Image De-noising and Enhancement for Salt and Pepper Noise Using Improved Median Filter-Morphological Operations

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Abstract. Image Enhancement is one of the most important concerns in Digital Image processing which is used to process the image so that we can view and assess the visual information it contains with greater clarity. In this Work a 2-step Image De-noising and Enhancement Algorithm is proposed i.e. the application of Improved Median Filter and Morphological Operations. In the First step Image is enhanced using a 3×3 neighborhood window processing and then using Morphological Operations to further enhance it. Our Method can remove salt-and-pepper-noise with noise level as high as 80%.

Keywords: Spatial Domain Techniques, Digital Image Processing, Mathematical morphology, Structuring Element, Morphological Operations, Salt and Pepper Noise.

1 Introduction

Image Enhancement is one of the key research fields in Image Processing as it is useful in several applications such as Feature Detection, Medical Image Processing, Remote Sensing, Machine vision etc., which improves the image quality and visual perception of human beings. Our enhancement operations can be achieved through the process of spatial domain filtering. Spatial Domain filtering simply indicates that the filtering process takes place directly on the actual pixels of the image itself. Further, morphology encompasses a powerful and important body of methods which can be precisely treated mathematically within the framework of set theory.

Digital Image Processing Techniques are fast and flexible because they integrate Mathematics and Technology. Digital Image Processing modifies images to improve them (enhancement, restoration), extract information (analysis, recognition), and change their structure. It improves the clarity of the Image for Human Perception. Edge Enhancement, Sharpen (create more contrast between neighboring pixels), Soften (blend the edges of neighboring pixels), Blur removing (blend together pixels of the image), Raising Contrast, Medical Imaging (CT scan and MRI images) are

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some of the Image Processing functions. Grayscale images are distinct from one-bit black-and-white images, which in the context of computer imaging are images with only the two colors, black, and white (also called *bi-level* or *binary images*). Grayscale images have many shades of gray in between 0 and 255. A 640 x 480 grayscale image requires over 300 KB of storage. Linear and Non Linear Filtering Techniques [5] are used for Image De-noising and Enhancement.

Mathematical Morphology (MM) was born in 1964 from the collaborative work of Georges Matheron and Jean Serra [17] [18]. The primary morphological operations are Dilation and Erosion. More complicated morphological operators can be designed by means of combining Erosions and Dilations. Mathematical morphology considers images as geometrical objects, to be analyzed through their interactions with other geometrical objects. It has various applications in bio-medical imaging, Geo-science, Remote sensing, Quality control, Document processing and Data analysis. Its techniques have been applied successfully to a variety of image processing tasks that, roughly speaking, involve shape information of image objects. The extraction and enhancement of shape information from images is one of the important tasks of mathematical morphology. Main idea behind Morphological Filtering [12] [13] [14] [16] is to examine the geometrical structure of an image by matching it with small patterns called structuring elements at various locations. By varying the size and shape of the matching patterns, we can extract useful information about the shape of the different parts of the image and their inter-relations. The Original Image may have high or low intensity values which masks the details. In this paper we propose an adaptive Image enhancement approach which mainly operates on image pixel values to reduce Salt and Pepper Noise [15] from the Image.

The paper is organized as follows. Section 2 discusses about several spatial Domain research works. In Section 3, we proposed a method for removing noise using improved median filter and morphological operations. We performed experiments on several images in Section 4.Finaly section 5 concludes the work.

2 Literature Survey: A Review

In this section, a handful of recent research works available in the literature for reducing noise and Enhancing the Images are briefly reviewed. Traditional Median Filter [1] is effective in reducing the salt and pepper noise as well as preserving boarder. But it works well for low noise levels (Up to 50%). H. Hwang proposed Adaptive Median Filter [2], which also works well for low noise levels. As noise level increases the Image will become blurred. K. S. Srinivasan proposed a Decision based noise reduction method [3] which works well for medium range of noise levels. A Method with hybrid Image Enhancement Technique for Noisy Dim Images Using Curvelet and Morphology have established by Muthu Selvi, Roselin and Kavitha [4]. This paper gives the new method for enhance the noisy dim image and improve the quality of the image. Morphological operations *open by reconstruction* and *closing by reconstruction* are applied to the Image and then the gamma function is applied for the purpose of illumination Correction. Morphological reconstruction filter closing by reconstruction has been found to produce better result compared to opening by reconstruction.

Jimenez Sanchez *et al*. [6] proposed a method to detect the image background and to enhance the contrast in grey level images with poor lighting, in which an approximation to the background using blocks analysis is computed. This was subsequently extended using mathematical morphology operators. However, a difficulty was detected when the morphological dilation and erosion were employed. Therefore, a new method to detect the image background was proposed, which is based on the use of morphological connected transformations. These morphological contrast enhancement transformations are based on Weber's law. But they can only be used satisfactorily in images with poor lighting. Rafael Verdú Monedero *et al* [7] proposed a spatially variant erosions/dilations and openings/closings approach. Structuring elements (SE) can locally adapt their shape and orientation across the direction of the structures in the image. The process of extracting shape and orientation of the SE at each pixel from the image is under study. This method is useful in the enhancement of anisotropic features such as coherent, flow-like structures.

A general method based on fuzzy implication and inclusion grade operators have been discussed by Yee Yee Htun *et al* [8].The fuzzy morphological operations have extended the ordinary morphological operations by using fuzzy sets, where the union operation and the intersection operation of the fuzzy sets have been replaced by a maximum operation, and a minimum operation respectively. In this work, fuzzy set theory, fuzzy Mathematical morphology based on fuzzy logic and fuzzy set theory, fuzzy Mathematical operations and their properties have been studied. The applications of fuzziness in Mathematical morphology in practical work such as image processing and illustration problems have been discussed. Fuzzy Filtering [9] also useful in Image Enhancement in which spatial data is transformed to Fuzzy Data and Fuzzy operations were carried out on this data and Finally converting the modified Fuzzy Data to Spatial Data.Morphological operations [10] [12] are useful in smoothing the Images. But they also remove thin features from the images along with noise. Morphological Image Cleaning algorithm which is explained in [11] preserves thin features while removing noise. This algorithm is best useful for Scanner noise, still video images noise etc.

3 Proposed Algorithm

The techniques we introduced in this work are considered the manipulation of the dynamic range of a given digital image to improve visualization of its contents which is based on Median Filtering Technique [19] [20]. Each pixel in the Image has a value in the range of 0 to 255. The Algorithm is given below.

3.1 Salt and Pepper Noise Reduction

Function Salt and Pepper

(1) Read the image.

(2) Add salt and pepper noise of chosen value.

(3) Read the size of the image [M×N] into a vector.

(4) For each pixel (0 to M and 0 to N), leaving the Boarder.
Repeat the following steps:
(5) Consider the 3×3 neighborhood window with central pixel as the processing pixel.
(6) If the processing pixel intensity value is 0 or 255, then repeat the steps 7 to 9.
(7) Copy the pixel intensity values except the central pixel into a vector.
(8) If all the elements in the vector are 0 or 255, then replace the processing pixel intensity value with mean of values in the vector. If we perform Median for all pixels whose intensity values are 0 or 255, then the resulting value is also 0 or 255 respectively, which is again a noisy pixel. So we consider only mean in this case.
(9) Otherwise remove the values 0 and 255 from vector and replace the processing pixel intensity value with median of values in the vector.
END Function.

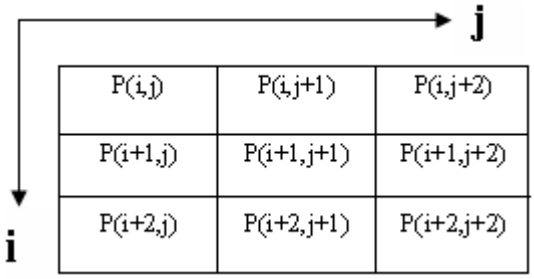

Fig. 1. Neighborhood Pixels of the Central Pixel P (i+1,j+1)

Central Pixel of the 3×3 neighborhood window is the processing Pixel. We will check for its intensity value. If the central pixel has intensity value other than 0 or 255 it will not be treated as a noisy pixel, so no further processing is required for that pixel. If it has the intensity value 0 or 255, then its intensity value is replaced by equation (1).If the central pixel intensity value is 0 or 255 and intensity values of all the neighborhood pixels values are also 0 or 255 then central pixel intensity value is replaced by equation (2).If Central Pixel intensity value is either 0 or 255, then

$$P(i+1, j+1) = \tilde{K} \quad (1)$$

Where $\tilde{K}$ is the Median of the vector (K) elements, which is 60 for the following case. Vector K contains all the neighborhood pixel intensity values.

55	125	75
42	0 or 255	78
230	210	125

Fig. 2. A Case where central pixel is 0 (Salt Noise) or 255(Pepper Noise)

If Central Pixel intensity value is either 0 or 255 and neighborhood pixels values are also 0 or 255, then

$$P(i+1, j+1) = \overline{K} \quad (2)$$

Where $\overline{K}$ is the Mean of the vector (K) elements, which is 85 for the following case. Vector K contains all the neighborhood pixel intensity values.

0	0	255
255	0 or 255	255
0	0	0

Fig. 3. A Case where central pixel is 0 (Salt Noise) or 255(Pepper Noise) and Neighborhood pixels are also either 0 or 255

3.2 Boarder Preserving

Image Boarders are also checked for salt and pepper Noise. The Algorithm has two cases of Boarder Preserving as shown below. Based on intensity values of the pixels appropriate method can be used.

Case 1: If all the Boarder Pixel Intensity values are either 0 or 255 then calculate the mean of them and replace at each 0 or 255 intensity value.

Function Borderpreserve_Mean //Mean Of All Borders//

(1) Read the values of all the borders into a vector.
(2) If all the Pixels has the intensity values either 0 or 255
(3) Replace the noised values in all the borders with the mean of the vector.

End Function.

Case 2: Otherwise calculate the median of vector and replace at each 0 or 255 intensity Value.

Function Borderpreserve_Median //Median Of All Borders//

(1) Read the values of all the borders into a vector.
(2) Remove the values 0 and 255 from that vector and calculate the median with the remaining values..
(3) Replace the noised values in all the borders with the median of the vector.

End Function

3.3 Morphological Operation

After Boarder preserving operation, morphological imopen function is performed on the Image with a 3×3 disk structuring element (SE). Morphological operations make the Image smooth as shown in the results. Morphological operators can process according to the shape of SE. Dilation and Erosion are the two basic Morphological

Operators. Dilation enlarges the boundaries so that holes in the region become smaller where as Erosion shrinks the boundaries so that holes in the region become larger. Erosion and Dilation are often used in combination to implement image processing operations known as “Opening” and ”Closing”,” Opening” is performed through erosion followed by dilation with another image, which is less destructive than Erosion alone.

4 Results and Discussion

4.1 Results

The proposed image enhancement using Improved Median Filter and morphological operations was implemented in the working platform of MATLAB (version 7.10) and obtained the results which are shown in Fig 4 and Fig 5.

Fig. 4. Results of proposed Method for Gray Scale Lena Image and Car Image (a) Images Corrupted with 20%,50% and 80% Salt and Pepper Noise (b) Noise Reduced by Improved Median Filter (c) Enhanced Images Using Morphological Operation

The enhancing process of the proposed system was evaluated with different standard images like Lena, Baboon, cameraman etc. Using these Images this work was tested by color and grayscale Images by applying the Improved Median Filter and morphological operation “imopen”. PSNR Values of Lena image at different noise densities are compared with different enhancement techniques, provided in the Table 1.

Table 1. Comparison of PSNR Values of Lena Image at Noise Densities 20%, 50% and 80%

Noise Level	PSNR in dB				
	MF	AMF	DBA	MDBA	Proposed Method
80 %	8.68	10.31	20.32	20.44	24.44
50 %	15.04	23.36	26.41	26.52	31.06
20 %	25.66	27.40	32.9	32.69	35.23

4.2 Discussion

Our Algorithm to enhance the Images using Improved Median Filter and Morphological operations does not require complicated calculation to enhance image contrast value. It performs well up to 80% of salt and pepper noise. If the noise level is equal or above 90% then this algorithm produces the blurred Images as shown in the Fig 5.

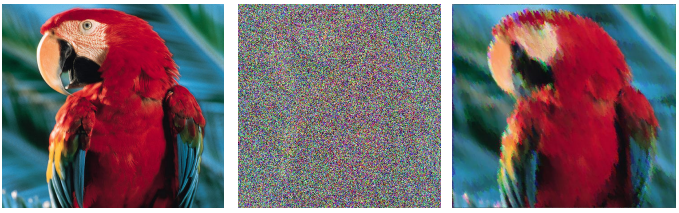

Fig. 5. Results of proposed Method for Parrot Image (a) Original Parrot Image (b) Corrupted with 90% Salt and Pepper Noise (c) Noise Reduced by Improved Median Filter

5 Conclusion

In this Paper, a hybrid image enhancement technique that combines Improved Median Filter and morphological operation is implemented. Initially, the Original Image is filtered using Improved Median Filter and then enhanced using Morphological Operation. The implemented Algorithm present the best performance both visually and quantitatively based on the measures such as mean square Error (MSE), Peak Signal to noise ratio (PSNR). This paper considers the morphological open function with 2 X 2 square structural elements for smoothening. Experiments were carried out on number of Images, with the noise levels 20%, 50% and 80%. The result was robust and achieved a very good Enhancement Level which proves the effectiveness of the Proposed Work.

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