A novel method for denoising images by applying bacterial foraging optimization technique

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Abstract— Nature inspired computing algorithms is a growing domain which finds applications in computer science including image processing. This article presents a new technique of denoising images by combining median filter and bacterial foraging optimization algorithm (BFOA) which is a type of nature inspired computing algorithm. Usually the images suffer from noises which will reduce image quality and distort images and hence denoising of images play an important role in image processing. This research paper analyses the appropriateness of applying BFOA on the filtered image produced by median filter to result in a better denoised image. In this proposed method of Bacterial Foraging based Optimisation, PSNR (Peak Signal to Noise Ratio) is used as fitness function to denoise the noisy images which are initially filtered by median filter. The implemented code is tested for Gaussian noisy images and for median filter and results show the optimization capability of BFOA based method and that it improves the denoising process of median filter.

Keywords— Image processing, Denoising, Bacterial foraging optimization, Median filter.

I. INTRODUCTION

The common types of noises in digital images are Gaussian noise, Salt and Pepper noise, Poisson noise and Speckle noise.
The filtering process plays an important role in retrieving correct information from images and filters like median filter, average filter etc are found to be useful in removing noises.
Several research works have already been carried out in the domain of improving the denoising process of images as well as in applying nature inspired computing methods in image processing. A new approach to enhance peak signal to noise ratio of highly corrupted image affected by salt-pepper noise was introduced K M. Bakwada et. al. in their work[1]. Improvement of adaptive median filter with bacterial foraging optimization (BFO) technique based on the fitness function Mean Square Error is considered and the superiority of the new method is demonstrated. S.Yaduwanshi and J.S.Sidhu, in their work, introduced application of BFO as an optimizing technique based on fitness function Mean Square Error to improve the de-noising of medical images like CT scan and MRI images[2]. V. Sharma et. al. conducted a study providing a comprehensive review of the Bacterial Foraging Optimization Algorithm and its variants along with their applicability in engineering applications such as electric load forecasting, network scheduling, antenna design etc. [3]. S.Gholami et. al. proposed a system in which an algorithm based on the BFO is used for adaptive nonlinear filter coefficients optimization to improve PSNR of images[4]. In the study conducted by S.K.Beenu on image segmentation applying bacterial foraging algorithm, the thresholding methods are evaluated w.r.to parameters PSNR, entropy and standard deviation and the results showed satisfactory results for the BFO based method[5]. Om Prakash Verma et. al. discussed about a novel fuzzy system for edge detection in noisy images using BFO and the test results showed superior performance and reduced computational complexity of BFO based method in comparison with edge detection operators such as Sobel, Canny, ACO and GA[6].
Nature inspired computing algorithms like ant colony optimization, bacterial foraging optimization, fire-fly algorithm and Bee colony optimisation algorithm are considered to be efficient in many phases of image processing and literature survey points to the suitability of BFO in improving the filtering of images. In most of the works reviewed, the fitness function of BFO was based on Mean Square error. The improvement that can be done for a frequently used filter like median filter is not well studied yet. The review of literature points to the possibility of exploring the ability of BFO in improving the performance of a filter like median filter.
This research work proposes Peak Signal to Noise Ratio as a fitness function in deciding the optimization of BFO in image filtering. Also, it is proposed to test Gaussian noised images for the median filter to confirm the suitability of applying BFO in better denoising of images.
In this research article, the coming sections are as follows - Section II describes filtering of images, Gaussian noise , and median filter. Section III discusses the general steps of Bacterial Foraging and the Optimization logic. Section IV discusses the proposed method for improved image denoising by applying median filter in combination with BFOA. Section V describes simulation and result of experiments and the last section presents conclusion and future directions related to this work.

II.NOISES IN IMAGES AND FILTERING

One of the most important tasks in image processing is to suppress the noise from images which have been corrupted by different factors and it is accomplished by filtering of images. One simple and popular filter, median filter, is considered in this research work along with Gaussian noised images.

A. *Gaussian Noise*

This noise arises in amplifiers or detectors and hence also known as electronic noise. Gaussian noise is caused by natural sources such as thermal vibration of atoms and discrete nature of radiation of warm objects. Gaussian noise generally disturbs the gray values in digital images and this noise model is characterized by its PDF which is given as

$$P(g)=\sqrt{\frac{1}{2\pi\sigma^2}}\ e^{-\frac{(g-\mu)^2}{2\sigma^2}}$$

where g = gray value, s = standard deviation and μ = mean.

Filters are noise reduction techniques applied on noisy images to reduce the effect of noises and there are many filters such as average filter, median filter, adaptive median filter etc.

C *Median Filter*

The median filter is a nonlinear digital filtering technique, usually used to remove noise from an image or signal. The underlying principle of the median filter is to run through the signal, entry by entry, replacing each entry with the median of neighbouring entries and this is different from the working of mean filter.

III.BACTERIAL FORAGING OPTIMIZATION

BFO is an optimisation method developed based on the foraging strategy of Escherichia Coli (E. Coli) bacteria, bacteria that live in the human intestine[7]. This computation method finds a place in other domains also due its merits - less mathematical complexity, faster convergence and more accuracy.

3.1 Process of bacterial foraging

Bacterial Foraging is explained by following steps[7]:-

- Chemotaxis
- Swarming
- Reproduction and
- Elimination-Dispersal

3.1.1 Chemotaxis

This process is the movement of an E.coli cell through swimming and tumbling via flagella.

3.1.2 Swarming

It is an observed behaviour of E-coli that they form intricate and stable spatio-temporal patterns known as swarms in semisolid nutrient medium. The cells when stimulated by a high level of succinate, release an attractant aspertate, which helps them to aggregate into groups and thus to move as concentric patterns of swarms with high bacterial density.

3.1.3 Reproduction

The least healthy bacteria eventually die when each of the healthier bacteria asexually split into two bacteria, and are then placed in the same location. This keeps the swarm size constant.

3.1.4 Elimination and Dispersal

Gradual or sudden changes in the local environment where a bacterium population lives may occur due to various reasons. Events can occur such that all the bacteria in a region are killed due to high temperature or a group is dispersed into a new part of the environment. Elimination and dispersal events, at the same time, may possibly destroy chemotactic progress, but they also assist in chemotaxis, since dispersal may place the bacteria near good food sources.

IV. PROPOSED METHOD OF BFO BASED OPTIMIZED FILTERING

In our proposed method of filtering images by applying median filter combined with Bacterial Foraging Optimisation Algorithm, PSNR (Peak Signal to Noise Ratio) is used as fitness function.

A. *The proposed denoising technique*

Images(with resolution 128×128, 256×256 and formats jpg, png, bmp and tif) are added with Gaussian noise with different standard deviation such as 1%, 2%,10%...., 90% etc. These noisy images are passed through a filter – median filter. And the parameters Mean Absolute Error (MSE) and Peak Signal to Noise Ratio (PSNR) of the filtered images are computed.

The proposed Bacterial Foraging Optimisation Algorithm based on fitness function PSNR is applied on the images resulted in the previous step. This step efficiently reduces noises which are not fully filtered by the median filter. The parameters PSNR and MSE of the optimised image are computed. The parameters values obtained from the median filtered images and further optimised images are computed.

B. *Proposed BFO algorithm for smoothening the filtered images.*

Different parameters considered are as follows - Number of bacteria in population used for searching, Dimension of search space, Number of Chemo tactic steps Na, Number of swimming steps, Number of reproduction steps Nb, Number of elimination and dispersal Nc, Probability of elimination and dispersal.

1: Start. Relevant parameters are initialized. Filtered image and Noisy images are given as input matrices.

2: Compute Fitness of initial population based on PSNR.
3: Perform chemotaxis (Swim/Tumble),(steps 4 to 5) Na times.
4: Compute Fitness function based on PSNR.
5: If current fitness is better than previous
a: Swim b: Else tumble
6: If chemotaxis is ended, Perform Reproduction, (steps 7) Nb times.
7: Keep half of population (with higher fitness value), Remove Other half (with low Fitness values).
8: If Reproduction is ended, Perform elimination and dispersal Nc times (Step 9).
9: Preserve higher fitness values and disperse lower fitness values.
10:Output:New filtered image
11: Stop

V EXPERIMENTAL RESULTS

The proposed noise reduction method, median filter combined with BFOA, is simulated on MATLAB 2017a and experiments are performed on 50 gray scale images and a few test cases have been presented here.

To analyse the performance of the proposed technique, the test image is corrupted with Gaussian noise of standard deviation from range of 0.01 to 0.9. The PSNR (Peak Signal to Noise Ratio), and MSE (Mean Squarre Error) are taken as performance measures. Results of performance evaluation of both denoising techniques (median filter and median filter combined with BFOA) have been shown qualitatively as well as quantitatively.

Fig. 1. a)Original Image -Puppy.jpg. b) Gaussian noised. c)median filtered d) BFO based method applied

Table 1. Quantitative analysis of the effect of applying standard filters as well as BFO based method on the image given in Fig1 w.r.to PSNR and MSE

image	Resolution	Type of noise, SD		Median filter		BFO	
				PSNR	MSE	PSNR	MSE
Puppy.jpg	128x128	Gaussian	0.02	18.8633	0.0130	22.0807	0.0062

Table 2. Image(cock.jpg - 256x256) added with Gaussian noise and filtered using Median filter alone and later by BFO based method.

Sl.No:	SD	Median filtered PSNR, MSE		BFO based Method PSNR, MSE	
1	0.1	12.1313	0.0612	13.0619	0.0494
2	0.2	9.9438	0.1013	10.6566	0.0860
3	0.3	9.0212	0.1253	9.6515	0.1084
4	0.4	8.5428	0.1399	9.1314	0.1221
5	0.5	7.9797	0.1592	8.5475	0.1397
6	0.6	7.6930	0.1701	8.2219	0.1506
7	0.7	7.4159	0.1813	7.9354	0.1609
8	0.8	7.2470	0.1885	7.7515	0.1678
9	0.9	7.0321	0.1981	7.5286	0.1767

The tables above demonstrate the results of filtering of images by median filter vs BFO optimized median filter.

From the results of 50 test cases, it is observed that Proposed denoising technique yields better performance at all noise levels in terms of parameters (PSNR, MSE) tested here. The high value of PSNR of images resulted after applying the proposed denoising technique indicates the effectiveness of the proposed BFOA based filtering technique. The low value of MSE of images resulted after applying BFOA based denoising technique also indicate effectiveness of BFO based approach combined with median filter. It is observed that the proposed denoising technique has better result in terms of image clarity.

5 CONCLUSION

In this work, a new method for optimized noise reduction is applied after combining median filter and bacterial foraging optimization algorithm. BFOA based method works on the basis of the fitness function PSNR of images. The image quality of resulted images after applying BFOA are compared with those resulted images after applying median filter alone in terms of parameters PSNR and MSE. From the results obtained, it is evident that BFOA combined with median filter is more efficient for reducing noises in images than compared to median filter if used alone. In the filtered images after applying BFOA smoothening, PSNR gets maximized and MSE gets minimized when compared to those images which were only filtered using median filters. Image gets smoothened with more clarity after the application of BFOA.

The proposed technique can be extended to cover the denoising of colour images. And, the applicability of BFOA method can be tested for images corrupted with Speckle or Poisson noises. More parameters can be tested for establishing the accuracy and potential of this proposed method.

REFERENCES

[1] K.M. Bakwad, S.S.Pattnaik, B.S. Sohi, S.Devi, S.V.Gollapudi, C.V.Sagar and P.K.Patra, Fast motion estimation using small population-based modified parallel particle swarm optimization, International Journal of Parallel, Emergent and Distributed Systems, 26(6), 457-476, 2011.

[2] S. Yaduwanshi and J.S. Sidhu, Application of bacterial foraging optimization as a de-noising filter, International Journal of Engineering Trends and Technology, 4(7), 3049-3055, 2013.

[3] V.Sharma, S.S.Pattnaik and Garg, A review of bacterial foraging optimization and its applications. International Journal of Computer Applications, 2012.

[4] S.Gholami-Boroujeny and M.Eshghi, Active noise control using bacterial foraging optimization algorithm, In Signal Processing (ICSP), IEEE 10th International Conference , pp. 2592- 2595, 2010.

[5] S.K. Beenu, Image segmentation using improved bacterial foraging algorithm, Int. J. Sci. Res.(IJSR), 2013.

[6] O.P. Verma, M. Hanmandlu, A.K. Sultania and A.S.Parihar, A novel fuzzy system for edge detection in noisy image using bacterial foraging. Multidimensional Systems and Signal Processing, 24(1), 181-198, 2013.

[7]K.M. Passino, Biomimicry of bacterial foraging for distributed optimization and control, IEEE control systems, *22*(3), 52-67, 2002.