International Journal of Engineering & Technology, 7 (2.17) (2018) 105-107

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research Paper

Constrained synthesis of the Linear Antenna Array using Social Group Optimization

Abdul Rahiman Sheik[1, 2]*, Dr.Kalva Sri Rama Krishna[3]

[1]*Research Scholar, Department of ECE, Acharya Nagarjuna University, A.P, India.*
[2]*Associate Professor, Dept of ECE, NRI Institute of Technology, Pothavarappadu, A.P, India.*
[3]*Professor & Head of Department, ECE Department, V R Siddhartha Engineering College, Vijayawada, A.P, India.*
**Corresponding author E-mail:ska.rehman@rediffmal.com*

Abstract

In this paper, novel algorithm known as social group optimization is use for array synthesis problem. The algorithm is implemented to the electromagnetic problem solving and its performance is evaluated. The array design is carried out with the objective of sidelobe level (SLL) suppression with uniform beam width (BW) constraint. The amplitude only technique is used to determine the coefficients of current excitation which produce the desired radiation pattern with the objectives and constraints. The analysis is carried out in terms of radiation pattern for different length of linear arrays. The simulation based experimentation is carried out in Matlab.

Keywords: *Linear arrays; antennas; Social Group Optimization; SLL; BW*

1. Introduction

Antennas are majorly used in areas where wireless communication is necessary. Antennas can be used to both emit and receive radio waves [1]. Every transmitting antenna is required to possess required amounts of gain in order to successfully transmit signals over a specified range. But a single antenna cannot meet up to the requirements when it comes to long distance communication. The gain of the antenna would not be sufficient to efficiently meet up to the requirements. If the gain is increased, its beam width also gets increased resulting in signals spreading to unwanted directions as well. This can be achieved with multiple antennas known as an array [2,3]. An array of antennas would be able to solve the range and gain issues which may not be possible with a single antenna. The beam width can also be accurately adjusted in case of an antenna array.

Several conventional techniques are used to design array antenna for desired radiation patterns. However, these techniques are local search methods and often involves in complex mathematical calculations. Moreover, these techniques cannot handle multi-modal problems and cannot give global solutions. Hence, in the recent past several nature inspired meta heuristic algorithms are proposed for efficient design of antenna arrays successfully [4-7].

In this paper, such an evolutionary computing technique which is inspired by social behaviour of the human known as social group optimization (SGO) [9] is used for the synthesis of linear arrays. The design objective involves in reducing the SLL keeping the BW as that of uniform linear array. Some related techniques are presented in [8]-[13].

Further, the paper is organized as follows. The brief problem statement is mentioned in Section 2.

2. Linear Antenna Array

Linear antenna array consists of number of antenna elements arranged in a straight line. The geometry of a simple linear array is as shown in Fig 1. In the figure, the array of elements are arranged along the straight line along x-axis.

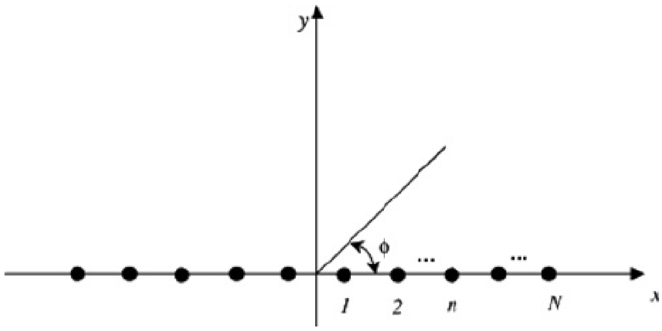


Fig. 1 Linear antenna array geometry

The radiation pattern of an N element equi-spaced non-uniform amplitude linear array is given as

$$F(\theta) = E(\theta)\sum_{n=1}^{N} a_n\, e^{j(n-1)(kd\cos\theta+\beta)}$$

Where,

a_n = amplitude only weight of each element

d is the equidistance between the elements

β is the progressive phase shift

θ is the angle from broadside

$E(\theta)$ is the element pattern

$E(\theta) = 1$ for isotropic sources

3. Problem formulation and algorithm

The problem statement can be defined as to find the appropriate current distribution of the array which produces the desired radiation pattern with the objectives (SLL) involving constraints (BW). The objective function plays a very important role in the array design which determines the convergence and the objectives. Accordingly, the objective function is formulated using the SLL and BW as shown in (1).

$$f1 = |SLL_{Des} - \max(|AF|_{(FN\text{-}90)})| \quad (1)$$
$$f_2 = |BW_{Des} - BW_{obt}|$$

The final cost function is given as

$$Cost = c_1 f_1 + c_2 f_2 \quad (2)$$

Where,
Max = maximum value
AF = Array factor
FN = fitness function
SLL_{Des} = Desired SLL magnitude
BW_{Des} = Desired BW
BW_{obt} = obtained BW
c_1 and c_2 are weighing coefficients

The SGO refers to the social behavior of the humans. A typical human has characteristics which may not be coherent with other human beings. These differences popup according to the situation. The situation can be a complex pro and the system. These features define the behavior. These behavioral features are responsible for the problem solving in general course of life. Similarly, in a society which has a group of such human beings, may utilize the individual skills for the some typical problem solving. However, it also contributes to the Group solving. Hence there is a tradeoff between the individual and group characteristics. The individual feature utilization for problem solving can be considered as the local search while the group solution is a global solution.

The local solution search is governed by the following equation.

$$Inew_{ij} = c * Iold_{ij} + r * (gbest(j) - Iold_{ij}) \quad (2)$$

Similarly the exchange of knowledge between the individuals in the society or group is governed by the following equation

$$Inew_{i,j} = Iold_{i,j} + r1 * (I_{i,j} - I_{r,j}) + r2 * (gbest_j - I_{i,j}) \quad (3)$$

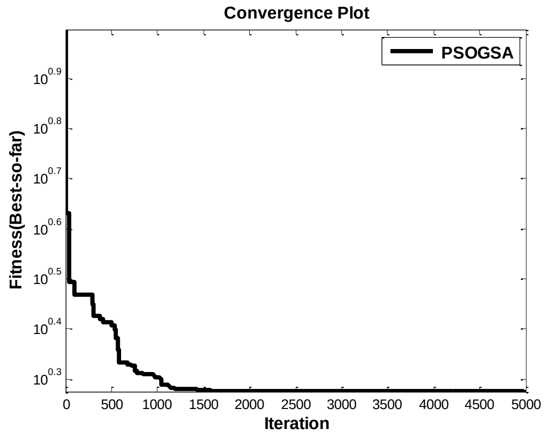
Otherwise

$$Inew_{i,j} = Iold_{i,j} + r1 * (I_{r,j} - I_{i,j}) + r2 * (gbest_j - I_{i,j}) \quad (4)$$

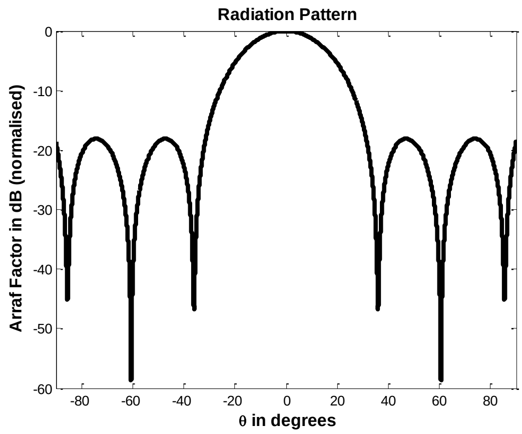
4. Results and Discussions

Results pertaining to the above discussion are presented in this Section as follows. The linear array is synthesized for N=10 to N=30 with an interval of 10. Totally four different linear arrays are synthesized. In all the cases the non-uniform distribution of current excitation are determined using the SGO algorithm. The convergence plots are also obtained for the analysis of convergence characteristics along with the radiation pattern plots as shown in Fig.2 through Fig.5.

In all the cases of varying length of the array, the corresponding SLL reported to be -13dB with different BW. All the synthesized linear arrays are compared with the uniform linear arrays in terms of their SLL keeping the corresponding BW constant. The corresponding radiation patterns for N-10, 20 and 30 are presented in Fig.2 through 5.

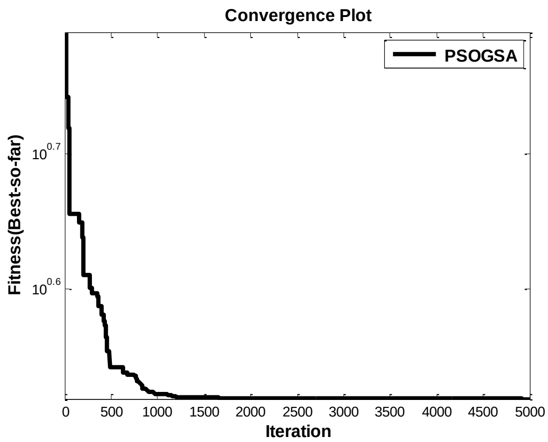


(a)

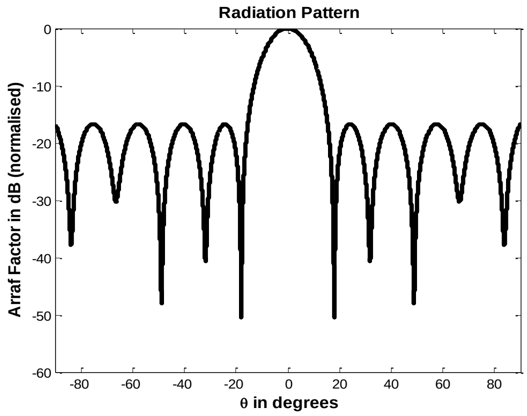


(b)

Fig.2: Linear array with N=10 (a) Convergence plot and (b) radiation pattern plot

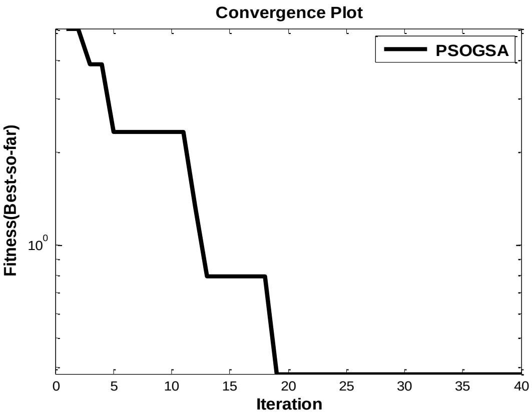


(a)

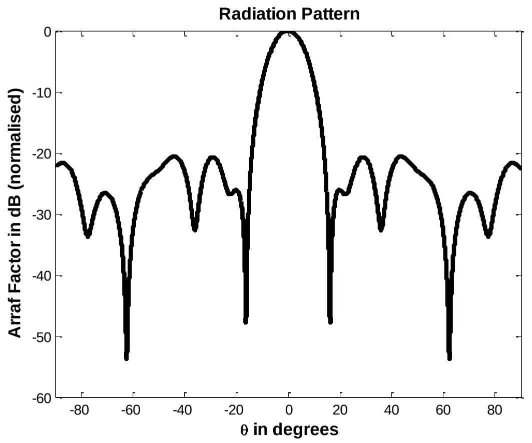


(b)

Fig.3: Linear array with N=20 (a)Convergence plot and (b) radiation pattern plot



(a)



(b)

Fig.4: Linear array with N=30 (a) Convergence plot and (b) radiation pattern plot

The corresponding SLL and the respective BW are listed in the Table 1. It is possible to compare the performance of the synthesized arrays in terms of their SLL from the table. The SLL appears to be improved when compared with the uniform linear array.

Table.1: Obtained SLL and BW of the synthesized linear array

Number of elements (N)	SLL (dB) SGO	Improvement (dB)	FNBW (degrees) Uniform
10	-18.1123	5.1	72
20	-16.2453	3.24	36
30	-20.6334	7.63	25
40	-20.3256	7.32	24

5. Conclusion

Hence, the performance of Linear antenna array with non uniform excitation is optimized using SGO Algorithm by reducing the side lobe level present in the radiation pattern. This optimization can also be applied to planar and circular arrays. Further improvement in performance can be obtained if the antenna array is subjected to multi-objective synthesis.

References

[1] C.A. Balanis, Antenna Theory: Analysis and Design, 2nd ed. Singapore: John Wiley and Sons, Asia (2003).

[2] Monzingo RA and Miller TW, Introduction to adaptive arrays, SciTech Publishing, 2005.

[3] Randy L Haupt, Antenna arrays: a computational approach, Wiley New York, 2010.

[4] Goldberg, D. "Genetic Algorithms in Search, Optimization, and Machine Learning." (1989).

[5] K.-K. Yan and Y. Lu, “Sidelobe reduction in array-pattern synthesis using genetic algorithm,” IEEE Transactions on Antennas and Propagation, vol. 45, no. 7, pp. 1117–1122 (1997).

[6] V. S. S. Chakravarthy Vedula, S. R. Chowdary Paladuga, and M. Rao Prithvi, “Synthesis of Circular Array Antenna for Sidelobe Level and Aperture Size Control Using Flower Pollination Algorithm,” International Journal of Antennas and Propagation, vol. 2015, Article ID 819712, 9 pages (2015).

[7] V. V. S. S. S. Chakravarthy and P. Mallikarjuna Rao, "Amplitude-only null positioning in circular arrays using genetic algorithm," *2015 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT)*, Coimbatore, 2015, pp. 1-5.

[8] M.L.M. Lakshmi, K.Rajkamal, S.V.A.V.Prasad, Md.Zia Ur Rahman, “Amplitude Only Linear Array Synthesis With Desired Nulls Using Evolutionary Computing Technique”, The Applied of Computational Electromagnetics Society Journal, vol.31, no.11, pp. 1357-1361, November, 2016.

[9] Suresh Satapathy and Anima Naik: "Social group optimization (SGO): a new population evolutionary optimization technique", Complex Intell. Syst., (2) 173–203 (2016).

[10] Y. Murali Krishna, Md. Zia Ur Rahman and B.V. Rama Mohana Rao, “Beam Steering in Smart Antennas using an Efficient Adaptive Signal Processing Algorithm,” International Journal of Research and Reviews in Signal Acquisition and Processing, Vol. 1(3), Sep. 2011.

[11] K. Sarath Kumar, Md. Zia Ur Rahman, “A New Computation Method for Pointing Accuracy of Cassegrain Antenna in Satellite Communication”, Journal of Theoretical and Applied Information Technology,Vol.95, no.13, 2017, pp.3062-3074.

[12] Md. Zia Ur Rahmna, K. Murali Krishna, “Efficient Adaptive Beamforming Algorithms for Smart Antennas”, International Journal of Control Theory and Applications,Vol.10, no.35, 2017, pp.173-181.

[13] Md. Zia Ur Rahman, et al., “A Low Complex adaptive algorithm for Antenna beam steering”, IEEE 2011 International Conference on Signal Processing, Communications, Computing and Networking Technology (ICSCCN 2011), ISBN: 978-1-61284-653-8, pp.317-321, 2011.