High Performance Fuzzy Filter and BFO Based Method for Removal of Mixed Noise from Images

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Abstract- **In image presence of noise might affect the results for some processing, such as image segmentation, edge detection, object recognition and data compression. Therefore, the process of image restoration or noise filtering should be taken on the image before other image processing takes place. In this paper high performance mixed noise (combination of salt and pepper noise and Gaussian noise) removal technique is proposed. This mixed noise removal is done and using Fuzzy filter and Hybrid Bacterial Foraging Optimization. The proposed method reduces mixed noise without compromising on edge sharpness by providing improved mean square error (MSE) and peak signal to noise ratio (PSNR) values at different noise densities.**

Keywords- **PSNR, MSE, Noise densities, Salt and Pepper Noise, Gaussian Noise.**

I. INTRODUCTION

Removal of noise from an image is an important area of digital image processing which involves the improvement of the degraded digital image based on the prior knowledge of the mathematical or probabilistic model of image degradation. At the time of image acquisition through sensors or communication channels, image may be contaminated by noise. In images presence of noise might affect the results for some processing, such as image segmentation, edge detection, object recognition and data compression. Therefore, the process of image restoration or noise filtering should be taken on the image before other image processing takes place. Attenuation of noise is an essential task in digital image processing as digital images play an important role both in daily life applications satellite television as well as research and technology such as geographical information systems and anatomy.

The challenge of this task is how to reduce noise while keeping the image details. There are many works on the restoration of images. Images are often corrupted by impulse noise during acquisition and transmission. Therefore, an efficient noise suppression method is required before subsequent image processing. Satellite television, magnetic resonance imaging, computer tomography as well as in areas of research many recent methods first detect the corrupted pixels and then restore them without affecting the uncorrupted pixels.

II. RELATED WORK

The research work is inspired from the recent innovations in the field of image filters. Various types of noises like impulse noise, Gaussian noise, mixed noise etc. can be removed or reduced by noise filtering process.

Jayasree.M, N. K. Narayanan[1] proposed an efficient noise removal technique to restore digital images corrupted by mixed noise, preserving image contents optimally. The proposed filtering technique consists of two steps: the noisy pixel detection step using fuzzy technique and the mixed noise filtering step. Noises addressed in this method are a combination of salt and pepper noise and Gaussian noise. This method reduces mixed noises considerably without compromising on edge sharpness. This mixed noise removal technique finds application in various segments of image processing like digital television, medical image processing, digital camera, surveillance systems etc.

Sanparith Marukatat [2] proposed local intensity distribution equalization (LIDE) method for image enhancement. LIDE applies the idea of histogram equalization to parametric model in order to enhance an image using local information. It reduces the amount of computational resources required by traditional method like the adaptive histogram equalization, but allows enhancing detail similar to the latter technique. Integral image was used to efficiently estimate local statistics needed by the parametric model. This data structure drastically reduces the computational cost especially for megapixel image where a large local window is preferred.

Bhagwati Charan Patel, G. R. Sinha [3] proposed a work that combines gray level Clustering and contrast enhancement algorithm which aims at improving contrast features and the suppression of noise. This technique is very helpful to visualize breast tumors of breasts of higher density that further helps in detection of breast cancer. Firstly, same gray level intensity values are grouped and clusters are formed accordingly then contrast enhancement method is applied over to it. The quantitative analysis using contrast improvement index, signal to noise ratio and root mean square error, was made to investigate the characteristic of the breast cancer images. The low contrast features are enhanced without introducing any artifacts.

Isma Irum, Muhammad Sharif, Mudassar Raza and Sajjad Mohsin [4] proposed a nonlinear hybrid filter for removing fixed impulse noise (salt & pepper) noise from color images.

Technique is based on mathematical morphology and trimmed standard median filter. Proposed filter is composed of a sequence of morphological standard and well known operations erosion-dilation and trimmed standard median filter. It removes the fixed impulse noise (salt & pepper) very well without distorting the image features, color components and edges. It does not introduce blurring and moving effects even in high noise densities (up to 90%). The standard similarity measure peak signal to noise ratio (PSNR) and computation time have been used to evaluate the performance of this hybrid filter.

S.Ravisankar, S.Sabari Guru Rajaa, S.S.Sriram Prasath [5] proposed a technique that uses Fuzzy Genetic Algorithm to find the optimal composite filters for removing all types of impulse noise from medical images. Here, a Fuzzy Rule Base is used to adaptively change the crossover probability of the Genetic Algorithm used to determine the optimal composite filters. Here Genetic Algorithm (GA) is used to determine composite filters that remove different levels of impulse noise from an image. In this method, the GA considers a set of possible filter combinations of a particular length, selects the best combinations among them according to a fitness value assigned to each combination based on a fitness function, and applies genetic operators such as crossover and mutation on the selected combinations to create the next generation of composite filters. The results of simulation on a set of standard test images for a wide range of noise corruption levels shows that output of this method performs standard procedures for impulse noise removal both visually and in terms of performance measures such as PSNR, IQI and Tenengrad values.

V.Murugan, T.Avudaiappan and Dr.R.Balasubramanian [6] investigates the performance of four denoising methods for removing the High Density Impulse Noise. These methods are adaptive Bilateral Filter (ABF), Fuzzy paper group filter (FPGF), Switching Bilateral Filter (SBF), and Boundary Discriminative Noise Detection Filter (BDND).The performance of the above four filters is compared by using five performance metrics. They are Peak-Signal to-Noise Ratio, Mean Square Error and Root Mean Square Error.

Christo Ananth, Vivek, Selvakumar.S, Sakthi Kannan.S [7] proposed a system that has a fuzzy filter which has the parallel fuzzy inference mechanism, fuzzy mean process, and a fuzzy composition process. In particular, by using no-reference Q metric, the particle swarm optimization learning is sufficient to optimize the parameter necessitated by the particle swarm optimization based fuzzy filter, therefore the fuzzy filter can cope with particle situation where the assumption of existence of “ground-truth” reference does not hold. The merging of the particle swarm optimization with the fuzzy filter helps to build an auto tuning mechanism for the fuzzy filter without any prior knowledge regarding the noise and the true image. Thus the reference measures are not need for removing the noise and in restoring the image. The final output image (Restored image) confirm that the fuzzy filter based on particle swarm optimization attain the excellent quality of restored images in term of peak signal-to-noise ratio.

III. FLOW OF WORK

Fig.1 shows the flow of proposed technique.

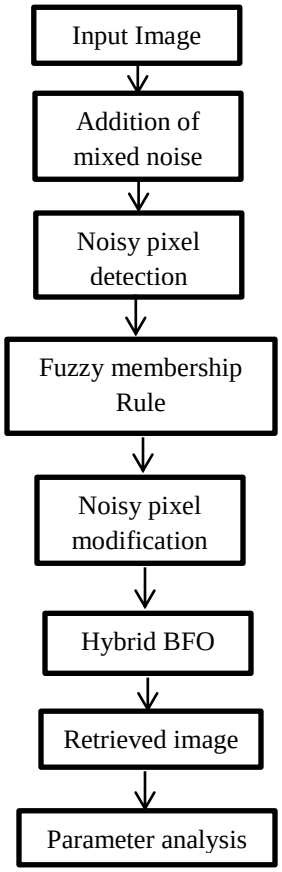

Fig.1 Flow of Proposed Technique

A. Image Uploading

Image has been uploaded to the system using image reader. Image has been stored in 2-D image matrix. Equation (1) represents the image that has been used as input to the system using reader function.

$$A = \sum_{\substack{0 \le i \le m \\ 0 < j < n}} P(i,j) \qquad (1)$$

B. Mixed Noise Addition

After selection of image, noise has been added to the image for conversion of image into noisy image. In the proposed work mixed noise viz. Gaussian noise and salt and pepper noise has been added to the image.

- *Salt and Pepper Noise*

It add certain amount of the pixels in the image that is either black or white. Salt and pepper noise can be used to model defect in the transmission of the image. Give the probability

that a pixel is corrupted, we can introduce salt and pepper noise in an image by setting a fraction of r/2 randomly selected pixels to black, and another fraction of r/2 randomly selected pixels to white.

- *Gaussian Noise*

Gaussian noise in digital images arise during acquisition e.g. sensor noise caused by poor illumination and/or high temperature, and/or transmission e.g. electronic circuit noise. Gaussian noise in digital image processing can be reduced using a spatial filter, though when smoothing an image, an undesirable outcome may result in the blurring of fine-scaled image edges and details because they also correspond to blocked high frequencies.

- *Mixed Noise*

Mixed noise has been used for noise addition process. The salt and pepper noise and Gaussian noise has been added. Both types of noise have been added to the system using different variance factor.

C. Noisy pixel detection

After adding the mixed noise viz.salt and pepper noise and Gaussian noise, detection of noisy pixel is done. Noisy pixel detection has been done using maximum and minimum based threshold value. In this work 3 * 3 window has been moved over the image. Image pixels value has been computed using different values of row and Column of the window size. Equation (2) shows the image pixels that has been denoted by x_{ij} and i and j are the values depends upon image size that is r*c. 1<i>r and 1<j>c are the values for i and j.

$$W_{ij}= \{x_{i-1j-1,} \dots\dots\dots., x_{ij}, \dots\dots\dots\dots. x_{i+1j+1}\} \quad (2)$$

where W represents window size that has been moved over the image. T1 and T2 are threshold values that have been implemented over the image for detection of noisy pixel.

D. Fuzzy membership rule

On the basis of detection of noisy pixel image pixel weightage has been defined for noise cancellation. Equation 3 shows the weightage parameters that are known as fuzzy membership parameters for image noise cancellation.

$$Y(i-f,j-f)=sum(sum(F.*x))/sum(sum(F)) \quad (3)$$

This function has been used for construction of noise pixel cancellation, where F denotes fuzzy membership weightage value and x denotes pixel values of the noisy image.

E. Noisy Pixel Modification

After cancellation of noise by using fuzzy membership rule we further modify the noisy pixel for improving peak signal to noise ratio.

F. Hybrid Bacterial Foraging Optimization

After cancelation of the noise bacterial foraging optimization operator has been implemented on the image so that noise cancellation can be optimized. Bacterial foraging optimization algorithm (BFOA) has been widely accepted as a global optimization algorithm of current interest for distributed optimization and control. BFOA is inspired by the social foraging behavior of Escherichia coli. Following pseudo code structure is representing the step-by-step details of the simulation of BFOA used in our work.

- The random moving patterns that the bacteria generate in the presence of chemical attractants and repellants are called chemotaxis. For E.coli, this process was simulated by two different moving modes ‘tumble ’and ‘run or move ’, and bacterium alternates between these modes until divided into two. Tumble bacterium randomly searches a direction of moving and in run it moves a number of small fixed length steps C(i) in the selected tumble direction ∅ (i) or better nutrients collection.
- As bacteria are not immortal and like to grow population for better social structure they uses rule of evolution and when appropriate conditions appear then individual will reproduce themselves after certain number of chemotaxis steps. For this purpose health of the bacteria, which is sum of fitness in each chemotaxis including initialization step is considered and to keep constant population bacterium with better health capture the position of bacterium with poor heath, for this purpose individual reproduce one of its identical clone.
- In the evolutionary process, elimination and dispersal events occur such that bacteria in a region are eliminated or a group is dispersed from current location and may reappear in the other regions due to environmental changes or some natural calamities. They have the effect of possibly destroying chemotactic progresses, but they also have the effect of assisting the chemotaxis, since dispersal may place bacteria near good food sources. From evolutionary point of view, elimination and dispersal was used to guarantee diversity of the individuals and to strengthen the ability of global optimization. In BFOA, bacteria are eliminated with a probability P_{ed}, and to keep population size constant, if a bacterium is eliminated, simply disperse one new bacterium to a random location of the search space.
- In the process of noise image optimization E.coli bacteria has been used and swarming behavior has been used for health evaluation. It is observed from experiment that when a group of E.coli bacteria is placed in the center of a semisolid agar with a single nutrient chemo-effecter, they move out from the center in a traveling ring of cells by moving up the nutrient gradient created by consumption of the nutrient by the group, and this cell-to-cell signaling attractant and a replant based network group can be modeled.

- On the basis of this process new modeled group of bacteria's has been replaced with existing image coefficients and new image has been formed.

IV. RESULTS

In order to evaluate the performance of this algorithm peak signal to noise ratio and mean square error has been calculated using following formulas:

- *TO CALCULATE MEAN SQUARE ERROR (MSE):*

$$MSE(dB) = \frac{1}{M \times N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (O - \mathrm{D})^2 \quad (4)$$

Equation4 shows the mean square error, where O the original is image of size $M \times N$ and D is the restructured image.

- *TO CALCULATE PEAK SIGNAL TO NOISE RATIO (PSNR):*

$$PSNR(dB) = 10log_{10}\left(\frac{255^2}{\frac{1}{M \times N}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(O-\mathrm{D})^2}\right) \quad (5)$$

Equation5 shows peak signal to noise ratio, where $O$the original is image of size $M \times N$ and D is the restructured image. The image taken in this paper is tested at different noise densities and mean square error, peak signal to noise ratio is obtained which is better as compared to noise pixel modification technique. Table1 shows the comparison between noise pixel modification technique and proposed method.

Salt and Pepper Noise Density (%)	Gaussian Noise Density (%)	MSE (Proposed Method)	PSNR in db (Propos-ed Method)	PSNR in db (Noise pixel modific-ation technique)
5	5	9.49586	55.3062	45.9424
7	5	9.40534	55.3781	45.9197
9	5	9.35386	55.4191	45.9436
11	5	9.25165	55.5014	45.8321
13	5	9.15834	55.5771	45.7873
15	5	9.13061	55.5996	45.7371
17	5	9.04845	55.6671	45.5861
19	5	8.93824	55.7583	45.3518
21	5	8.92604	55.7684	45.2913
23	5	8.81471	55.8618	45.211

Table 1. Comparison between noise pixel modification technique and proposed method

V. CONCLUSIONS

The proposed system is designed to remove noise from different images. In this work mixed noise is added in image then fuzzy membership function is used for noise cancellation. After that Hybrid BFO is applied in which noisy image optimization E.coli bacteria and swarming behavior has been used to remove noise from image to get improved MSE and PSNR value. This system has been compared with noisy pixel modification technique and got better results.

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BIBLIOGRAPHY

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