read the corrupted image and choose the pixel value of either 3×3 or 5×5 window and it is represented as Or.
2. Calculate the interpolation value of the pixels and it is represented as .
3. Find the absolute difference, $D = Ir - Or$.
4. If the absolute difference is greater than the threshold value then replace the current pixel value with the interpolated value.

Denoised image will be obtained.

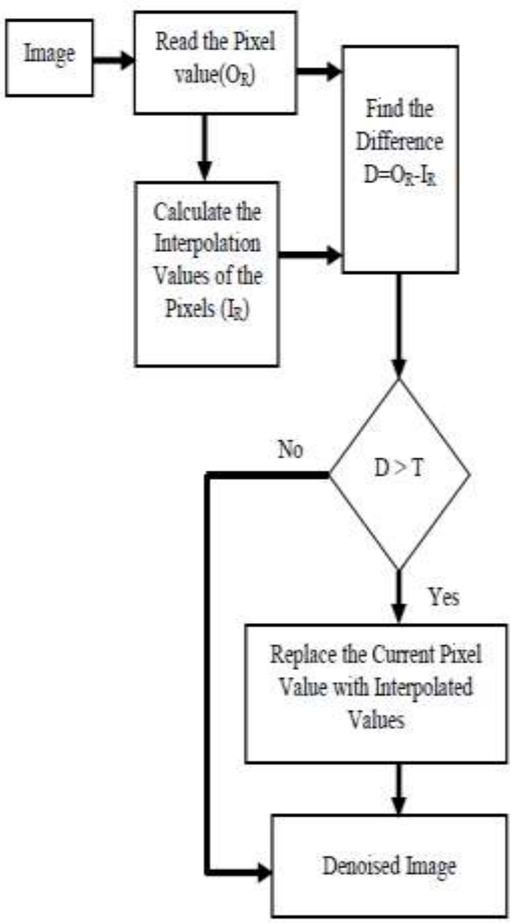

Fig. 3: Block diagram of the proposed system

This Interpolation is defined as “filling in the pixels in between”. Interpolation is to create acceptable images at altered resolutions from a single low-resolution image. Interpolation is the calculation of the value of a function between the values already known or filling in the pixels in between. The proposed interpolation technique processes the corrupted images by first detecting the RVIN. The architecture for proposed interpolation system is shown in the Figure 4.

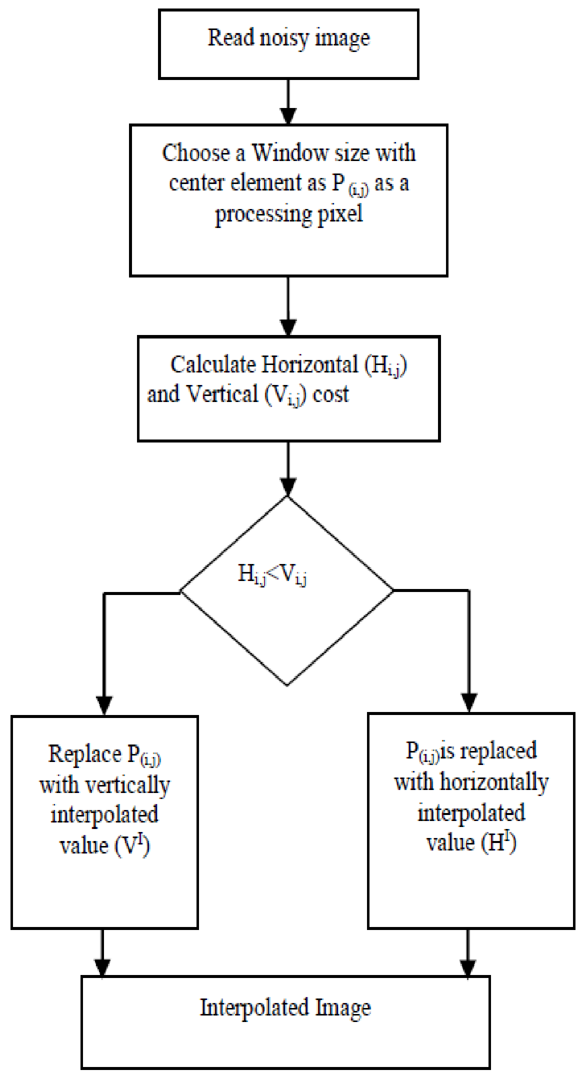

Fig. 4: Block diagram of the Adaptive Interpolation Algorithm.

To classify the smooth and sharp sections on the image with noise and to intercalate the obtained

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noise component, the difference costs of Hi,j(horizontal) and Vi,j(vertical) are calculated first as given by the subsequent equations for every pixel location present in the 5 X 5 window size.

CONCLUSION

In this letter, a NAFSM filter for effective removal of saltand-pepper noise is presented. The proposed filter is able to suppress high-density of salt-and-pepper noise, at the same time preserving fine image details, edges and textures well. In addition, it does not require any further tuning or training of parameters once optimized. By carefully considering the tradeoff between the complexity of the filtering algorithm and the performance of the filter, the proposed NAFSM filter is able to yield good filtering results with efficient processing time. Future research should, in the authors' opinion, focus on estimating the local information adaptively based on fuzzy inference in order to further shorten the processing time when the image is corrupted with high-density of salt-and-pepper noise. **REFERENCES**

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