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Synthesis of Linear Antenna Array Using PSO to Reduce Side Lobe Level for WLAN

Mayank Vishwakarma ,Kanchan Cecil
Department of Electronics and Communication, Jabalpur Engineering College M.P., India

Abstract*—this paper uses Particle Swarm Optimization (PSO) algorithm optimization method for the synthesis of broadside linear antenna array. In this paper optimum value of current of each antenna element is determined which produces radiation pattern with minimum side lobe level. Optimization is done using MATLAB. PSO algorithm is used which enables search in broader space along randomly generated directions to produce new generations. This improves the performance greatly to achieve the directivity and maximum reduction in side lobe level with minimum function calls and efficiently applicable for WLAN.

***Keywords*—Antenna array, PSO, cost function, fitness function WLAN**

I. INTRODUCTION

With the advent of technology and recent developments in communication, wireless communication has reached to new level. Recent updates in wireless communication were not possible without application of smart antennas. Use of smart antennas is one of the vital characteristic that has led to third and fourth generation standard developments. However, smart antenna theory always driven by the Antenna array and so do the wireless communication. With antenna pattern synthesis there comes speed and robustness to the existing system thereby improvising transmission parameters [3]. Along with this radio wave propagation is a matter of research that accounts to faster and reliable transmission, since wireless is generated from the roots of radio communication. However, there is a long way to go and research will contribute entirely for new upgrades in it. The primary objective of this paper is to study the effect of linear array antenna on wireless local area Network (WLAN) and then the optimization of a linear array antenna using PSO for side lobe level reduction thereby improving the communication.

II. ANTENNA ARRAY

An antenna array [5] is a set of N spatially separated antennas. In this paper, antenna with N=5 elements are considered as array of antenna. An array of antenna can have number of elements which may include several thousand elements. An antenna array is preferred over single antenna as it has ability to filtrate the intentional electromagnetic radiation in the air. Consider a linear array of n isotropic elements of equal amplitude and separated by distance d. The total field E at a far field point P in the given direction φ is given by,

$$E = 1 + e^{j\psi} + e^{2j\psi} + e^{3j\psi} + \cdots \ldots\ldots\ldots\ldots + e^{(n-1)j\psi}$$

Where, ψ = total phase difference of the fields from adjacent sources. It is given by;

$$\psi = 2\Pi \left(\frac{d}{\lambda}\right) \cos\varphi + \alpha$$

α is the phase difference between excitation current of adjacent element of antenna array.
The basic setup of an arbitrary antenna array is shown in Figure 1.

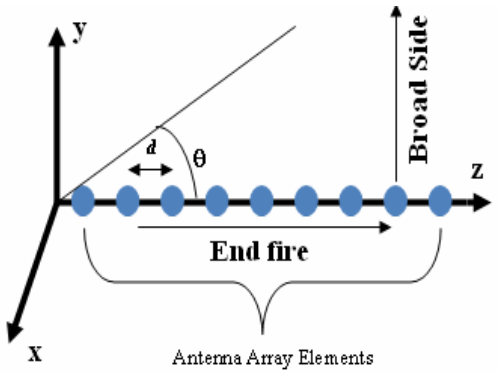

Fig:1 Uniform Antenna Array

The array factor for, N number of elements

$$AF = \sum_{n=1}^{N} E_n = \sum_{n=1}^{N} e_n{}^{jk}$$

Where $E_n = e_n{}^{jK}$ and K= (nkdcosθ + β_n) is the phase difference. β_n is the phase angle. The antenna array can be used to:

- It increases the overall gain of the transmission.
- It helps to determine the direction of incoming signals
- Maximize the Signal to Interference Plus Noise Ratio(SINR)
- "Steer" the array so that it is most sensitive in a particular direction
- Cancel out interference from a particular set of directions
- Provides diversity reception

III. OPTIMIZATION TECHNIQUES

With the current development in antenna technology, optimization techniques have been as popular as a method of improving the recent standards in various parameters. In this paper we have used the particle swarm a optimization method. The increased level of side lobes can significantly

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degrade the system performance as well as antenna power efficiency. Though it is confirmed that Side lobe reduction is the basic way to achieve power efficiency and signal losses during transmission, yet it has to be followed with certain processes that results in side lobe reduction. Below are the processes through which the fact can be achieved.

1) Amplitude Only Control
2) Phase Only Control
3) Position Only Control
4) Complex Weights (Includes amplitude and phase control).

Set of variable attenuators are used within the Amplitude Only Control to adjust the element amplitudes. If the element within the amplitudes reveals even symmetry around the array, the number of attenuators and the computational time are seem to get considerably reduced. The trouble related to phase-only and position-only nulling is it's intrinsically nonlinearity. Also, the problem could not be solved by with any analytical methods. However, use of some approximation in it helps to get the problem solved.

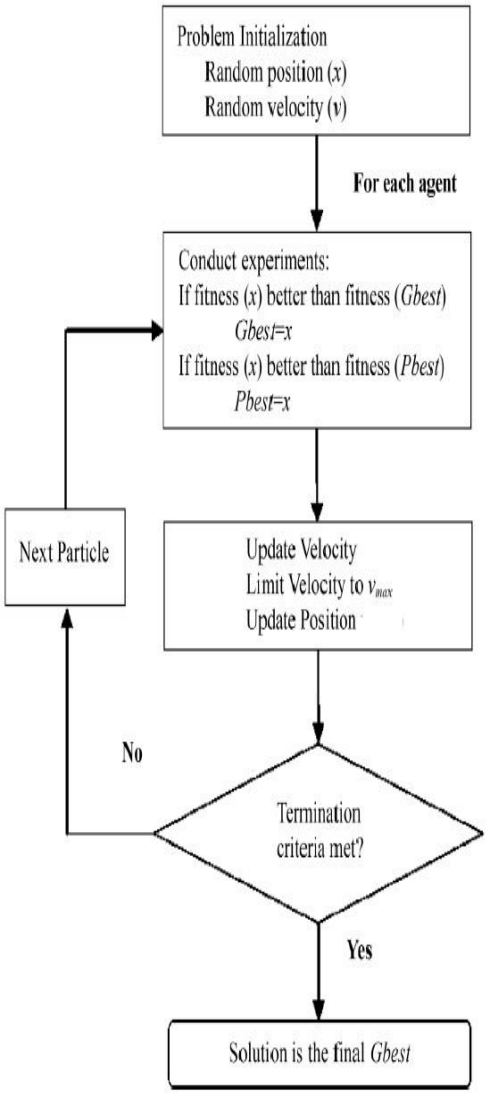

Fig 2 Particle swarm optimization flow chart

To linearize the nulling in via phase only method, perturbations are assumed to be minor. Use of mechanical driving is in position-only control while that of phase-only control [5] uses the phase shifters. Because of low cost and easier to implement, phase only control is often used as technique for side lobe level reduction for an antenna array.

For a broadside linear array of 'n' number of isotropic elements, 100 iterations utilize the approximate amount of time for side lobe reduction. However, after certain number of iteration in the experiment, the side lobe level (measured in db) seems to get reduced eventually with a considerable amount. As shown in figure below, the pattern received through employment of technique to considerably reduce the side lobe level justifies that with the same spacing the use of Genetic Algorithm [11] produces side-lobes which are just as low as possible. The PSO method [12][13] has been demonstrated to be effective in optimizing difficult, multidimensional, and discontinuous problems in a variety of fields. Like bees searching a field for the location of the highest concentration of flowers, particles in PSO are attracted to the best location found by the entire swarm and to the best location personally encountered by the particle. Eventually, after being attracted to areas of high flower concentration, all bees swarm around the best location. As an evolutionary algorithm, PSO shares the ability of GA to handle arbitrary nonlinear cost functions. One advantage of PSO over GA is the algorithmic simplicity.

IV. SYSTEM DESCRIPTION

The MATLAB based simulation code has been generated for the development for the beam pattern from given antenna array pattern and has facilitated with the PSO based optimization.

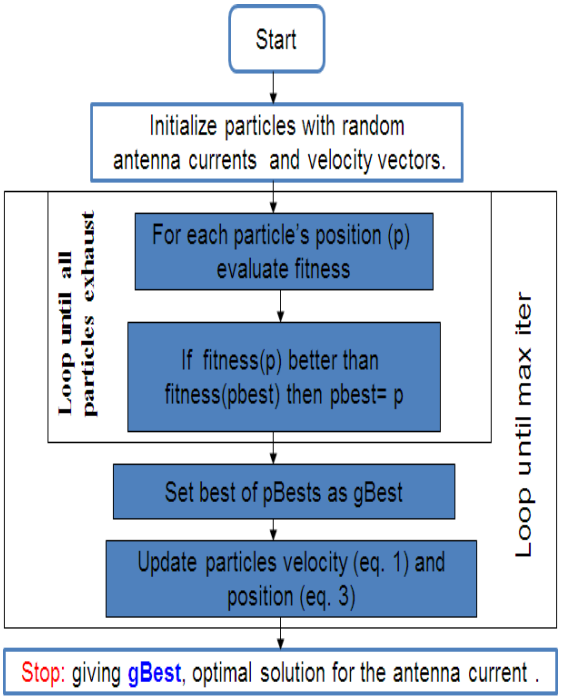

Fig 3 system description flow chart

V. SIMULATION RESULTS

The following parameters are used for the system development in MATLAB.

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Table 1

S. No.	Parameter	Value
1	Frequency of operation	2.4 GHz
2	Spacing between elements d	5 cm
3	Phase between two elements	0 Radian
4	Type of antenna array	Broadside
5	No. of element	5
6	Output parameter	side lobe level, Directivity and Beamwidth

Comparisons between GA and PSO is given in following table

Table 2

S.NO	Parameter	Without optimization	GA	PSO
1	Side lobe level reduction in db	-12.04	-31.70	-34.38
2	Directivity(dB)	10.57	10.83	10.93
3	Beamwidth(degree)	34.13	33.27	28.24

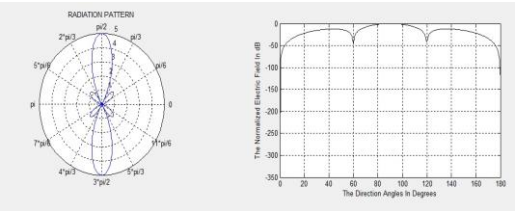

Fig 3:- Unoptimized Radiation pattern

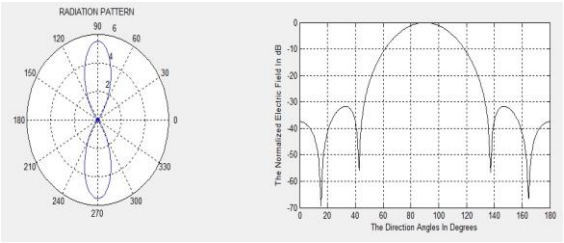

Fig 4:- optimized Radiation pattern using Genetic Algorithm

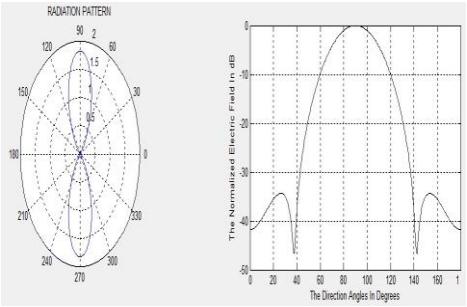

Fig 5:- optimized Radiation pattern using PSO

VI. CONCLUSION

In this paper Particle swarm optimization [12] algorithm in MATLAB is used to obtain maximum reduction in side lobe level relative to the main beam. This paper compares the results of PSO and Genetic Algorithm, and it is found that the changes found in comparison gives better values of antenna elements weights as compared to GA. Enhancement in directivity and maximum reduction in side lobe level is observed in the work can be extended to improve the greater directivity also while reducing side lobe level, same experiment can be done for array with large number of elements as compared to this.

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