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Design of Digital FIR Low Pass Filter using PSO Algorithm

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Abstract:

The design of a good performance FIR filter is the main problem in signal processing field in order to determine the sample value in the transition zone.Obviously, Interpolator is the optimal sampling point which cannot be guaranteed by genetic algorithm method. It takes longer time in operation because of its complex method in structure and suffers from local optimal solutions. Particle swarm optimization (PSO) method is used to determine the frequency response of digital low pass FIR filter, As a result the optimal filter coefficients are obtained with error function is minimization and fast convergence speed, when compared with the errors obtained from windowing techniques. This algorithm is implemented in FIR filter in an efficient way to improve the stop band attenuation such that the errors are reduced by the samples which are interpolated near the discontinuity. The performance of PSO have been verified via computer simulations using MATLAB.

Keywords — **Finite Impulse Response (FIR) filter , genetic algorithm , Particle Swarm Optimization (PSO) algorithm , window techniques and MATLAB.**

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I. INTRODUCTION

Filters, in DSP, are the ones which take input in digital form and produces digital output. Finite Impulse Response filter is indeed an agreeable choice since the stability is good and the design is quite easy and simple. There are numerous applications of digital filters which include telecommunication, control system, signal processing as well as in many video processing and audio processing ,guarding(defense) equipmentsand so on. A digital filter is better than an analog filter because of its better performance , small in size, reliability, higher accuracy and a number of applications as mentioned above. Basically, digital filters are of two varieties:infinite impulse response (IIR) and finite impulse response (FIR). Conventionally,many other famous methods to design filters which are digital in nature like windowing techniques and the method of frequency sampling. This window technique comprises of the windowfunctions which areChebyshev window, Butterworth window,Kaiser window,Rectangular window and Hanning window(for Finite Impulse Response filters)that can be additionally changedinto low pass , high pass, band pass filters provided all are digital. This technique used in the design of FIR digital filters is brisk, sturdy and convenient.However it is normally insignificant.So, the primary aim in designing an optimized digital filtersrequires precise and proper supervision of frequency spectrum parameters which are usually greatly non linear, non uniform, andnondifferentiable.Themost efficient and more oftenly utilizedprocedure to design a definite linear phase filter based on Chebyshev error criterion. Parks and McCellellan suggested the utilization of an algorithm commonly called as the PM algorithm (Remez algorithm)for designing a FIR filter which is better than the traditional methods used for FIR filter design.However,there exists the limitations of complicated calculationsand higher pass band ripples. This kind of filter hasmore error in the design and needs to be minimized to an optimum level . It is known that the filter optimization techniques aren'tnewly developed,while a number of efforts weremade to design an optimized filtersome of which are Genetic algorithm, Differential Evolution. The drawback of Genetic algorithm is that it gave productiveoutput for local optimaland was not successful in obtaining overall(global) optimum.

In this paper,we employa progressive methodology known as PSO(Particle Swarm Optimization) for the designing an optimized Finite Impulse Response filter which is digital. Primarily, Eberhart and Kennedy introduced this approach. PSO is a calculational method roused byfish schooling and bird flocking . Of course, the goodness of particle swarm optimization lies in the implementation ease along with therapidconvergingpace. Also,the particle swarm optimization technique necessitateszero gradient and attainsoverall optimum in the minimization of the given objective function in certain design issues. Theconventional PSO has the disadvantage that it might be influenced by early convergence and stagnation problem. A several number of modified conventional PSO technique exists. However,the results of the above mentioned algorithms have to be further improved because of the intrinsic isssues of dependence, control parameters and premature convergence. Therefore,this project describes the digital FIR filtermodel using PSO approach which attempts to optimize error efficiently and obtain optimal coefficients which best matches with the expected frequency response.

II. PSO ALGORITHM AND ITS IMPLEMENTATION

Particle Swarm Optimization technique is a population based stochastic optimization technique based on the real life example of bird flocking or fish schooling.PSO has some common things with computational evolution procedures such as Genetic Algorithms. In PSO, is initiated with the random solutions populations along with searching for a optimal solution by updation of the generation. Nevertheless, this system will have no evolutionary operator like the crossovers or mutations which are found in GA. The potent solution in PSO, known as particles, navigate(fly) throughoutthe problem area by following currents optimum particles. As compared to the GA, the merits of PSO technique are : easy to implement as well as less parameter to adjust,applied in many areas such as functional optimization, artificial neural network training, fuzzy system control, and other areas where Genetic Algorithm application can be done

The PSO equation is given by,

v[] = v[] + c1 * rand() * (pbest[] - present[]) + c2 * rand() * (gbest[] - present[]) (a)

present[] = persent[] + v[] (b)

The particle updates its velocity and location respectively according to the equations (a) and (b).

The pseudocode used in this paper in order to design the filter is as follows

```
 For each particle
  Initialize particle
End

Do
  For each particle
     Calculate fitness value
     If the fitness value is better than the best
fitness value (pBest) in history
        set current value as the new pBest
  End
```

Choose the particle with the best fitness value of all the particles as the gBest
For each particle
Calculate particle velocity according equation (a)
Update particle position according equation (b)
End
While maximum iterations or minimum error criteria is not attained

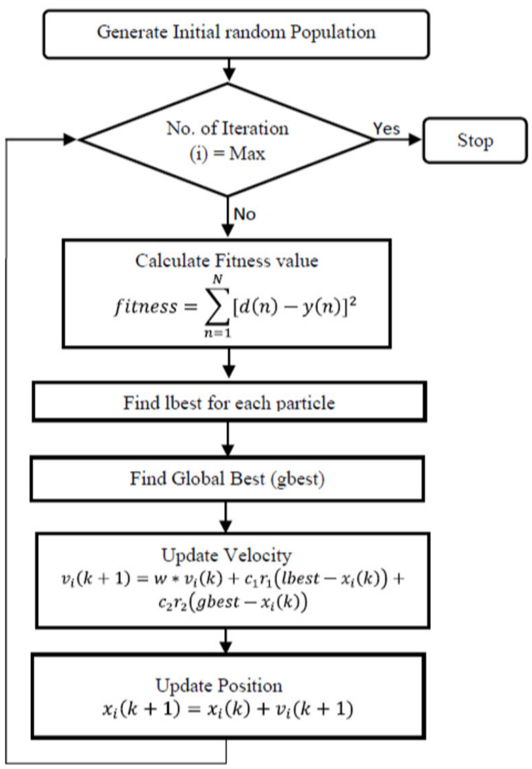

fig.1 PSO flowchart

The following fig.1 depicts the flowchart of the PSO Algorithm. Here, in our code we try to modify the velocities and positions of the particles in order to obtain an optimized output along with the error minimization.

RESULT

We write the code for designing the digital low pass filter and simulate it in the MATLAB software. Here, the low pass filter is designed with the following specifications.The PSO based designed filter is compared against a filter designed based on window function.The goal of this paper is to minimize the objective function, magnitude error and Pass-band and Stop-band ripples.

Figure 2 depicts the normalized graph of magnitude versus the normalized frequency. The low pass filter designed using PSO algorithm is compared against the standard normalized filter designed using rectangular window. The graph shows that at a normalized frequency of 0.6 the magnitude is found to be between -30 and -40db.

Population : 28
Iterations : 500
Passband frequency : 4kHz
Stopband frequency : 6kHz
Passband ripple : 0.001
Stopband ripple : 0.0001
Frequency : 8kHz

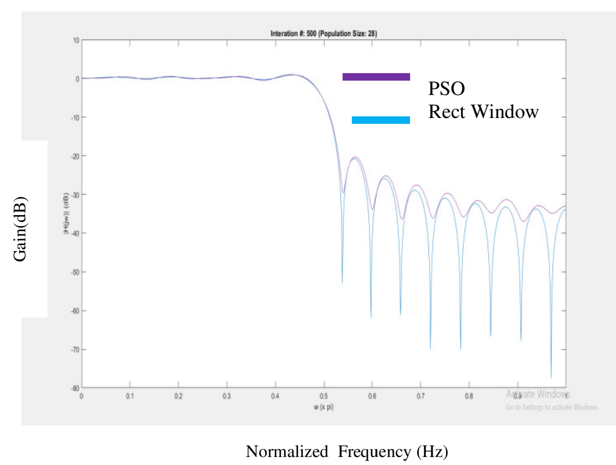

fig.2 Normalized simulation results

CONCLUSIONS

The development of PSO is still ongoing. And there are still many unknown areas in PSO research such as the mathematical validation of particle swarm theory. Many researchers are working on this algorithm today and trying to enhance the capability of this algorithm. The low pass filter designed above can be used in audio signal processing to process audio signals of frequency range 8KHz to provide a noise free quality audio experience. Once the error function is minimized , we can obtain a precise solution and optimize the filter. PSO algorithm is still being modified in order to obtain an optimized solution to apply it in fields of signal processing. Thus, the challenge is in finding optimal values in the PSO equation and obtaining an efficient result.

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