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Optimization of Linear FIR Filters Using Particle Swarm Optimization (PSO)

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ABSTRACT: Particle swarm optimization is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. Particle swarm optimization algorithm is the solution for optimization of hard problems quickly, reliably and accurately. Various approaches have been used in the past but particle swarm optimization outperforms other algorithms such as Genetic algorithm (GA), Parks and McClellan algorithm (PM). This paper presents the review of optimization of linear FIR filters using various approaches.

KEYWORDS: FIR Filter, Particle Swarm Optimization, Genetic Algorithm, Parks and McClellan Algorithm, Matrix laboratory.

I. INTRODUCTION

Digital: Digital means the use of discrete signals to represent data in the form of numbers.
Signal: Signal is variable parameter by which information is conveyed through an electronic circuit.
Processing: Processing means to perform operations on data according to programmed instructions.
Digital filters are used in wide variety of applications from signal processing, aerospace, control system, telecommunication, system for audio and video processing. Basically filters refers to a frequency selective device which extracts the useful portion of input signal lying within its operating frequency range. Evolutionary optimization technique such as Genetic algorithm (GA), Parks and McClellan algorithm (PM), Particle swarm optimization (PSO) are implemented for the design of optimum digital filters. These approaches providing better control on performance parameters. In this paper the designs of the optimal FIR high pass filters of different orders have been performed. The simulation results have been compared to those obtained by the well accepted algorithms such as Genetic algorithm, Parks and McClellan algorithm. The result justify that the proposed optimal filter design approach using PSO outperforms PM and GA, not only in the accuracy of filter but also in speed and solution quality.

II. LITERATURE SURVEY

Shruti Singh presented the optimization of FIR filter using PSO based algorithm. In this filter was being optimized using particle swarm optimization and compared with conventional frequency sampling method of optimization. PSO (particle swarm optimization) was used as an optimization technique to optimize the output parameters of the FIR filter. PSO initializes a group of random particles (solutions) and then searches for optimal solution by updating generated values. Being an optimization method the aim was to find the global optimum of a real value function. We can observe that all parameters of FIR filters were better after using particle swarm optimization and indicates PSO was an efficient and can be easily implemented.

Saurabh Kumar proposed an analysis of FIR filter using particle swarm optimization. In this there were analysis of FIR filter using PSO. The purpose of filters was to allow some frequencies to pass unaltered, while completely blocking others. FIR filters were linear phase filter both phase delay and group delays were constant in these filters. There were comparison between GA and PSO. GA was good global searching method but it was difficult to realization, because of complexity of coding. PSO can be efficiently used due to its global search ability as compared to genetic algorithm and also indicates that PSO algorithm technique can be used for application area like telecommunication where desired frequency can be selected to get best result.

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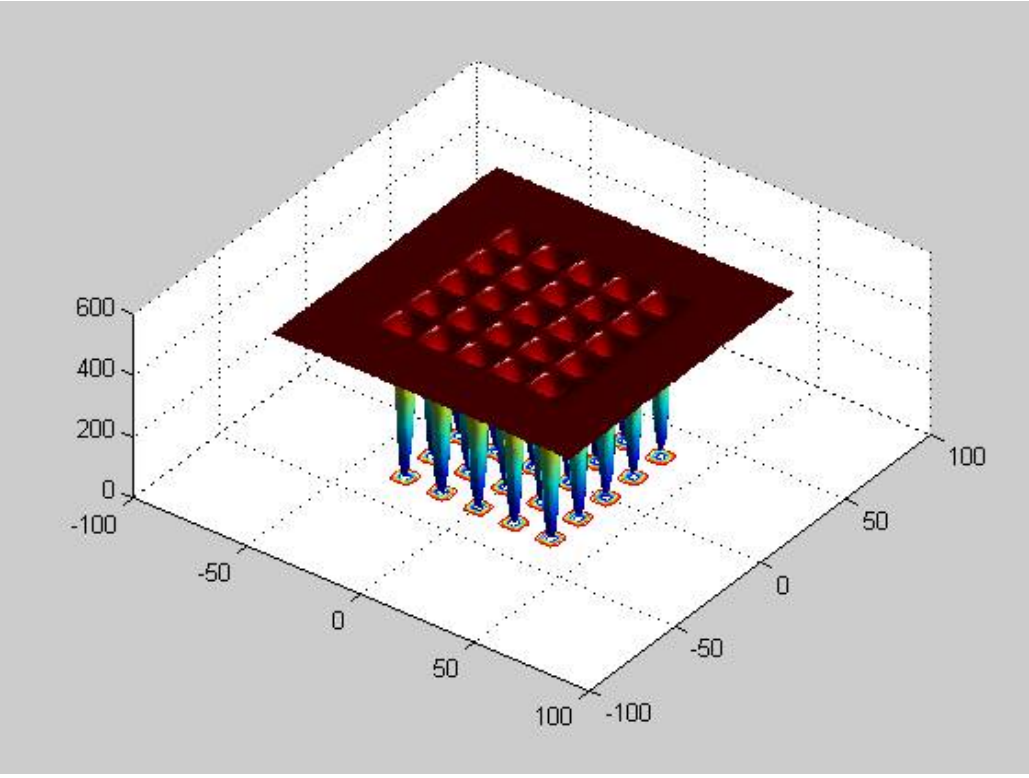
Sangeeta Mandal presented the swarm intelligence based optimal linear FIR high pass filter design using particle swarm optimization with constriction factor and inertia weight approach. PSO was flexible robust population based optimization technique which can easily handle with non differential objective functions. In this paper the designs of the optimal FIR high pass filter of different orders have been performed. The simulation results has been compared to those obtained by well accepted algorithm such as genetic algorithm (GA). The result justify that the proposed optimal filter design approach using PSO-CFIWA outperforms GA, not only in accuracy of the designed filter but also in speed and solution quality.

HC Leung proposed an approach that the particle swarm optimization for OPF with consideration of FACTS (flexible ac transmission system) devices. In this paper a particle swarm optimization method approach to solve the optimal power flow (OPF) in power system in corporate with flexible ac transmission system (FACTS). In this paper the solution process, PSO coupled with full AC power flows selects the best regulations to minimize the total cost and keep the power flows within their security limits. It was shown that this may increase the controllability of the system and provide wider operating margin as well as voltage stability with more reserve capacity.
Ahmad Ayatollahi proposed a comparison between genetic algorithm and PSO for linear phase FIR digital filter design. A comparative study between genetic algorithm and particle swarm optimization in FIR filter design was presented in this paper. In this many evolutionary computation techniques such as GA and PSO have been emerged into optimum filter design. GA was difficult to implement because of coding complexity and its convergence speed was low. The PSO was simple to implement and its convergence may be controlled via few parameters. It was unlike GA, because PSO updates itself without any genetic operator such as crossover mutation and according to simulation results concluded that PSO was able to converge to the global optimal with less time consumption.

III. OPTIMIZATION USING PSO

This example shows how to optimize using the particle swarm optimization.
The objective function in this example is De Jong's fifth function, which is included with Global Optimization Toolbox software. We have
dejong5fcn



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This function has 25 local minima.
When we try to find the minimum of the function using the default particle swarm optimization settings.

```
fun = @dejong5fcn;
nvars = 2;
rng default % For reproducibility
[x,fval,exitflag] = particle swarm(fun,nvars)
x =  -31.9521  -16.0176
fval = 5.9288
exitflag = 1
```

It is unclear at this point that solution x is global optimum. Looking at the function plot shows that the function has local minima for components in the range [-50,50]. So restricting the range of the variables to [-50,50] helps the solver locate a global minimum.

```
lb = [-50;-50];
ub = -lb;
[x,fval,exitflag] = particleswarm(fun,nvars,lb,ub)
x =  -16.0079  -31.9697

fval = 1.9920
exitflag = 1
```

This looks better: the new solution has lower fval than the previous one. To better search the region we try to minimizing again with more particles..

```
options = optimoptions('particleswarm','SwarmSize',100);
[x,fval,exitflag] = particleswarm(fun,nvars,lb,ub,options)
Optimization ended: change in the objective value less than options.TolFun.

x = -31.9781  -31.9784
fval = 0.9980
exitflag =1
```

This looks even more better. Rerun the solver with a hybrid function. Particle swarm optimization calls the hybrid function after particle swarm optimization finishes its iterations.

```
options.HybridFcn = @fmincon;
[x,fval,exitflag] = particleswarm(fun,nvars,lb,ub,options)
Optimization ended: change in the objective value less than options.TolFun.
x = -31.9783  -31.9784
fval = 0.9980
exitflag = 1
```

particle swarm optimization found essentially the same solution as before. This gives that particle swarm optimization reports a local minimum and that the final x is the global solution.

IV. CONCLUSION

Particle swarm optimization is best technique as compare to other techniques. We have optimization using PSO which shows global solution and even in local minima reduce the system losses. Comparison is done with 1.) Genetic algorithm 2) Constriction factor and inertia weight approach 3) Parks and McClellan algorithm. Particle swarm optimization is an efficient and can be easily implemented and all the parameters of fir filter are better after using PSO. Hence PSO increase the controllability, convergence speed, easier implementation and robustness of the system with less time consumption. The computational results reveal that the proposed algorithm converges to the specified optimum result within very small number of iterations. Therefore, PSO method is a powerful tool for the design of linear FIR filters.

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