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THE MODIFIED APPROACH TO REDUCE POISSON NOISE IN X- RAY IMGES BY USING MODIFIED HARRIES OPERATOR

MR. SACHIN A. SAWALKAR[1], DR. R. M. DESHMUKH[2]

1. M.E (Scholar) Electronic& telecommunication Engg, D.R.G.I.T.& R, Amravati.
2. Head Of Department, Electronic &telecommunication Engg, D.R.G.I.T.& R, Amravati.

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Abstract: - X-radiation is a form of electromagnetic radiation. Most X-rays have a wavelength ranging from 0.01 to 10 nanometers, corresponding to frequencies in the range 30 petahertz to 30 exahertz (3×10^{16} Hz to 3×10^{19} Hz) and energies in the range of 100 eV to 100 keV. X-rays are produced using digital receptor where x-rays are passed through host person body and strikes digital receptor. This collection of X-rays follows a photon counting statistics. It is well known that this photon counting follows Poisson distribution which results in degradation of X-ray image quality. X-rays imaging involves exposing a part of the body to a small dose of ionizing radiation to produce pictures of the inside of the body. X rays are used to detect or diagnose abnormalities within the body. They are a painless, non-invasive way to help diagnose problems such as broken bones, tumour, dental decay, and the presence of foreign bodies. X-ray image processing goes through denoising process to remove Poisson noise by using modified Harris operator which is used for region classification of X-ray image. Response matrix of modified Harris operator differntiate noisy and noise free pixels and according to that median filtering or mean filter is used to denoise X- ray images.

Keywords: X-ray, Poisson noise, Modified Harris operator, Response matrix.

Corresponding Author: MR. SACHIN A. SAWALKAR

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INTRODUCTION

X-rays were discovered in 1895 by Wilhelm Conrad Röntgen, who received the first Nobel Prize in Physics in 1901. Several important discoveries have been made using X-rays. These penetrating rays are also used in many applications. In an X-ray tube the electrons emitted from the cathode are accelerated towards the metal target anode by an accelerating voltage of typically 50 kV. The high energy electrons interact with the atoms in the metal target. Sometimes the electron comes very close to a nucleus in the target and is deviated by the electromagnetic interaction. In this process, which is called bremsstrahlung (braking radiation), the electron looses much energy and a photon (X-ray)is emitted.This beam travels through the air, comes into contact with our body tissues, and produces an image on a metal film. Soft tissue, such as skin and organs, cannot absorb the high-energy rays, and the beam passes through them. Dense materials inside our bodies, like bones, absorb the radiation. X-rays are one type of electromagnetic radiation. They are commonly used in hospitals to produce photographs of bones which is used for breaks or fractures. X-rays have the following properties: they can penetrate less dense matter such as skin and body tissue (but not bone). X-rays have wavelengths much shorter than visible light, but longer than high energy gamma rays. Their wavelength is well suited to study crystal structures and details of the human body. There are several types of noises degrade quality of images. All those noises are studied in "A Comparative. Study of Various Types of Image Noise and Efficient. Noise Removal Techniques" [1].

X-ray imaging system image degradation is mainly due to the system of random noise. X-ray generation and interaction with matter, in both time and space to satisfy Poisson random process. For fast X-ray imaging systems, due to the exposure time is short, X-ray quantum noise generated more prominent, seriously affecting the quality of the image. Quality improvement of the degraded medical image is important, which is a current research topic. The medical data represented by photon images has a tendency to be degraded by Poisson noise. X-ray images are cast on digital receptor when X-ray collected and absorb by them. This collection of X-ray by receptor follows photon counting statistics and it is well known that this photon counting follows Poisson distribution which results in degradation of X-ray images by addition of Poisson noise to it. "Noise Removal for Medical X-ray images in Multiwavelet Domain", mention that the noise in the X-ray images is a realization of Poisson noise and not the Gaussian noise [2]. In "Performance Evaluation of Various Denoising Filters for Medical Image" did another survey on denoising technique of image, briefly describe spatial filtering techniques & also mention their features [3].

II. POISSON NOISE AND ITS BEHAVIOR

Noise is any undesirable signal. When Noise entered into image, It is corrupted & have to improve its appearance for a specific application. The techniques applied are application-oriented. Also, the different procedures are related to the types of noise introduced to the image. In case of image, noise can increase or decrease the grey level values of single pixel or bunch of pixels results in poor image quality. In "Image Denoising: Recent Trends", list down the trends in image denoising, also author explain the noise beyond gaussianity [4]. According to author, in general, noise is classified as additive, multiplicative or mixed type. Being random in nature, every noise follows some specific distribution. X-ray gets affected by Poisson noise. Poisson process is used to model Poisson noise which is an electronic noise many times called as shot noise. Random movement of discrete packets of light and or electric charge gives rise to Poisson noise or shot noise. X-ray are generated from electrons coming out of cathode applied by high voltage, these high velocity electrons strike over a anode and X-rays are generated. X-ray images are formed by such X-rays when they pass through host patient body and collected by receptor used at other end. This whole process of collection of X-ray follows photon counting phenomenon in result Poisson distribution. Hence X-ray are effected by Poisson noise which follows Poisson distribution. Noise is characterized by its Probability density function (pdf) like Gaussian, uniform, Poisson, etc., or spatial domain properties like correlation or Frequency domain properties like white noise vs pink noise. Poisson distribution is shown in figure 1; distribution formula is shown in equation 1.

$$P(x|k) = \frac{k^X}{X!} e^{-k}; \quad X = 0,1,2....\infty \qquad (1)$$

k – Probability of event occurrence per interval

X – No of interval in given time

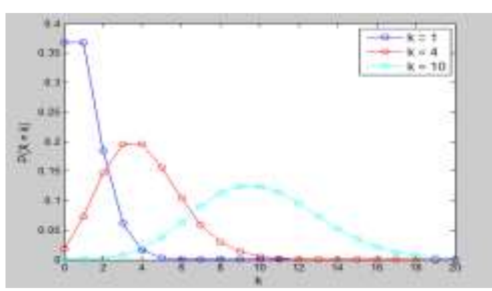

Figure 1: **Poisson noise distribution**

IV. Modified Harris operator

Corner detection is an approach used within computer vision systems to extract certain kinds of features and infer the contents of an image. Corner detection is frequently used in motion detection, image registration, video tracking, image mosaicing, panorama stitching, 3D modelling and object recognition. Corner detection overlaps with the topic of interest point detection. The Harris Corner Detector is a mathematical operator that finds features in an image. Any image consisting of mainly three regions namely flat region, edge portion and corner points. For flat region, there is no change in intensity for all direction. For edges, intensity does not change in direction of edge. In case of corner points, find intensity variation in all directions. A corner is a point for which there are two dominant and different edge directions in the vicinity of the point. X-ray images contain information about bone fracture, bone breakage, bone operations. This information is mainly is in form of lots of overlapping edges and or bright area in black background. Hence to remove noise perfectly from X-ray image need to find out noise added on edges and bright area. When noise gets added, intensity variation takes place at these regions compare to other neighboring regions. This intensity variation is find out by Harris operator algorithm. Harris operator is well used in watermarking algorithms proposed by Harris C., and Stephens M. in. It is used to find out corner points of image by gradient finding operation [5]. The Harris matrix gives the intensity variation of a pixel compare to its neighbor and Response matrix contains 1 if a pixel have maximum intensity variation compare to neighbor and 0 if not. In case of watermarking, a mask of 3 x 3 or 5 x 5 or any odd value is moved on image and intensity variation of center pixel is checked against remaining pixels in H matrix and if found largest then 1 is assign to respective location in Response matrix. To use Harris operator in denoising, proposed modification as in [6]. 2 x 2 mask is moved over Harris matrix of X-ray image in overlapped manner and 1 is assign in Response matrix for respective largest intensity variation. The advantage of modification is that getting maximum number of intensity variation points to denoise. Differentiate in between background and foreground i.e. area of interest on X-ray image is possible with the help of Response matrix hence result in avoiding such region from denoising and save total number of operations to be done. Figure 2 shows chest X-ray image & its response matrix in which clearly shows background and foreground i.e. area of interest on X-ray image

Figure 2: Chest X-ray image and its Response Matrix Image

V. Region Classification

Region classification includes differentiating area of interest from area of non interest. In case of X-ray images shown in figure 2, contains area of interest which is part of chest and also area of non interest which is black background part of image. In general, effect of noise is not so visible and effective for this black background part as intensity variation in black area is not so visible compare to white and other shades of grey color. Using modified Harris operator, getting 0 values in Response matrix for respective black background part shown in figure 3 and hence keep them unprocessed. In case of other area where noise is dominantly visible and effective, Response matrix contains 1 at those locations and processed them. Therefore the occurrence of 1 and 0 in Response matrix is responsible to classify the noisy and noise free regions. Figure 3 shows the Response matrix of image and classified region.

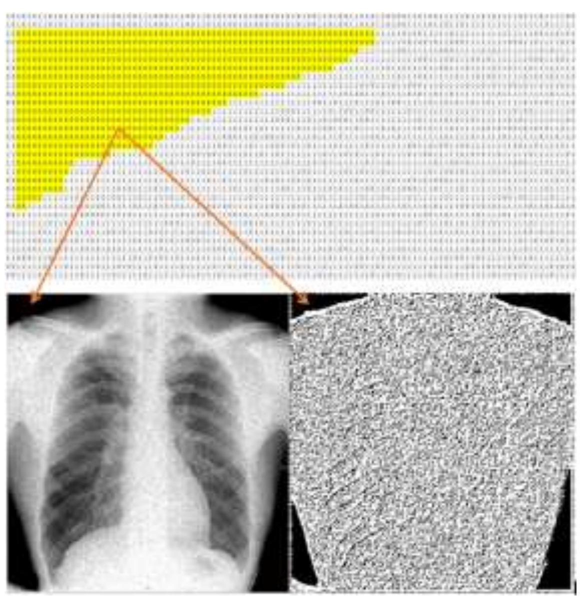

Figure 3: Response matrix and its location with respect to Image

VII. Proposed Work in Spatial Domain

Filtering is a technique for modifying or enhancing an image. Spatial domain operation or filtering. Filtering is a neighborhood operation, 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. Spatial domain image filtering blurs the edges leads to information loss. Hence people go for directional transforms but proposed a spatial domain approach which includes decision of pixels to denoise. Figure 3.18 shows block diagram of our proposed work. In spatial domain, block wise modified Harris operator is applied on noisy X-ray image and Response matrix is generated. From Response matrix prediction of noise and noise free pixels is done. To get noise free image, median filter [7] is applied to locations realized from Response matrix.

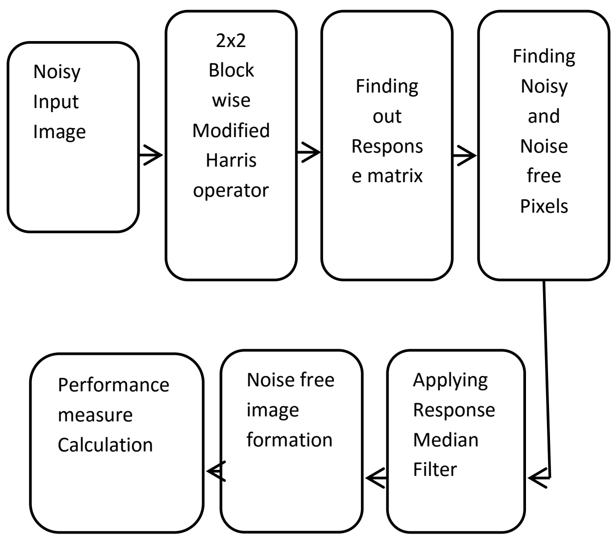

Figure 4: Block diagram of our proposed work

In paper, proposed two types of filtering in spatial domain depending on content of Response matrix. Response matrix contains 1 and 0 for more intensity variation and less intensity variation respectively, depending on this proposed two following methods.

1. A Proposed 1st method: Response median filtering

Median filtering follows this basic prescription. The median filter is normally used to reduce noise in an image, somewhat like the mean filter. However, it often does a better job than the mean filter of preserving useful detail in the image. This class of filter belongs to the class of edge preserving smoothing filters which are non-linear filters.

The median is just the middle value of all the values of the pixels in the neighborhood. Note that this is not the same as the average (or mean); instead, the median has half the values in the neighborhood larger and half smaller. The median is a stronger "central indicator" than the average. In particular, the median is hardly affected by a small number of discrepant values among the pixels in the neighborhood. Consequently, median filtering is very effective at removing various kinds of noise. Figure 5 illustrates an example of median filtering.

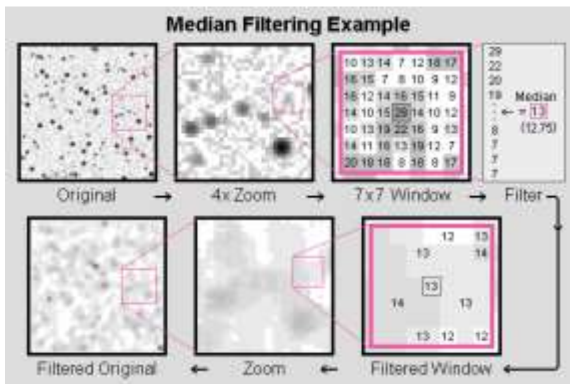

Figure 5: Median Filtering Example

Like the mean filter, the median filter considers each pixel in the image in turn and looks at its nearby neighbors to decide whether or not it is representative of its surroundings. Instead of simply replacing the pixel value with the mean of neighboring pixel values, it replaces it with the median of those values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value.

2. B Proposed 2nd method: Hybrid filtering

Depending on values of Response matrix, previously performed only median filtering. Now consider both values of Response matrix as 0 and 1 as know 1 represent more intensity variation pixels, hence applying median filter to it called Response median filter. When find 0 in response matrix, simply apply mean filter to the pixels of noisy image as intensity variation is less.

VIII. **Quality Measure**

The PSNR & MSE is often used as a quality measurement between the original and a noisy image. The higher the PSNR, the better the quality of the denoised image, or reconstructed image. The Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) are the two error metrics used to compare image denoise quality.

1. Mean Square Error.

The MSE is the cumulative squared error between the Denoised and the noise image. MSE is calculated as follows,

$$\mathrm{MSE} = \frac{1}{\mathrm{M*N}} \sum_{\mathrm{i=0}}^{\mathrm{M-1}} \sum_{\mathrm{j=0}}^{\mathrm{N-1}} [\mathrm{I(i,j)} - \mathrm{X(i,j)}]^2$$

Where, I is original image

X is Denoised image.

M and N are dimensions of original image

2. PSNR – Peak Signal to Noise Ratio.

PSNR is used to calculate amount of distortion in original and denoised image due to insertion of noise and generally given in dB

PSNR=10*log10(Imax*Imax) / (MSE)

Where, MSE is mean square error

Imax is maximum grey value of image.

IX. Result

In this project two methods are proposed for denoising in spatial domain depending on contents of Response matrix. In first method, The median filter applied to all pixels for which Response matrix contains “1” value. In case of X-ray image, if it contains visible black are with pixels value “0”, then amount of noise effect is very less, hence less or no amount of change in pixels value takes place. Second case is for response matrix, if in a window of 3 x 3 excluding centre pixels, if there are four 0 and four 1 are present that means the noise is simply equally spread along the centre pixle. Therefore instead of removing noise, it respreads using mean filter. Proposed algorithms are tested on different images and results are mention. Comparison between two algorithm is done on the basis of PSNR, MSE.

- **For table 1.1 to 1.3**

Results of imags used for experimentation in table 1.1 to 1.3, every table contains, in a first row- original image, in sacond row Poisson noise added image in a third row shows result produced by using response median filtering methods and in last row shows result produced by using Hybrid Filtering method . It is observed from these tabels that, sufficant improvement is achieved by second method over first method and getting improvement in result as processing full image in second proposed image compare to first proposed method.

Table 1.1- Original Image Size = 512 x 512

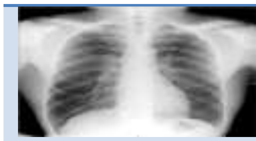	Original Image
	Poisson noise added Image
	Noise removed using Response Median Filtering PSNR = 30.63dB
	Noise removed using Hybrid Filtering PSNR = 32.23dB

Table 1.2 - Original Image Size = 512 x 512

	Original Image
	Poisson noise added Image
	Noise removed using Response Median Filtering PSNR = 32.09dB
	Noise removed using Hybrid Filtering PSNR = 34.14dB

Table 1.3 - Original Image Size = 512 x 512

	Original Image
	Poisson noise added Image

	Noise removed using Response Median Filtering PSNR = 31.78dB
	Noise removed using Hybrid Filtering PSNR = 33.71dB

X. CONCLUSION.

A new denoising technique foe X-ray image is proposed using Modified Harris operator. A significant improvement is also achieved compare to present algorithms.

- Implementation of Hybrid method gives better results over present spatial domain and transform domain methods.
- Edges are maintained using our proposed method with the use of Modified Harris operator.
- Modified Harris operator differentiates between noisy and noise free pixels and therefore decision is taken, where to apply linear and non-linear filter.
- Visual appearance is also improved in case of denoised X-ray image compare to present algorithms.

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