Optimization of a Digital FIR Filter Using Particle Swarm Optimization

Shivani Sharma and Amit Thakur

Abstract: In this paper we optimized the fir filter using particle swarm optimization (PSO).The purpose of the filters is to allow some frequencies to pass unaltered, while completely blocking others. FIR filters are linear phase filters both phase delay and group delays are constant in these filters. When the search space is too large to search exhaustively, population based searches may be a good alternative, however, population based search techniques cannot guarantee you the optimal (best) solution. The simulations of designing FIR have been done and the simulation results show that the method of FIR tilter design proposed in this paper is better than the method of genetic algorithm (GA) and immune algorithm (IA) not only in the convergence speed but also in the performance of filter.

Keywords: FIR Filter, PSO, Matlab.

I. INTRODUCTION

The digital filters are an essential part of DSP. In fact, their extraordinary performance is one of the key reasons that DSP has become so popular. The purpose of the filters is to allow some frequencies to pass unaltered, while completely blocking others. The digital filters are mainly used for two purposes: separation of signals that have been combined, and restoration of signals that have been distorted in some way. Analog (electronic) filters can be used for these tasks, as these are cheap, fast, and have a large dynamic range in both amplitude and frequency; however, digital filters are vastly superior in the level of performance. In this work, a type of digital filter i.e., FIR filters is used to separate one band of frequencies from another. The primary attribute of FIR filters is their stability. This is because they are carried out by convolution rather than recursion. FIR filters are linear phase filters both phase delay and group delays are constant in these filters [1]. Equalizer complexities are two conflicting parameters; hence a compromise is usually sought. For equalization, many efficient adaptive algorithms have been developed such as the total least mean squares (TLMS) [2], [3]. Algorithm play a key role for the equalization but adaptive filter [4] is also main we can use FIR or IIR filters. As we know IIR filters not easy to implement and question on stability so we can use Finite Impulse Response or Partial Impulse Response filters and will show in this paper under which condition which one is beneficial.

2. FIR FILTERS

In finite impulse response filters, the impulse response is of finite duration. This means that the impulse response of fir filters has a finite numbers of non-zero terms. Consider the FIR filter with the input-output relationship governed by:

$$y[n] = \sum_{i=0}^{N} a_i \, x[n-i] \qquad (1)$$

where $x(k)$ and $y(k)$ are the filter's input and output, respectively, and N is the filter order. The transfer function of this FIR filter can be written in the following general form:

$$H(z) == \sum_{I=0}^{N} a_i z^{-i} \qquad (2)$$

An important task for the designer is to find values of a_i such that the magnitude response of the filter approximates a desired characteristic while preserving the stability of the designed filter. The stability is assured if all the poles of the filter lie inside the unit circle in the z-plane. The Digital filters have various stages for their design.

3. PARTICLE SWARM OPTIMIZATION

The PSO algorithm is an adaptive algorithm based on a social-psychological metaphor; a population of individuals (referred to as particles) adapts by returning stochastically toward previously successful regions. Particle Swarm has two primary operators: Velocity update and Position update. During each generation each particle is accelerated toward the particles previous best position and the global best position. The new velocity value is then used to calculate the next position of the particle in the search space. The particle swarm algorithm is used here in terms of social cognitive behavior. It is widely used for problem solving method in engineering. In PSO, each potential solution is assigned a randomized velocity, are "flown" through the problem space. Each particle adjusts its flying according to its own flying experience and its companions' flying experience.

The ith particle is represented as $X_i = (x_{i1}, x_{i2}, \text{-------} x_{id})$. Each particle is treated as a point in a D-dimensional space. The best previous position (the best fitness value is called pBest) of any particle is recorded and represented as $P_i = (p_{i1}, p_{i2} \text{------} p_{id})$.Anther "best" value (called gBest) is recorded by all the particles in the population. This location is represented as $P_g = (p_{g1}, p_{g2} \text{------} p_{gd})$. A t each time step, the rate of the position changing velocity (accelerating) for particle i is represented as $V_i = (v_{i1}, v_{i2} \text{-----} v_{id})$. Each particle moves toward its pBest and gBest locations. The performance of each particle is measured according to a fitness function, which is related to the problem to be solved [3].

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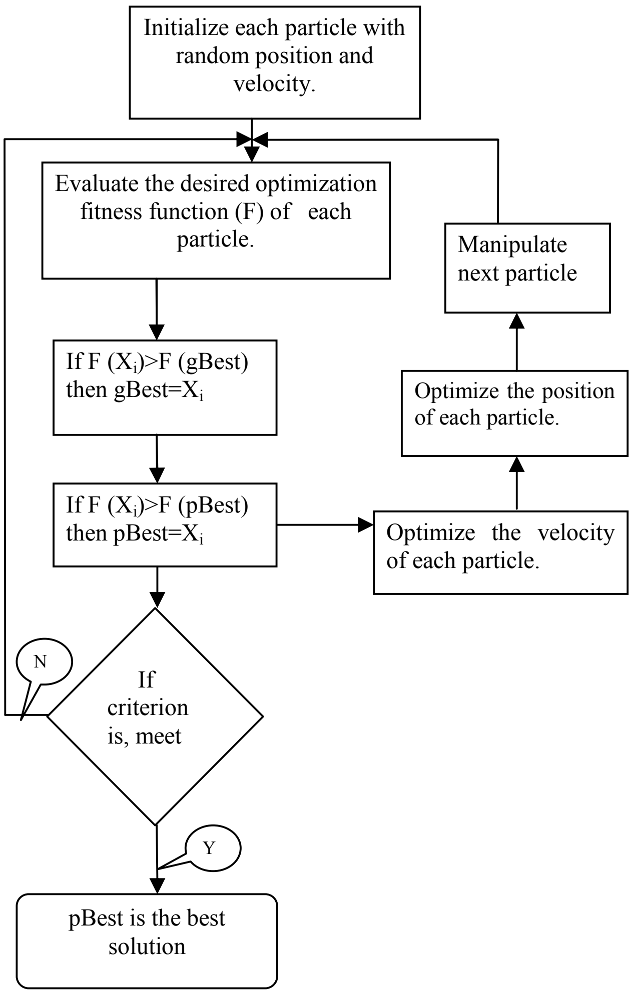

Fig 1: Flow diagram of PSO

4. SIMULATION RESULTS

This section represents the simulation frame work for the design of FIR filter using PSO. Simulation is carried out for certain specification such as T1 = 5 dB, T2 = 7 dB, central frequency = 1000 Hz, The plots of normalized frequency and magnitude are shown in Figure 1.

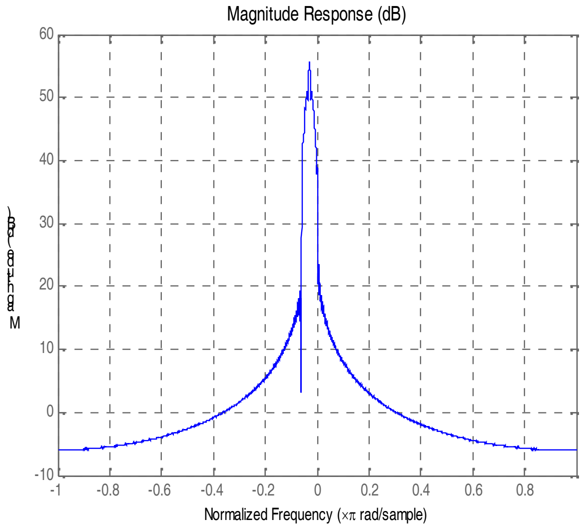

Figure 2: Magnitude Response

In this graph the value of t1 = 10 and the value of t2 = 14 and the central frequency = 1500 MHz

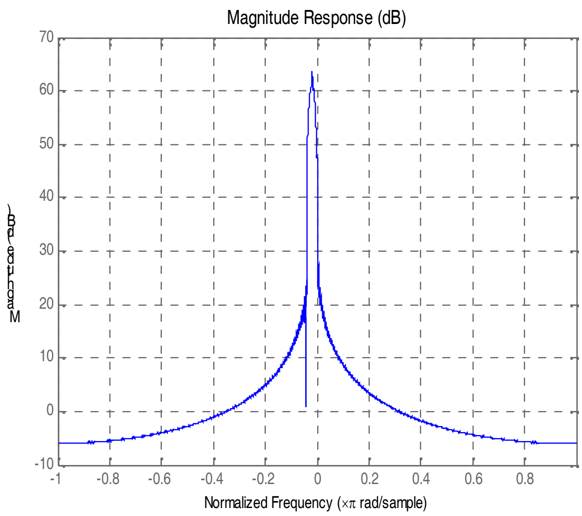

Figure 3: Magnitude Response

In this graph the value of t1 = 15 and the value of t2 = 21 and the central frequency = 2000 MHz

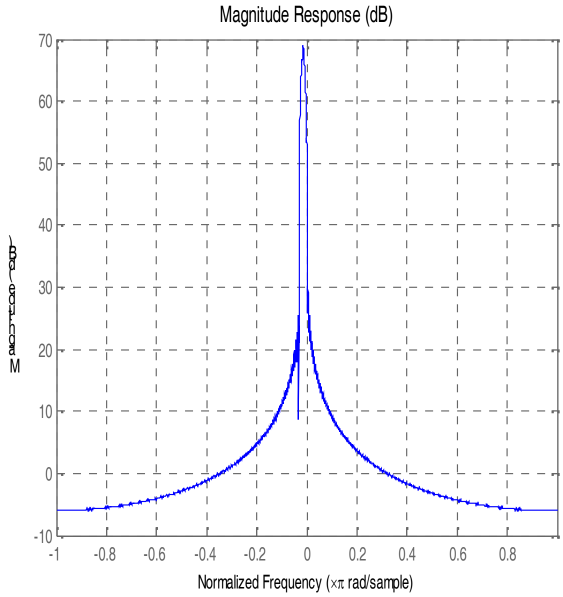

Figure 4: Magnitude Response

5. CONCLUSION AND FUTURE SCOPE

To design filters with special requirements such as a trade-off in norms or concerning quantization effects there is a need of more general optimization techniques.FIR digital filters are widely used in the field of signal processing due to its distinguishing features such as: the stability, linear phase and easiness for realization. Traditionally, there exist some methods for FIR digital filters design, such as window method, frequency sampling method and best uniform approximation. Unfortunately, each of them is only suitable for a particular application. In recent years, many evolutionary computation techniques, such as simulated annealing approach (SA), genetic algorithms (GA), particle swarm optimization (PSO), have been employed to design FIR digital filters. GA is a good global searching method, but it is difficult to realization because of the complexity of coding. PSO is a recently proposed random search algorithm and has been applied to many real-world problems,

6. REFERENCES

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