International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

# Design of Digital Filter by Differential Evolution

**Sudhir A. Kadam, Mahesh S. Chavan**

***Abstract*:. This methodology for stable and robust design of FIR filters. Differential evolution (DE) is taken as a global search technique and it uses local search algorithm to find the optimal solution for the design. DE is implemented here to design low pass, band pass as well as high order filters and results which are obtained can also be applied to higher order filters. The recombination approach involves the creation of new candidate solution components based on the weighted difference between two randomly selected population members added to a third population member. This perturbs population members relative to the spread of the broader population. In conjunction with selection, the perturbation effect self-organizes the sampling of the problem space, bounding it to known areas of interest.**

***Index Terms: Crossover, Mutation, Local Search, population.***

## I. INTRODUCTION

Differential evolution is used to eradicate the problem arose In FIR filters due to their non-linearity and stability aspects [1] .The other aspect of using DE is that it makes the search for global minima way easier and it doesn't get stuck at local minima. It is population based algorithm and it operates on parameters such as crossover, mutation, local search and selection.DE is based on biologically speaking the "survival of fittest", which means it consider a current generation of candidate solutions and passes it to the next one if it fits the fitness criteria allowed by the algorithm.

## II. DIFFERENTIAL EVOLUTION METHOD

### A. Digital FIR Filter Design

FIR filters have wide application in Digital Signal Processing. FIR filters are implemented as system Identification problem. The DE algorithm successively adjusts the filter parameters [2]. The process repeats itself till the error between filter output and the unknown system is minimized.

**Revised Manuscript Received on 30 July 2019.**
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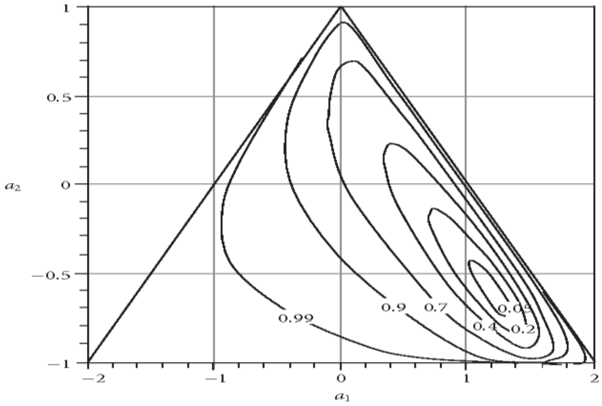



**Fig. Error Surface Of Filter**

### B. Methodology

Mutation

It is the process where a vector differential is added to a individual population of vectors. There is a possibility of the mutant being escaped from the search domain.

Crossover

Using crossover operator in DE a new trial element is constructed using the present and mutant elements. During the process for each variant relationship between crossover rate and mutation probability is taken into account [4].

It is defined as an equation:

$$u_{ji,G+1} = \begin{cases} v_{ji,G+1} \text{ if } (rnd_j \leq CR) \text{ or } j = rn_i, \\ q_{ji,G} \text{ if } (rnd_j > CR) \text{ and } j\ 6 = rn_i \end{cases}$$

CR stands for the crossover constant. It is index chosen randomly.

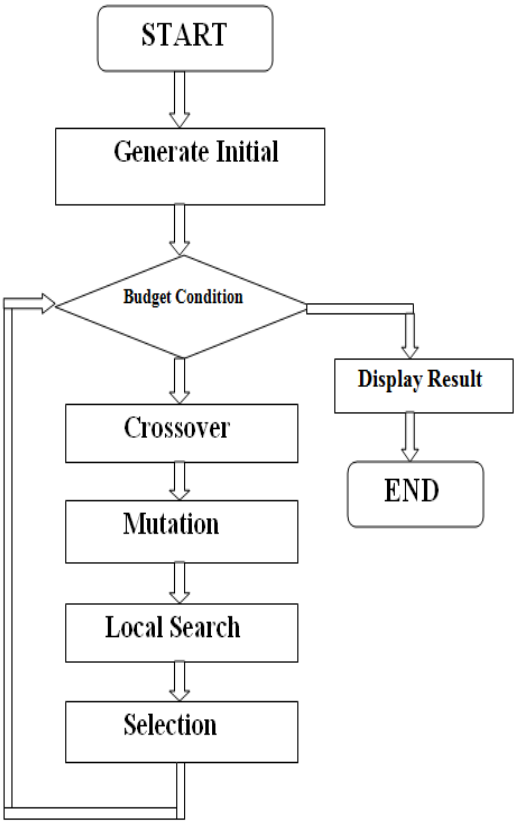
Selection

It works on "hit and trial" mechanism. Here, presentation of trial vector and its parent being compared. All the solutions possess the same probability of being selected as parents and not dependent of their fitness value. The better one of trial vector and it's parent are passed on to the next generation. It has a significant or we can say powerful advantage of converging performance over Genetic algorithm.

Local Search

Many of the real world problems include very large number of the decision variables. To improve the resourcefulness of DE to solve the problems. An unusual local search Operation is being used. It combines orthogonal crossover and opposition based learning scheme. At the time of DE evolution one individual is chosen randomly to undergo the process.

In this the current solution which contains the filter coefficient is disturbed along positive and negative direction. The best point is recorded. Hence, it can improve the DE's search ability without requiring much computing time.




### C. FLOW CHART

In this method first we initialize a population of random variables. A budget condition is set to check whether the current population is fit enough to be passed onto the next generation. If yes, then, we have obtained the optimal solution of the given problem. If no, then crossover is done. For the information exchange between a mutant vector and current target vector crossover is introduced. And then Mutation operation adds vector differential to a population vector of individuals. This is very important in DE. After mutation and crossover a local search is performed to see whether the current population is fit enough. Finally, this selection criteria lets the fit species and the unfit ones are again checked against the budget condition and so the process repeats itself.

## III. SIMULATION RESULT

We used a Rastrigin function as an artificial landscape to check the stability of the filter that we designed. It is a concave function. It is used as an artificial landscape for optimization problems. It has a number of local minima in it, so our algorithm did not get stuck in the local minima during optimization.

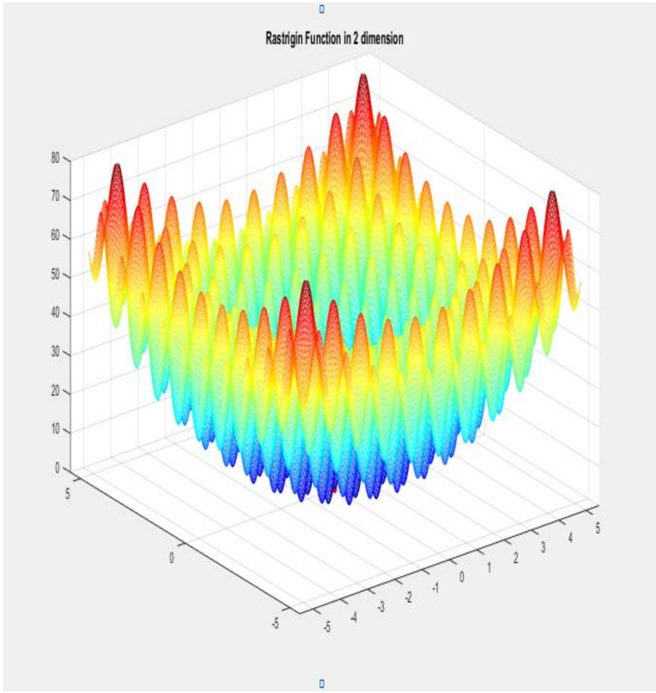



**Fig. Restrigin Function In 2-D**

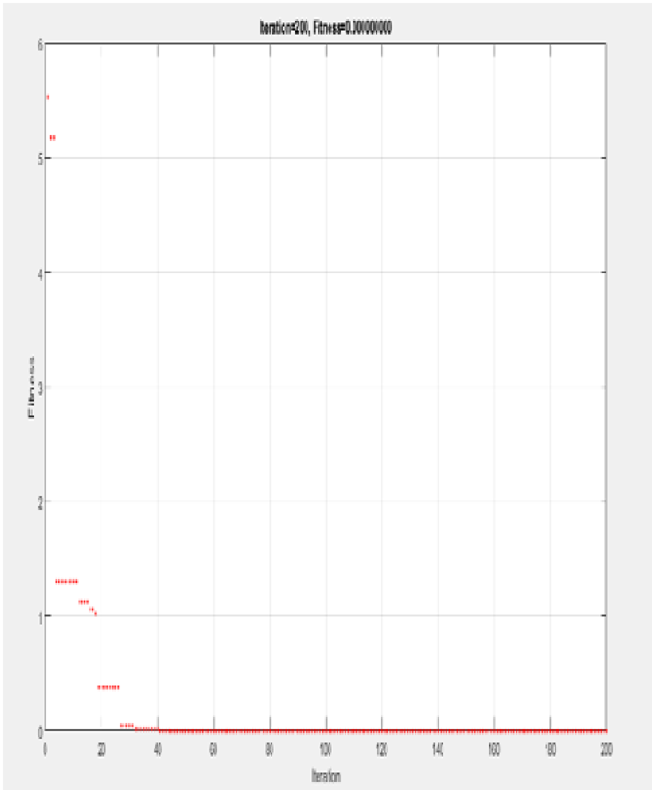


**Fig. Fitness V/S Iteration**

*Retrieval Number B2420078219/19©BEIESP*
*DOI: 10.3940/ijrte.B2420.078219*
*Journal Website: www.ijrte.org*



*Published By:*
*Blue Eyes Intelligence Engineering & Sciences Publication*

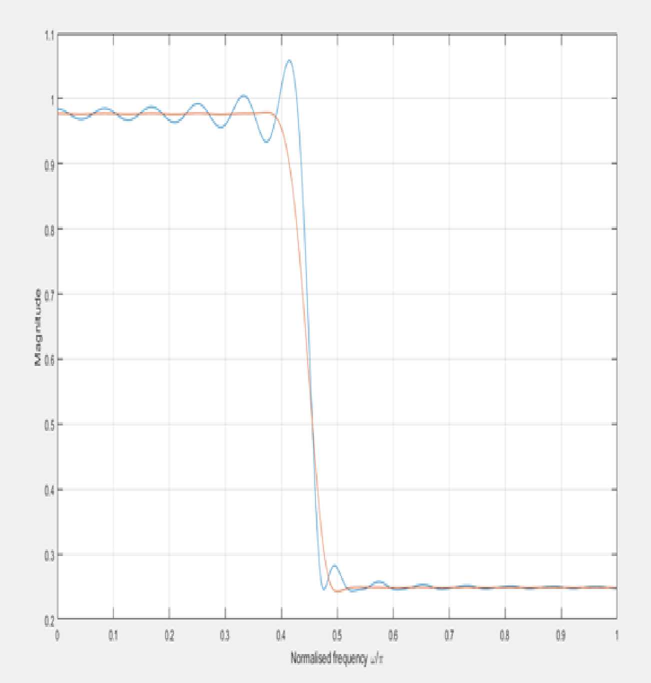



**Fig. Magnitude V/S Normalized Frequency**

This is the Magnitude v/s Normalized frequency graph of the FIR filter we have designed. It's a low pass filter. The phase error here has been minimized to zero.

There are no ripples in the stop band but the passband contains some ripples. The maximum value of magnitude is 1.08. and the cut-off frequency lies at 04.95.

**TABLE I**

| Serial Number | Filter Parameters | | |
|---|---|---|---|
| | Name | Representation | Value |
| **1.** | Population Size | L | 50 |
| **2.** | Boundary Constrains of Optimization Variables | S | 2 |
| **3.** | metamorphosis Factor | Fm | 0.51 |
| **4.** | cross Rate | R | 0.89 |
| **5.** | No. of Iterations | | 200 |

**FILTER PARAMETERS**

## IV. CONCLUSION

The DE here is used for the design of FIR filter. The DE method has the following merits over genetic algorithm (GA) and PSO:

- It exhibits controllable convergence speed.
- It is easier to implement.
- It is robust in comparison.

We have used exploratory local search method to find the optimal solution. We can implement and design lower as well as higher order digital filters. It works well on random values and also supports non-linearity. This randomization support is because the De algorithm uses probability distribution.

- Significant speedup using DE over exhaustive search.
- Additional testing needed.
- The concepts of differential evolution method have been discussed in a very simple way.
- Further, its algorithm has been developed. Also, DE programming codes in MATLAB environment have been given and an example has been solved successfully which demonstrate the effectiveness of the algorithm.

The following conclusion can be drawn from this work:-

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

## ACKNOWLEDGMENT

I would like to extend my sincere gratitude Inspiration and guidance are invaluable in every aspect of life, which we have received from our respected project guide Prof. Dr. Mahesh S. Chavan, who gave us his careful and ardent guidance because of which we are able to complete this paper. More words won't suffice to express our gratitude to his untiring devotion me to publish a paper on "Design of Digital Filter by Differential Evolution" He undoubtedly belongs to the members of the artistic gallery who are masters in all aspects.

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