Image Fusion Algorithm for Impulse Noise Reduction in Digital Images

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Received: 22 April 2011 Accepted: 20 May 2011 Published: 2 June 2011

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.

Index terms— Image Fusion, Image Restoration, Image Processing, Impulse Noise.

1 Introduction

igital 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.

2 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 -225) or pepper value (gray level -0) and it appears as black and white spots on the images. If p is the total noise density then salt noise and pepper noise will have a noise density of p/2.This can be mathematically represented by (1) zero or 255 with probability p y ij =

x ij with probability 1-p

Where y ij represents the noisy image pixel, p 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 p 1 and p 2 and the total noise density will be p=p 1 + p 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). n ij with probability p y ij =

x ij with probability 1-p

where n ij is the gray level value of the noisy pixel.

3 III.

4 Noise Density Calculation

Algorithm:

1. Let I be the noisy image of size NXN of an object or scene captured by sensor. The value of ND ranges from 0 to 1.

5 IV.

6 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?? (n-1) and j=2?.. (n-1) for an image of size nxn. If b ij = '0', then pixel x ij is 'uncorrupted'. Hence go to step [5].

[2] Select a 3x3 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 = median(A).

(5) [5] Increment i, j and consider next x ij, b ij and go to step [2].

7 V.

Image Fusion Algorithm [1] Let I 1 , I 2 ,......, I n be the noisy images of an object or scene captured by sensors S 1 ,S 2 ,......,S n respectively. Let I i be of size NXN where i =1,2,?,n. Iteration index k i .

[2] Compute the noise densities of the images I i . Noise densities are computed for the iteration count k i . 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,..,n are divided into non-overlapping rectangular blocks (or regions) with size of mxn (10x10 blocks). The j th image blocks of R i are referred by R i j [6] Variance (VAR) of R i j is calculated for determining the sharpness values of the corresponding blocks and the results of R i j are denoted by VAR i j . VAR is defined as:'0' if L 1 < y<L 2 BM = '1' if y<L 1 or y>L 2 (3) = 1.

8 = 1

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

9 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

1

Figure 1: Figure 1 :

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 ND= sumN in BM(4) s * '1' N of

[Note: 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.4]

Figure 2:

1

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.		

Figure 3: Table 1 :

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. [1] [2] [3]

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 i j , where k denotes the rank, the ordering of variances is given by

and this implies the same ordering to the corresponding blocks

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;

VI.

.1 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 i mpulse 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 res ults are shown in Figure **??**. Table **??**1

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