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Genetic Algorithm Based Denoising of Medical Image

P. Robert[1] **and Celine Kavida A.**[2]

ABSTRACT

In image processing, the qualities of images are conjectured by improvising the reduction of noises in the images. Digital images are obtruded with variety of noises that affects the quality of an image. One of the most important process is image de-noising in the image processing techniques as it forms the basis of all other image processing algorithms such as image segmentation, image feature extraction etc. The main goal in de-noising of an image is to obtain the original details of an image as maximum as possible. This paper presents an adaptive genetic algorithm which denoises an image and produces best sample. On the basis of parameter performance can be calculated i.e. PSNR (peak-signal-to-noise-ratio) & SSIM (Structure Similarity). The experiments are done in the mat lab programming language and the results are plotted.

Keywords: Image Denoising, Parameter Optimization, Bilateral Filter, Genetic Algorithm

1. INTRODUCTION

Mainly for the governments and the companies that are commercial, medical imaging may be the only source of images to make decision for the future. In urban area planning the municipalities these medical images can be used and also to evaluate the target after the strike by the armed forces and so on [1]. So these images quality affects the decision either in a good or bad way. But unfortunately, from the medicals the qualities of all images that have been gathered are not always good, it is because of the heat generated electrons, the bad sensor, wrong ISO settings, vibration and the clouds [2]. So, to remove that noise from the medical image there have been several alternatives used by authorities while keeping all the features. During this denoising process keeping these fine features of noisy image is very critical for the people. Images that will be picking up the noises from variety of sources are captured with both the digital camera and the conventional film cameras. Further use of these images for experimental work will often require that noise be partially removed [9] the component of digital signal processing is digital image processing. With the aid of mat lab software for improving image qualities, modification of digital data is made by digital image processing. To maximize the clarity, to increase the sharpness of image and the details of features of interest to extraction information & also for further analysis is lead only when an image is processed [8]. For the purpose of target detection or for natural life saving purposes this segmentation process is worked out with small details. For removing unwanted noise and by preserving the edges this Bilateral Filter which is one of the effective denoising algorithm is used. And from the user two parameters are received from this algorithm. To achieve the meaningful result the most suitable parameter values should be selected by the user. The main objective of this particular paper is finding the optimum parameter set by using the alg aorithm known as GENETIC multi objective genetic optimization algorithm as by optimizing those parameters using this particular algorithm. Some of the objective of the image quality measurements is needed in order to understand the probable success of this denoising algorithm. In this particular work, namely there are some image quality functions, such as Mean Square Error (MSE), Structural

[1] Dept. of IT, Vel Tech Multitech Dr RR & Dr SR EngineeringCollege, India, *Email: probert@veltechmultitech.org*

[2] Dept. of Physics, Vel Tech Multitech Dr RR & Dr SR Engineering College, India, *Email: celinearuldoss@gmail.com*

Similarity Index (SSIM) and Entropy will examine how triumphant was that selected denoising algorithm. So, These objective functions when in closed form are difficult to be expressed and are squabbling with each other. In order to obtain these optimal solutions for this multi objective optimization problem the GENETIC algorithm is applied. And those optimal solutions will represent all non-dominant solutions and will emphasize all fine possible objectives. “By plotting these optimal solutions in the following objective space then the solutions can be achieved. When making this trade-offs for the conflicting objectives this optimal solution provides full freedom for the decision maker.” [10]. This GENETIC algorithm will be implemented in Mat lab and the image filter that has the executable file would also be called under the Mat lab environment. And finally, in order to show the perfect effectiveness of selected method the results will be represented graphically.

2. NOISE IN IMAGES FROM VARIOUS ORIGIN

At the time of image acquisition (or) transmission there is the possibility that noise can be added in an image. [7]. There are so many factors for introducing noise in an image [4]. In the digital image there are various sources in which noise can be added they are

a) During the image acquisition process and under various environmental conditions the image sensor is affected

b) The possibility of generating the noise in a particular image can be due to insufficient light levels and sensor temperature.

c) And an image can get corrupted if there is interference in the transmission channel.

d) And noise in the image can be generated if there are any dust particles that are present on the scanner screen

e) The mechanism for gathering data if the image is acquired directly in a digital format then they can introduce noise.

2.1. Different Types of Noise

Noise is an unwanted effect that is produced in an image. There are many factors that introduce the noise into an image during the process of image acquisition (or) transmission, [4]. This paper is focusing on removing certain kind of noise using genetic algorithm with the concept of bilateral filtering and parameter such as PSNR and SSIM.

3. MODELS FOR DENOISING

3.1. Existing Model

The main essential part of reconstruction of image process is denoising of an image. [16]. During the process of capturing, acquisition and processing an image can be normally affected by noise. Denoising is done to

Table 1
Types of Noise

Photo electronic	*Impulse*	*Structured*
Photon noise	Salt	Periodic, stationary
Thermal	Pepper	Periodic, Non Stationary
	Salt and Pepper	Aperiodic
	Line drop	Detector Striping
		Detector Banding

improve the visual Quality. Usually an image quality can be measured by the use of peak signal-to-noise ratio (PSNR) and also with root mean square error (RMSE). Figure [2] shows the denoising of image basic model[9].

In this existing model, firstly an image is taken and then some noise will be introduced to that image in order to produce a noisy image and now this noisy image will be decomposed by using the wavelet transform and following it thresholding is done to shrink that decomposed image and lastly apply different filters to that decomposed image in order to remove that noise from that noisy image and finally the needed denoised image can only be obtained by applying the inverse wavelet transform. So, to calculate the performance parameter between that noisy image and the image that is denoised can be calculated by using the following two method. They are peak signal-to-noise ratio (PSNR) and root mean square error (RMSE).

3.2. Proposed Model

Denoising of image basic model is shown in Figure [3]. The input image is added with noise to produce noisy image. The noisy image is subjected for bilateral filter and then genetic algorithm is applied on the output which is obtained from bilateral filter.

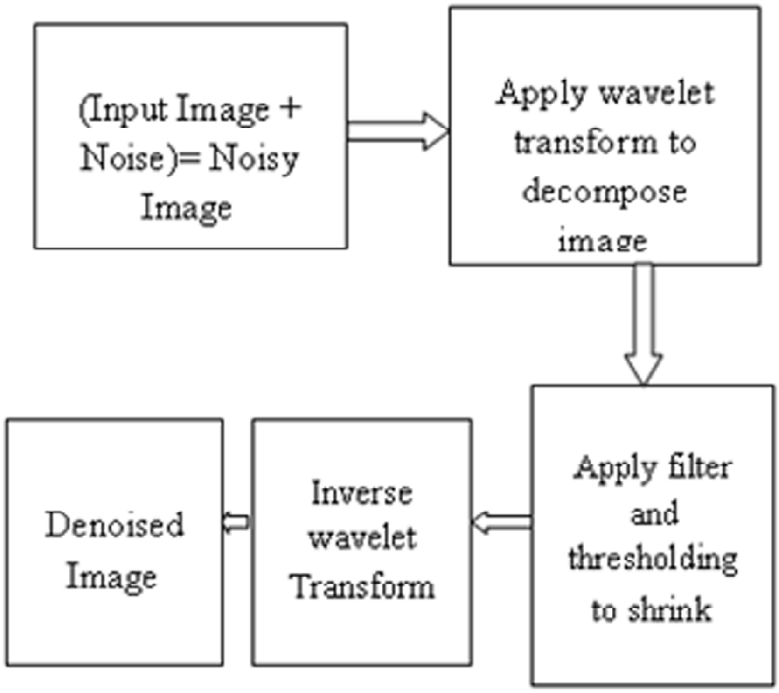

Figure 1: Existing Denoising Model

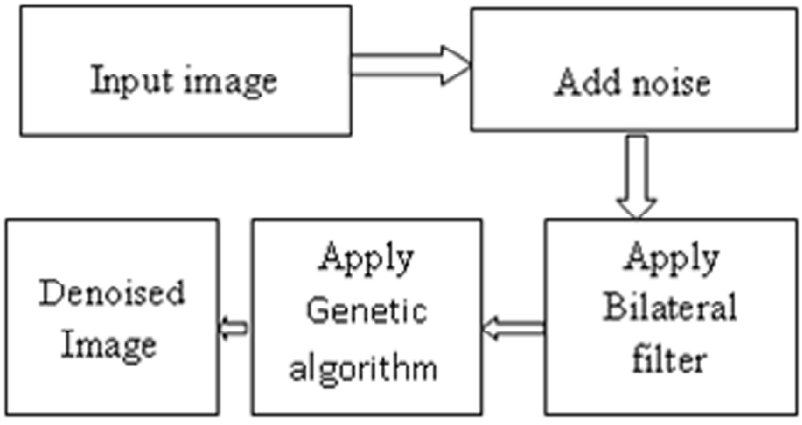

Figure 2: Proposed Model for Denoising

The performance of denoised image is far better than existing model. In this proposed model the performance parameter can be calculated between the noisy image and the image that is denoised by using two methods. They are signal-to-noise ratio (PSNR) and Structural Similarity Based Image Quality Assessment (SSIM).

4. PROCESS OF BILATERAL IMAGE FILTER

Tomasi and Manduchii were the two who introduced this Bilateral Image filter in the year 1998. The main concept of this filter is that the image that has the close pixels will actually have that nearby position in that spatial domain. So this is the reason why they can contain the nearby intensity values. The range filtering can be defined by averaging the pixel values with dissimilarity and with weights decay. Here the image intensity will define the weight. As output, those range filters that are divulged will be non linear filters. To bring dexterous, smooth and edge preserved images range and domain filters are combined in bilateral filter. "For reducing noise in an image this bilateral filter is capable of maintaining edges by an order of magnitude". The Bilateral Image has the following equation:

$$h(\omega) = k()^{-1} \int f(\omega)\, c(\omega, x)\, s(f(\omega), f(x))dx$$

Where *w* points the coordinates, $f(\omega)$ represents the input and $h(\omega)$ indicates the output images. In this Equation $c()$ and $s()$ are represented as spatial and intensity domain convolution kernels respectively. *X* which is computed for Integral represents a pixel of *w*'s neighborhood. The following equations represent the computation of normalization factor as follows

$$k(\omega) = \int_x c(\omega, x) s(f(\omega), f(x)dx$$

$$c(\omega, x) = e\left(\frac{\|k - x\|^2}{\sigma c^2}\right), s\left(f(\ ), f(x)\right) = e\left(\frac{\left(f(\omega) - f(x)\right)^2}{\sigma s^2}\right)$$

For the computation of σ_c value, how close the pixel neighbours should be considered will be decided by the user and also it checks how close should be the neighbors.

4.1. Proposed work

By using genetic algorithm the objective of this paper will set optimizing the parameter to find the optimum parameter. To understand the image quality measurement is taken which is called as PSNR (Peak Signal to Noise Ratio) in order to understand the denoising algorithm success. The main function of this ratio is to find the ratio between the powers of disturbing noise the power and the power which affects the representation quality. The genetic algorithm is applied to find the minimum PSNR difference between the image and the algorithm. Under mat lab environment this genetic algorithm is implemented. And finally the effectiveness of this method is shown in terms of graphical representation.

4.2. Genetic Algorithm

Genetic algorithm is a Meta heuristic algorithm and this algorithm mimics the natural selection process [5]. Genetic algorithm is an iterative process, with the population in an each iteration called a generation. Genetic algorithm tries to optimize the range and domain sigma of the bilateral filter in this paper.

The Pseudo code for the genetic algorithm:

1. Initialize a population P. The size depends on the nature of the problem and is generated randomly
2. During each successive generation, a portion of the population is filtered using a fitness function.

3. Crossover is down between the parents and child is produced.
4. The child is mutated to get diversity in the solutions obtained
5. The process is terminated once the terminating condition is finished

In this work the objective function used is the PSNR. It gives the information about the peak signal to noise power in the image.

4.3. Related Work

Emin kugu[1] tried to optimize the bilateral filter with the spea2 optimized parameters. He used the multi Objective optimization algorithm to optimize the domain and range sigma of the algorithm. He used four different objective functions such as the entropy, Structural similarity index, Mean square error and the Laplacian kernel operator to evaluate the fitness functions. The SPEA2 algorithm is as follows

Inputs: N : Population Size

: $\bar{N}$ archive size

T: Maximum number of generations

Output: A: dominated set

Step 1: First population P_0 should be created then initial archive should be $\bar{P}_0 = \varnothing$ and set the value $t = 0$.

Step 2: In P_t and $\bar{P}_t$, each individuals fitness value should be assigned.

Step 3: Copy all those non dominated individuals in P_t and $\bar{P}_t$ to $\overline{P_{t+1}}$ exceeds $\bar{N}$ then reduce $\overline{P_{t+1}}$ by means of that truncation operator otherwise if size of $\overline{P_{t+1}}$ is less than $\bar{N}$ *then* fill $\overline{P_{t+1}}$ with dominated individuals in $\bar{P}_t$ and $P_{t.}$

Step 4: A can be set to the set of decision vectors which can be represented by the non dominated individuals in $\overline{P_{t+1}}$ stop if another stopping criterian is satisfied or if $t \geq T$

Step 5: To fill the mating pool this binary tournament selection should be performed with replacement on $\overline{P_{t+1}}$

$\overline{P_{t+1}}$ and by means of the truncation operator otherwise if size of $\overline{P_{t+1}}$ is less than $\bar{N}$ *then* fill $\overline{P_{t+1}}$ with dominated individuals in $\bar{P}_t$ and $P_{t.}$

Step 6: A can be set to the set of decision vectors which can be represented by the non dominated individuals in $\overline{P_{t+1}}$ stop if another stopping criterian is satisfied or if $t \geq T$

Step 7: In order to fill the mating pool this binary tournament selection should be performed with replacement on $\overline{P_{t+1}}$

Step 8: Set $\overline{P_{t+1}}$ to fill the mating pool. And apply the operators that are recombination and mutation to the mating pool set.

The proposed algorithm by Emin Kugu is an optimization algorithm which has multiple objectives. Our work differs from this algorithm by the fact that single objective optimization is done which reduces the convergence time to reach the desired value. Similar to Emin Kugu, also tried using To reach the highest value of peak signal to noise ratio(PSNR) using the risk minimization method by optimizing the distance and range of the 2D bilateral filter and this method was tried by Peng and Rao.

5. TEST AND RESULTS

The algorithm is designed in the mat lab and the outputs are generated. In case-1 the population overall size will be set to 10 and then the number of population count was set to 10. Domain sigma parameter will be ranging from 1 to 9 and the range sigma parameter will be ranging from 1 to 9.In these medical images were taken and corrupted with additive white Gaussian noise. The PSNR and SSIM values for noisy image and GA are plotted in the table 1. In case-2 the population size was set to 20 and the number of population was set to 20. And the value of range sigma and domain sigma parameters values are same. In case-3 the population size was set to 50 and the number of population was set to 50.

Case-1: Max_itr = 10, pop_size = 10

Case-2: Max_itr = 20, pop_size = 20

Case-3: Max_itr = 50, pop_size = 50

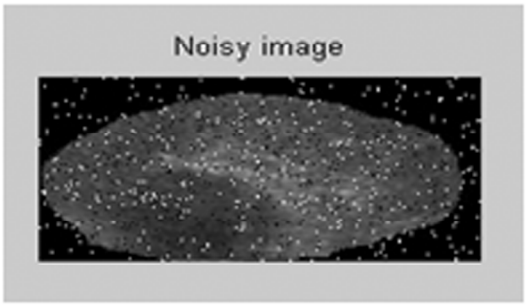

Figure 3: Noisy Image

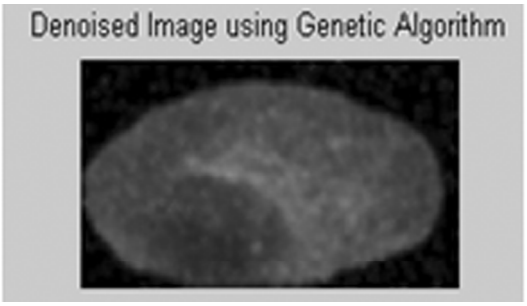

Figure 4: Denoised Image

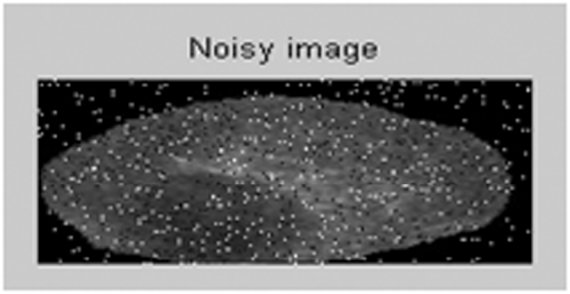

Figure 5: Noisy Image

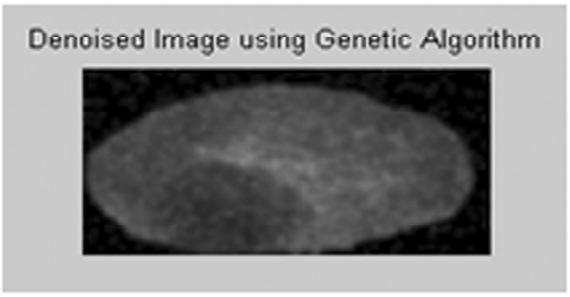

Figure 6: Denoised Image

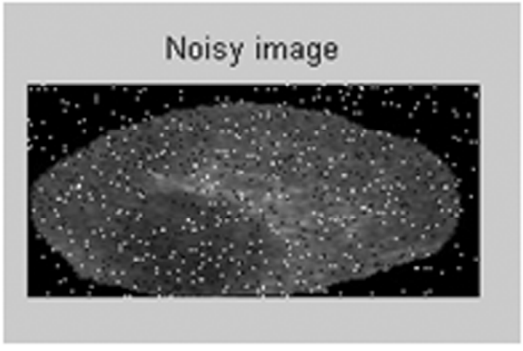

Figure 7: Noisy Image

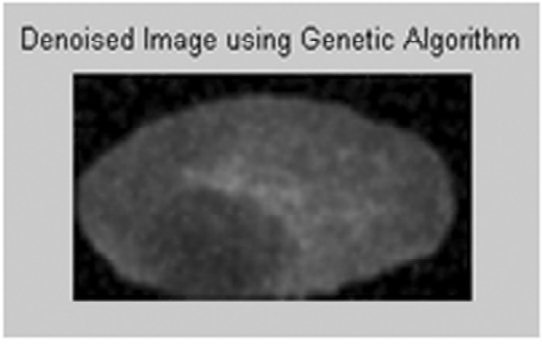

Figure 8: Denoised Image

Table 2
PSNR and SSIM values for noisy image and Denoised image

Noise Type	*Noisy Image*		*Denoised Image*	
	RMSE	*PSNR*	*RMSE*	*PSNR*
Salt & Pepper	31.3692	18.2007	20.8864	21.9292
Poisson	11.6066	26.8362	7.4466	30.6917
Gaussian	52.0443	13.8035	15.8531	24.1285

Table 3
PSNR and RMSE values for noisy image and Denoised image

Noise Type	*Noisy Image*		*Denoised Image*	
	SSIM	*PSNR*	*SSIM*	*PSNR*
Salt & Pepper	0.6996	65.6412	0.9604	75.9826
Poisson	1.000	75.2715	0.9887	81.3726
Gaussian	0.8230	68.9516	0.9600	76.0647

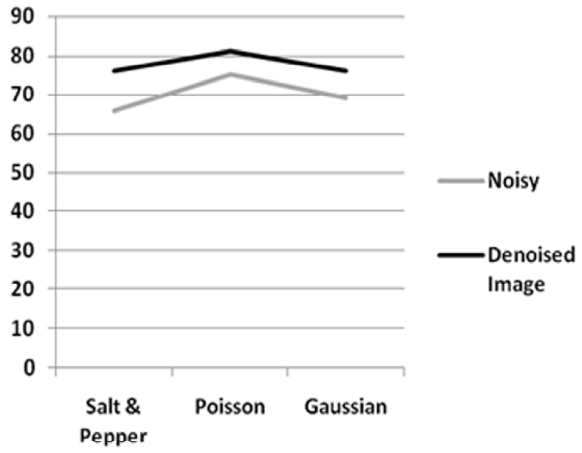

Figure 9: PSNR values of noisy image and denoised image represented in Chart format.

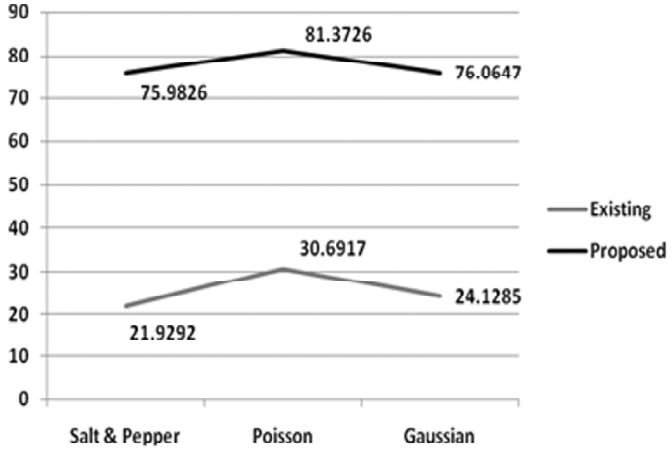

Figure 10: Comparison of PSNR values of Existing system and Proposed System

In this paper, the performance of proposed algorithm is tested under various images. The kidney image is given as input to combination of enhanced bilateral and genetic algorithm. From image noise is removed and its PSNR values for various noises are represented in table and graphical chart. The PSNR values of the proposed algorithm much higher than the existing algorithm [Figure 8]. The proposed algorithm is considerably giving better results than existing algorithm.

6. CONCLUSION

The final results of this test case proved that if the parameters are optimized properly then this bilateral filter method provides the expected and valid denoising performance. The any images can be optimized while preserving the edges. The results also showed that genetic algorithm was performing efficiently with the optimization of the algorithm parameters.

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