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Color Image Denoising Methods Based on Modified Mean-Median (MMM) Method

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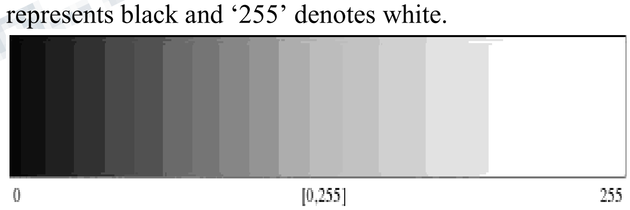
Abstract; - **Image enhancement techniques are best solution for improving the visual appearance of images to a human viewer. It also preserves the structure features of the image. Enhancement of the noisy image data without losing any significant information is very challenging. In this paper we have introduced the modified mean median based method for removing impulse noise effectively while preserving details of the image. The proposed filter would be better than many of the existing filters such as the median filter and its variant and other fuzzy filters. The advantages of these method are that it reduces Impulse noise in a grayscale image as well as the color image (low-level impulse noise), it preserves edge sharpness, it does not introduce blurring artifacts or new colors artifacts in comparison to other states of the art methods.**

Index Terms**—Image Denoising, Gaussian Noise, MSE, PSNR**

I. INTRODUCTION

An image is worth a thousand words. In the modern age, images are the most common and convenient means of conveying or transmitting information. Visual information in the form of digital images allows humans to perceive and understand the world surrounding them in a better manner. Hence, processing of images by computer has been drawing a very significant attention of the researchers over the last few decades. The process of receiving and analyzing visual information by digital computer is called digital image processing. Mathematically, an image is a two-dimensional function, f (x,y) , where x and y are spatial (plane) coordinates and the amplitude of f at any coordinate (x,y) is called the intensity or gray level of the image at that point. When x, y and the amplitude values are all finite discrete quantities then image is known as a digital image [1]. A digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as picture elements, image elements, pels or pixels. Pixel is the term most widely used to denote the element of a digital image. [1, 2, 3] A rectangular array of pixels is known as bitmap.
Digital image processing is the use of computer algorithms to perform image processing on digital images. Digital Images can be of different types such as binary, gray-scale and color images [4].

1.Binary images: Binary images use only a single bit to represent each pixel. They are the simplest type of images and can take only two discrete values, black and white. Black is represented with the value ‘0’ while white with ‘1’. This inability to represent intermediate shades of gray limits their usefulness in dealing with photographic images. It finds applications in computer vision areas where the general shape or outline information of the image is needed.
2. Gray-scale images: They are known as monochrome or one-color images. A black and white image is made up of pixels each of which holds a single number corresponding to the gray level of the image at a particular location. These gray levels span the full range from black to white in a series of very fine steps. For an 8-bit image there will be 256 gray levels where ‘0’ represents black and ‘255’ denotes white.



Gray scale levels for an 8-bit image

3. Color Images: A color image is made up of pixels each of which holds three numbers corresponding to the red, green, and blue levels of the image at a particular location. Red, green, and blue (RGB) are the primary colors for mixing light. Any color can be created by mixing the correct amounts of red, green, and blue light. Assuming 256 levels for each primary, each color pixel can be stored in three bytes (24 bits) of memory. This corresponds to roughly 16.7 million different possible colors. For images of the same size, a gray scale image will use three times less memory than a color image. In this study, we have used several standard gray scale images for our experimental and simulation results. For

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image processing, we need to convert the natural images into digital images by the process of digitization. A digitized image can be stored in a computer memory or on some form of storage media such as hard disk or CD-ROM. This digitization procedure can be done by scanner, or by video camera connected to frame grabber board in computer. Once the image has been digitized, it can be operated upon by various image processing operations. Digital image processing operations can be broadly divided into following classes:

Digital image processing classes

Examples of operations within each class are as follows:
1) Image Enhancement: Brightness adjustment, contrast enhancement, image averaging, convolution, frequency domain filtering, and edge enhancement.
2) Image restoration: Photometric correction, inverse filtering, and noise removal
3) Image analysis: Segmentation feature extraction, object classification
4) Image compression: Lossless and lossy compression
5) Image synthesis: Topographic imaging, 3-D reconstruction

The fields that use digital image processing techniques can be divided into criminology, microscopy, photography, remote sensing, medical imaging, forensics, transportation and military applications.

Out of the five classes of digital image processing, cited above, this thesis deals with image restoration. To be precise, the paper devotes on a part of the image restoration i.e. impulse noise removal from images, stated in the Problem Definition. Further, this paper also discusses how image noise removal can be utilized for high quality image enhancement.

II. IMPULSE NOISE

The digital image acquisition process converts an optical image into a continuous electrical signal that is, then, sampled [4]. At every step in the process there are fluctuations caused by natural phenomena that adds a random value to the exact brightness value for a given pixel. This process introduces noise in an in image. There are many types of noises that contaminate images. One of such noise is Impulse Noise. Impulse noise is generally introduced into images while transmitting and acquiring them over an unsecure communication channel. Impulse noise affects images at the time of acquisition due to noisy sensors or at the time of transmission due to channel errors or in storage media due to faulty hardware. Sharp and sudden disturbances in the image signal introduce impulse noise. Its appearance is randomly scattered white or black (or both) pixels over the image.

(a) (b)

(a) Original image (b) Image corrupted with impulse noise

Let Y(i , j) : Gray level of an original image
X(i , j): Gray level of noisy image X at a pixel location (i ,j)
$[N_{min}\ N_{max}]$: Dynamic range of Y
Impulsive noise may be defined as:

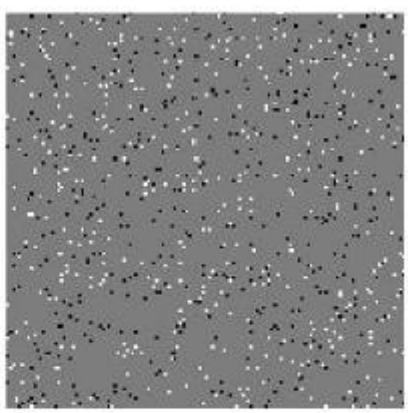
$$X(i,j) = \begin{cases} Y(i,j) & with\ 1-p \\ R(i,j) & with\ p \end{cases}$$

R(i , j) is the substitute for the original gray scale value at the pixel location (i, j)
Impulse noise has the property of either leaving a pixel unmodified with probability 1- p

or replacing it altogether with probability p. This is shown in Eq (1).
Two common types of impulse noise are:

Salt & Pepper Noise (SPN)
For images corrupted by salt-and-pepper noise, the noisy pixels can take only the maximum and the minimum values in the dynamic range i.e.
When R(i , j)={ Nmin , Nmax}

Salt & Pepper Noise dynamic range



Salt & Pepper Noise

Random Valued Impulsive Noise (RVIN)
For images corrupted by Random-valued noise, the noisy pixels can take any random value in the dynamic range i.e. R(i , j).can vary between{N_{min} , N_{max}}
In this study our focus is to remove Salt & Pepper noise (Fixed valued impulse noise).

III. IMPULSE NOISE DETECTOR & IMPULSE NOISE DENSITY PREDICTION

Step 1: Select window of size T x T pixel. Assume that the pixel being processed is X_{ij} .

Step 2: If X_{ij} = 0 or X_{ij} = 255 then X_{ij} is corrupted pixel then set value of H_{ij} to 1. Where H_{ij} is is index matrix 2D at the coordinate *(i,j)* .
Step 3: If 0 < X_{ij} < 255 then it is may be uncorrupted pixel and to check whether it is corrupted or not, first transform the window from 2-D to 1-D vector and then sort the element of this vector in ascending order and If the X_{ij} between first and fifth index value then X_{ij} j is uncorrupted pixel then set value of H_{ij} to 0 .otherwise it is corrupted pixel and set value of H_{ij} to 1.
Step3: if X_{ij} is an uncorrupted pixel and its value is left unchanged. Otherwise follow the following step:

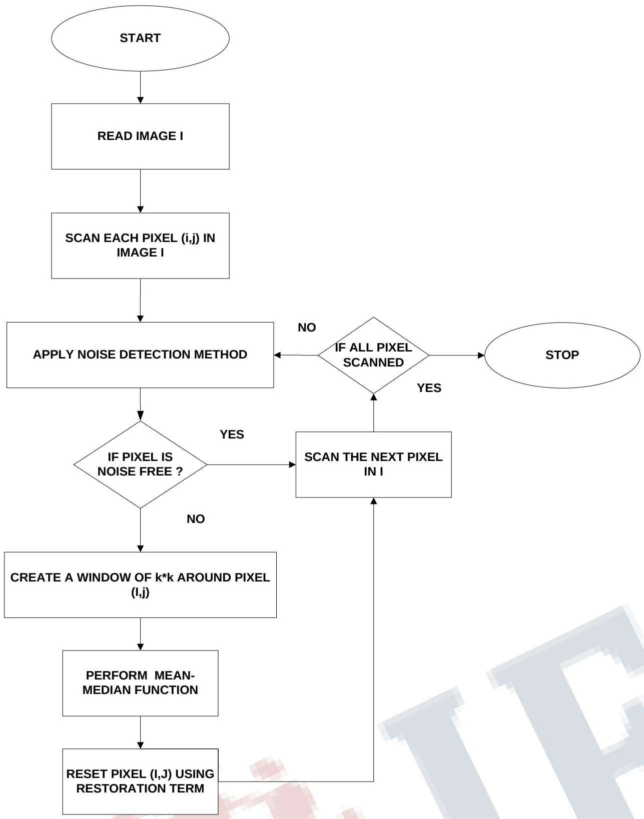
Step3.1 find the window T x T around the corrupted pixel X_{ij} such that it have some element (except 0 and 255) on it.
Step 3.2 .eliminate all 0 and 255 from the window and find the median of the remaining pixels. Suppose median is denoted by M_d
Step 3.3.Obtained the Filter value by calculating the linearity value between the average of noise free values without M_d element, with the median value of noise-free pixels. And it can obtain by following formula:

$$M_f = \frac{1}{n}\sum_{i=1}^{n} W_f$$

$$M_f = M_f - M_d$$

$$Pf(i,j) = M_f + \frac{(Mean(W_f) - M_d}{2})$$

Step 3.4 .Replace t X_{ij} he value of X_{ij} to the value $Pf(i,j)$.



IV. QUALITY MEASUREMENT METRICS

The quality of the enhanced image is measured by calculation of certain quality measurement metrics [10-12]. These metrics gives the comparison ratio between the original image and the modified image. The quality may be assessed on the basis of these values. The metrics used in this paper are as follows: peak signal- to-noise ratio (PSNR),Execution Time(Tr).

Peak signal to noise ratio (PSNR)

The PSNR depicts the measure of modification in the original image. This metric is used for discriminating between the original and enhanced image. The easy computation is the advantage of this measure. It is formulated as:

$$\boxed{PSNR = 10 \log (L-1)^2 / MSE}$$

Where MSE is MEAN SQUARE ERROR defined in next section .

the method should not significantly amplify the noise level and thus a high value of PSNR is required A low value of PSNR shows that the constructed image is of poor quality.

Mean Square Error

One obvious way of measuring the similarity is to compute an error signal by subtracting the test signal from the reference, and then computing the average energy of the error signal. The mean-squared-error (MSE)[36] is the simplest, and the most widely used, full-reference image quality measurement. This metric is frequently used in signal processing and is defined as follows:-

$$\boxed{MSE = \sqrt{\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(\mu_{ij} - m_{ij})^2}{M \times N}}}$$

Where μ_{ij} is the Denoised image and mij is the original image. A large value for MSE means that the image is of poor quality.

Processing Time

Processing Time T(r) defines the time required to complete the execution of proposed method that is required by fuzzifcation and defuzzification process.and measured in ms.

Average of percentage error

To measure percentage of error in the noise prediction can be calculated by using following formula.

$$AE_{\hat{p}} = \frac{|p - \hat{p}|}{p} \times 100\%$$

Meanwhile the average of percentage error can be calculated as

$$\overline{AE_{\hat{p}}} = \frac{1}{n}\sum_{i=1}^{n} AE_{\hat{p}}(i)$$

Denoted:

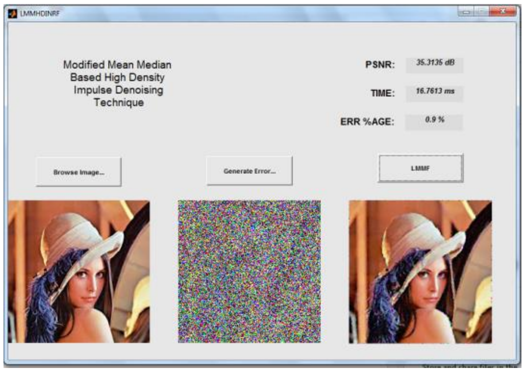
$\hat{P}$ is impulse noise prediction

(%) p is the actual value of impulse noise (%)

$AE_{\hat{p}}$ is Absolute error of p and $\overline{AE_{\hat{p}}}$ is average of absolute error of p , n is total data sample.

V. EXPERIMENTAL RESULT

In this section, we demonstrate the performance of the proposed method in comparison with some existing contrast enhancement methods.



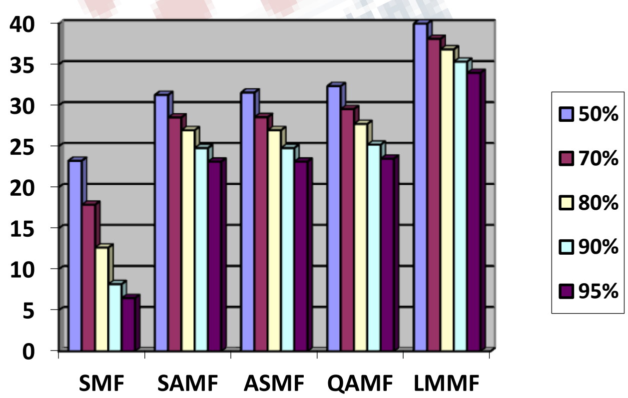
A. Simulation Result

In the following figure 2, we have shown contrast enhancement by proposed methods on different images.

TABLE I. ABSOLUTE MEAN BRIGHTNESS ERROR (AMBE)

NOISE	SMF	*SAMF*	*ASMF*	*QAMF*	*LMMF*
50%	23.243	31.282	31.584	32.368	39.999
70%	17.876	28.54	28.572	29.565	38.137
80%	12.647	26.975	26.981	27.739	36.856
90%	8.194	24.796	24.797	25.21	35.346
95%	6.492	23.137	23.137	23.492	33.984

Based on results of Table I, we observe that proposed has least values in all three images as compare to other methods. Further if we look at last row of Table I, which shows average results of AMBE then we find that proposed method has least average AMBE values among other methods.



VI. CONCLUSION & FUTURE WORK

In this paper we have introduced the modified mean median based method for removing impulse noise effectively while preserving details of the image. The proposed filter would be better than many of the existing filters such as the median filter and its variant and other fuzzy filters. The advantages of the these method are that it reduces Impulse noise in a gray scale image as well as color image (low level impulse noise),It preserves edge sharpness , It does not introduce blurring artifacts or new colors artifacts in comparison to other state of the art methods..

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