A Novel Approach to Image Edge Enhancement Using Artificial Bee Colony Optimization Algorithm for Hybridized Smoothening Filters

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***Abstract*-- In this Modern era, image transmission and processing plays a major role. It would not be possible to retrieve information from satellite and medical images without the help of Image processing techniques. Image edge Enhancement is the art of examining images for identifying objects and judging their significance. The proposed work uses the concept of Artificial Bee Colony Algorithm which proved to be the most powerful unbiased optimization technique for sampling a large solution space. Because of its unbiased stochastic sampling, it was quickly adapted in image processing and thus for image edge enhancement as well. This paper deals with the techniques that help in improvising the quality of the image edges and in solving various complex image processing tasks such as segmentation, feature extraction, classification and image generation. The edge enhancement is done using hybridized smoothening filters by The Artificial Bee Colony optimization algorithm and compared it with the genetic algorithm.**

Keywords: Image edge enhancement, hybridized smoothening filter, Genetic Algorithm (GA), Artificial Bee Colony (ABC) Algorithm, neighbourhood search

I. INTRODUCTION

In the modern information era, digital images have been widely used in an aggrandizing number of applications and the effort on edge enhancement has been focused mostly to improve visual perception of images that are unclear (blurred). Edges are the representations of the discontinuities of image intensity functions. For processing these discontinuities in an image a good edge enhancement technique is essential [1]. These edge enhancement techniques fall under two categories: smoothening filters and sharpening filters [2]. Smoothing filters are used for blurring and noise reduction [2]. Noise reduction can be accomplished by blurring with linear filters (mean, median and mode) and nonlinear filters (circular, pyramidal and cone) [3]. Sharpening filters (Laplacian, Sobel, Prewitt and Robert filters) are used to highlight fine details in an image or to enhance details that have been blurred but because of their results of complexity and image quality, smoothening filters are used which involves simple subtractive smoothened image concept which reduces complexity and makes the images look sharper than they really are.

In the paper [3], B.Tirimula Rao et al, 2009 developed a new approach to edge enhancement by using the smoothening filters which results in low complexity. This can also be done with the help of a new filter called the hybridized smoothening filter (a sequence of smoothening filter). The optimal magnitude (for different combinations of smoothening filters) of the hybrid filter is found by using The Artificial Bee Colony Algorithm [4] and is compared with that obtained by The GA [5]-[6]. The proposed work also compares the performance and robust stability of the proposed filters, to that of linear and nonlinear filters theoretically and experimentally. We are trying to explore the potential edge enhancement possible by virtue of various soft computing techniques in the process of exploration we have worked with GA and ABC.

Hybrid filters, its optimization using GA and ABC are explained in section II. In Section III, experiments done and the results obtained are discussed in brief and further in Section IV represents conclusion and the future work in this domain.

II. FRAMEWORK OF ARTIFICIAL BEE COLONY OPTIMISATION ALGORITHM TO HYBRID FILTERS

A. Hybrid filters:

Hybrid filter is defined as the series of existing filters (smoothening filters) to optimize the magnitude of the image [7]. It can efficiently remove large amounts of mixed Gaussian and impulsive noise besides preserving the image details. In this approach, hybrid filter is taken as combination of smoothening filters (for e.g. 1-2-3-4-5-6 i.e. suppose 1-mean, 2-median, 3-mode, 4-circular, 5-pyramidal, 6-cone.The output of mean filter is taken as input for median filter and the output of median filter is given as input to the next and so on). This hybrid filter yields optimal threshold values using clustering algorithm mentioned in (C.1.i.) [8, 9]

B. Genetic Algorithm:

The best optimal hybrid filter is chosen with the help of GA [5]. GA's, discovered by Charles Darwin are based on natural selection. They employ natural selection of fittest individuals as optimization problem solver. Optimization is

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performed through natural exchange of genetic material between parents. Off springs are formed from parent's genes. Fitness of off springs is evaluated. The fittest individuals only are allowed to breed. In computer world, selection is done by fitness function. Matching of parents is represented by cross-over and mutation operations [5, 6, 10, 11, 12, 13, 14, 15, 16, 17]. The GA has good global search ability but lacks local search ability [4]. This is enhanced in the ABC algorithm which is discussed elaborately in the following section.

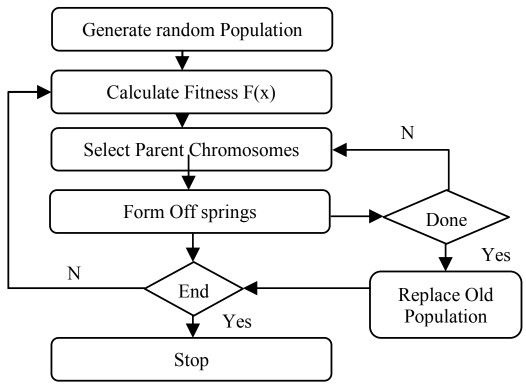

Fig 1: Process of Genetic Algorithm [2]

C. Artificial Bee Colony Algorithm [4]:

ABC is a new member of swarm intelligence (a branch of nature inspired algorithms focused on insect behavior) that tries to model natural behavior of real honey bees in food foraging. The foraging property of bees is used in problem modeling and solution, using several mechanisms of which waggle dance is a key to optimally locate food sources and to search for new ones. The dancing behavior of foraging bees while performing waggle dance is such that the direction of bees indicates the direction of the food source in relation to the sun, the intensity of the waggles indicates how far away it is and the duration of the dance indicates the amount of nectar on related food source.

The bee system consists of

1) Food sources
   The value of a food source depends on parameters like its proximity to the nest, richness of energy and ease of extracting this energy.
2) Foragers
   i. Unemployed foragers: There are two possibilities for an unemployed forager
      a) Scout Bee: if the bee starts searching spontaneously without any knowledge. Their percentage varies from 5% to 30% according to the information into the nest.
      b) Recruit Bee: if the bee starts searching by using the knowledge from waggle dance done by some other bee.
   ii. Employed foragers: when the recruit bee finds and exploits the food source it will raise to be an employed forager who memorizes the location of the food source, loads a portion of nectar and unloads the nectar to the food area in the hive (apiary).
      a) If the nectar amount is exhausted the bee abandons the food source and becomes an unemployed bee
      b) If there are still sufficient amount of nectar it continues to forage without sharing the food source information with the nest mates
      c) Or it can go to the dance area to perform waggle dance for informing the nest mates about the same food source
   iii. Experienced foragers: These types of foragers use their historical memories for the location and quality of food sources. They can be an inspector, a reactivated forager or a recruit bee.

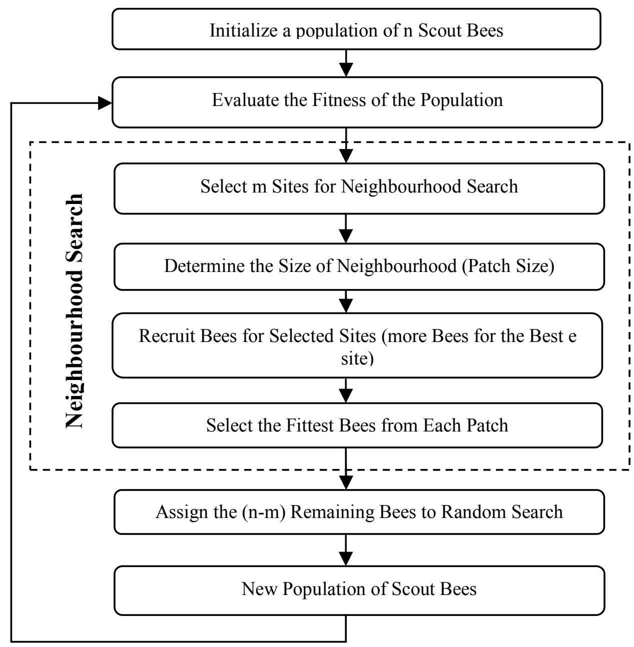

Fig 2: Artificial Bee Colony Algorithm

A simple ABC (Fig.2) consists of six steps:

Bee's algorithm starts with Scout bees being placed randomly on the search space. The main steps include

1. Initialize population with random solutions
2. Evaluate fitness of the population
3. Determine a certain number of fittest bees and select their sites for neighbourhood search
4. Recruit a certain number of bees for selected sites, evaluate their fitness

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5. Select the fittest bee from each site to form the new population
6. Assign remaining bees to search randomly and evaluate their fitness

D. FrameWork

1. Initialization of Random population:

Image is represented as a matrix of pixel values and the random population with the set of optimal magnitudes obtained for the hybrid filter combinations. First optimal magnitudes of the image are obtained by using Adaptive thresholding with Foreground and Background Clustering algorithm as described below [18].

i) Adaptive thresholding with foreground and background clustering algorithm:

In the foreground and background clustering (FBC) approach to document image binarization, each pixel is assigned to a foreground cluster or a background cluster. Pixel clustering is based on a variant of the K-means algorithm due to McQueen, where the cluster means are updated, and each time a data point is ascribed to a cluster. Since only one background and one foreground are assumed, K=2, i.e. only two clusters are considered, which makes the overall implementation easy.

a) Region selection

Divide the document into all inclusive mutually exclusive sub regions. Select the document sub region for which the threshold be computed, and a region containing the sub region that will be used to determine the threshold sub region. For example, the region may consist of *N* contiguous scan lines, where the sub region is the center *M* scan lines, with *M<N*.

b) Initialization

Initialize the background cluster mean and the foreground cluster mean to be the same as computed for the previous sub region. If there is not one, set the two initial cluster means with a large separation between them. For each pixel inside the region, iterate between steps 3 and 4.

c) Pixel Assignment

Assign each pixel to the nearest cluster.

d) Cluster Mean Update

After each new pixel assignment update the relevant cluster mean.

e) Threshold Calculation

After all pixels in the region have been assigned, set the threshold for the sub region equal to the average of the foreground and background cluster means. After obtaining the optimal magnitude of the image we take the random population with the magnitudes of different combinations which are closer to the obtained optimal magnitude.

2. Evaluation of fitness

An individual's fitness is measured by the sum of intensities of edges in an enhanced image, because a gray image with a visual good contrast includes many intensive edges [6]. The sum of intensities of edges *E(k)* included in the enhanced image is calculated by the following expression

$$E(k) = \sum_x \sum_y \sqrt{\delta h_k(x,y)^2 + \delta v_k(x,y)^2}$$

$$\delta h_k(x,y) = g_k(x+1,y-1) + g_k(x+1,y) + g_k(x+1,y+1) - g_k(x-1,y-1) - g_k(x-1,y) - g_k(x-1,y+1)$$

$$\delta v_k(x,y) = g_k(x-1,y+1) + g_k(x,y+1) + g_k(x+1,y+1) - g_k(x-1,y-1) - g_k(x,y-1) - g_k(x+1,y-1)$$

The fitness of the individual 'n' is obtained by the following expression

$$F(x_n) = rand(x_n)/E(k)$$

where rand (x_n) contains all hybrid filter combinations that gives optimal magnitudes.

3. *Neighbourhood bees*[4]

In this step the neighbourhood solutions for the given best solution are generated. This is done by using the bee crossover: population is sorted with respect to the fitness values and the fixed parent in the first generation is determined by the first chromosome in the list. In the second generation, the fixed parent is the second chromosome in the list and so on. These neighbourhoods are generated by first generating random population and selecting the required combination in the given range. The range is set in a way that it is 10% of the magnitude for which the neighbourhoods are being generated. The least of these neighbourhood fitness values is taken, compared and is updated with parent value.

4. Recruiting the bees to selected neighbours

Here the hybrid filter combination which gives the best fittest value is taken. The parent's fitness value is updated if its neighbour's fitness values are lower than that of the parent's and this hybrid filter combination is used for the further cycles.

5. Random search of remaining bees

Now the best of hybrid filter combinations (two in our case) for which the neighbourhood search is done is made up for the next cycle and rest of the combinations (five)are generated randomly for the next cycle. By doing so, the search space increases and gives a maximum probability of getting the global optimum solution.

6. Rule of selection, extinction and multiplication:

Rules of selection, extinction and multiplication of individuals in the ABC algorithm are described in this section. Search initially starts with the number of scout bees in the bee hive (seven). Only those individuals that have lower fitness are selected from the population and are survived to the next generation (best two fit values are taken as the parents). On the other hand, individuals that have

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higher fitness are extinguished in the hive and are made Scout bees or Onlooker bees as they do not have qualifications to survive to the next cycle. Neighbours are found by taking the random population (25) for each first two best solutions. The remaining combinations (5) are discarded and new bees are recruited in their place by random search. Thence, the number of individuals in the population is kept constant in all generations.

E. Completion of evolution:

The population is evolved by the ABC algorithm using evolutionary rules described above. Random bee's information is given to each individual in the first generation. The individual with the best fitness value is selected in the population in every cycle. As per our experimental results, the ABC algorithm converges to global optima in a maximum of five cycles.

III. EXPERIMENTS & RESULTS

Table 1 avers how the hybrid filter obtained by ABC algorithm excellently enhances the image's edges as compared to other filters. Fig.3 explains that the hybrid filters generated by The ABC Algorithm efficiently enhances the image's edges better than the traditional Sobel filter, which overcomes the limitation of the paper [3].

A. Values obtained through different filters:

TABLE 1: OBSERVATIONS OF DIFFERENT IMAGES USING DIFFERENT FILTERS

Optimal Threshold Magnitude Using	**Images**				
	Camera Man	***Skull***	***Tower***	***Original Image***	***Noisy Image***
Adaptive Clustering	2462	21676	133200	30271	23727
Mean Filter	1425	17126	133833	29620	26658
Median Filter	2553	15522	148998	19065	22267
Mode Filter	2386	13668	143792	17541	26229
Circular Filter	2071	28768	144141	37998	24523
Pyramidal Filter	2283	28273	124668	27951	21803
Cone Filter	2438	19272	146705	23464	25693
Hybrid Filter using GA	2468	22200	133265	30280	23747
Hybrid Filter by ABC	2464	21682	133208	30273	23732

Table 1 gives the spectacular view of all the filters applied on different images. The values in the table are the optimal threshold magnitudes obtained using different filters. The first annotated column shows the original magnitude of every image. This is compared after enhancing the image with particular filter. With these values it can be intervened that the differences between the original optimal magnitude and obtained magnitude using hybrid filter is very less whereas that obtained using smoothening filters is high.

This negotiates that hybrid filters generated by ABC algorithm enhances the image edges very efficiently when compared to smoothening filters and thus gives a clear distinction on how the optimal magnitudes for the optimal hybrid filters are nearer for The ABC algorithm and The GA, yet the values obtained by the GA are not so efficient as those obtained by the ABC Algorithm

B. Hybrid filter by ABC enhances the original image very efficiently when compared to smoothening filters and that obtained by the GA:

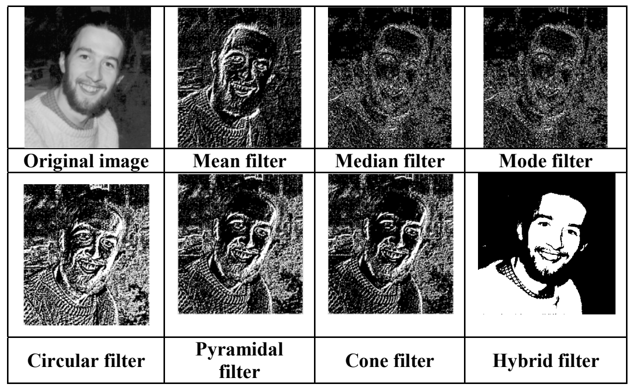

Fig 3: Results of Original Image Using Different Filters

Images in Fig.3 depict the results of every filter after edge enhancement. Visualizing these images one can definitely affirm that hybrid filters allays the trade-offs of smoothening filters and mitigates noise effectually. Apropos (Table 1) the optimal magnitudes of the images are close enough the recurring images appears identical, although their optimal combination of hybrid filters differ.

For the above image the optimal hybrid filter combinations are as follows:

Genetic Algorithm: 1 4 1 6 2 5

Artificial Bee Colony Algorithm: 4 5 5 3 3 6

From this comparision ABC Algorithm stands aloft.

C. Time Complexity

Time complexity is taken into consideration under two categories Processing time and Computation time. Generally while using an Artificial Bee Colony algorithm the repeatability of the process is excessively time consuming. But to obtain the best hybrid filter combination ABC takes less time (i.e. say 5 iterations that we confine to) when compared to other ABC methods and more when compared to the GA. Although the outcome of ABC seems to be appeasing yet it differs in its computational time. ABC algorithm has a computational time of O (n^2) albeit O (n) for GA.

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D. Hybrid filters by ABC proven to overcome the limitation of sobel filter and spurious edges:

Original image	Sobel filter optimized image	Hybrid filter optimized image by ABC

Fig 4: Results of Skull Image Using Sobel and Hybrid Filters (by ABC).

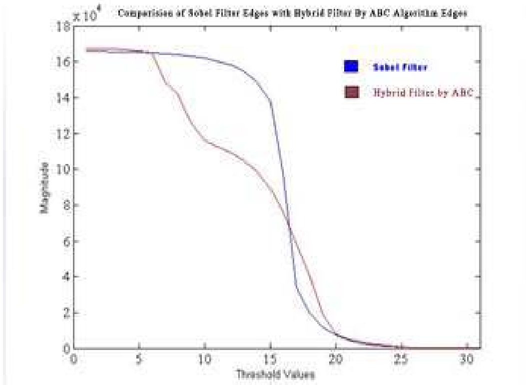


Fig 5: Comparison of Sobel and Hybrid Filter (by ABC)

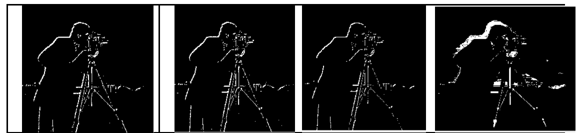
Apropos paper [3], the limitation that only Sobel filter is canny to enhance the image's edges efficiently is proved to be a carp by hybrid filters as a stimulus. Sobel filter cedes real edges and also spurious edges which are absent in the image. Fig.4 ascertains that by using Sobel filter, spurious edges are obtained which are not present in the image whereas hybrid filter by ABC Algorithm clearly enhances the image with only real edges. The above graph shows the comparison between Sobel filter and hybrid filter by ABC Algorithm. Fig.5 shows the graphical representation for the Sobel and hybrid filter

E. Results of different images using different filters:

In the below observations the images cameraman, skull, tower [5], original image and noisy image (Bin Wang *et al.*, 1993, original image corrupted by Gaussian noise with a mean of zero and a standard deviation (σ) of 8) are taken as references for our work.

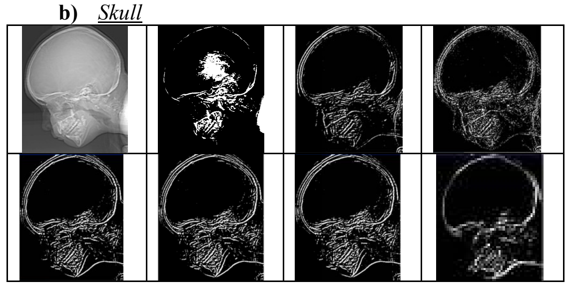
a) Cameraman:

Image	Mean filter	Median filter	Mode filter

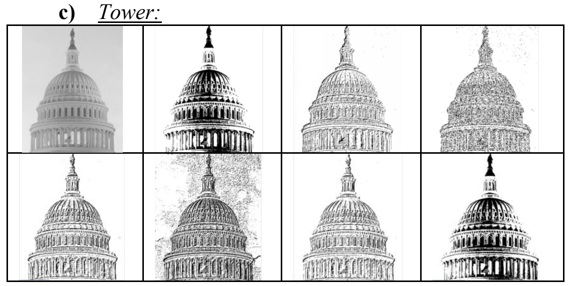


Circular filter	Pyramidal filter	Cone filter	Hybrid filter by ABC

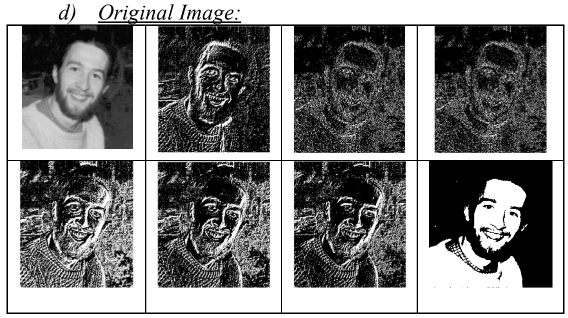
b) *Skull*



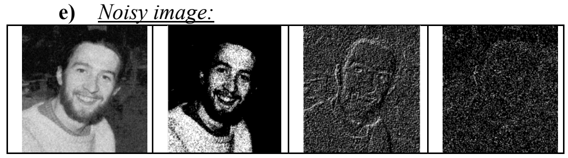
c) *Tower:*



d) Original Image:



e) *Noisy image:*



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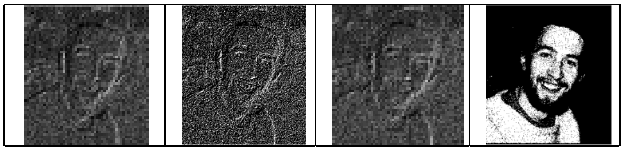

IV. CONCLUSION & FUTURE WORK

On appraising the above novel techniques ABC Algorithm provides better image quality compared to smoothening filters and baroque results in displaying the output image. This new method of hybrid filters is compared against all the smoothening filters conferred and also with the outputs of the GA. ABC algorithm analyzed and implemented to hybrid filters, outperformed GA in terms of speed in optimization and accuracy of results. The ABC algorithm gives pacifying optimal magnitudes for the images and is more efficient algorithm than the GA. In ABC the probability of falling into the local optimum is low because of the combination of local and global search since the aim of the algorithm is to improve the local search ability of the GA without degrading the global search ability. Thus, ABC stands as a cynosure in the field of edge enhancement by using hybrid filters. If processing time is not an issue only efficiency is prime criteria then we can apply any complex soft computing technique

Motivation is therefore exploring the scope of application of soft computing in the field of edge enhancement. We have done our research in the direction of edge enhancement by hybrid filters as it has not been explored till date. Although numerous edge enhancement approaches have been proposed in different real-world applications, in order to examine the performance on edge enhancement against noise and several other factors of an image we extend connotations to our work with Artificial Immune System (AIS), Ant Colony Optimization technique (ACO), Neuro Fuzzy, Neuro Genetic, Simulated Annealing, Partical Swarm Optimization and fuzzy logic

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REFERENCES

[1] B. Bhanu, Sungkee Lee, J. Ming. “Adaptive image segmentation using Genetic algorithm”. IEEE transac-tions on systems, man and cybernetics, 1995, Vol.25, No.12, 1543 – 1567.

[2] Gonzalez and Woods (2001), Digital Image Processing, Vol. 2nd Edition,567-633, Prentice Hall

[3] B. Tirimula Rao, K. Venkat Rao, G. Kiran Swathi, G. Pruthvi Shanthi, and J. Sree Durga. "A Novel Approach to Image Edge Enhancement Using Smoothing Filters." The Icfai University Journal of Computer Sciences (April 2009), Vol.3, No.2, 37-53.

[4] Adil Baykaoglu, Lale Ozbakir, Pinar Tpakan. “Artificial Bee Colony Algorithm and its Application to Generalized Assignment Problem” Swarm Intelligence: Focus on Ant and Particle Swarm Optimization, Book edited by:Felix T.S. Chan and Manoj Kumar Tiwari, ISBN 978-3-902613-09-7, pp.532, December 2007

[5] Mantas Paulinas and Andruis usinskas “A Survey of Genetic Algorithms Applications For Image Enhancement and Segmentation”, ISSN 1392 –124X INFORMATION TECHNOLOGY AND CONTROL, 2007, Vol.36, No.3, 278-285.

[6] F.Saitoh. “Image contrast enhancement using GEnetic ALGORITHM”. IEEE international conference on systems, man, and cybernetics, IEEE SMC’99, 1999, Vol.4, 899 – 904.

[7] Yaow-Ming Chen. "Passive Filter Design Using Genetic Algorithms."IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS (Feb 2003), Vol.50, Issue 1,202-07

[8] Yusuke Ojima, Satoshi Kirigaya, and Toru Wakahara. "Determining Optimal Filters for Binarization of Degraded Grayscale Characters Using Genetic Algorithms." IEEE Document Analysis and Recognition, 2005. Proceedings. Eighth International Conference (Sept. 2005),Vol.2,ISBN: 0-7695-2420-6, 555-59.

[9] N.R. Harvey, S. Marshall. “The design of different classes of morphological filter using Genetic algorithms.” IEEE fifth international conference on image processing and its applications, 1995, ISBN: 0-85296-642-3, 227 – 231.

[10] Abutaleb, and A.S.Kamel "A Genetic algorithm for the estimation of ridges in fingerprints." IEEE Transactions on Image Processing (Aug 1999), Vol.8, Issue 8, 1134-139

[11] Ki-Seung Lee, Eun Suk Kim, Won Doh, and Dae Hee Youn. "Image enhancement based on signal subspace approach." IEEE Transactions on Image Processing, (Aug 1999),Vol.8,Issue 8,1129-134.

[12] Nurhan Karaboga, and Bahadir Cetinkaya. "Design of minimum phase digital IIR filters by using Genetic algorithm." IEEE Transactions on Signal Processing Symposium, 2004. NORSIG 2004. Proceedings of the 6th Nordic (2004), ISBN: 951-22-7065-X, 29-32

[13] Surapong Auwatanamongkol. "Inexact graph matching using a Genetic algorithm for image recognition." ELSEVIER Publications on pattern recognition letters, Vol.28 1428-437.

[14] Takezawa, M.Honda, H.Miura, J.Haseyama, and H. Kitajima. "A Genetic-algorithm based quantization method for fractal image coding." IEEE Transactions on Image Processing, 1999. ICIP 99. Proceedings. 1999 International Conference (1999),Vol.1, 458-61.

[15] M. K. Lee, S, W. Leung, T. L. Pun, and H. L. Cheung. "EDGE DETECTION BY GENETIC ALGORITHM." IEEE Transactions on Image Processing, 2000. Proceedings. 2000 International Conference (2000), Vol.1, 478-80.

[16] Nan-Ning Zheng, Shen Li, Wei-Pu Xu, and Hui Wang. "A novel fast motion estimation method based on Genetic algorithm." IEEE Image Processing,999. ICIP 99. Proceedings. 1999 International Conference (1999),Vol.1,66-69

[17] Yaow-Ming Chen. "Passive Filter Design Using Genetic Algorithms."IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS (Feb 2003), Vol.50, Issue 1,202-07

[18] Andreas E. Savakis. “ADAPTIVE DOCUMENT IMAGE THRESHOLDING USING FOREGROUND AND BACKGROUND CLUSTERING”.IEEE Proceedings of International Conference On Image Processing ICIP’98, 1998, ISBN: 0-8186-8821-1, Vol 3,785-789

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