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Position only Antenna Array Synthesis using Normal Distributed Invasive Weed Optimization

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Abstract*: Nowadays, low-side lobe antenna arrays are used in many communications systems such as satellite, cellular, radar and wireless communications. The antenna array with low side lobe rates should be designed to avoid noisy contact. A new stochastic approach to synthesize a linear antenna array to suppress normal distributed invasive weed optimization (NDIWO) is proposed in this paper synthesize a linear antenna array to suppress the side lobe levels. NDIWO is applied for optimization of the positions of the antenna elements. A 28-element linear array is designed and synthesized by using the proposed and other popular evolutionary algorithms. The acquired radiation designs are gathered with the calculations like particle swarm optimization (PSO) and differential evolution (DE). The numerical results illustrate that the NDIWO optimized antenna array performs superior over PSO and DE optimized arrays in terms of low PSLL and convergence properties.

Keywords*: Antenna array, Invasive weed optimization, PSO, DE, Normal distributed Side lobe level.

I. INTRODUCTION

For radio, satellite, phone or radar communications networks, array antennas are commonly used. Such antenna arrays are used to enhance the path and signal performance by extending antenna system coverage area and increasing antenna system efficiency through the ability to control antenna array beams. The method of interaction depends on the antenna array composition. Narrow beam width and low SLL are needed to improve its ability to place nulls in the desired directions and not deviate from EM emissions and place nulls in undesirable directions. There is considerable versatility in controlling the radiation pattern shape without the uniform feeding network being influenced by the use of non-uniform component spacing in aperiodic arrays.

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It is possible to acquire an aperiodic antenna array by discharging the elements in an array or by nonlinear spacing of elements. It is possible to obtain unequally spaced antenna arrays by altering the geometric locations of antenna components The opening length of the antenna changes based on the arrangement in an unequally spaced range. Advantages of non-uniform spacing in antenna array are the removal of grating lobes and bandwidth scanning applications. Synthesis of aperiodic antenna array is a simple feeding network involving non-convex and non-linear optimization. Many algorithms such as genetic algorithm (GA)[3-7], differential evolution (DE)[8-12], and particle swarm optimization (PSO)[13-15] are implemented to optimize electromagnetic design problems, Ant colony optimization (ACO)[16].

Because of its global experience and regional problems, it is applied in the synthesis of antenna array. It shows a significant potential for application in the synthesis of the antenna array. In the IWO antenna array, errors in the amplitude and phase excitation of individual elements are used when positioning nulls in defined directions and generating the radiation pattern with the least possible side lobe rates.

II. NDIWO

Invasive plant settlement in nature is the foundation for the method of Invasive Plant Optimization. The behavior of the cropping field weed colonization can be explained as follows.

(i) Weeds occupy a wide area in cropping field and fill the places between the crops.

(ii) Every weed after settling in a appropriate area grows by in taking the left out or unused resources to a flowering weed and thus produces new weeds

(iii) This process continues until the weed hits its full expansion limit due to limited resources.

(iv) Now those weeds that are environmentally adapted can thrive and produce new weeds.

A. Algorithm:

These are the key words used to describe the process of the algorithm.

Agent/Seed	Value of optimized variable.
Fitness	The value which decides the strength of the result for each seed.
Plant	An operators or seed after estimating its Fitness value

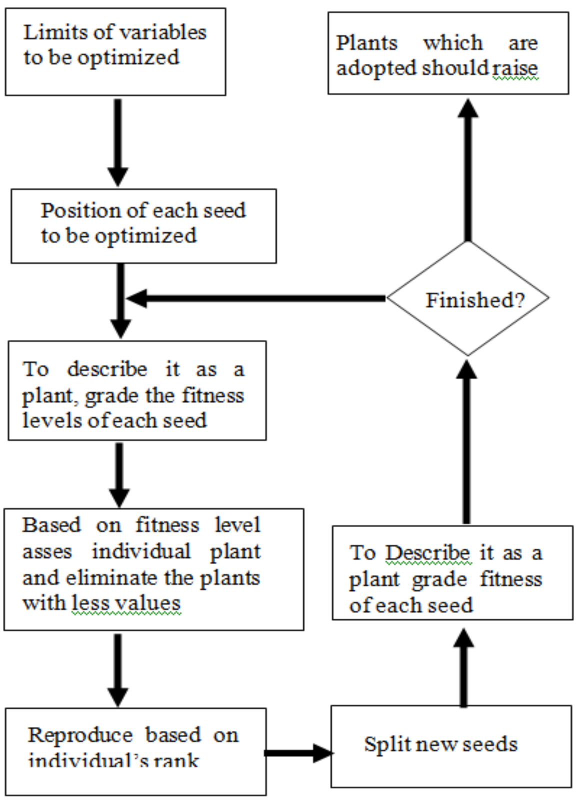
Colony	Group of complete operators or seeds
Population size	The number of plants present in the colony.
Maximum number of plants	Maximum number of plants which can produce new seeds in the colony.

B. Features of NDIWO:

One essential property is that it allows every one of the operators or plants to take participation within the replica method. More, it's do able that several the plants with the lower fitness carry additional helpful data compared to the fitter plants. This algorithmic guide, the IWO, offers an opportunity to the less work plants to breed and if the seeds by them smart finesses within the colony, they will survive.

Another essential feature of Iwo is that weeds regenerate while not union. Every weed will manufacture new seeds, severally. This property adds a substitution attribute to the algorithmic rule that every agent might have completely different range of variables throughout the optimization method. Thus, the quantity of variables is often chosen mutually of the optimization parameters during this algorithmic rule. Optimizing the quantity of variables provides such a remarkable feature to the optimization that may handle some new magnetic force style issues. The effectuality of this sort of optimization for choosing aperiodic cut array antennas.

C. Flow chart:



III.LINEAR ANTENNA ARRAY

It is defined as the arrangement of arrays in linear or straight-line fashion.

The azimuth plane comprises of an array and the array factor of that array (AF) is:

$$AF(\theta) = \sum_{m=1}^{M} e^{j2\pi\left(\frac{d}{\sigma}\right)\sin(\varepsilon)} A_m$$

Where ε is the azimuth angle

By using wavelength, the elements can be normalized and the spacing between these elements is d/σ= 1/2

$$A_m = I_m e^{\emptyset m}$$

Where I_m and $\emptyset m$ are the excitation amplitude and phase of element n respectively.

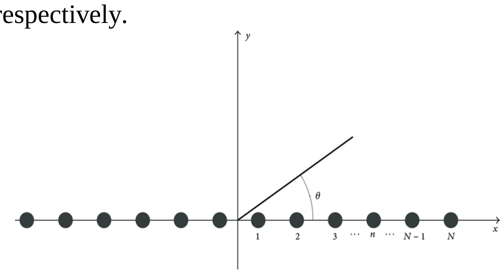


Fig.1.Representation of linear antenna array..

IV. OBJECTIVE FUNCTION

In the antenna array for the individual elements, controlling of null positioning by employing non uniform excitations and to depreciate the side lobes is the main aim of the optimization. This can be done by using fitness function which is as mentioned below

$$\sum_m \frac{1}{\Delta\theta_m} \int_{\theta_{lm}}^{\theta_{um}} |AF(\theta)|^2 \, d\theta + \sum_j |AF(\theta_j)|^2$$

Where θ_{lm} and θ_{um} are the minimized side lobe spatial coordinates.

θ_k is the nulls angular position

$$\Delta\theta_m = \theta_{um} - \theta_{lm}$$

By solving the firs term of the above fitness function equation, the minimized SLL is obtained and by solving the second term, we obtained the null controls.

V.NUMERICAL OBSERVATIONS

A 28-element linear antenna array was considered to illustrate the functioning of NDIWO, PSO, and DE methods for optimizing antenna element positions for minimum SLL peak in the side lobe region. Due to its more popularity, this example has been synthesized and synthesized with more common stochastic methods. Table I includes the parameter configuration for NDIWO, PSO and DE algorithms. The angular region of side lobe area has been sampled at 0.2^0. All the algorithms are verified for 50 trails to obtain the mean performance of the algorithms. MATLAB is used for all the simulations. The optimized position of the elements and the performance of their array using NDPSO, PSO and DE are shown in Table II.

The radiation patterns generated using the 28-element linear array's NDIWO, PSO, and DE are shown in Fig. 2. It can be seen that, in contrast to PSO and DE, NDIWO generates a lower PSLL. NDIWO produces -22.09 dB of PSLL, PSO produces PSLL of -20.57 dB and DE produces PSLL of -19.10 db. The first null beam width was maintained as the first null beam width of the periodic array. The convergence graphs used by NDIWO, PSO and DE for the 28-element linear antenna array are shown in Fig.3. It can be observed from Fig. 3 that, NDIWO outperforms slower than PSO and DE in terms of low PSLL. Also, it can be concluded that NDIWO converges faster than PSO and DE. After the scrutiny it can be concluded that, the NDIWO outperforms the advanced evolutionary algorithms PSO and DE in terms of low PSLL and convergence speed.

I. Parameters setup for NDIWO, PSO and DE

NDIWO		PSO		DE	
Parameters	Values	Parameters	Values	Parameters	Values
S_{max}	3	Number of particles	50	Number of particles	50
S_{min}	0	Number of generations	500	Number of generations	500
$\sigma_{initial}$	1	c_1	2	SF	0.9
σ_{finial}	0.00015	c_2	2	CR	0.5
P_{max}	20	ω	0.9	-	-
n	3	-	-	-	-
Initial population size	10	-	-	-	-

II. Optimized positions and their array performance of 28 element linear array using NDIWO, PSO and DE

Algorithm	Optimized Positions (Since linear antenna array is symmetric, so half of the positions are given below)	PSLL dB	Beam Width Deg.
Periodic Array	0.2500 0.7500 1.2500 1.7500 2.2500 2.7500 3.2500 3.7500 4.2500 4.7500 5.2500 5.7500 6.2500 6.7500	-13.3	8
IWO	0.2500 0.7500 1.2500 1.7500 2.2500 2.7500 3.3330 3.9639 4.4949 5.2448 6.0142 6.8718 7.8338 8.6492	-22.09	8
PSO	0.2500 0.7500 1.2500 1.7500 2.2500 2.7500 3.2500 4.0960 4.6616 5.2048 5.9802 6.8325 7.6693 8.5440	-20.57	8

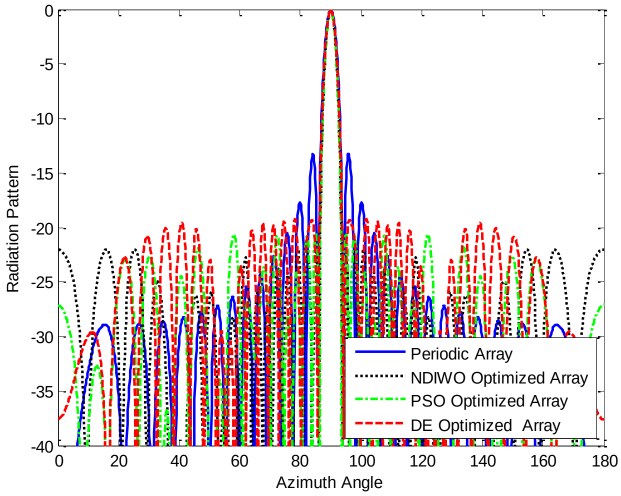


Fig.2.Normalized Radiation patterns of 28 element Linear array using NDIWO, PSO and DE.

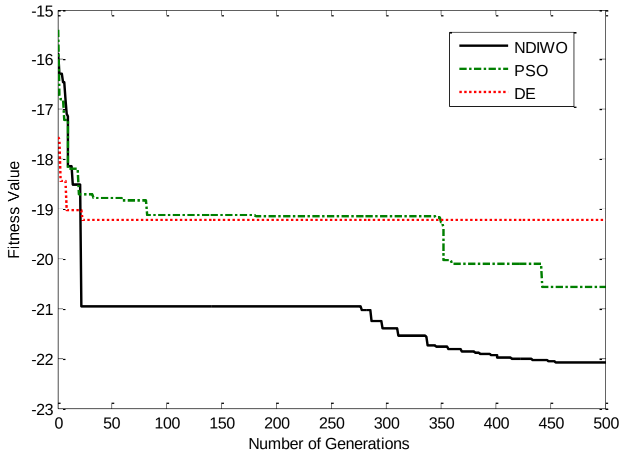


Fig.3. Convergence properties of NDIWO, PSO and DE while synthesizing 28 element linear array.

VI. CONCLUSION

In this paper, to depreciate the side lobe levels, the NDIWO is proposed to synthesize the linear aperiodic array A linear array of 28 elements is synthesized by optimizing the antenna positions of the antenna elements. The results obtained were consistent with sophisticated PSO and DE algorithms. It can be observed that, a significant minimization of SLL is achieved using the NDIWO. In terms of producing low side lobe rates, NDIWO also outperforms PSO and DE. Although the proposed method focuses on linear array synthesis, due to its global and convergence properties it may applies to other complex antenna array synthesis.

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