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DESIGN OF FIR FILTER USING PSO: A REVIEW

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ABSTRACT

Digital filters are devices which allow some frequencies to pass without being altered while completely blocking others. Mainly two types of digital filters are available: FIR (finite impulse response) and IIR (infinite impulse response). FIR filters are used in wide variety of applications due to their linear phase response and stability. Filter designing involves use of traditional non-optimization techniques that provides suboptimal results. In order to further enhance the efficiency of designed filter, a number of optimization techniques have been proposed. Particle Swarm Optimization (PSO) is one of such optimization algorithm. This paper presents a review of FIR filter designing using PSO.

KEYWORDS: FIR, IIR, PSO, Optimization Techniques.

I. INTRODUCTION

Digital filter is a system or a network that can be used to improve the quality of a signal. Digital filters are used in wide variety of applications like signal processing, telecommunication, control systems and many more. Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) are basically the two kind of digital filter used for filtering purpose. Impulse response of digital FIR filters is finite in duration with linear phase characteristics and is always stable. On the other hand, IIR filters have infinite duration impulse response and may be unstable sometimes. Because of the linear phase response and stability FIR has great benefits over IIR.

Various techniques are available to design FIR filters. Some traditional non-optimization techniques are: frequency sampling method and windowing method. Optimization based traditional algorithm is Parks-McClellan algorithm. With the essence of time many optimization based techniques have evolved in the field of filter design. These techniques give better control on parameters as well as better approximate the ideal filter. Differential evolution [2], Simulating annealing (SE) [3], Tabu search [4], Genetic algorithm [5] and Artificial intelligence algorithms are some intelligent optimization techniques, which provide better facility of designing digital filters.

The Particle Swarm Optimization (PSO) [6] is a population based intelligent optimization technique that is effective in multidimensional nonlinear environment. It is developed from swarm intelligence and inspired by social behavior of birds flocking and fish schooling. It is based on the natural process in which swarms of particles share their individual knowledge. PSO algorithm uses a number of particle vectors moving around for finding optimal solution in search space. The solution is obtained according to personal experience of each particle vector. Many authors have worked on PSO based FIR filter designing. This paper presents a review of research work for FIR filter designing using PSO.

The rest of the paper is arranged as follows. In section II, the FIR filter design problem is formulated. Section III, discusses the literature review of the various research works carried out for FIR filter designing using PSO. Finally, Section IV concludes the paper.

II. FILTER DESIGN PROBLEM

The z-transform of a low pass digital filter is characterized as:

$$H(z) = \sum_{n=0}^{N} h(n) z^{-n}, \quad n = 0,1 \dots \dots . . N \qquad (1)$$

Here N is the order of filters having (N+1) coefficients. And h(n) is the filter's impulse response.

Frequency response of filter is given as:

$$H_i(e^{j\omega}) = \sum_{n=0}^{N} h(n) e^{-j\omega n} \qquad (2)$$

Through $\omega = \frac{2\pi}{N}$.The frequency is sampled in [0, π] at N points.

An error function is given by equation (3) that gives the appropriate error used for filter designing.

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$$E(\omega) = G(\omega)[H_d(e^{j\omega}) - H_i(e^{j\omega})] \quad (3)$$

Here $E(\omega)$ is the approximate error, $H_d(e^{j\omega})$ and $H_i(e^{j\omega})$ are frequency response of approximate filter and desired filter respectively. G (ω) is the weighting function which provides independent control on parameter such as different frequency bands. The design objective is to find out optimum filter by using approximate filter coefficients.

Frequency response of the desired Low Pass filter is given as,

$$H_d(e^{j\omega}) = 1 \quad for\ 0 \le \omega \le \omega_c; \quad (4)$$
$$= 0 \quad otherwise$$

ω_c is the cut of frequency. In order to achieve higher stop band attenuation and accurate control on the transition width, we need an error fitness function. We have to minimize error function by improving the flexibility of (δ_p/δ_s) to acquire the desired level of pass band, δ_p and stop band ripples, δ_s respectively.

III. LITERATURE SURVEY

A. Praneet et al. [7] mentioned the concept of minimization of error fitness function using evolutionary PSO algorithm. This paper provided a new calculation for velocity direction and updating the particle position direction while improving the quality of solution in search space. Enhancement in searching capability leads to a higher probability of obtaining optimal solution. It is found that using PSO technique desired magnitude response and best coefficients are obtained.

J. I. Ababneh et al. [8] discussed the design of FIR filter using PSO and genetic algorithm. The authors have designed FIR filter using PSO and compared the results obtained by using the Genetic Algorithm. PSO has provided ease of implementation in both the perspective of coding as well as parameter selection.

S. Mandal et al. [9] proposed craziness based PSO algorithm (CRPSO) for generating optimal filter coefficients and tried to meet desired specifications. The authors have introduced Craziness operator in the velocity vector. CRPSO based optimal high pass FIR filter of different orders have been designed and the results have been compared with the Parks- McClellan (PM), evolutionary algorithm RCGA(Real coded genetic algorithm), and conventional particle swarm optimization (PSO).

N. Aggarwal, P. Kaur et al. [10] discussed the design of linear phase low pass FIR filters using particle swarm optimization algorithm. The minimum pass band and stop band ripples have been achieved by using the optimization techniques. They have identified that the proposed approach converges to the specified optimum result within very small number of iteration and less time.

M. Najjarzadeh, A.A et al. [11] studied the comparison between Genetic Algorithm and PSO for designing FIR filter. Both algorithms generate a set of filter coefficients and tried to meet the ideal frequency characteristic, for which existing filters algorithm do not work. After the simulation result it is found that PSO is better than GA not only in convergence speed but also in performance of filters. PSO is able to converge to the global optima with less time consumption.

N. Aggarwal et al. [12] investigated that for designing a low pass filters that is able to calculate filter coefficients, complex calculations are required. The authors have designed a low pass FIR using artificial neural network and optimization of that network is done by using PSO. It is found that in comparison with ANN, the trained network calculate the filter coefficient for unknown parameter in specified range.

S. Kumar et al. [13] investigated that when search space is too large to search exhaustively, population based search approach may be a good alternative, but this technique cannot guarantee the optimal (best) solution. They have also demonstrated that it is better than GA and immune algorithm (IA) both in speed of convergence and performance of filters.

S. Mukherjee et al. [14] paper proposed a procedure for updating velocity direction and swarm direction of PSO for improving the solution superiority. This technique is known as improved particle swarm optimization (IPSO) for designing of FIR low pass filter. This method gave good results because it is using nonlinear stochastic global optimization approach based on IPSO.

A. Deep Borah et al. [15] introduced a paper in which they work on craziness based particle Swarm optimization algorithm and analyzed optimized output to make a comparative study of the conventional PSO techniques. The simulation results defined the optimized efficacy of the CRPSO and gave the best results in terms of maximum pass band and stop band ripples with attenuation and transition width. This technique gave best capability to converge to global optimum with narrow transition width. Their main objective was to minimize the weighting error function to get the required filter response.

M. Shukla et al. [16] presented a paper in which they proposed linear phase digital low pass finite impulse response (FIR) filter design using particle swarm optimization and its two new variants, dynamic and adjustable particle swarm optimization (DAPSO) and particle swarm optimization with variable acceleration factor (PSO-

VAF). They proved the superiority of the PSO-VAF method over the other PSO based methods. They have used two fitness functions for filter design.

S. Mandal et al. [17] presented a study about design of FIR band pass filter using Novel based particle swarm optimization (NPSO) algorithm and attempt to meet the ideal frequency response features. They have presented a new equation for study of swarm updating and particle velocity vector, which increased the solution quality. They focused on the modified inertia weight mechanism to monitor the weight of the particles.

J. Kumari et al. [18] presented an approach for optimization of FIR filters parameters using PSO algorithm. This paper introduced a concept of optimization which minimized the maximum error between desired and actual frequency response and gave better results for filter design. The proposed PSO technique is easy for calculating the FIR filter coefficients rather than using complex calculative window method.

A. Kaur et al. [19] have stated in their paper that the traditional non optimization method suffers the problem of inefficient frequency response and also need ADC. This paper gave evolutionary computation technique i.e. PSO for the design of high pass (HP) filter. Proposed study gave accurate simulation results, easier implementation and fast convergence speed. This method gave accurate results within small number of iterations.

S. M. Ahmed et al. [20] used the design technique that was implemented using MATLAB in form of interactive toolbox for filter design using GA. Simulation results for filter design using GA were compared and it was found that GA gave us the exact cut off frequency. And ripples in pass band and stop band regions were attenuated successfully, but problem was that the GA was inefficient in determining the global optimum in term of convergence speed and solution quality.

IV. CONCLUSION

FIR filters have wide variety of applications in signal processing domain. Many traditional methods are there that try to obtain an optimal FIR filter. Many authors have proposed techniques to get the accurate coefficient in less computational time. The exact frequency response of FIR filter can be obtained by making use of various optimization algorithms like GA, chebyshev, and PSO etc. to produce the highest stop band attenuation and the lowest stop band ripples. This paper presents a review of filter designing using PSO. Many authors have proposed different variants of PSO and proved PSO to be a very efficient, reliable and evolutionary design technique for FIR filter design.

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