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Comparative Response of FIR Filter Using GA PSO BBO

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Abstract: Digital filters have found important applications in an increasing number of fields in science and engineering, and design techniques have been developed to achieve desired filter characteristics. This paper presents optimization techniques for the design of optimal digital FIR low pass filter. The design of digital FIR filters possible by solving a system of linear equations. In this paper, design techniques of low pass FIR filters using Genetic Algorithm (GA), Particle Swarm Optimization (PSO) and Biogeography based optimization are presented and comparison of these fir low pass filter design techniques on the basis of elapsed time. The implementation is done in matlab7.5.

Keywords: Fir filter, Genetic algorithm, PSO, BBO etc.

I. INTRODUCTION

Digital filters are useful structures for digital signal processing applications and in signal analysis and estimation. An operation of digital filter design is calculation of filter transfer function coefficients that provide desired amplitude requirements. Two types of filters provide these functions are finite impulse response (FIR) filters and infinite impulse response (IIR) filters. Typical filter applications include signal pre-conditioning, band selection, and low pass filtering.

FIR has following advantage over IIR Filter

1. FIR filter is Finite IR filter and IIR filter is Infinite IR filter.
2. FIR filters are non-recursive. That is, there is no feedback involved .Where as an IIR filter is recursive. There is feedback involved
3. The impulse response of an FIR filter will eventually reach zero. The impulse response of an IIR filter may very well keep "ringing" ad-infinitum.
4. IIR filters may be designed to accurately simulate "classical" analog filter responses where as FIR filters, in general, cannot do this.
5. FIR filter has linear phase and easily control where as IIR filter has no particular phase and difficult to control
6. FIR filter is stable and IIR filter is unstable
7. FIR filter depend only on I/P where as IIR filter depend upon both I/P and O/p
8. FIR filter consist of only zeroes and IIR filter consist of both poles and zeroes.

FIR filters are filters having a transfer function of a polynomial in z- and is an all-zero filter in the sense that the zeroes in the z-plane determine the frequency response magnitude characteristic. The z transform of an N-point FIR filter is given by:

$$H(z) = \sum_{n=0}^{N-1} h(n)z^{-n} \qquad \textbf{(1.1)}$$

FIR filters are particularly useful for applications where exact linear phase response is required. The FIR filter is generally implemented in a non-recursive way which guarantees a stable filter. FIR filter design essentially consists of two parts

(i) Approximation problem
(ii) Realization problem

The approximation stage takes the specification and gives a transfer function through four steps. They are as follows:

(i) A desired or ideal response is chosen, usually in the frequency domain.
(ii) An allowed class of filters is chosen (e.g. the length N for a FIR filters).
(iii) A measure of the quality of approximation is chosen.
(iv) A method or algorithm is selected to find the best filter transfer function.

The realization part deals with choosing the structure to implement the transfer function which may be in the form of circuit diagram or in the form of a program. There are essentially three well-known methods for FIR filter design namely:

(1) The window method
(2) The frequency sampling technique
(3) Optimal Filter Design Method

II. PROPOSED WORK

Optimal digital FIR low pass filter is designed using different optimization techniques. For this purpose, three main optimization techniques are used. These optimization techniques are Genetic algorithm (GA), Particular swarm optimization (PSO), Biogeography based optimization.

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III GENETIC ALGORITHMS

GA operates with a collection of chromosomes, called a population. The population is normally randomly initialized. As the search evolves, the population includes fitter and fitter solutions, and eventually it converges, meaning that it is dominated by a single solution. Holland also presented a proof of convergence (the schema theorem) to the global optimum where chromosomes are binary vectors.GA use two operators to generate new solutions from existing ones: crossover and mutation. The crossover operator is the most important operator of GA. In crossover, generally two chromosomes, called parents, are combined together to form new chromosomes, called offspring. The parents are selected among existing chromosomes in the population with preference towards fitness so that offspring is expected to inherit good genes which make the parents fitter. By iteratively applying the crossover operator, genes of good chromosomes are expected to appear more frequently in the population, eventually leading to convergence to an overall good solution. The mutation operator introduces random changes into characteristics of chromosomes. Mutation is generally applied at the gene level. In typical GA implementations, the mutation rate (probability of changing the properties of a gene) is very small, typically less than 1%. Therefore, the new chromosome produced by mutation will not be very different from the original one. Mutation plays a critical role in GA. As discussed earlier, crossover leads the population to converge by making the chromosomes in the population alike. Mutation reintroduces genetic diversity back into the population and assists the search escape from local optima. Reproduction involves selection of chromosomes for the next generation. In the most general case, the fitness of an individual determines the probability of its survival for the next generation. There are different selection procedures in GA depending on how the fitness values are used. Proportional selection, ranking, and tournament selection are the most popular selection procedures. Genetic algorithms find application in bioinformatics, phylogenetics, computational science, engineering, economics, chemistry, manufacturing, mathematics, physics and other fields. The genetic algorithm loops over an iteration process to make the population evolve. Each consists of the following steps:

SELECTION The first step consists in selecting individuals for reproduction. This selection is done randomly with a probability depending on the relative fitness of the individuals so that best ones are often chosen for reproduction than poor ones.

REPRODUCTION In the second step, offspring is bred by the selected individuals. For generating new chromosomes, the algorithm can use both recombination and mutations.

EVALUATION Then the fitness of the new chromosomes is evaluated.

REPLACEMENT During the last step, individuals from the old population are killed and replaced by the new ones.

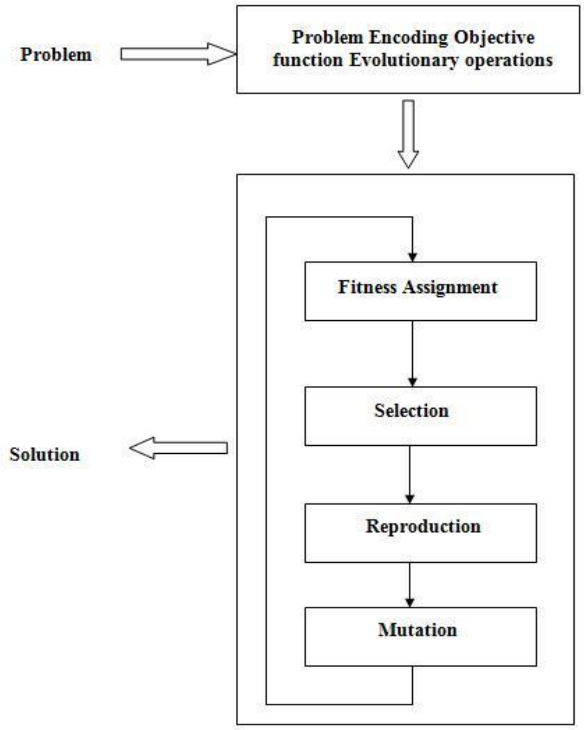

Fig1. GA flow chart

IV. PARTICLE SWARM OPTIMIZATION

Particle swarm optimization (PSO) is optimization techniques that can be flexible, robust population-based stochastic search or optimization techniques with implicit parallelism, which can easily handle with non-differential objective function, unlike traditional optimization method. PSO is less susceptible to getting trapped on local optima unlike GA. PSO is a techniques used to explore the search space of a given problem to find the settings or parameters required to maximize a particular objective. The PSO works by simultaneously maintaining several candidate solutions in the search space. During each iteration of the algorithm, each candidate solution is evaluated by the objective function being optimized determine the fitness of that solution. Each candidate solution can be thought of as particle "flying" through the fitness landscape finding the maximum or minimum of the objective function. Particle swarm optimization is a robust stochastic optimization techniques based on the movement and intelligence of swarms.

PSO uses a number of agents (particle) that constitute a swarm moving around in the search space looking for the best solution. Each particle is treated as a point in an N-dimensional space which adjusts its "flying" according to its own flying experience as well as the flying experience of other particles. The PSO is easy to apply and its convergence may be managed using a small number of factors. PSO is an elastic, vigorous population-based stochastic search or optimization method with understood parallelism, which can, with no trouble, handle non-differential purpose functions, different customary optimization techniques**.**

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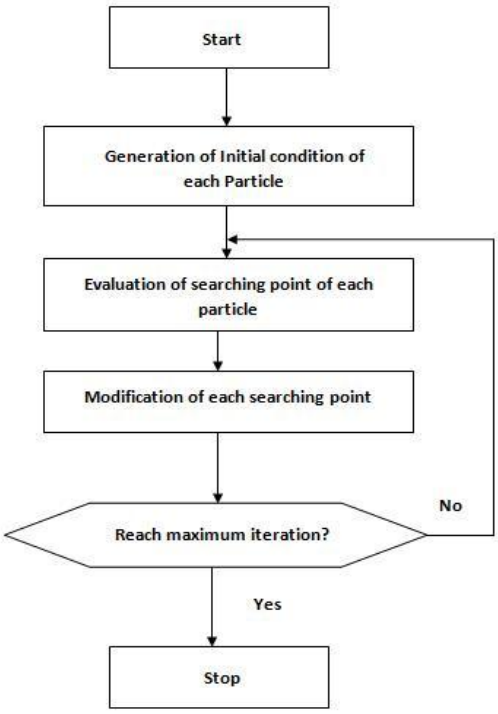

Fig2. PSO flow chart

Migration
The BBO migration strategy in which many parents can contribute to a single offspring, but it differ in at least one important aspect. BBO migration is used to change existing habitat. Migration in BBO is adaptive process; it is used to modify existing islands. Migration stage arises when LSI occurs. When species are less compatible with their habitat then they migrate.

Mutation
In BBO, the mutation is used to increase the diversity of the population to get good solution.

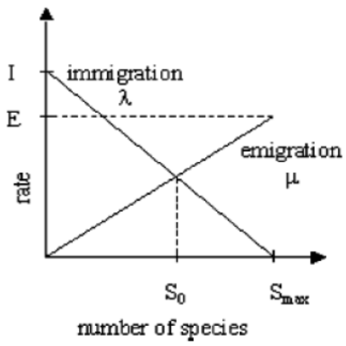

Fig3. BBO working

V BIOGEOGRAPHY BASED OPTIMIZATION

Biogeography based optimization a type of evolutionary algorithm. As its name implies, BBO is based on mathematical study of biogeography. Biogeography is the study of the distribution study of animals and plants over time and space. BBO is an evolutionary process that achieves information sharing by species migration. It is modeled after the emigration and immigration of species between habitats to achieve information sharing.BBO operates by migrating information between individuals, thus resulting in a modification of existing individual. Individual do not die at the end of generation One characteristic of BBO is that the original Population is not discarded after each generation. It is rather modified by migration. BBO is a population based optimization algorithm it does not involve reproduction or the generation of “children”. Mathematical equations that govern the distribution of organisms were first discovered and developed during 1960. Mathematical model of biogeography describe how species migrate from one island to another, how species arises, and how species become extinct. Biogeography basically on two criteria’s HIS and LIS. Geographical area that are well suited and more compatible residence for biological species are said to have highly suitability index (HSI). Features that correlate with HIS include such factors as rainfall, diversity of vegetation, diversity of topographic features, land, area and temperature. The variables that are characterizing habitability are called suitability index variables. Habitat with HSI tend to have large number of species, while those with low HSI have a small number of species.HSI are more static than LSI. LSI have a high species immigration rate because of their sparse population. BBO basically depends upon following theory:

VI. RESULT AND DISCUSSION

PSO

Filter order =10, window = boxcar
ELAPSED TIME= 3.676708

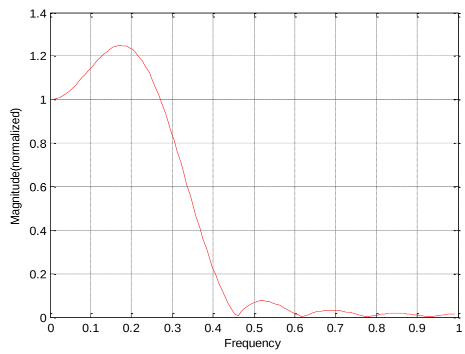

Fig 4

Here in this we have used the filter order as 10 and window used as boxcar and no. of ripple in the stop band are less as compared to other two algorithms techniques but the transition width of stop band more as compared other two. The resultant value of elapsed time is more as compared to other and the value is 3.676708.

GA
Filter order =10,
Window = boxcar
ELAPSED TIME= 1.597850

The filter order in this used is 10 and window used is boxcar same as we have used in PSO previously the value of elapsed time is 1.597850 the stop band ripple in this case are more as compared to PSO but stop band

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Transition width is lesser.

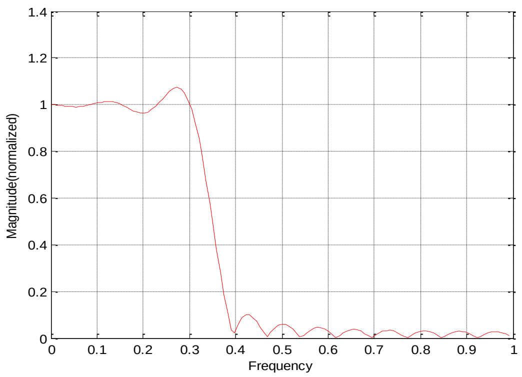

Fig 5

The value of elapsed time is less as compared to PSO.

BBO

Filter order =10,
Window = boxcar
ELAPSED TIME= 0.041017

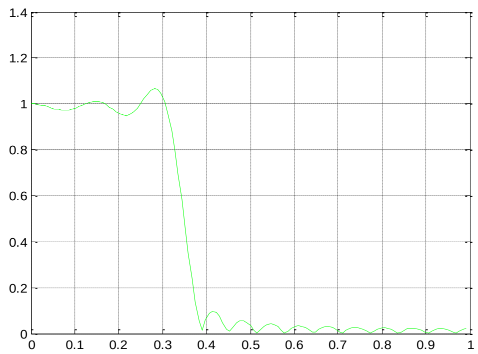

Fig 6

In this case the value of filter order is10 and window used is boxcar in this case the stop band attenuation is more as compared to other two and ripple are more and somewhat same as that of GA but the elapsed time value is lesser as compared to other and the value is .041017. Even this technique BBO is the latest one and advanced on even a lot of work still to be done on this algorithm which is based on migration of species.

Comparison between GA, BBO, PSO on the basis of elapsed time.

Table 1

Technique	Filter order	window	Elapsed time
PSO	10	boxcar	3.676708
GA	10	boxcar	1.597850
BBO	10	boxcar	0.041017

VII. CONCLUSION

An alternative approach for FIR filters design using Biogeography based optimization. Extensive results justify that the proposed algorithm on the basis of elapsed time with boxcar window provides the better results as compared to GA and PSO with different windows in the form of Normalized plots for the FIR LP filter.

VIII. ACKNOWLEDGMENT

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