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Design of Digital Filter by particle swarm optimization algorithm

Mr.Sudhir Kadam[1], Dr. M. S. Chavan[2]
[1]*Electronics and Telecommunication Engineering, Bharati Vidyapeeth Deemed to be University College of Engineering Pune, India.*
[2]*Department of Electronics Engineering KIT's college of Engineering, Kolhapur, India.*
Corresponding Author: Mr.Sudhir Kadam

Abstract: *The particle swarm optimization (PSO) algorithm is used to design low pass infinite impulse response filter. The use of Digital filters in implementing high performance circuits in digital signal environment is becoming increasingly popular. In this paper the rationale is to design a FIR filter by PSO method. The filter coefficient is calculated by PSO methods. The PSO is a simple, algorithm based on the swarms for search and optimization from a multidimensional space.*
Keywords - *Correction factor, Digital filter, Correction factor, swarms.*

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I. INTRODUCTION

The PSO is a method of optimization which is based on population algorithm. The notion of the PSO are-Swarming behavior of animals like birds and fish are observed under PSO. In particle swarm optimization, particles pass in the search of space creating a problem for optimization. The result in the position of a particle gives the candidate solution to the optimization problem at hand. In the search-space every particle searches their better positions. According to the rules it can be done by change the velocity of the particles which follows the principles of bird flocking. To solve optimization problem, swarm intelligence is used where the particle swarm optimization comes under it. It's thought was produced from swarm knowledge and was motivated by social conduct of fledgling running or fish tutoring. In the calculation each molecule goes about as a point in the N-dimensional space. Every molecule keeps the data in the space area for each cycle and the best arrangement is determined that has gotten by that molecule is called individual best (pbest). This arrangement is gotten by the individual encounters of every molecule vector. Another best esteem that is followed by the PSO is in the areas of that molecule and this esteem is called gbest among all pbests.
The population candidate solution, dubbed particles problems are solved using PSO with the help of simple mathematical formulae with respect to the position and the velocity of the particle

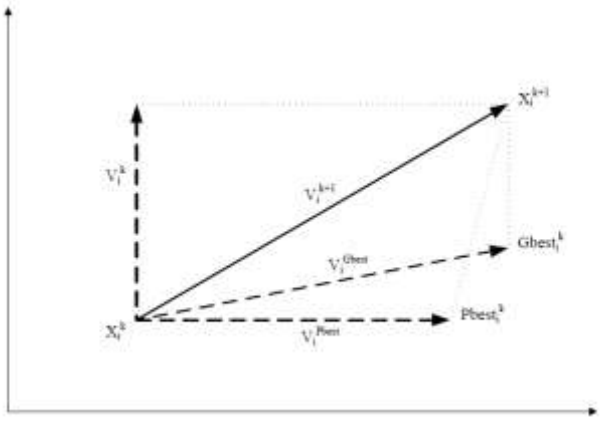


Fig.1 PSO search mechanism in 3D space.

FILTERS: - Filtering is a process with which a frequency spectrum of a signal can be adjusted according to desired specifications given by the designer. Digital filter are used in number of application like speech recognition, image enhancement, radar processing, secure communication and biomedical engineering, so great attention is required for efficient designing of digital filter. The use of Digital filters in implementing high performance circuits in digital signal environment is becoming increasingly popular. In addition, the digital

filter characteristics can change easily under software control. So, there is a need of optimization methods to satisfy prescribed specification use to design digital filters.

II. CONCEPT

The PSO algorithm design of LP-IIR digital filter is done. In which, filter coefficient parameters such as PB and SB frequencies, filter length and also stop band and pass band ripple sizes are given.

The Particle swarm optimization is based on the following concepts-

- The PSO algorithm maintains multiple potential solutions in single time it does not require different time.
- Particle represents each solution in the fitness landscape/search space
- Objective function evaluate the solution during each iteration to determine its fitness
- Objective function returns the particles "fly or swarm" through the inquiry space to locate the greatest esteem.

The principle Steps that need to be followed in Particle Swarm Optimization are-

- Initialize population of n particles with random positions xi & vi,
- For every swarm:-
  Calculate f(xi),
  If new personal best set pi=xi,
- For the whole population identify-
  global best {pg}.
- Velocity and position update:
- Convergence

III. DESIGN TECHNIQUES

Optimization Techniques:-

The parameters that provide the maximum/minimum value of a target functionis found by optimisatiom technique

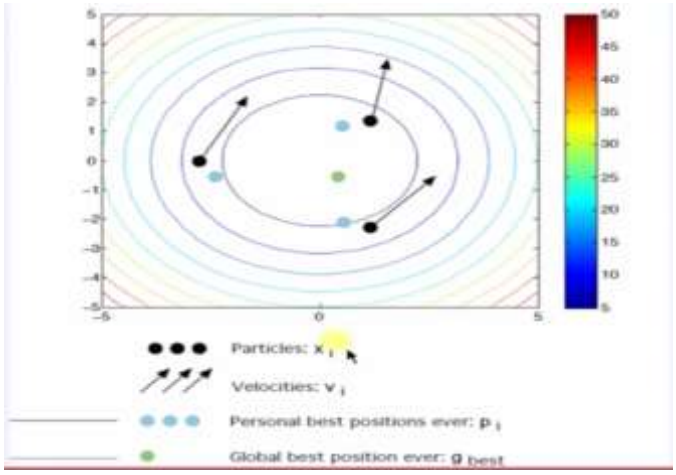


Fig.2 Optimization Parameters Value

Each particle maintains:-

a) Solution and fitness

b) Velocity

c) Individual best position

DESIGNING:-

- The solution to the optimization problem is (obviously) derived from gbest.
- Possible termination conditions that might be used:
- Solution exceeds some quality threshold.
- Average velocity of agents falls below some threshold (agents may never become completely stationary).
- A certain number of iterations is completed.

Algorithm Of Pso

A straightforward type of the PSO calculation is takes a shot at the no. of swarms or populace of hopeful arrangements which is otherwise called particles. as indicated by the few equation the particles are

move around in inquiry space. the best known position of the particles manage the development of that specific molecule in the hunt space and the whole swarm's best known position. When we discover the refreshed places of the particles in the swarm then we concentrated on the development of the swarm.The procedure is rehash until the point when we got the best arrangements.

✓ Steps1:-

The swarm is created in which every particle in the swarm contains some vector elements. Every particle has its own random position in space domain.

✓ Steps2:-

calculate the $f(x_{i})$ for every particle.

✓ Steps3:-

By comparisons between every particle in the swarm fitness value with the current's fitness, Pbest is calculated.

✓ Steps4:-

To calculate gbest, comparing between $f(x_{i})$ and swarm of previous best values.

✓ Steps5:-

Update the positions and the velocity. The equivalent equation for update position and velocity is written as:-

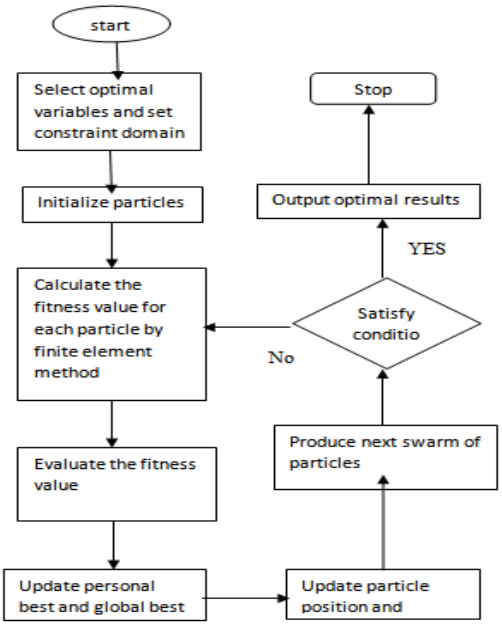
$$Vi = Vi + 2 * rand(\ \ ) * (Pbest - Xi) + 2 * rand(\ \ ) * (gbest - Xi)$$
$$Xi = Xi + Vi \qquad (1)$$

Where, rand () is the random number having value in lies 0 and 1. Xi are position and Vi are velocity vector.

✓ Steps6:-

Follow the steps from 2 till 5 again to meet the stopping criterion.

Flow chat:-



The PSO optimization was performed using the help of MATLAB software.

The following definitions were used in programming the structure of the PSO-

GBEST:- gbest is the maximum hard constraint value at the final iteration.

CORRECTION FACTOR:- C1, C2 are learning factors which we have seen in the above equation. c1 and c2 usually equal to 2.

INERTIA:- Inertia plays a major role in PSO, which calculates the convergence of the particle in the swarm.

ITERATION:-PSO is an significant algorithm, in which location of the particles and the best location updated per iterations.

SWARM:- A large group of particles moving together is swarm. we have given the value of swarm is 50.We change accordingly.

Table: 1

Name	Value
Correction Factor	2
Gbest	29
I	50
Inertia	1
Iteration	30
ITR	30
Step	51
Swarms	50*7 double
Swarm	50
Temp	3.367101487052307e-08
U	19.993966660773033
V	9.787458552988774
Value	0.045210267879854

The values of Table 1 above were used in the MATLAB

Right FACE:- The endeavor constants C and ecumenical best positions. Low qualities limit the kineticism of the particles and high qualities result in sudden kineticism toward, or past, target districts. Henceforth the endeavor constants C1 and C2 decide the impact of individual best 1 and C2 are set to be 2.0 as per past encounters. C1, C2 are learning factors which we have outwardly seen in the above condition

Idleness: - Inertia weight is a vital parameter in PSO, which altogether influences the intermingling and investigation abuse exchange off in PSO process. Since initiation of Inertia Weight in PSO, a sizably voluminous number of varieties of Inertia Weight system have been proposed. Here the inactivity is 1 which gives the phenomenal outcomes.

Cycle: - The PSO is an iterative calculation, where molecule positions and best positions are refreshed per emphasis. Here the emphasis is 30 betokens the figure window demonstrate the 30 places of particles moving towards the specific point.

A cosmically monstrous gathering of particles moving together is swarm. We have given the estimation of swarm is 50. We transmute as needs be.

Swarm: - Arbitrary hunt is connected to introduce every component of swarm grid. Ecumenical pursuit is connected to investigate the beginning point and after that the initiation point is irritated in neighborhood seek space to record the best beginning stage. The hunt procedure is started by instating the variable using which is used to figure target work.

Steps: - In this the steps value is 51 as we have discuss in the program

steps =step +1,

where the step is 51.

U: - Velocity and position updates are the two primary operators of Particle Swarm. best location and precedent best location and the next location will be assigned from the incipient assigned velocity.

The velocity of the particle is a stochastic variable and is, consequently, subject to engender an uncontrolled trajectory, making the particle follow wider cycles in the quandary space. It is an updated best initial velocity. Which we have given 20 in the program and we got the exact value: 19.993966660773033 in the workspace window.

V: - Speed and position refreshes are the two essential administrators of Particle Swarm. It is in a general sense an iterative procedure and amid emphasis, molecule speed is refreshed from current to early esteem, ecumenical best position and foremost best position and the following position will be allocated from the nascent appointed speed. This procedure will be iterated until the point when the blunder will be limited.

It is an updated best final velocity. Which we have given 10 in the program and got the exact value: 9.787458552988774 in the workspace window.

Value: - Best value so far in group or swarm (pbest) among gbests is 7.0915e-08. It is the particular best value in swarm.

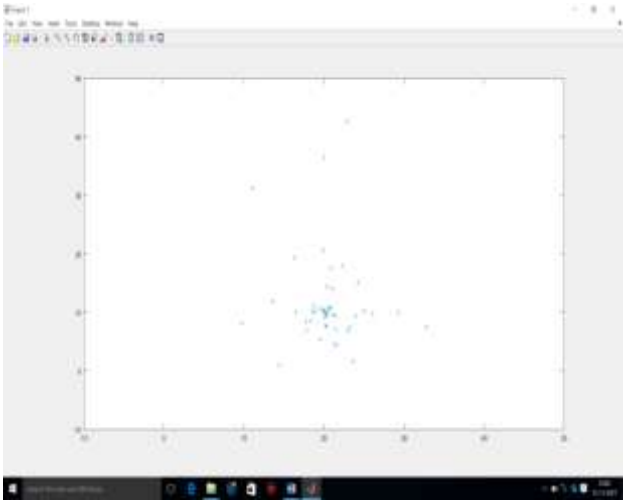


Fig.3 - Fitness Vs Solution graph represents the Best value so far in group or swarm (gbest) among pbests.

IIR Filter Design: -
Steps for designing a digital IIR filter utilizing PSO Algorithm:
Filter Designation:-
In this step, for designing LP- IIR filter following designations are utilized: Sampling Frequency Fs=1000Hz, cut-off frequency=0.3, stop and ripple=0.01 and pass band ripple=0.1.
Fitness Function Generation:-
PSO calculation in a general sense limited the mistake by using wellness work. In wellness work, blunder among perfect and a structured channel is taken. As referenced before, for IIR Butterworth channel is used. Wellness work is characterized as:

$$\text{Fitness}=\frac{1}{N}\sum_{K+1}^{N}(ideal(K)-actual\ (k)) \qquad (2)$$

Where, ideal (K) and genuine (K) are the magnitude replication of the ideal and the genuine filter, where N is the number of samples2.

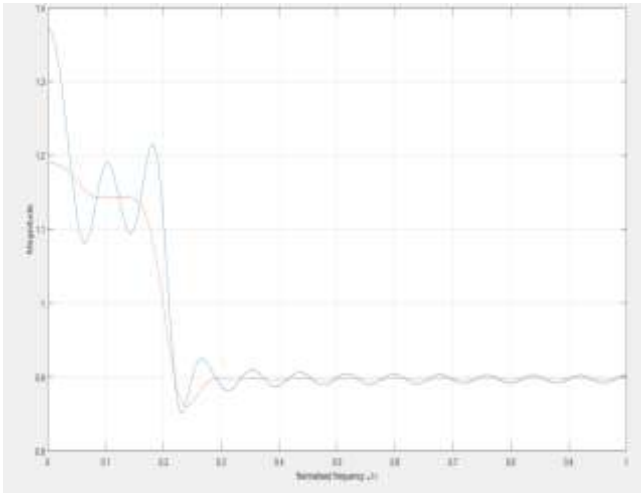


Fig.4 – IIR Filter implementation using Particle Swarm Optimization Algorithm

IV. CONCLUSION

Particle Swarm Optimization (PSO)is used to build digital low-pass IIR filter. Therefore, it recommended the inherited quality of controllable speed, easier implementation and robustness. In this we concluded by the profound PSO are comparatively better in the ripples and the magnitude error. The results represent all the poles which lies into a circle with a unit radius & the value is little less than 1. LP, HP, BP and BS be easily perceived by using PSO. According, to the result gained from the design of filter.

i. Demand for the additional testing.
ii. Remarkable speedup using PSO search.

Moreover, the algorithm has been developed. Also, PSO programming codes in MATLAB environment have been given and an example has been solved successfully which demonstrate the effectiveness of the algorithm. The following conclusions can be drawn from this work:-

(i) The MATLAB codes can be extended to solve any type of optimization problem of any size.

(ii) Any equality constraint needs to convert into corresponding two inequality constraints.

(iii) The MATLAB codes are generalized for solving any optimization problem with inequality constraints of any size.

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