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Fast Impulse Noise Removal Using Efficient Weighted-Average Filtering

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Abstract - *A novel and effective method for impulse noise removal in corrupted color images is discussed. The new method consists of two phases. The first phase is a noise detection phase where a modified Hopfield innovative weighted-average filter is used to detect impulse noise pixels. The second is a noise filtering phase where the disadvantage of taking Vector Median in a single color space is addressed and a new algorithm based on performing Vector Median first in RGB space and then in HSI space is presented. The results of simulations performed on a set of standard test images on a wide range of noise corruption show that the proposed method is capable of detecting all the impulse noise pixels with almost zero false positive rates and removes noise while retaining finer image details. It outperforms the standard procedures and is yet simple and suitable for real time applications.*

Index Terms - *Image denoising, impulse detector, impulse noise, weighted-average filtering.*

1 INTRODUCTION

Images are often corrupted by impulse noise during acquisition and transmission. Therefore, an efficient noise suppression method is required before subsequent image processing operations. Many recent methods first detect the corrupted pixels and then restore them without affecting the uncorrupted pixels. Various solutions for estimating the intensity of noisy pixels can be divided into four categories of median-based filters, fuzzy-based algorithms, adhoc ideas and weighted-average filters.

Most of impulse noise removal algorithms are variations of median filtering. Best examples are Decision Based Algorithm (DBA), Median based Switching filter (MS), and Modified Decision Based Unsymmetrical Trimmed Median Filter. Also, due to the nature of impulse noise, some methods are proposed based on fuzzy logics, such as Detail Preserving Filter (DPF), Noise Adaptive Fuzzy Switching Median (NAFSM) filter, and Turbulent Particle swarm optimization based Fuzzy Filtering (TPFF).

In Specialized Regularization method is proposed to restore noisy pixels. Opening Closing Sequence filter is presented in based on mathematical morphology. In Edge Preserving Algorithm (EPA) is proposed which adopts a directional Correlation dependent filtering technique. In Robust Outlyingness Ratio is combined with the Non Local Means to detect and filter the noisy pixels. In a method is presented which employs an iterative impulse detector and an Adaptive Iterative Mean filter to remove the general fixed valued impulse noise.

Another well-known approach is weighted-average filtering, which exploits the correlation among neighboring pixels to restore the corrupted pixels. The Switching based Adaptive Weighted

Mean filter and the Cloud Model filter employ this approach for impulse suppression. Both filters adaptively determine the filtering window and use complex weighting rules. In SAWM method, the weights are specified based on the degree of compatibility between pixels, and the CM filter uses the certainty degrees of uncorrupted pixels as their weights. These filters are time varying; that is they have to perform pixel by pixel restoration, rather than processing the image as a whole. This constraint opposes efficient implementation.

We propose a two-step method for real time impulse noise suppression. First, we employ an impulse detector to identify the corrupted pixels. It examines the spatial correlation of suspicious image pixels to decrease the false detection of uncorrupted pixels as corrupted. Second, we restore the image using a weighted-average filter. The filter operates on the nearest neighboring interpolated image and can be implemented using matrix based operations.

The rest of this paper is organized as follows. Defines the impulse noise model. The experimental results and comparisons are provided in concludes the letter.

2 IMPULSE NOISE MODEL

Fixed Valued Impulse Noise (FVIN), also known as Salt-and-Pepper Noise (SPN), is commonly modeled by:

$$X_{i,j} = \begin{cases} N_{min} & \text{with probability } p/2 \\ X_{i,j} & \text{with probability } 1\text{-}p \\ N_{max} & \text{with probability } p/2 \end{cases} \quad (1)$$

where x and p are the original and corrupted images and noise density, respectively, and (i,j) is the image coordinate. This model implies that the pixels are randomly corrupted by two fixed extreme grey-values, N_{min} and N_{max} with the same probability. For impulse noise suppression, we first specify the impulse values and locate the corrupted pixels, and then estimate their original values using the information provided by the uncorrupted pixels.

3 THE PROPOSED METHOD

The high similarity between grouped blocks in each 3D array enables a highly sparse representation of the true signal in a 3D transform domain and thus a subsequent shrinkage of the transform spectra results in effective noise attenuation. The peculiarity of the proposed method is the application of a grouping constraint on the chrominance by reusing exactly the same grouping as for the luminance. The boundary detector and mirror models were added to detect the boundary information and provide mirror pixels for green, red and blue color interpolations, which can efficiently improve the quality of interpolated pixels located in the boundary.

The proposed C-BM3D achieves state of the art performance in terms of both PSNR and subjective visual quality. This is achieved at a reasonable computational complexity. In addition, effective complexity scalability can be realized by exploiting the complexity performance.

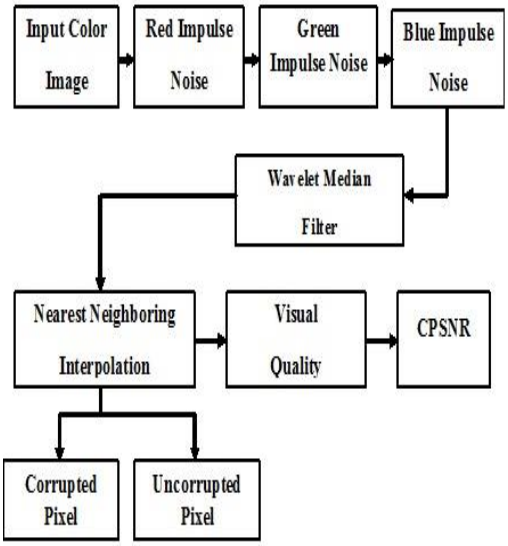
3.1 Image Restoration

For image restoration, we propose a wavelet median filter. In the proposed method, first we construct an initial image using the NNI. In this image, each noisy pixel takes the color value of its nearest known pixel. We then improve the initial image by employing median filter, which applies different procedures for weighting the known and noisy pixels.

3.2 Weight Assignment Procedures

The weight assignment to known pixels is based on the fact that due to the spatial correlation of image pixels, the information of adjacent pixels overlaps. In other words, two separate pixels have more information than two adjacent pixels. This confirms the observations that, with a fixed noise density, random losses can be restored better than block and burst losses. To quantify the value of unique information in each known pixel, we should determine the solitariness of that pixel. The weight assignment to noisy pixels is based on this image property that farther image pixels have lesser correlation with each other.

It computes the Distance Transform of the image to obtain the DM and the CPM. Each element of DM and CPM contain the Euclidean distance of the corresponding image pixel with the nearest known pixel and the index of that pixel, respectively.



Block Diagram of Color Image Noise Technique

Input Color Image

If the input image is color image, im2bw converts the input image to color, and then converts this color image to binary by thresholding.

Red Impulse Noise

Color digital images are made of pixels, and pixels are made of combinations of primary colors represented by a series of code.

Green Impulse Noise

"Channel" is a conventional term used to refer to a certain component of an image.

Blue Impulse Noise

An RGB image has three channels: red, green, and blue. RGB channels roughly follow the color receptors in the human eye, and are used in computer displays and image scanners.

Wavelet Median Filter

Mean filter for every pixel in the image the pixel value is replaced by the mean value of its neighboring pixels NxM with a weight. This will resulted in a smoothing effect in the image. Median filter for every pixel in the image, the pixel value is replaced by the statistical median of its neighboring pixels NxM. Although median filter also provides a smoothing effect, it is better in preserving detailed image.

Nearest-neighbor interpolation

Nearest-neighbor interpolation is the fastest and crudest filtering method it simply uses the color of the texel closest to the pixel center for the pixel color. While fast, this results in a large number of artifacts texture 'blockiness' during magnification, and aliasing and shimmering during magnification.

Corrupted Pixel

3Dimentional window Sxy‘ of size 3x3 is selected and is denoted as S(1), S(2),.....S(9) as shown in fig 1. Let the pixel to be processed is Y(x,y). Next, the pixel values inside the window are sorted by arranging the rows, columns and the right diagonal in the ascending order

S (1)	S (2)	S (3)
S (4)	S (5)	S(6)
S (7)	S (8)	S (9)

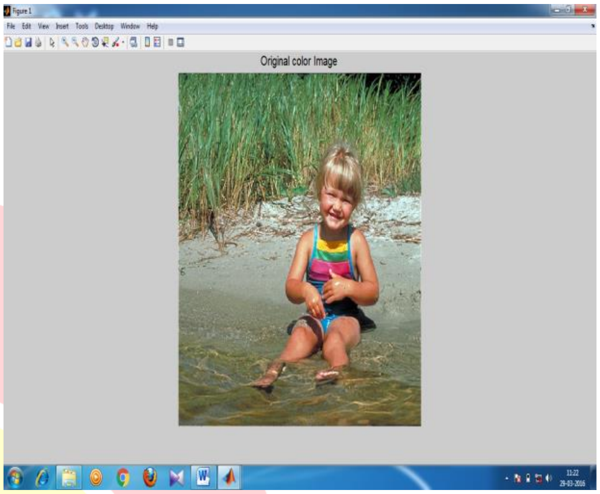
Hence, the first element of the window, S(1) so obtained is the minimum value Ymin, the last element of the window, S(9), is the maximum value Ymax and the middle element of the window, S(5), is the median value Ymed.

Uncorrupted Pixel

The need of fuzzy logic arises which modifies the value of pixel obtained from the first subunit in order to remove noise, if present, and to improve the preservation of image details by fuzzy switching. The third subunit is basically a uncorrupted Pixel unit which aims at preserving the details of the image by border correction and by increasing contrast and sharpness.

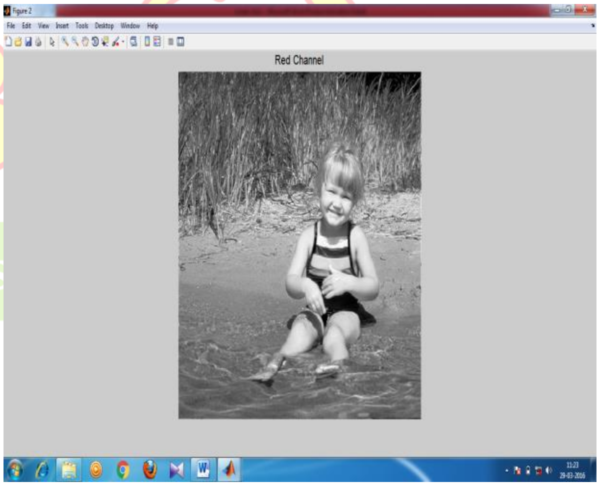
4 SIMULATION RESULT

4.1 Input Color Image



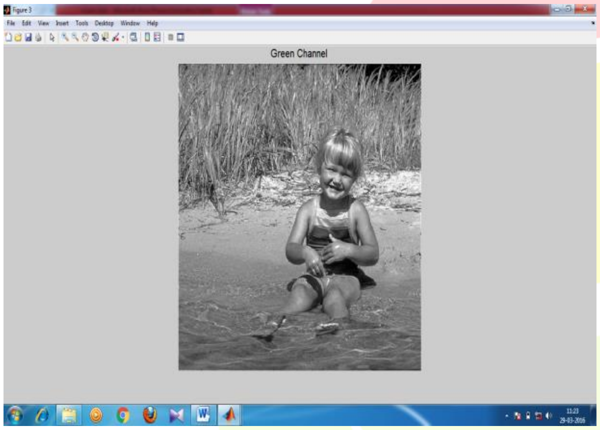
BW = im2bw (I, level) converts the color image to a binary image. The output image BW replaces all pixels in the input image with luminance greater than level with the value 1 (white) and replaces all other pixels with the value 0 (black). Specify level in the range [0, 1]. This range is relative to the signal levels possible for the image's class. Therefore, a level value of 0.5 is midway between black and white, regardless of class.

4.2 Red Impulse Noise



A channel in this context is the color image of the same size as a color image, made of just one of these primary colors. For instance, an image from a standard digital camera will have a red, green and blue channel. A color image has just one channel.

4.3 Green Impulse Noise



In reality, any image format can use any algorithm internally to store images. For instance, GIF images actually refer to the color in each pixel by an index number which refers to a table where three color components are stored. The discrete color channels can always be determined, as long as a final color image can be rendered.

4.4 Blue Impulse Noise

If the RGB image is 24-bit each channel has 8 bits, for red, green, and blue in other words, the image is composed of three images (one for each channel), where each image can store discrete pixels with conventional brightness intensities between 0 and 255. If the RGB image is 48-bit (very high color-depth), each channel is made of 16-bit images.

4.5 Insert Impulse Noise

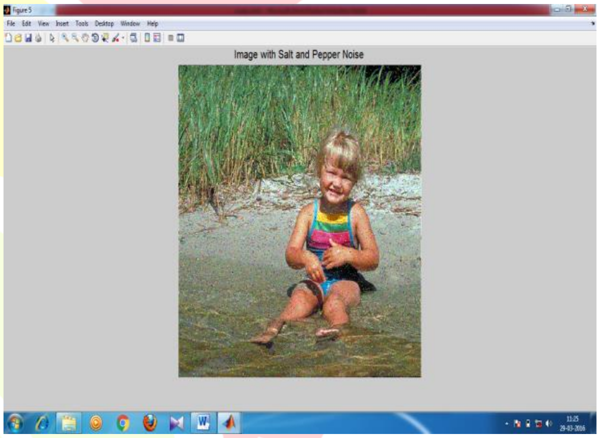
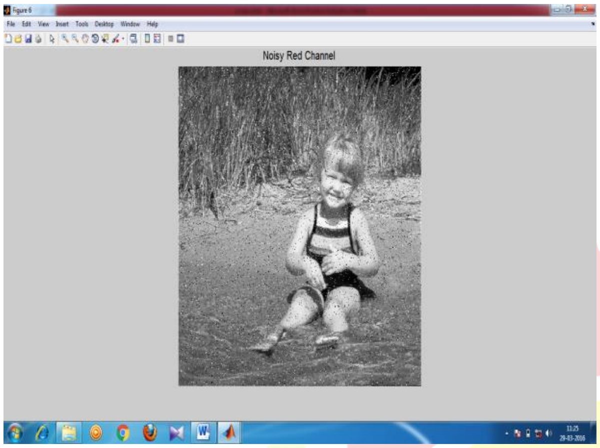


Image noise is random variation of brightness or color information in images and is usually an aspect of electronic noise. It can be produced by the sensor and circuitry of a scanner or digital camera. Image noise is an undesirable by-product of image capture that adds spurious and extraneous information. The weights are specified based on the degree of compatibility between pixels, and the CM filter uses the certainty degrees of uncorrupted pixels as their weights. These filters are time varying that is they have to perform pixel by pixel restoration, rather than processing the image as a whole. This constraint opposes efficient implementation.

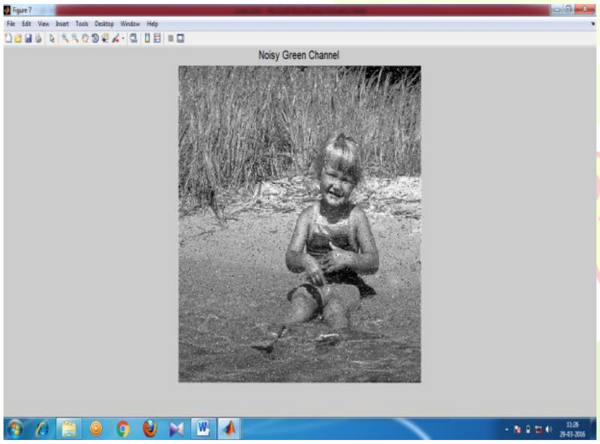
4.6 Red Channel Noise Image



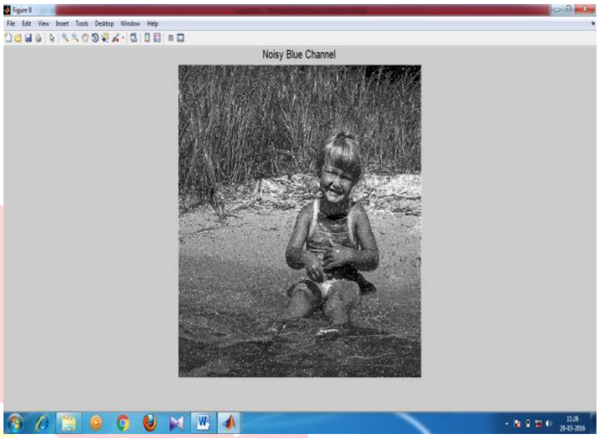
A channel in this context is the gray scale image of the same size as a color image, made of just one of these primary colors. For instance, an image from a standard digital camera will have a red, green and blue channel. A color image has just one channel.

4.7 Green Channel Noise Image

An index number, which refers to a table where three color components are stored. However, regardless of how a specific format stores the images, discrete color channels can always be determined, as long as a final color image can be rendered.



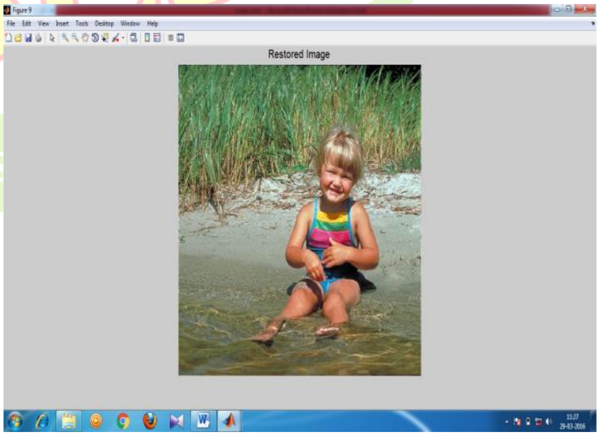
4.7 Blue Channel Noise Image



The CM filter uses the certainty degrees of uncorrupted pixels as their weights. These filters are time-varying; that is they have to perform pixel-by-pixel restoration, rather than processing the image as a whole. This constraint opposes efficient implementation.

4.8 Output Image

The results of different methods for restoring images corrupted by SPN with various noise densities. The results demonstrate that the EWA filter performs better than other methods. Fig 3.4.9.1 exhibit the restored images of the three best filters for images Lena and Bridge corrupted by 80% and 90% SPN, respectively. We have also included the SSIM for better comparisons.



5 CONCLUSION

It proposed a method for fast impulse noise removal from images. The proposed filter first constructs an initial image using the nearest neighboring interpolation and then improves it by employing a weighted-average filter, which applies different procedures for weighting the known and noisy pixels. Experimental results verify that the proposed method outperforms the best existing methods in both qualitative and quantitative measures and is quite suitable for real-time applications. The performance in terms of both CPSNR and subjective visual quality. This is achieved at a reasonable computational complexity. In addition, effective complexity scalability can be realized by exploiting the complexity performance.

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