Circular Array Synthesis Using Social Group Optimization Algorithm

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Abstract - Circular arrays have the advantage of certain inherent features like pattern steering capabilities. However, synthesis of circular arrays is a complex issue. In this paper, the synthesis of circular arrays with the objective of sidelobe level suppression is carried out using novel social group optimization techniques. The produced patterns are compared with those of the uniform distribution of circular arrays. The circular array of 20, 30 and 50 elements is designed with the SLL of -25dB as target. The analysis of the array is carried out in terms of the radiation patterns.

Keywords: Circular array, SGOA, SLL, Optimization

I. INTRODUCTION

Array synthesis for smart antenna applications has a predominant role in wireless communications. They are often treated as highly directive antennas. Directivity of an antenna has a direct impact on the physical dimensions of it. Whereas the physical dimensions are function of operating wavelength, for example the height of the antenna is half-wavelength. This is evident from mathematical relations and from the existing literature in this field. This is not intended as most of the communication under wireless technology is frequency dependent. Any variation in the frequency of operation of the antenna will have impact on the application.

A typical antenna array consists of N elements and named as an N-element array [1-9]. All the elements are spatially distributed. Basing on the geometrical distribution, the array antenna is named as linear, planar and circular array. By varying the amplitude and/or phase excitation of an array element, the resultant radiation pattern can be modified as per the requirements. These three parameters known as Amplitude, Phase and Spacing between the elements are the three steering parameters for an antenna array. Evolutionary optimization methods are used to generate radiation pattern with predefined nulls by controlling complex weights in linear arrays [3,4]. Similarly amplitude only, phase only and spacing only array synthesis using evolutionary algorithms have also reported good results in obtaining desired nulls and optimised SLL [5-9].

In this paper, the recent socio-culture inspired optimization algorithm known as social group optimization algorithm (SGOA) is used to synthesize circular array. Further, the paper is organised as follows. The problem statement is mentioned in Section 2 and the corresponding mathematics related to the formulation of the array factor of circular array and its geometry is given in Section 3. Results pertaining to the objectives are given in Section 4 and the overall conclusions are given in Section 5.

II. PROBLEM STATEMENT

Elements in uniform circular arrays (UCAs) are equally spaced along the circumference of thecircle. General uniform distribution of the amplitudes on each element which is a simple case is the uniform distribution. The uniform distribution typically has unit amplitude on all the elements of the array similarly and uniformly. The corresponding SLL of the UCA is reported to be -7.9dB for 20, 30 and 50 element lengths. The same is evident from the Fig.1, Fig.2 and Fig.3.

In order to optimize the SLL, one or more of the steering parameters have to altered. In this paper, the circular array synthesis is carried out using Amplitude only technique in which only the amplitudes of each element are determined using the SGOA.

Accordingly, the problem statement can be mentioned as to determine the appropriate coefficients of amplitude distribution of every element which produces the desired SLL and pattern shape.

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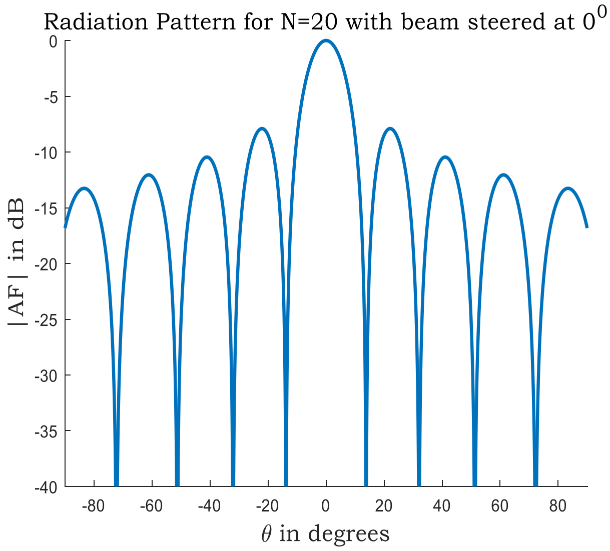

Fig.1: Radiation pattern of UCA of N=20

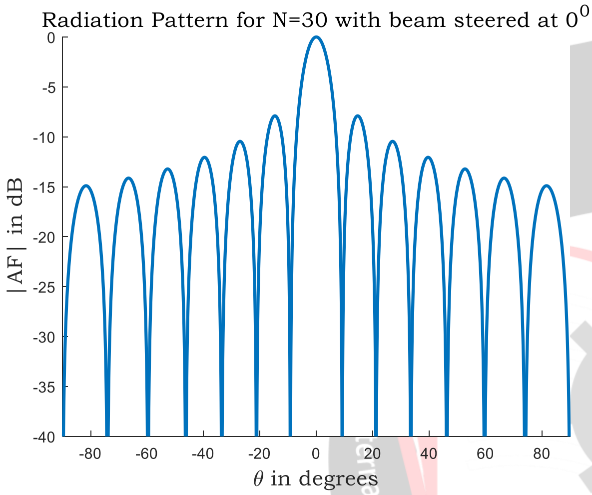

Fig.2: Radiation pattern of UCA of N=30

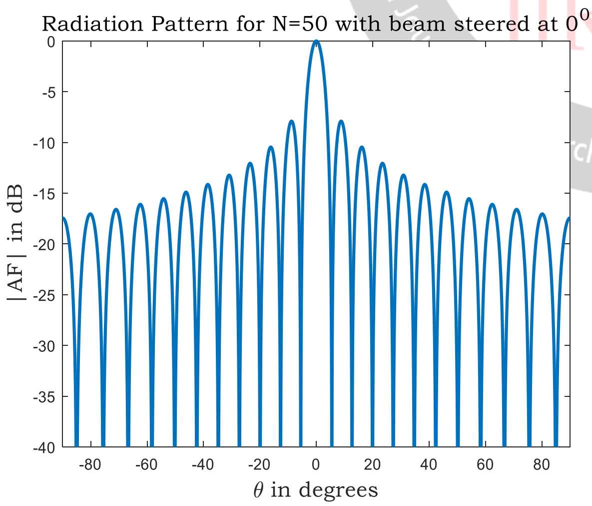

Fig.3: Radiation pattern of UCA of N=50

III. Formulation of Array Factor of Circular Array

A nonuniform circular array geometry is as shown in the fig.4. The isotropic radiators are arranged on the circumference of the circle of radius 'r' with uniform spacing.

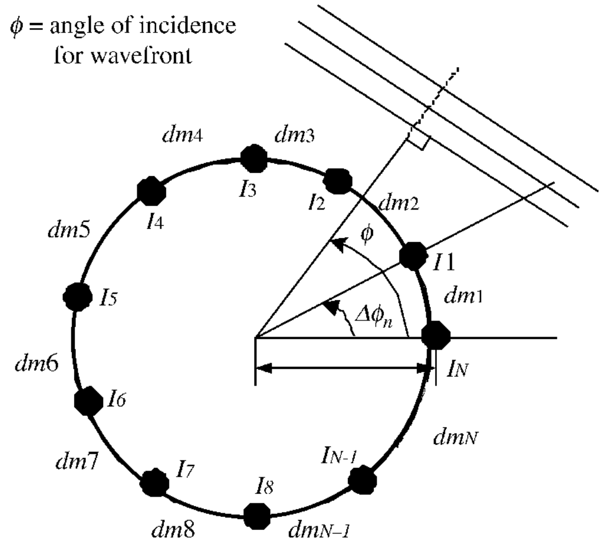

Fig. 4. Non-Uniform Planar Circular Array geometry in the x-y axis.

The corresponding array factor of this geometry is given as [11]

$$AF(\phi) = \sum_{n=1}^{N} I_n.\exp(j.(kr.\cos(\phi - \phi_n) + \beta_n))$$

n is element number

N is number elements in the array

I_n is the current excitation of the nth element

β_n is the phase excitation of the nth element

the 'kr' and ϕ_n are given as

$$kr = \frac{2\pi r}{\lambda} = \sum_{i=1}^{N} d_i$$

$$\phi_n = \frac{2\pi}{kr} \sum_{i=1}^{n} d_i$$

IV. RESULTS

As mentioned in the problem statement, the objective of the simulation experimentation is to optimize the SLL of CA to -25dB. Accordingly, the SGOA is applied to synthesize the patterns of CA by determining the amplitude distribution which produces the desired radiation patterns.

In the first case, the amplitude distribution is shown in Fig.5 which is obtained using the SGOA. The corresponding suppressed pattern for N=20 is as shown in Fig.6. It is noticeable that the corresponding SLL is brought down to -25 dB.

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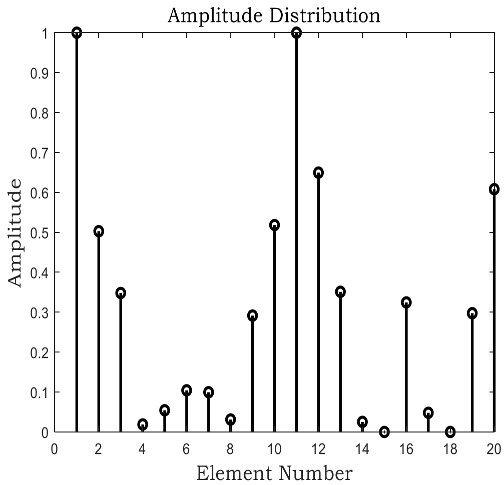

Fig.5: Non-uniform amplitude distribution of CA for N=20

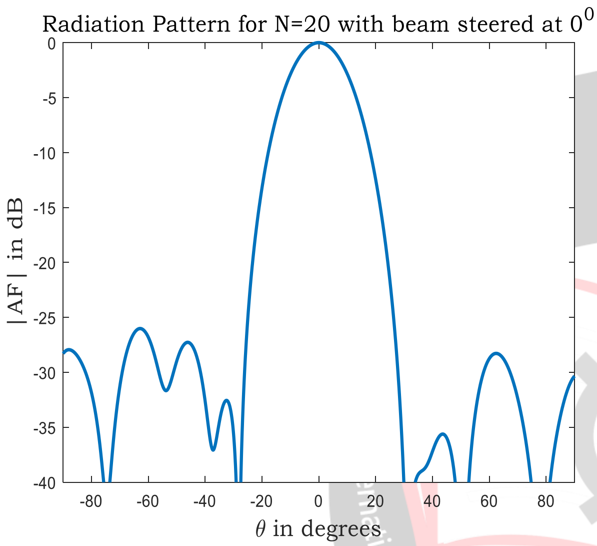

Fig.6: Synthesized radiation patterns of 20 element CA using SGOA

As a second case, the obtained amplitude distribution using SGOA for N=30 is as shown in Fig.7. The corresponding suppressed pattern for N=30 is as shown in Fig.8. A very low optimized SLL of -25dB is observed in the corresponding pattern.

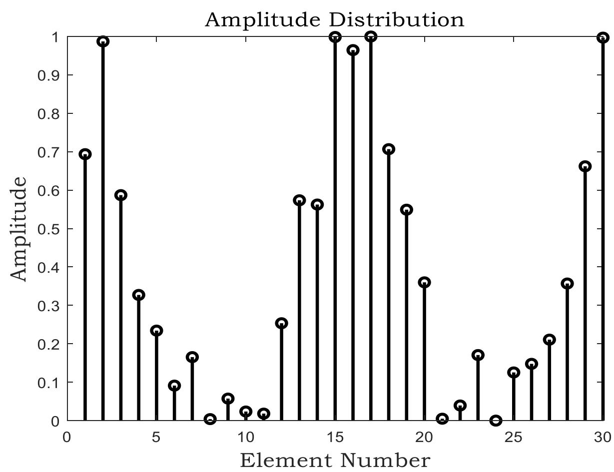

Fig.7: Non-uniform amplitude distribution of CA for N=30

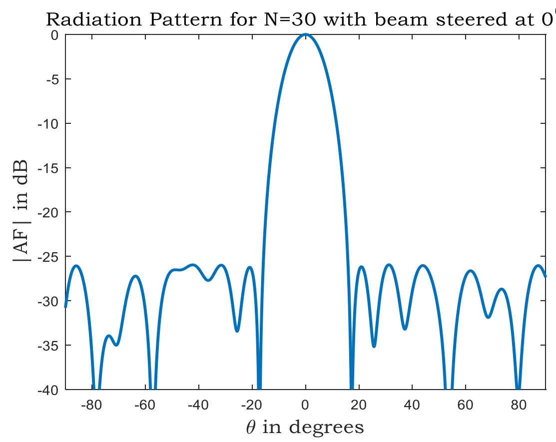

Fig.8: Synthesized radiation patterns of 30 element CA using SGOA

In the third case, the obtained amplitude distribution using SGOA for N=50 is as shown in Fig.9. The corresponding suppressed pattern for N=50 is as shown in Fig.10. A very low optimized SLL of -25dB is observed in the corresponding pattern.

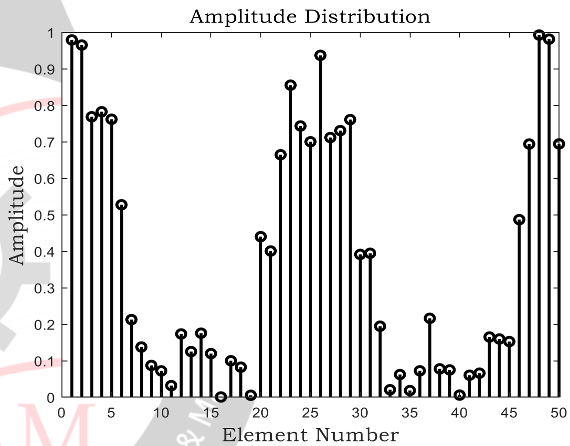

Fig.9: Non-uniform amplitude distribution of CA for N=50

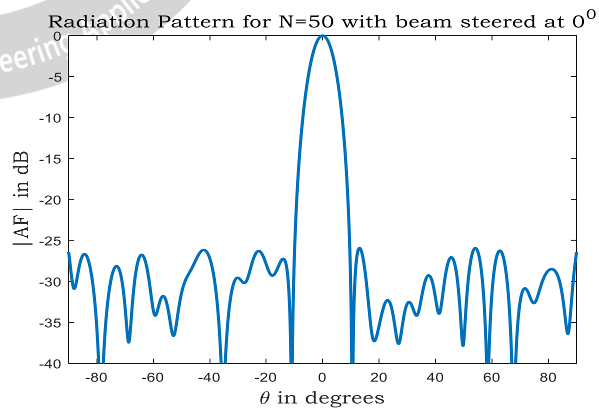

Fig.10: Synthesized radiation patterns of 50 element CA using SGOA

V. Conclusion

The novel social swarm inspired metaheuristic algorithm is implemented for circular array synthesis successfully. The SLL optimized in order to obtain a SLL as low as -25dB which is much better than that of the uniform distribution of

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-7.9dB. Further, the work can be expanded to realtime applications like pattern synthesis of RADAR and several applications.

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