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Image Fusion Algorithm for Impulse Noise Reduction in Digital Images

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Image Fusion Algorithm for Impulse Noise Reduction in Digital Images

M. Jaya Manmadha Rao^α, Dr.K.V.V.S.Reddy^Ω

Abstract- This paper introduces the concept of image fusion technique for impulse noise reduction in digital images. Image fusion is the process of combining two or more images into a single image while retaining the important features of each image. Multiple image fusion is an important technique used in military, remote sensing and medical applications. The images captured by different sensors undergo filtering using pixel restoration median filter and the filtered images are fused into a single image, which combines the uncorrupted pixels from each one of the filtered image. The fusion algorithm is based on selecting the sharper regions from the individual de-noised images. The performance evaluation of the fusion algorithm is evaluated using structural similarity index (SSIM) between original and fused image. Experimental results show that this fusion algorithm produce a high quality image compared to individually de-noised images.

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I. INTRODUCTION

Digital images are often corrupted during acquisition, transmission or due to faulty memory locations in hardware [1]. The impulse noise can be caused by a camera due to the faulty nature of the sensor or during transmission of coded images in a noisy communication channel [2]. Consequently, some pixel intensities are altered while others remain noise free. The noise density (severity of

the noise) varies depending on various factors namely reflective surfaces, atmospheric variations, noisy communication channels and so on.

In most image processing applications the images captured by different sensors are combined into a single image, which retains the important features of the images from the individual sensors, this process is known as image fusion[3][4]. In this paper, the images captured by multiple sensors are differently noised depending on the proximity to the object, environmental disturbances and sensor features. These noise images are filtered using pixel restoration median filter and the filtered images are fused into a single image based on the sharpness of the regions from the de-noised images, thus producing a high quality image. The entire process of our technique is shown in figure 1. The performance evaluation of the image fusion is evaluated using SSIM [7] index between the original and fused image.

This paper is organized as follows: Section II present the impulse noise in images, Section III present the method for noise density calculation in an image, Section IV present the pixel restoration median filter Section V present the image fusion algorithm, Section VI present experimental results and finally Section VII reports conclusion.

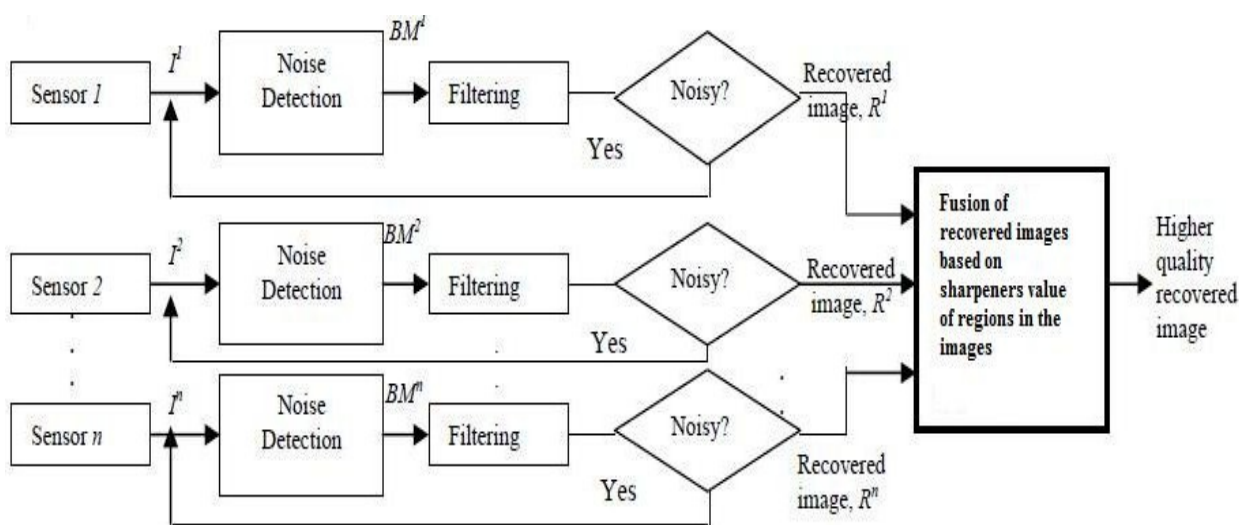


Figure 1: Image Fusion Technique

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II. IMPULSE NOISE IN IMAGES

Impulse noise [5] corruption is very common in digital images. Impulse noise is always independent and uncorrelated to the image pixels and is randomly distributed over the image. Hence unlike Gaussian noise, for an impulse noise corrupted image all the image pixels are not noisy, a number of image pixels will be noisy and the rest of pixels will be noise free. There are different types of impulse noise namely *salt and pepper* type of noise and random valued impulse noise.

In *salt and pepper* type of noise the noisy pixels takes either salt value (gray level -255) or pepper value (gray level -0) and it appears as black and white spots on the images. If ρ is the total noise density then salt noise and pepper noise will have a noise density of $\rho/2$. This can be mathematically represented by (1)

$$y_{ij} = \begin{cases} \text{zero or 255 with probability } p \\ x_{ij} \text{ with probability } 1-p \end{cases} \quad (1)$$

Where y_{ij} represents the noisy image pixel, ρ is the total noise density of impulse noise and x_{ij} is the uncorrupted image pixel. At times the *salt noise and pepper* noise may have different noise densities ρ_1 and ρ_2 and the total noise density will be $\rho = \rho_1 + \rho_2$.

In case of random valued impulse noise, noise can take any gray level value from zero to 225. In this case also noise is randomly distributed over the entire image and probability of occurrence of any gray level value as noise will be same. We can mathematically represent random valued impulse noise as in (2).

$$y_{ij} = \begin{cases} n_{ij} \text{ with probability } p \\ x_{ij} \text{ with probability } 1-p \end{cases} \quad (2)$$

where n_{ij} is the gray level value of the noisy pixel.

III. NOISE DENSITY CALCULATION

Algorithm:

1. Let I be the noisy image of size $N \times N$ of an object or scene captured by sensor.
2. The noise boundaries of noisy image I are computed by spike detection technique [6]. Let L_1 and L_2 be the lower and upper noise boundaries for the noisy image.
3. The binary map (BM) of the noisy image is developed using the noise boundaries L_1 and L_2 . If the image pixel 'y' lies within the noise boundaries, then it is uncorrupted and represented by a '0' in the binary map. The corrupted pixel is represented by a '1' in binary map.

$$BM = \begin{cases} '0' \text{ if } L_1 < y < L_2 \\ '1' \text{ if } y < L_1 \text{ or } y > L_2 \end{cases} \quad (3)$$

4. Compute the noise density ND of the noisy image.

$$ND = \frac{\text{sum of '1's in } BM}{N * N} \quad (4)$$

The value of ND ranges from 0 to 1.

IV. PIXEL RESTORATION MEDIAN FILTER

Image X and Binary Map of the image BM are inputs to the PRMF algorithm[6].

- [1] Let pixel x_{ij} and corresponding b_{ij} are selected from image X and binary map BM respectively, where $i=2, \dots, (n-1)$ and $j=2, \dots, (n-1)$ for an image of size $n \times n$. If $b_{ij} = '0'$, then pixel x_{ij} is 'uncorrupted'. Hence go to step [5].
- [2] Select a 3×3 window W_x in X and W_b in BM centered around $(i, j)^{th}$ pixel x_{ij} in X and b_{ij} in BM respectively.
- [3] Check for '0's (uncorrupted pixels) in W_b and store corresponding elements of W_x in vector A .
- [4] If A is a null vector go to step V. Else replace x_{ij} with median of vector A .
 $x_{ij} = \text{median}(A)$. (5)
- [5] Increment i, j and consider next x_{ij}, b_{ij} and go to step [2].

By using this algorithm iteratively along with updated binary map of the recovered image, noise fades from the noisy image.

V. IMAGE FUSION ALGORITHM

- [1] Let I^1, I^2, \dots, I^n be the noisy images of an object or scene captured by sensors S^1, S^2, \dots, S^n respectively. Let I be of size $N \times N$ where $i = 1, 2, \dots, n$. Iteration index $k^i = 1$.
- [2] Compute the noise densities of the images I . Noise densities are computed for the iteration count $k^i = 1$. If $K^i = 1$ compute ND^i .
- [3] Filter the noisy images using pixel restoration median filter. The filtered images are denoted as R^i shown in figure 1.
- [4] Check for the noise in the processed images. If the images are still noisy, then increment the iteration index $k^i, k^i = k^i + 1$ and goto step [2].
- [5] The recovered images R^i for $i = 1, 2, \dots, n$ are divided into non-overlapping rectangular blocks (or regions) with size of $m \times n$ (10×10 blocks). The j^{th} image blocks of R^i are referred by R_j^i .
- [6] Variance (VAR) of R_j^i is calculated for determining the sharpness values of the corresponding blocks and the results of R_j^i are denoted by VAR_j^i . VAR is defined as:

$$VAR = \frac{1}{m \times n} \sum_x \sum_y (f(x,y) - \bar{f})^2 \quad (6)$$

Where \bar{f} is the average grey level over the image.

$$\bar{f} = \frac{1}{m \times n} \sum_x \sum_y f(x,y) \quad (7)$$

In order to determine the sharper image block, the variances of image blocks from n recovered images are sorted in descending order and the same ordering is associated with image blocks. The block with the maximum variance is kept in the fused image. The fusion mechanism is represented as follows:

If $VAR_{(k)}$ is the variance of block $R_{(k)}$, where k denotes the rank, the ordering of variances is given by

$$VAR_{(1)} > VAR_{(2)} > \dots > VAR_{(n-1)} > VAR_{(n)} \quad (8)$$

and this implies the same ordering to the corresponding blocks

$$R_{(1)} > R_{(2)} > \dots > R_{(n-1)} > R_{(n)} \quad (9)$$

Where the subscripts are the ranks of the image blocks. Since the block with the largest variance is in the fused image, it will correspond to rank 1 of the ordered blocks ie;

$$Fused\ Block = R_{(1)} \quad (10)$$

VI. EXPERIMENTAL RESULTS

The proposed method of image fusion for impulse noise reduction in images was tested on the true color parrot image with 290x290 pixels. The impulse noise is added into the image with noise density 0.45, 0.5, 0.6. The noisy images are processed using pixel restoration median filter individually. The filtered images are fused into a single image using the Image fusion method. The experimental results are shown in Figure 2. Table (1) shows the SSIM value of fused image with different noise densities of input images with respect to original image.

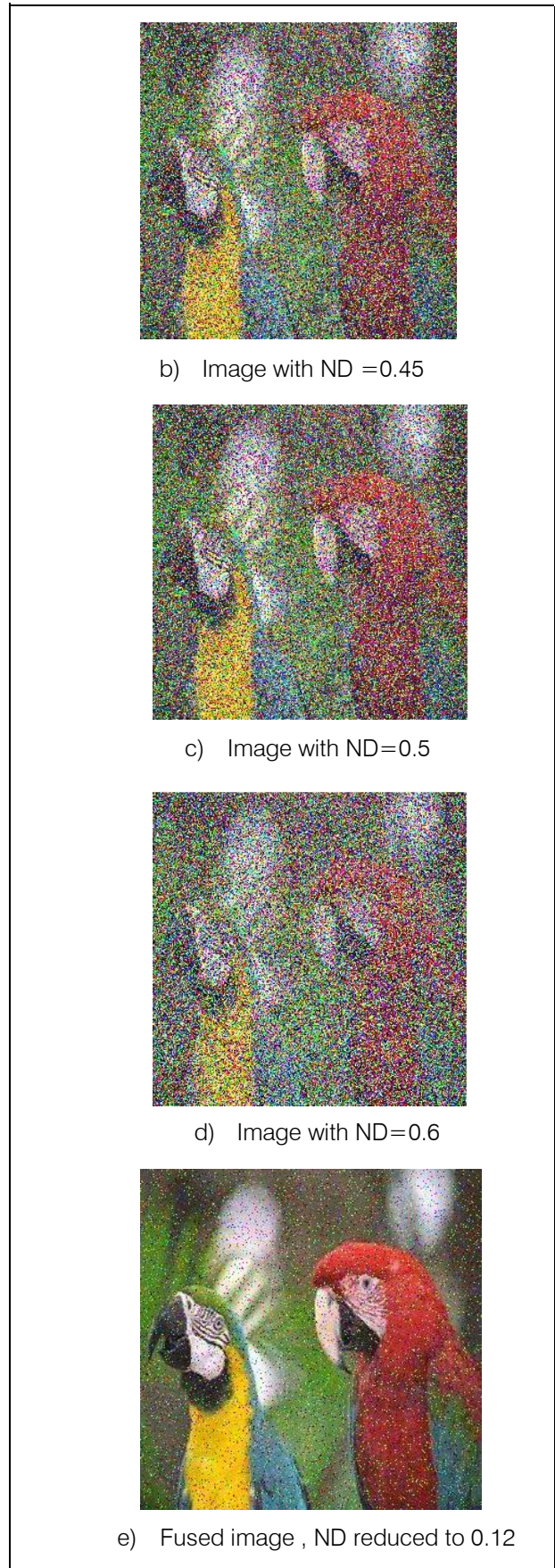


Figure 2 : Illustration of Proposed Technique

Table 1: Performance evaluation of Image Fusion using SSIM index with different ND's

Noise densities of 3 input images			SSIM value of fused image with respect to original image
0.2	0.35	0.4	0.8436
0.3	0.4	0.5	0.7342
0.5	0.6	0.7	0.5743
0.6	0.7	0.8	0.4468

VII. CONCLUSION

In this paper, an image fusion technique for impulse noise reduction in digital images is presented. The proposed technique helps to attain high quality images. Images of an object or scene, captured by multiple sensors undergo filtering using pixel restoration median filter individually and these de-noised images are fused by the proposed technique. The proposed method is simple and can be used for real-time imaging applications.

REFERENCES RÉFÉRENCES REFERENCIAS

1. Tao Chen, Kai-Kaung Ma and Li-Hui Chen, "Tri-state median filter for image Denoising", IEEE Transactions on Image Processing, Vol 8, no.12, pp.1834-1838, December 1999.
2. Reihard Berstein," Adaptive nonlinear filters for simultaneous removal of different kinds of noise in images," IEEE Trans on circuits and systems , Vol.cas-34, no 11,pp.127-1291, Nivember 1987.
3. O.Rockinger," Image sequence fusion using ashift invariant wavelet transform," IEEE transactions on image processing, 3:288-291, 1997.
4. Chaveli Ramesh and T.ranjith, "Fusion performance measures and a lifting wavelet transform based algorithm for image fusion", In Proc. 5th International conference on image fusion, july 2002,pp 317-320.
5. S.Indu, Chaveli Ramesh, " A noise fading technique for images corrupted with impulse noise", Proceedings of ICCTA07, IEEE.
6. S.Indu, Chaveli Ramesh, "Image Fusion Algorithm for Impulse Noise Reduction", Proceedings of ARTCom.2009, IEEE.
7. Z. Wang and A. C. Bovik, "A universal image quality index," IEEE Signal Processing Letters, vol. 9, pp. 81-84, Mar. 2002.