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Optimized Noise Reduction in Images Applying Artificial Bee Colony Based Technique

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Abstract: ***Digital image processing techniques have become inevitable in image related research areas and the major challenge is in collecting good quality images. Usually images suffer from noises and this will affect the accuracy of research findings. Because of this reason, noise removal is a crucial step in image processing tasks. Biologically-inspired soft-computing algorithms, originated by imitating evolution and foraging techniques of insects and animals in nature, have attracted a lot of research interests . This study presents development of a noise reduction technique based on a biologically inspired algorithm – Artificial Bee Colony Algorithm(ABC) - and analyses its optimization capabilities. This study throws light towards the potential of ABC algorithm to work as an effective smoothening filter for images.***

Keywords: ***ABC algorithm, noise reduction, optimization.***

I. INTRODUCTION

Digital images with enough contrast and sufficient details is very necessary for many applications in areas like computer vision, remote sensing, autonomous navigation, and biomedical image analysis. The major challenge in all these domains is the noise affecting the images and the consequent loss of significant information in image content. Filtering is one solution for noise reduction. But commonly used filters like average filter, median filter etc are found to be performing with low accuracy in the case of many noisy images, though these filters are generally acceptable everywhere due to their simplicity in their operations. Hence some method is required for the improved noise reduction. In many complex problems, bio-inspired computing techniques are found to be providing good solutions and Artificial Bee Colony algorithm is one such technique which has proved its optimization capability in many complex image processing tasks.

This study aims at exploring the potential of Artificial Bee Colony algorithm in resulting optimized noise reduction in images. In this research paper, the whole work is arranged in different sections as follows:

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Section II discusses the research works related to this domain. Section III discusses the proposed method for noise reduction by applying ABC algorithm. Section IV discusses implementation and result of experiments and the final section presents conclusion and future directions.

II. LITERATURE REVIEW

There are several useful applications of Artificial Bee Colony Optimization algorithm in different stages of image processing based applications. In 2011, Karaboğa N and Cetinkaya M.B developed a technique based on ABC algorithm for the design of adaptive FIR and IIR filter[1]. In 2012, Erik Cuevas et al. presented an algorithm based on ABC for the automatic detection of multiple circular shapes from complicated and noisy images and showed that it is better than the conventional Hough Transform principles based methods[2]. In 2012, Yimit A et al. presented a work on automatic image enhancement by ABC algorithm and this new method performed better than genetic algorithm-based method[3]. Yigitbasi ED and Baykan NA, in their study in 2013, carried out the edge detection by ABC and the results showed that this new method performed better than the methods of Sobel, Canny, Roberts for edge detection[4]. Khader AT et al. in their survey of literature suggested that ABC algorithm have been applied to many different areas such as engineering design applications, bioinformatics applications, image processing applications and benchmarking optimizations[5]. Jie Yang et al, in 2016 proposed a new method for image restoration using ABC algorithm by combining it with wiener filter and showed that this method is better for image restoration[6]. In 2017, Linguo Li et al. applied ABC algorithm for multi level thresholding of images and the experimental results showed that this method can search out the optimal thresholds efficiently, precisely, and speedily, and the thresholds are very close to the results examined by exhaustive searches[7]. In 2013, Suman Yaduwanshi et al. showed the application of BFO as a digital filter to de-noise images and suggested that nature inspired computing algorithm like BFO has enough potential in image processing tasks and denoising optimizations [8].

The findings of different research works points to the need of analyzing the potential of ABC, a swarm intelligent algorithm, in applying for the problem solving of a significant issue like optimization in filtering.

III. DATA AND METHODLOGY

This proposed work for optimized noise reduction is done by designing a new method based on ABC algorithm.

ABC algorithm is a type of swarm intelligence based optimization algorithm which is inspired by the foraging behaviors of bees, and was proposed by Karaboga and Basturk in 2005 for numerical function optimization[9].

A. ABC algorithm

The colony of bees is composed of three types of bees: employed bees, onlooker bees and scouts. A bee searching for a food source is called an employed bee, and a bee waiting on the dance area to choose a food source it should go to is an onlooker bee. A scout is a bee that carries out a random search. Half of the colony involves the onlookers, and the other half consists of the employed bees[10].

The general process of bees foraging can be represented as below as an algorithm.

1. Estimate the nectar amount for each source by employer bees.
2. Memorizing the highest nectar amount by employer bees.
3. Sharing the nectar information by employed bees with the onlookers.
4. Evaluation by the onlookers of the nectar amount found out by employed bees.
3. Memorising the highest nectar amount as best solution by onlooker bees.
4. Food source is chosen or abandoned.
8. Replacement of the abandoned food sources by new food sources by the scout bees and repetition of steps until the stopping criteria is met or all search space is exhausted.

B. Proposed ABC based algorithm for noise reduction in images

This proposed work for optimized noise reduction is done by designing a new method based on ABC algorithm. The median filtered image and the noisy image are given as input to this algorithm. The filtered image is further optimized based on the fitness function PSNR(Peak signal to noise ratio) by the ABC algorithm.

The ABC algorithm to apply for optimized image filtering can be represented as below.

1. Initialize the search space and artificial bees.
2. Begin search by artificial employee bees based on fitness value randomly on pixels.
3. Estimate the fitness value for each pixel.
4. Record the best fitness value.
5. Share the fitness information with the artificial onlookers bees.
6. Evaluation of the fitness value found by all artificial employed bees by the artificial onlooker bees.
7. Record the best fitness value among all the above values as the best solution.
8. Replacement of the abandoned pixels by new pixels by the artificial scout bees and repetition of steps until the stopping criteria is met or all search space is exhausted.
9. The set of new pixels resulted at the end of the process is the optimized image.

C. Steps for the proposed denoising technique

A set of 100 images is subjected to Salt & pepper noise with noise density varying from 0. 01 to 0.9. Images are taken in various resolutions (such as 64x64, 128×128, 256×256) and in different formats (.jpg, .png, .bmp and .tif). These noisy images are passed through a median filter. The parameters PSNR, SNR, MSE and SSIM of the filtered images are computed. These images are passed through the proposed ABC Algorithm. This step efficiently reduces noises which are not yet filtered by the median filter. Then the PSNR, SNR, MSE and SSIM parameters of the optimized image is computed. The results are compared for reaching a conclusion on the performance of the ABC based method.

IV. RESULTS AND DISCUSSION

The proposed denoising optimization technique is implemented on MATLAB platform (matlab 2019a on machine with specifications : Processor : Intel(R) Core (TM) i3-6006U CPU @ 2.009GHZ, RAM 8GB, Windows10 - 64 bit OS). Results of performance evaluation of these denoising techniques have been shown quantitatively as well as qualitatively. The better efficiency, of the new method of ABC based algorithm, is clear from the tables and figures.

Table 1: Values of parameters PSNR and SNR of test images corrupted with Salt & Pepper noise at different noise densities (image name : coins.png (128 x 128)).

Noise density	Median filtered image - PSNR	ABC filtered image - PSNR	Median filtered image - SNR	ABC filtered image - SNR
0.01	24.4377	25.7763	17.7068	19.0454
0.02	21.7333	22.7898	15.0805	16.137
0.03	20.2262	21.2182	13.6292	14.6212
0.04	19.1131	19.9917	12.5901	13.4687
0.05	18.0968	19.0182	11.5742	12.4955
0.06	17.3749	18.2812	10.9587	11.8651
0.07	16.5503	17.4393	10.1682	11.0571
0.08	15.9911	16.8605	9.6783	10.5478
0.09	15.6403	16.4968	9.3697	10.2261
0.1	15.0492	15.8818	8.8627	9.6953
0.2	12.2999	13.1285	6.5579	7.3866
0.3	10.4787	11.3209	5.1376	5.9798
0.4	9.1857	10.0112	4.3399	5.1654
0.5	8.2427	9.0543	3.6685	4.48
0.6	7.3385	8.1337	3.1857	3.9809
0.7	6.6325	7.4143	2.7672	3.549
0.8	5.6763	6.4055	2.1041	2.8334
0.9	5.0051	5.6905	1.7184	2.4038

Table 2: Values of parameters MSE and SSIM of test images corrupted with Salt & Pepper noise at different noise densities (image name : coins.png (128 x 128)).

Noise density	Median filtered image - MSE	ABC filtered image - MSE	Median filtered image - SSIM	ABC filtered image - SSIM
0.01	0.0036	0.0026	0.7566	0.8303
0.02	0.0067	0.0053	0.6058	0.7042
0.03	0.0095	0.0076	0.5113	0.625
0.04	0.0123	0.01	0.4601	0.5759
0.05	0.0155	0.0125	0.3982	0.526
0.06	0.0183	0.0149	0.3508	0.4871
0.07	0.0221	0.018	0.3095	0.4514
0.08	0.0252	0.0206	0.2876	0.4307
0.09	0.0273	0.0224	0.2703	0.4157
0.1	0.0313	0.0258	0.2439	0.3913
0.2	0.0589	0.0487	0.1541	0.3152
0.3	0.0896	0.0738	0.1259	0.2889
0.4	0.1206	0.0997	0.1182	0.2778
0.5	0.1499	0.1243	0.128	0.2767
0.6	0.1846	0.1537	0.1702	0.3016
0.7	0.2171	0.1814	0.1966	0.3134
0.8	0.2706	0.2288	0.1927	0.2913
0.9	0.3159	0.2697	0.1953	0.2811

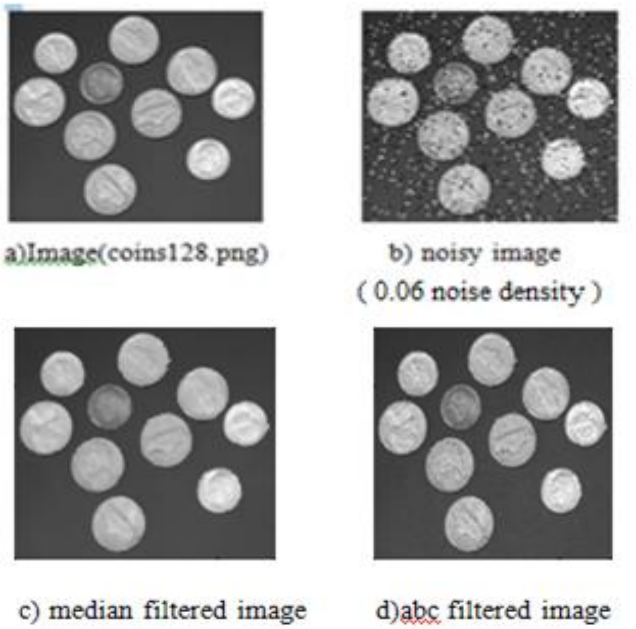

Fig 1: Visuals of original image, noisy image, median filtered image and ABC based filtered image.

From the results, it is observed that proposed denoising technique yields better performance at all noise densities in terms of all parameters (PSNR, SNR, MSE and SSIM) considered here. The high values of PSNR and SNR for all images of proposed ABC based denoising technique indicates that signal to noise ratio is raised as compared to the median filtering results. The lower value of MSE of proposed denoising technique compared to the results of median filtering also indicates the good performance of the proposed method. It is also observed that the SSIM values results obtained from ABC based method is higher than that of the values of applying median filtering alone.

The observations from the above tables and figures clearly indicate that the ABC based method of optimized denoising yields good results for noisy images.

V. CONCLUSION

In this research work, an efficient method is developed based on ABC for the optimized denoising of images. Performance of this technique is compared with the performance of the median filter and results are presented as images and tables for visual judgement as well as quantitative judgement. The parameters PSNR, SNR, MSE and SSIM are analysed for all images with respect to median filter and ABC based method. It is concluded from the results that the ABC based method performs better than the median filter and it is more accurate, and stable on high noisy levels too.

There is enough scope for improvement in the proposed denoising technique. This technique can be improved by combining with more optimization techniques such as ACO (ant colony optimization), and PSO(Particle Swarm Optimization) algorithms. Better objective functions can be designed to get better results and more parameters can be tested for better accuracy.

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