Optimisation of FIR filter coefficients using PSO and BAT algorithm

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Abstract

Natural image distortions effect human visual experience. In this paper an effective methodology has been used to design FIR filter using particle swarm optimization and BAT optimization. A viable methodology has been proposed in this paper for optimizing FIR filter coefficients using PSO and BAT algorithm. Image enhancement is the process of manipulation or adjustment of image with software for improving image quality 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 PSO algorithm has been depicted by the comparison of simulation results from these two techniques.

Keywords: FIR, PSO, BAT algorithm, generations, FIR filter

I. INTRODUCTION

Many optimization techniques have been used by researchers in their work. Some have used BAT optimization and few have used wavelet transform but in other fields. It decomposes the signal into low and high frequency components using the thresholding process for redundant in an efficient way. 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[1]. Filtering can be used in image enhancement. We can brighten or sharpen the image by removing noises from the image. Optimization can be applied in image enhancement. Calculus or gradient based optimization techniques require function to be continuous, unimodel and smooth with some constraints but actually functions can be discontinued or noisy having multiple optimums for which sometimes derivatives may not exist [2]. Now research is going on to find some metaheuristic search algorithms. These are the robust tools to deal with solving machining optimization problems.

However, in recent years there is an increasing trend in the application of other meta- heuristic algorithms [3] such as ant colony optimization, artificial bee colony, improved harmony search algorithm, and cuckoo search algorithm for solving machining optimization problems. The Bat algorithm is a metaheuristic algorithm for global optimization. It is inspired by the echolocation behaviour of microbats. It was developed by Xin-She Yang in 2018 [4] . It is based on [5] swarm intelligence and inspired from the echolocation behaviour of bats.

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.

DSP plays a vital role in human life. Digital filters can be used to in biomedical and seismic applications very efficiently because of low frequency signals. FIR filter design involves multi parameter and multi-modular optimization.

II. LITERATURE SURVEY

A comprehensive review paper in which optimisation of parameters has been presented by means of the meta-heuristic algorithms[6]. A hybrid FCM-ALO based Technique is being used for Image Segmentation [7]. In this a new image segmentation approach based on Fuzzy logic Ant Lion Optimization has been applied. Fuzzy logic can present information in a more robust way. Nature inspired algorithms like ALO has the ability to find optimal parameters for optimization. A strategy has been proposed [8] for improving the image

defogging algorithm. Two image restoration algorithms have been used. They used divided strategy to enhance the image. Image has been divided into two parts. To calculate the intensity of each pixel. Window function of filters is used to calculate the intensity. Improved defogging algorithm further implemented Linux based ARM machine to reduce the image data transmission time. There is a scope to get better results using BAT algorithm. A method for enhancing underwater images by designing dehazing algorithm and a contrast enhancement algorithm [9] to restore the visibility, colour, and natural appearance has been presented. This contrast enhancement algorithm is based on a histogram distribution prior. The proposed method presented two versions of enhanced output. One is suitable for display is of genuine colour and natural appearance and second with high contrast and brightness has been used for extracting more valuable information [10]. In this work, distance between the camera and object was considered, result could be better if distance between object and water surface is considered [11]. The proposed method had not removed the noise from the image. 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.

III. FIR Filters

FIR filters are opted for their characteristics like assured stability, linear phase and low coefficient sensitivity, but large numbers of arithmetic operations are required for implementation. Finite impulse response filters assure a stable filter [12]. Finite impulse response filters consist of zeroes and not poles. These filters have a transfer function in polynomial form in 'z' plane.

Z transform of Finite impulse response filter is:

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

For n=0,1,……N (i)

When order of filter is N and number of coefficients are N+1

Finite impulse response filter design 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.

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 PSO parameters and BAT optimization parameters
iii. Graphical visualization of the results.

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

Fitness function of the filter is represented as

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

Where g(ω), Hd(ω) and Hi(ω) are the weighting factor, desired response of the filter and actual response of the FIR filter respectively.

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

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

Particle Swarm Optimization

PSO was invented by Kennedy & Eberhart in 1995.

Classical optimization methods require optimization problem to be differentiable but there is no such requirement in PSO. Therefore PSO can also be used on to optimise the noisy, irregular and continuous signals. It is initiated with a group of random particles and optimum value is searched by updating the generations. In every iteration, each particle is updated by the two "best" values, ‘pbest’ and ‘gbest’. ‘pbset, is local best solution and ‘gbest’ is the global best solution.

The particles update their velocity and positions as follows:

V[ ]=V[] + C1 Xrand[ ] X{ pbest [ ] – present [ ] + c2 X rand [ ] X { gbest [ ] – present [ ]} (ii)

Present [ ] = present [ ] + V [ ] (iii)

V [ ] is the particle velocity

present [ ] is the current particle

Rand [ ] is a random number between zero and one.

Generally, c1 = c2 = 2. c1, c2 are learning factors.

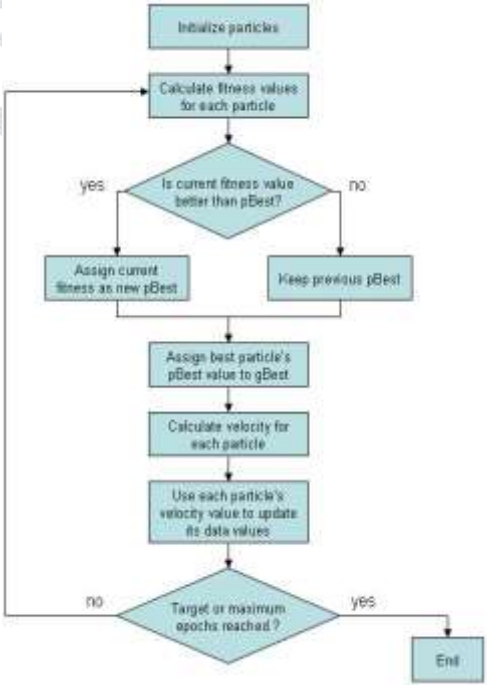

Fig 1: Flow Chart of PSO

IV. BAT algorithm

This algorithm nature inspired metaheuristic and relatively new optimization algorithm. Bats use their capability of distance measure and to distinguish 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 using these nature inspired metaheuristic algorithms. These algorithms overcome some drawbacks of gradient based optimization methods. Bats emit ultrasonic waves of different frequency and measure the time spent

The pulses emitted by micro bats are of about 8ms to 10ms but has a fixed frequency in the range of 25kHz-100kHz. Some species may emit the frequency signal of the order of 150kHz and echolocation burst is of 5 - 20 ms. Microbats may emit 10 - 20 such burst in a second. This rate gets increased if they are near to their prey. The emitted pulse could be of the range of 110 dB 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. We have to consider virtual bats. Let vi be the [13] velocity and xi be the position of bats. Velocities and positions are updated as per the equations stated below.

$fi = fmin + (fmax - fmin)\beta$

$vi^t = vi^{t-1} + (x^t - x^*)fi$

$xi^t = xi^{t-1} + vi^t$

xi^t is the new solution and vi^t is the velocity of particles. Range of β is 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.

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

Parameters	**PSO**	**BAT**
Population size	100	100
Order of filter	40	40
Generations	6000	6000
C1 and C2	1.5 and 2.55	--
Vmin-Vmax	0.2-0.9	
Number of samples	512	512
β		0-1
fmin-fmax		0-2kHz

Table 2: COMPARATIVE RESULTS OF PERFORMANCE PARAMETERS OF PSO AND BAT ALGORITHM FOR THE FIR LPF

Stop Band ripples		Pass band Ripples		Transition band	
PSO	BAT	PSO	BAT	PSO	BAT
0.0751	0.0859	0.0781	0.0740	0.0684	0.0671

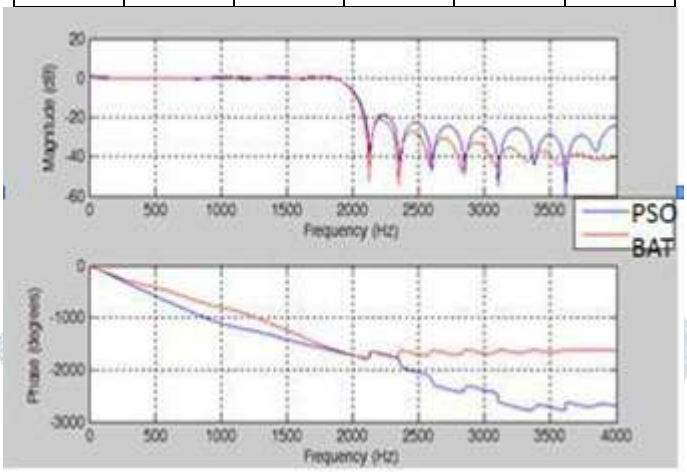

Figure 2: Gain and phase response of LP Finite Impulse Response Filter

V. CONCLUSION AND FUTURE SCOPE

This work presented computation and analyse the response of FIR filter using PSO and BAT algorithm. Coefficients have been optimized using these techniques and found better response using BAT algorithm 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. The differential evolution or such fast bio-inspired techniques can be applied to reduce the training time. Using other optimization techniques like hybrid of BAT algorithm and ANT-LION optimization [14] can be carried out for the similar purpose to reduce complexity of the computational methods.

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