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Performance Analysis of Median Filter With Respect to Different Padding Methods in the Context of Removing Salt and Pepper Noise

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***Abstract* - Image Processing is one of the major areas of research. Images are often corrupted with different types of noise such as Gaussian noise, Poisson noise, Salt and Pepper noise, Speckle noise etc.The present work analyses the performance of the median filter with respect to different padding methods in the context of removing salt and pepper noise.Peak Signal-to-Noise ratio and Mean Squared Error have been considered as parameters for performance evaluation. The results obtained show thatthe Peak Signal-to-Noise Ratio and Mean Squared Error obtained between the original image and the filtered image obtained by applying median filter with symmetric padding method on the image corrupted with salt and pepper noise is same as the Peak Signal-to-Noise Ratio and Mean Squared Error obtained between the original image and the filtered image obtained by applying median filter with replicate padding method on the image corrupted with salt and pepper noise respectively.**
***Keywords:* Median Filter, Salt and Pepper Noise, Padding**

I. INTRODUCTION

An image can be defined as defined as a two dimensional representation of a picture. Image noise [1] is random variation of brightness or color information in images. It can be produced by the sensor and circuitry of a scanner or digital camera. Images are often affected with different types of noise such as Gaussian noise, Poisson noise, Salt and Pepper noise, Speckle noise etc.Salt and Pepper noise [2] a form of noise sometimes seen on images. It is also known as Impulse noise. This noise can be caused by sharp and sudden disturbances in the image signal. It presents itself as sparsely occurring white and black pixels.

An image containing salt and pepper noise will have dark pixels in bright regions and bright pixels in dark regions.Filtering [3] is technique for modifying or enhancing an image. Filtering is a sliding neighborhood operation [4], in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some set of pixels, defined by their locations relative to that pixel which is called the center pixel.The center pixel is the actual pixel in the input image being processed by the operation. The neighborhood is a rectangular blockand as we move from one element to the next in an image matrix, the neighborhood block slides in the same direction. If the neighbourhood has an odd number of rows and columns, the center pixel is actually in the center of the neighborhood. If one of the dimensions has even length, the center pixel is just to the left of center or just above the center. For an m-by-n neighborhood, the centre pixel is floor (([m n]+1)/2).As the neighbourhood block slides over the image, some of the pixels in a neighborhood might be missing, especially if the center pixel is on the border of the image. To process these neighborhoods, sliding neighborhood operations pad the borders of the image, usually with zeros. These functions process the border pixels by assuming that the image is surrounded by additional rows and columns of zeros. This is known as zero padding method. These rows and columns do not become part of the output image and are used as parts of the neighborhoods of the actual pixels in the image. If padding is done by repeating the border elements then it is known as replicate padding method. If padding is done by mirror reflections of itself then it is known as symmetric padding method. The steps of Sliding Neighborhood operations are as follows.

1. Select a single pixel.
2. Determine the pixel's neighbourhood.
3. Apply a function to the values of the pixels in the neighborhood. This function must returna scalar value.
4. Find the pixel in the output image whose position corresponds to that of the centre pixel intheinput image. Set this output pixel to the value returned by the function.
5. Repeat steps 1 through 4 for each pixel in the input image.

The Median filter [5] is a nonlinear digital filtering technique used to remove noise from an image or signal. Median filtering is very widely used in digital image processing because it preserves edges while removing noise. The main idea of the median filter is to run through the image pixel by pixel, replacing each pixel with the median of neighbouring pixels. The pattern of the neighbours is called the window which slides pixel by pixel over the entire image. Image filtering [6] is useful for many applications including smoothing, sharpening, noise reduction and edge detection.

II. RELATED WORK

A brief review of different types of noise which corrupts Images, classification of Image Denoising algorithms and comparative study of different Image denoising algorithms has been presented in [7].A comparative study of different filters such as Average Filter, Standard Median Filter, Adaptive Median Filter and Alpha Trimmed Mean Filter has been performed in the context of removing Gaussian Noise, Salt and Pepper Noise and Speckle noise with varying densities has been presented in [8].A comparative study of different filters such as Median Filter, Bilateral Filter, Non Local Mean Filter in the context of removing Gaussian noise with varying levels of standard deviation has been presented in [9].A comparative study of Image Denoising methods such as Median Filter and Wavelet transform in the context of removing Additive White Gaussian Noise has been performed in [10].A new technique based on decision based approach and Adaptive Median Filter for removing impulse noise has been developed [11].A comparative study of Average Filter, Median Filter, Gaussian Filter, Alpha trimmed Median Filter, Fuzzy logic based Alpha Trimmed Median Filter in the context of removing different types of noise such as Gaussian noise, Poisson noise, Salt and Pepper noise and Speckle noise has been presented in [12].A new median based filter known as progressive switching median filter [13] has been proposed to restore images corrupted by salt-and-pepper noise. A two-stage filter for removing salt-and-pepper noise using noise detector based on characteristic difference parameter and adaptive directional mean filter has beenproposed[14]. A new fuzzy switching median filter [15] has been proposed for detecting and removing Salt-and-Pepper noise. A selective adaptive median filter [16] has been proposed for restoration ofgray scale images that are highly corrupted by salt-and-pepper noise.

III. EXPERIMENTAL RESULTS

Images of different sizes have been considered and they are made to be corrupted with salt and pepper noise. Then the median Filter with different padding methods such as Symmetric, Replicate and Zeros has been applied on the images corrupted with salt and pepper noise. The filtered Images obtained by applying Median Filter with different padding methods have been tabulated for analysing the quality of the images. Peak signal-to-Noise Ratio and Mean Squared Error obtained between the original images and filtered images obtained through different padding methods have been calculated and tabulated.

TABLE I IMAGES OBTAINED AFTER APPLYING MEDIAN FILTER WITH DIFFERENT PADDING METHODS ON IMAGESCORRUPTED WITH SALT AND PEPPER NOISE

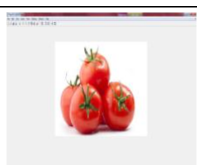
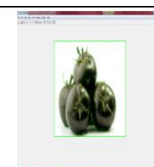
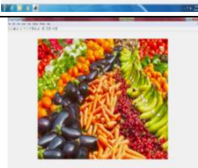
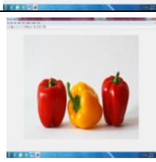
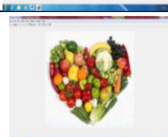
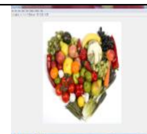
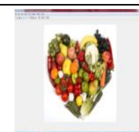
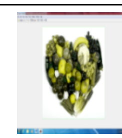
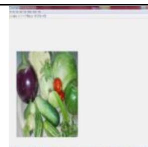
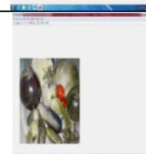
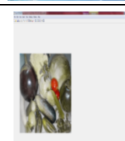
S. No.	Original Image	Image corrupted with salt and pepper noise	Filtered Image obtained through Median Filter with Symmetric padding method	Filtered Image obtained through Median Filter with Replicate padding method	Filtered Image obtained through Median Filter with Zero padding method
Image-1					
Image-2					
Image-3					
Image-4					

Image-5					
Image-6					
Image-7					
Image-8					
Image-9					

From Table I, it is clearly evident the filtered images obtained by applying median filter with zero padding method on the images corrupted with salt and pepper noise is different in colour from the original images and other filtered images obtained through symmetric padding method and replicate padding method.

TABLE II PEAK SIGNAL TO NOISE RATIO (PSNR) OBTAINED BETWEEN THE ORIGINAL IMAGE AND THE FILTERED IMAGES OBTAINED BY APPLYING MEDIAN FILTER WITH DIFFERENT PADDING METHODS ON THE IMAGES CORRUPTED WITH SALT AND PEPPER NOISE

S. No.	Peak Signal to Noise Ratio obtained between the original image and the Filtered Image obtained by applying Median Filter with Symmetric padding method on the image corrupted with salt and pepper noise	Peak Signal to Noise Ratio obtained between the original image and the Filtered Image obtained by applying Median Filter with replicate padding method on the image corrupted with salt and pepper noise	Peak Signal to Noise Ratio obtained between the original image and the Filtered Image obtained by applying Median Filter with zero padding method on the image corrupted with salt and pepper noise
Image-1	77.0038	77.0038	66.3182
Image-2	76.2513	76.2513	60.4611
Image-3	68.9547	68.9547	63.2474
Image-4	72.2590	72.2590	61.4794
Image-5	73.5710	73.5710	64.7094
Image-6	76.7160	76.7160	66.8179
Image-7	85.2883	85.2883	63.9403
Image-8	78.3351	78.3351	65.2672
Image-9	70.6286	70.6286	68.6468

From Table II the results obtained show that the Peak Signal-to-Noise Ratio (PSNR) obtained between the original image and the filtered image obtained by applyingmedian filter with symmetric padding method on the image corrupted with salt and pepper noise is same as the Peak Signal-to-Noise Ratio (PSNR) obtained between theoriginal image and the filtered image obtained by applying medianfilter with replicate paddingmethodonthe image corrupted with salt and pepper noise.The Peak Signal-to-Noise Ratio (PSNR) obtained between the original image and the filtered image obtained by applying median filter with zero padding method on the image corrupted with salt and pepper noise is lowest among the Peak Signal-to-Noise ratio values obtained through three padding methods.

TABLE III MEAN SQUARED ERROR (MSE) OBTAINED BETWEEN THE ORIGINAL IMAGE AND THE FILTERED IMAGES OBTAINED BY APPLYING MEDIAN FILTER WITH DIFFERENT PADDING METHODS ON THE IMAGES CORRUPTED WITH SALT AND PEPPER NOISE

S. No.	Mean Squared Error obtained between the original image and the Filtered Image obtained by applying Median Filter with Symmetric padding method on the image corrupted with salt and pepper noise	Mean Squared Error obtained between the original image and the Filtered Image obtained by applying Median Filter with replicate padding method on the imagecorrupted with salt and pepper noise	Mean Squared Error obtained between the original image and the Filtered Image obtained by applying Median Filter with zero padding method from the image corrupted with salt and pepper noise
Image-1	0.0013	0.0013	0.0152
Image-2	0.0015	0.0015	0.0585
Image-3	0.0083	0.0083	0.0308
Image-4	0.0039	0.0039	0.0463
Image-6	0.0014	0.0014	0.0135
Image-5	0.0029	0.0029	0.0220
Image-6	0.0014	0.0014	0.0135
Image-7	1.9242e-04	1.9242e-04	0.0262
Image-8	9.5405e-04	9.5405e-04	0.0193
Image-9	0.0056	0.0056	0.0089

From Table III, the results obtained show that the Mean Squared Error (MSE) obtained between the original image and the filtered image obtained by applying median filter with symmetric padding method on the image corrupted with salt and pepper noise is same as the Mean Squared Error (MSE) obtained between the original image and the filtered image obtained by applying median filter with replicate padding method on the image corrupted with salt and pepper noise.. The Mean Squared Error (MSE) obtained between the original image and the filtered image obtained by applying median filter with zero padding method on the image corrupted with salt and pepper noise is highest among the Mean Squared Error values obtained through three padding methods.

IV. CONCLUSION

Images are often corrupted with different types of noise. Filtering is used to reduce the noise in the images. The median filter is an effective method for removing salt and pepper noise. The present work has made an analysis of the median filter with respect to different padding methods in the context of removing salt and pepper noise. The results obtained show that the Peak Signal-to-Noise Ratio and Mean Squared Error obtained between the original image and the filtered image obtained by applying median filter with symmetric padding method on the image corrupted with salt and pepper noise is same as the Peak Signal-to-Noise Ratio and Mean Squared Error obtained between the original image and the filtered image obtained by applying median filter with replicate padding method on the image corrupted with salt and pepper noise respectively.

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