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Comparative Analysis of Optimal Design of FIR Filters Using GA and BAT Algorithm

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Abstract

This work demonstrates a valuable technique to design linear phase Finite Impulse Response filter by employing genetic algorithm and BAT algorithm. Classical gradient based method is not efficient approach in accurate design of filters. Evolutionary approach is a better choice. In this paper MATLAB tool has been used to compare and analyze the FIR filter by using GA and BAT algorithm. Results using BAT algorithm have been found better than genetic algorithm.

Image enhancement is the process of manipulation or adjustment of the image with software to improve the quality of the image to make it more suitable for the further analysis. Noises can be removed by using different types of filters. Optimization effectiveness of BAT algorithm over Genetic algorithm has been depicted by the comparison of simulation results from these two techniques. Non-differential, non-linear and constrained FIR filter design problems can be solved by using FIR filters.

Keywords: Filters, GA, BAT algorithm, generations, FIR filter

I INTRODUCTION

Digital Signal Processing manages the improvisation of reliableness of digital communication systems by using multiple techniques and also manages their accuracy. Applications of DSP are telecommunication, biomedical systems, audio and image processing, consumer electronics systems, military and defence systems, automotive and aerospace systems. Digital filters are used very effectively in applications with low frequency.

Now research is going on to find some metaheuristic search algorithms. These are the powerful tools to solve optimization problems in machines. Regarding machining parameters optimization a review paper has been presented in which meta-heuristic-based search algorithms like GA, simulated annealing and PSO have been discussed. For solving machining optimization problems, other meta-heuristic algorithms[2] like ant colony optimization and improved harmony search algorithm are in trend. The Bat algorithm is a more powerful meta-heuristic algorithm than genetic algorithm and PSO. Xin-She Yang developed this algorithm in 2018[3]. It is based on the echolocation nature of micro bats and swarm intelligence. BAT algorithm is relatively new optimization algorithm [1]. Bats use their capability to measure the distance and to differentiate between prey and background.i.e they can detect different types of insects even in darkness. Multi dimensional multi-modal optimization problems can be solved by employing these metaheuristic algorithms. These algorithms overcome the some drawbacks of gradient based optimization methods. Bats emit ultrasonic waves of different frequency and measure the time spent to transmit and receive back the echo. The pulses emitted by micro bats are of 8 ms range and have a fixed frequency of 25 kHz to 100 kHz.

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Some species may emit the frequency signal of the range of 140-150 kHz. per second. [4]. This rate gets increased if they are near to their prey. The emitted pulse could be of the range of 110dB which come in ultrasonic range. This can even be louder when search for their prey to quietest when they are near to their prey. They can manage the obstacle even of human hair size.

II. Literature Survey

Yutan Wang, et. al.,(2018). [5] proposed combination of noise reduction based on optimal channel-processing with peak signal to noise ratio of 54.6629. Optimization problem which were formulated for image enhancement can be solved by using weighted Bat algorithm [6] and adaptive cuckoo search algorithm [7] with PSNR of 25.533 and of 24.6514 respectively. Same satellite image data set was used to test all these algorithms for denoising images which were corrupted by three different Gaussian noises of variance level of 10, 20 and 30 percent. In this work filter coefficients had also been optimized. Sharma et al., proposed FIR filter design using swarm optimization techniques [8]. A linear phase FIR filter was designed by using PSO, Cuckoo search, and artificial bee colony. All these techniques are nature inspired. The amount of ripple in the desired band of frequency is controlled by the objective function. For a filter having order 21, the pass band ripples and reject band ripples are 0.0156 and reject band attenuation is 28.8603. Results with cuckoo search optimization are better than other two edge detector based on the fractional order differentiation operation. They have detected the edges efficiently[9]. Omkar Singh and Ramesh Kumar Sunkaria presented the filtering method to remove the artefacts like Baseline Wander and power-line interference from ECG by using low pass and high pass filter with Wavelet transform. For BW removal, the empirical wavelet filter gad been used but it provides a high output. Both high pass and low pass filter have been used in this study. The correlation factors are 0.9963 and 0.9948 for input SNR of 10 and 5dB respectively. EW filter removes both BW and PI and gives better performance than other filters[10]. Senapati et.al. (July, 2017) presented the use of filters to reduce the total harmonic distortion in the load line during distribution of power. Filters have been used using Bee Colony Optimization and fuzzy logic. The control strategy used in this work leads to draw constant current during steady state condition by the load [11]. The current source has very low total harmonic distortion of range 1.40 percent depicting effectiveness of this study. Suryanarayana Gunnam et. al. presented use of dual tree complex wavelet transform to design digital filter for image resolution in their work.[12]. A high resolution (HR) image has been preserved by preserving the image contrast and edges. PSNR in the range of 20.98 to 26.23 has been achieved for different types of images. Aziz et.al. presented multi-objective whale optimization algorithm in their work. It is for content-based image retrieval (CBIR) [13]. CBIR is used to extract visual features like color, texture and shape of the image. A vector is formulated to represent all its extracted features. Effectiveness of this proposed optimization technique has been represented in terms of Precision, Recall and Time having respective values as 0.8315, 0.8936 and 2413.870. Chongyi Li et. al., presented enhancement method for enhancing underwater images by designing dehazing algorithm and a contrast enhancement algorithm to restore the visibility, colour, and natural appearance[14].

III. METHODOLOGY

A. FIR Filters

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FIR filters are the best choice for linear phase applications. A non recursive way is used to implement FIR filter which provides the stability to the filter [15]. This filter consists of Zeros only. All the zeros in z-plane determine the Magnitude and its frequency response.

FIR filter has transfer function as follows:

$$H(z) = \sum_{n=0}^{N} H(n)\, Z^{-n}$$

Where n = 0 ,1, . . . N (i)

Where number of coefficients are N+1 and order of filter is N.

Design of FIR filter has two stages one is approximation stage and second one realization stage. Specifications of the FIR filter are taken in first stage i.e. approximation stage and accordingly a transfer function is formulated. Further best transfer function is formulated by using the methods mention below:

a. A desired response is selected
b. Desired class of filter is decided
c. Quality of approximation is selected
d. To find best transfer function an algorithm is selected

In realization stage the transfer function is implemented be selecting the structure. This structure may be a program or a circuit diagram.

MATLAB tool has been used to design FIR filter, which consists of of parts mentioned below:

i. Selection of Filter specification
ii. Selection of GA parameters and BAT optimization parameters
iii. Graphical visualization of the results.

Results of FIR filter design using GA and nature inspired BAT algorithm has been analysed.

Fitness function of the filter is represented as

$$E(\omega) = g(\omega)\,[H_d(\omega) - H_i(\omega)] \qquad \text{(ii)}$$

Where $g(\omega)$, $H_d(\omega)$ and $H_i(\omega)$ are the weighting factor, desired response of the filter and actual response of the FIR filter respectively.

$$H_d(\omega) = \begin{cases} = 1 & \text{for } 0 \le \omega \le \omega_c \\ = 0 & \text{otherwise} \end{cases} \qquad \text{(iii)}$$

GA and nature inspired BAT algorithm has been used to optimise the fitness function.

B. Genetic Algorithm

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Genetic algorithms were invented in the 1960s by John Holland and were developed in 1960s at the University of Michigan and the 1970s by Holland and colleagues. The traditional theory of GA works on the basic principle that 'Fittest will survive'. Good solutions are the combinations of values in the string which have higher fitness value. GA is based on the concepts and principles of natural selection and evolution. The powerful heuristic of the genetic algorithm is effective in solving complex, combinatorial and related problems. GA optimizers are especially viable when the objective is to locate an approximate global minimum in a high-dimension, multi-model function domain, in a near-optimal manner [4].

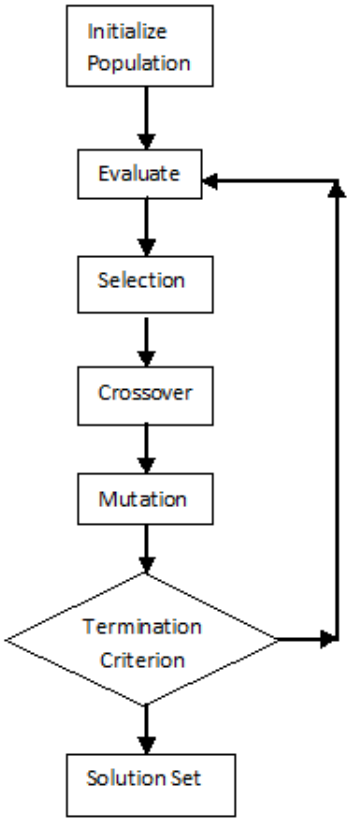

Fig 1: Flow Chart of Genetic Algorithm

C. BAT algorithm

This algorithm is nature inspired metaheuristic and relatively new optimization algorithm. This is based on the echolocation property of micro bats. The algorithm was successfully applied by Islam et.al. [16]. This is developed by Xin-She Yang in 2010 [15].

In this algorithm we have to consider virtual bats. Let v_i be the velocity and x_i be the position of bats. Their velocities and positions are updated in d-dimensional search as per the following equations:

$$f_i = f_{min} + (f_{max} - f_{min})\beta$$

$$v_i^t = v_i^t - 1 + (x^t - x^*)f_i$$

$$x_i^t = x_i^t - 1 + v_i^t \qquad \text{(iv)}$$

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Where β ranges from 0 to 1

x* is the current global position

As $f_i\lambda_i$ is the velocity increment so we can change either frequency of wavelength. Order of filter has been taken as 50.

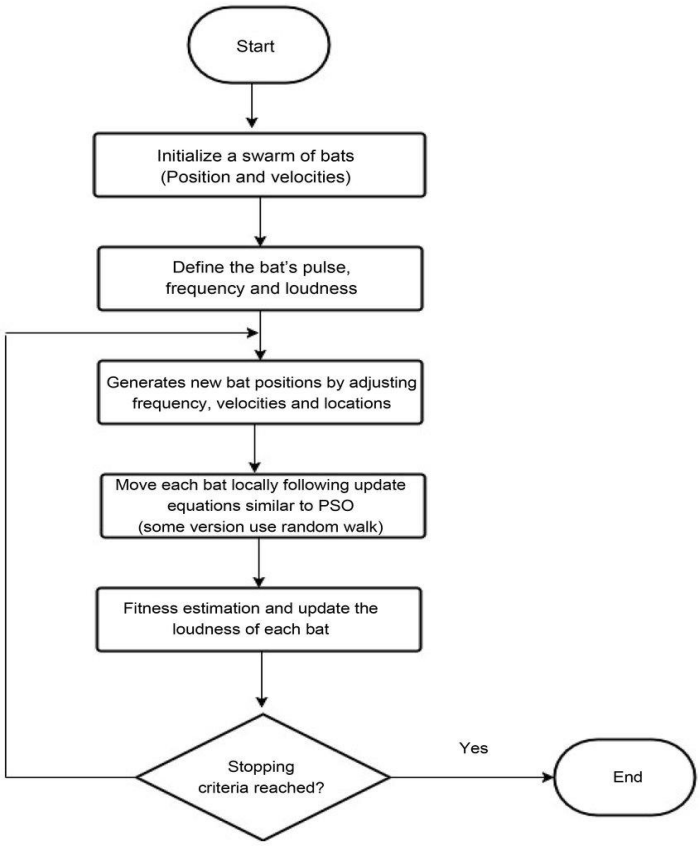

Fig 2: Flow Chart of BAT algorithm

Table 1: Parameter values taken for comparison of GA and BAT algorithm

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Parameters	Genetic algorithm	BAT Algorithm
Population size	120	120
Crossover	0.7	------
Mutation	0.5	0.5
Order of filter	50	50
Generations	10000	10000
β	---	0-1
f_{min}-f_{max}	---	0-4kHz
Number of samples	512	512

Table 2: COMPARATIVE RESULTS OF PERFORMANCE PARAMETERS OF GA AND BAT ALGORITHM FOR THE FIR BPF of order 50

Optimization technique	GA	BAT algorithm
Stop Band ripples	0.0893 0.0925	0.0766 0.0860
Pass band Ripples	0.1110	0.1096
Transition band	0.0533 0.0551	0.0527 0.0547

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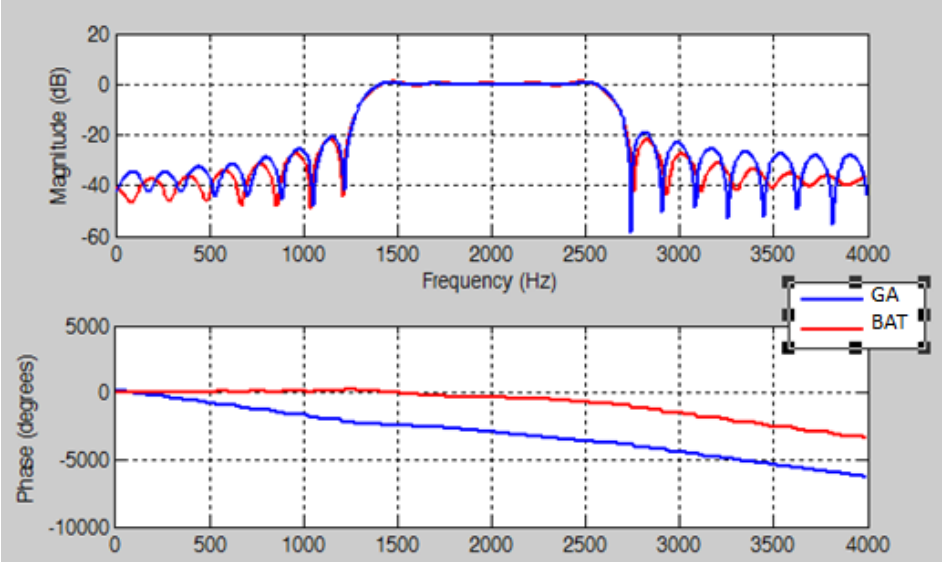

Figure 3: Gain plot and phase response of BP FIR filter

In this paper, GA technique has been proposed for the design of FIR digital filters. Compared to BAT algorithm method, it has been found that BAT algorithm is able to converge to the global optima and the fitness is greatly improved. In terms of pass band ripples, stop band ripples and transition band, the results of low- pass filters demonstrate that BAT algorithm is an efficient and alternative approach for FIR digital filters.

IV. Conclusion and Future scope

The work presented in this paper is to compare and analyse the response of FIR filter using genetic algorithm and BAT algorithm. Coefficients have been optimized using these techniques and found better response using BA for higher order filters. Better responses are found using BAT algorithm for higher order filters. Although these optimization techniques are giving better results but still the performance of FIR filters can be improved. Systems designed using higher population size take more training time. Although these optimization techniques are giving better results but there is still some room to improve the performance of FIR filters using other optimization techniques like hybrid of BAT algorithm and ANT-LION optimization [17]. This can be carried out for the similar purpose to reduce complexity of the computational methods.

REFERENCES

[1] X. S. Yang and X. He, “Bat algorithm: literature review and applications,” International Journal of Bio-Inspired Computation, Vol. 5, no. 3, p. 141, 2013.

[2] MAD\guyb_deleted_05052015, “Optimization of Image Processing Algorithms: A Case Study,” 23:41:34 UTC, https://software.intel.com/en-us/articles/optimization-of-image-processing-algorithms-a-case-study, 09-Nov-2018.

[3] “Bat algorithm,” Wikipedia, 09-Oct-2018.

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[4] A. Logoglu, T. Koza, S. Kockanat, and N. Karaboga, "Examination Of Success Of The Finite Impulse Response Digital Filter Designed Using The Bat Algorithm," Signal Processing and Communications Applications Conference, pp. 1–4, 2018.
[5] Wang et al. "Study on The Method of Colour Image Noise Reduction", 2018.
[6] K. G. Dhal and S. Das, "A Dynamically Adapted and Weighted Bat Algorithm in Image Enhancement Domain," Evolving Systems, Jan. 2018.
[7] S. Suresh, S. Lal, C. Chen, and T. Celik, "Multispectral Satellite Image Denoising via Adaptive Cuckoo Search-Based Wiener Filter," IEEE Trans. on Geosci. Remote Sens., Vol. 56, no. 8, pp. 4334–4345, Aug. 2018.
[8] I. Sharma, B. Kuldeep, A. Kumar, and V. K. Singh, "Performance of Swarm Based Optimization Techniques for Designing Digital FIR Filter: A Comparative Study," Engineering Science and Technology, an International Journal, Vol. 19, no. 3, pp. 1564–1572, Sep. 2016.
[9] S. Kumar, R. Saxena, and K. Singh, "Fractional Fourier Transform and Fractional-Order Calculus-Based Image Edge Detection," Circuits, Systems, and Signal Processing, Vol. 36, no. 4, pp. 1493–1513, Apr. 2017.
[10] Singh-Sunkaria, "ECG Signal Denoising via Empirical".
[11] R. Senapati, R. N. Senapati, and M. K. Maharana, "Study and Analysis of Performance of 3-Phase Shunt Active Filter in Grid-tied PV-Fuel Cell System Employing Sinusoidal Current Control Strategy," p. 15, 2018.
[12] G. Suryanarayana and R. Dhuli, "Shock Filter Based Image Super-Resolution using Dual-Tree Complex Wavelet Transform and Singular Value Decomposition," COMPEL - The International Journal For Computation And Mathematics In Electrical And Electronic Engineering, Vol. 35, no. 3, pp. 1162–1178, May 2016.
[13] M. A. E. Aziz, A. A. Ewees, and A. E. Hassanien, "Multi-Objective Whale Optimization Algorithm for Content-Based Image Retrieval," Multimedia Tools and Applications, Vol. 77, no. 19, pp. 26135–26172, Oct. 2018.
[14] C.-Y. Li, J.-C. Guo, R.-M. Cong, Y.-W. Pang, and B. Wang, "Underwater Image Enhancement by Dehazing With Minimum Information Loss and Histogram Distribution Prior," IEEE Trans. Image Process., Vol. 25, no. 12, pp. 5664–5677, Dec. 2016.
[15] H. Zhu, X. Yin, and X. Wang, "Improved Image Defogging Method and Its Application in Video Monitoring System Based on ARM," Sensor Review, Vol. 34, no. 3, pp. 266–272, Jun. 2014.
[16] T. Islam, M. E. Islam, and M. R. Ruhin, "An Analysis of Foraging and Echolocation Behavior of Swarm Intelligence Algorithms in Optimization: ACO, BCO and BA," International Journal of Intelligence Science, Vol. 08, no. 01, pp. 1–27, 2018.
[17] T. Tian, C. Liu, Q. Guo, Y. Yuan, W. Li, and Q. Yan, "An Improved Ant Lion Optimization Algorithm and Its Application in Hydraulic Turbine Governing System Parameter Identification," Energies, Vol. 11, no. 1, p. 95, Jan. 2018.

