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Optimal Side Lobe Reduction in Symmetric Linear Antenna Array Using Genetic Algorithm

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Abstract- The antenna arrays have a wide range of applications such as phase array radar, satellite communications and other domains. In order to reduce interference antenna array should have lower side lobes and pattern symmetry in azimuth angles. The nonlinear least square (NLS) method cannot meet the demand of such complex optimization problems. Genetic algorithm is an evolutionary algorithm following the principle of natural selection. In this paper Side lobe levels for a linear array antenna are reduced using Genetic algorithm.

Index Terms: Linear Array Antenna , Genetic Algorithm, Side Lobe levels, Array Factor.

1. INTRODUCTION

The antenna is the basic part of the wireless communication. It is mainly used to transmit and receive signals. To get better radiation, it is necessary to modify the geometric configuration or the other parameter of the device. A group of antennas arranged in a geometrical configuration is called as a antenna array.

Linear arrays with narrow main beamwidth are used in point to point communications and high angular resolution radars. However, in applications where angular symmetry in direction finding is desired, they are not suitable. To overcome this restriction, efforts were made to design the linear arrays. Linear array antenna is an assembly of similar radiating elements geometrically and electrically in the form of a line. The radiation pattern of linear array antenna with isotropic elements depends mainly on parameters like the excitation current, phase, and the spacing between the elements. In the array design process excitation currents, excitation phases, and inter element spacing are the parameters that can be controlled to achieve the required objective. The below expression gives the array factor of a linear array antenna.

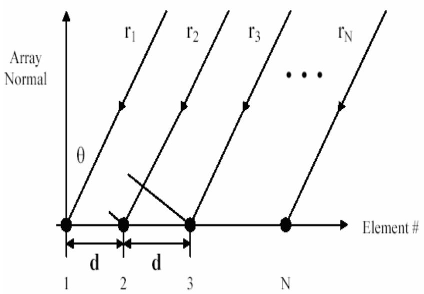

Figure 1: Linear Array of N elements

Array Factor of Linear Array is given as follows

$$AF=\sum e^{j(N-1)\psi}$$

Where $\psi=\beta d\cos\theta$.

2. GENETIC ALGORITHM (GA):

Genetic algorithm (GA) is a populati ed global optimization algorithm which works on the mechanics of natural selection. It can be used to optimize a solution of any problem involving a population. GA is best suited if the objective function is discrete, highly non linear, high dimension, stochastic and has unreliable or undefined derivatives.

GA conceptually follows steps inspired by the biological process of evolution. It follows the idea of survival of the fittest which means only the fittest of the generations survive to next generation. Better and better solutions evolve from previous generations until a near optimal result is obtained.

Terms related to GA:

Gene – Gene is a single encoded part of the solution space, i.e. either single bits or short block of adjacent bits that encode an element of the candidate solution.

Chromosome – A string of genes that represents the solution.

Population –The number of chromosomes available to test.

Selection – It is a process of selecting proportion of the existing population to bread a new breed of generation. Parents with better fitness can have better chances to produce offspring. Three types of selection mechanisms are there which popular rank, tournament and roulette wheel.

Crossover – Crossover is a genetic operation that combines (mates) two individuals (parents) to produce two new individuals (Childs). The idea behind this operation is that the new chromosome may be better than both of the parents if it takes the best features from each of their parents. There are 4 types of crossover single point, two point, uniform and real value.

Mutation - A genetic operator which maintains genetic diversity from one generation of chromosomes to the next. It is analogous to biological mutation. Mutation Probability determines how often the parts of a chromosome will be mutated. Types of mutation are bit reversal and polynomial.

Fitness function - A fitness function quantifies the optimality of a chromosome so that the particular solution may be ranked against all the other solutions. It gives the closeness of a given solution to the desired result. Most functions are stochastic and designed so that a small proportion of less fit solutions are selected. This helps keep the diversity of the population large, preventing premature convergence on poor solutions. The fitness function for the optimization is given as

Fitness=min (max (20*log AF)/AF)

Termination – Termination of the algorithm will be done if a solution is found that satisfies minimum criteria or fixed number of generations found or allocated budget (computation, time/money) reached or the highest ranking solutions fitness has reached.

Flow chart For GA:

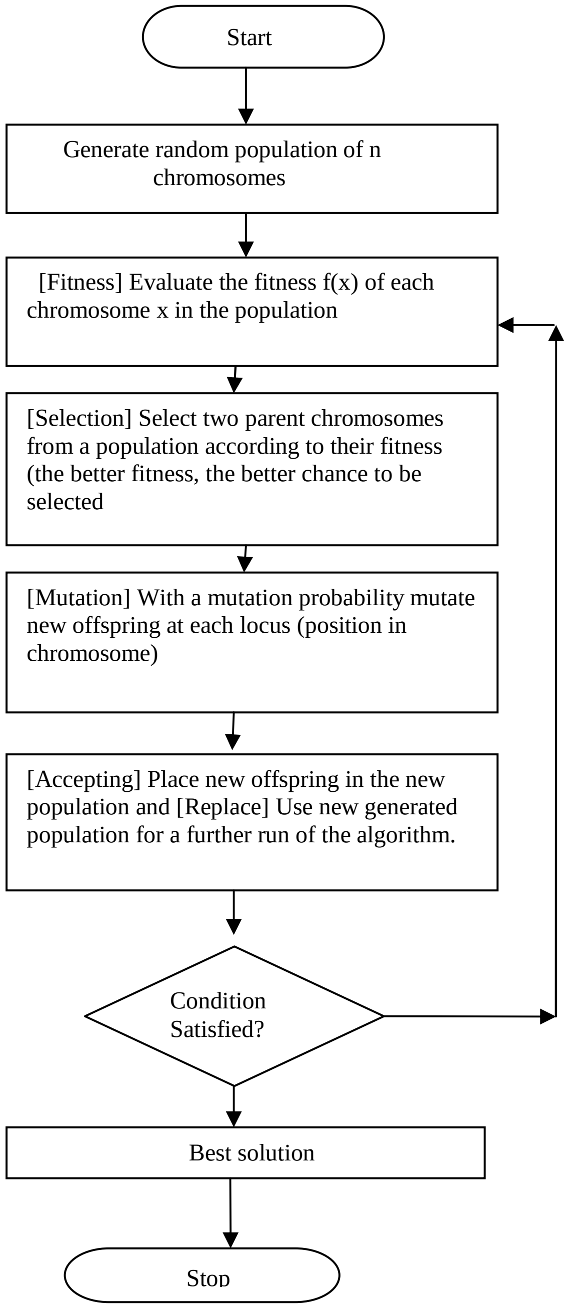

Figure 2: Flow chart for Genetic Algorithm

Outline of the Algorithm:

The following outline summarizes how the genetic algorithm works:

1. The algorithm starts by generating a random initial population.
2. The algorithm then populates a sequence of new populations. At each step, the algorithm makes use of the individuals in the current generation to create the next generation. To create the new

population, the algorithm performs the following steps:

a. Ranks each member of the current population by computing its fitness value.

b. Scales the raw fitness scores to convert them into a more usable range of values.

c. Selects parents, based on their fitness.

d. Some of the individuals in the current population that have better fitness are chosen as best off springs. These elite individuals are passed to the next population.

e. Produces children from the parents. Children are produced either by making random changes to a single parent—mutation—or by combining the vector entries of a pair of parents—crossover.

f. Replaces the current population with the children to form the next generation of individuals.

3. The algorithm terminates when one of the stopping criteria is met.

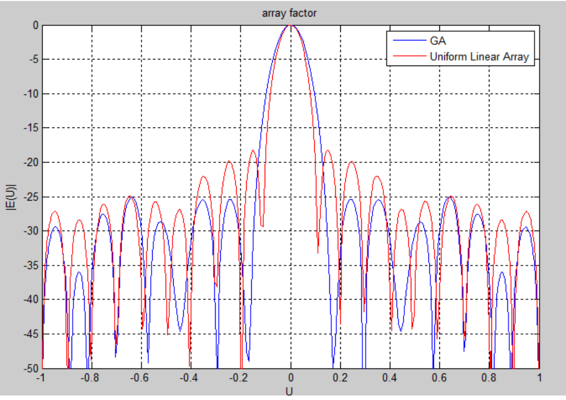

Figure 4: Plot for 10 element array

Type of excitation	1st SLL	2nd SLL	Max SLL
Uniform linear array	-18.5dB	-20dB	-18.5dB
Linear array with GA	-25.5dB	-25.5dB	-25dB

4. RESULTS & DISCUSSION:

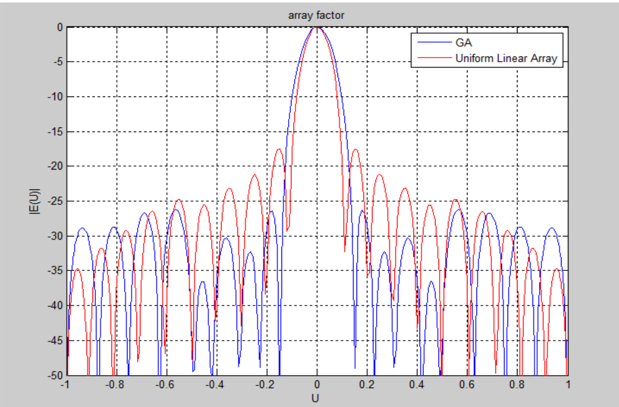

Figure 3: Plot for a 10 element array

ype of excitation	1st SLL	2nd SLL	Max SLL
Uniform linear array	-17dB	-22dB	-17dB
Linear array with GA	-27dB	-33dB	-26dB

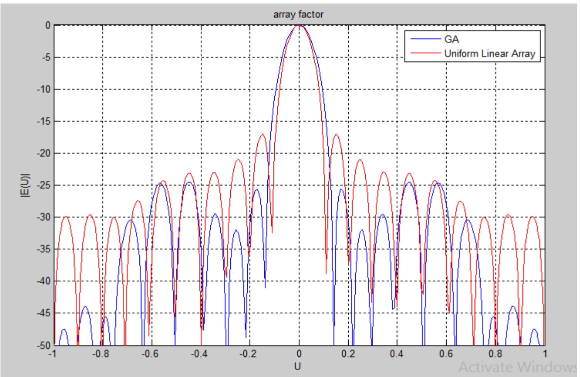

Figure 5: Plot for 10 element array

Type of excitation	1st SLL	2nd SLL	Max SLL
Uniform linear array	-17dB	-21.5dB	-17dB
Linear array with GA	-26dB	-33dB	-25dB

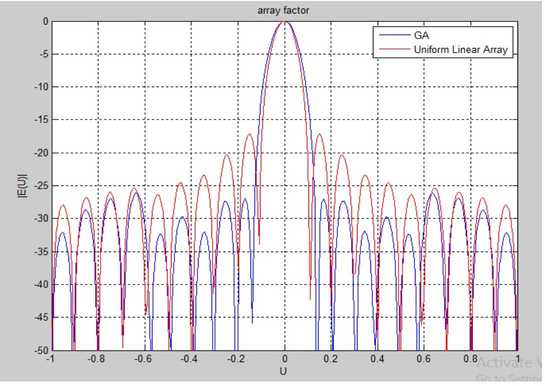

Figure 6: Plot for 10 element array

Type of excitation	1st SLL	2nd SLL	Max SLL
Uniform linear array	-18dB	-20dB	-18dB
Linear array with GA	-27.5dB	-28dB	-27dB

CONCLUSION:

It is evident from the above results that the application of excitation currents obtained by GA optimizes side lobe levels to a greater extent compared to uniform excited arrays. Above radiation plots clearly show that results obtained with GA are comparatively better with a SLL reduction of around -8dB (for 1st SLL) than that of results obtained by uniform excitation for the linear antenna arrays.

The work can be extended to linear array antennas with multiple rings and other array antennas to get a better side lobe level which may enhance the capability of scanning in multiple directions with low interference.

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