M-PATTERN GENERATION USING PARTICLE SWARM AND FIREFLY OPTIMIZATION TECHNIQUES

R. KRISHNACHAITANYA
Dept. of ECE,
S.R.K.R. Engineering College, Bhimavaram, India
Email: rkc639@gmail.com

P. MALLIKARJUNA RAO
Dept. of ECE,
Andhra University, Visakhapatnam, India
Email: pmraoauece@yahoo.com

K.V.S.N.Raju
Dept. of ECE,
S.R.K.R. Engineering College, Bhimavaram, India
Email: kvsn45@gmail.com

G.S.N. RAJU
Centurion University, Visakhapatnam, India
Email: vccutmap@cutm.ac.in

Abstract- Array antennas are used to generate pattern with high directivity. To radiate the field in particular direction by array antenna is modified to suite the requirements of communication system. Optimization methods like firefly and Particle Swarm Optimization are utilized to generate the field pattern of desired shape. An M shaped pattern is generated which can cover two distinct location without receiving interference from nearby regions. The pattern is utilized to communicate with different users simultaneously without receiving interference from nearby users. The pattern acquired utilizing firefly has better shape than the pattern obtained using particle swarm optimization. In this synthesis using optimization technique the pattern obtained is near to the desired shape as the element number of the array increases from 20 to 100 elements.

I. INTRODUCTION

In present day's communication array antennas has an important role to play. Antenna can be classified based on their construction as Continuous line source and discrete no of elements. There are different strategies for the assurance of the required shaped beam. Beam shaping can be categorized in to three types like location of nulls, decrease of side lobe level (SLL), and pattern with desired shape. schelkunoff polynomial strategy can be utilized to synthesize pattern such that nulls can be generated in desired locations. Fourier transform method [1] and Woodward Lawson method can be utilized to produce desired shaped beams. Taylor line source method and tschebyscheff polynomial method can be utilized to

control the SLL in the radiation pattern. Taylor method has the feature of controlling the initial few side lobe levels at a particular level. All these traditional methods require high amount of mathematical computation. Optimization methods can be used instead of traditional methods to determine the array parameters. Optimization methods like modified Tabu search algorithm,[2] particle swarm optimization, and firefly algorithm are utilized to produce the desired shaped beam [3]-[8] for different configurations of array antennas. Different shaped beams like flat top pattern, cosecant pattern, cosecant pattern with controlled side lobes, pencil beam can be generated using different optimization methods.
The paper is described as in section 2 antenna array factor function to define the shaped beam. Section 3 defines the objective function utilized to find the antenna parameters. Section 4 shows the results generated for different array configurations.

2. SHAPED BEAM PATTERN FUNCTION FOR ARRAY ANTENNAS

The expression in linear array used to generate shaped beam [9], the far field (array factor) equation for different observation angles is given in Eq. (1)

$$\left.\begin{aligned} A(u) &= \sum_{x=-X}^{-1} a_x e^{j(\beta s_x u + p_x)} + \sum_{x=1}^{X} a_x e^{j(\beta s_x u + p_x)} \\ u &= \sin\theta \\ \beta &= 2\pi/\lambda, \\ s_x &= \frac{(2n+1)}{2} \times \frac{\lambda}{2} \; for - X \le n \le -1 \\ s_x &= \frac{(2n-1)}{2} \times \frac{\lambda}{2} \; for 1 \le n \le X \end{aligned}\right\} \quad (1)$$

p_x = phase fed to the antenna elements.
θ = Observation angle.
a_x = excitation amplitude that is fed to the elements.
s_x =distance between the antenna elements.
X =number of elements.
x = element number.
λ=wave length.

3. OBJECTIVE FUNCTION

In this M-pattern shape pattern design mean square error (MSE) is observed. The Objective function is to reduce the MSE between the desired pattern value and the obtained pattern value in the region x= -1, 1. PSO and Firefly optimisation algorithms are run by changing the values of phase and amplitude of linear array antenna as to minimize the resultant function.

$$\text{Resultant function} = \frac{1}{S}\sum |H(x)|^2 \quad (2)$$

$$H(x) = S_1(x) - S_2(x) \quad (3)$$

$S_1(x)$ =obtained sample value.
$S_2(x)$ =desired sample value.
S= represents total sample points in the total region.
$x = \sin\theta$.

4. RESULT

In this paper Firefly and PSO are synthesized to generate M-shaped pattern. The obtained pattern has pattern in the shape of M which is formed by joining two triangle pattern beams joining together one opposite to other. Each triangle has a width of u=0.4 with the beam becoming zero at the center and two narrow beams between u=0 to 0.4 and u=0 to -0.4.m pattern shape is generated for different number of elements for n=20 to 100. For 20 elements the pattern obtained using both the optimization methods is almost similar in terms of SLL and the pattern shape. The beam in the region u=0 to u=0.4,-0.4 there is deviation between the obtained pattern and the desired pattern. For 40 elements the shaped beam obtained using firefly has reduced the SLL better than PSO algorithm. In the region between u=0 to u=0.4,-0.4 the pattern obtained is matched with the desired pattern shape. At u= 0.4 at the narrowed region the obtained pattern has slight deviation from the desired shape. In regions for n=60, 80 the side lobe level has reduced when compared to the SLL obtained for n=20, 40. The pattern obtained for n=60, 80 using both the optimization methods is almost similar to the desired shape and very slight deviation at the narrowed point for u=0.4.

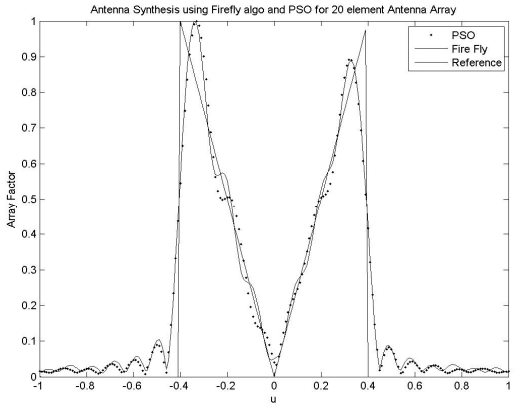

Figure 1. M-pattern for n=20 using PSO and Firefly algorithm

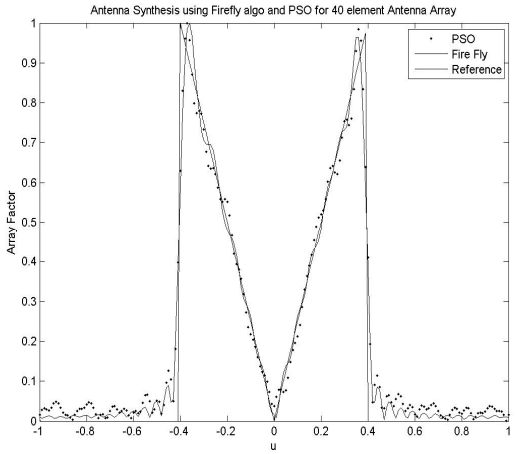

Figure 2. M-pattern for n=40 using PSO and Firefly algorithm

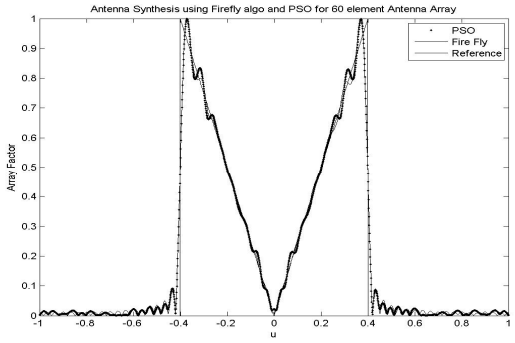

Figure 3. M-pattern for n=60 using PSO and Firefly algorithm

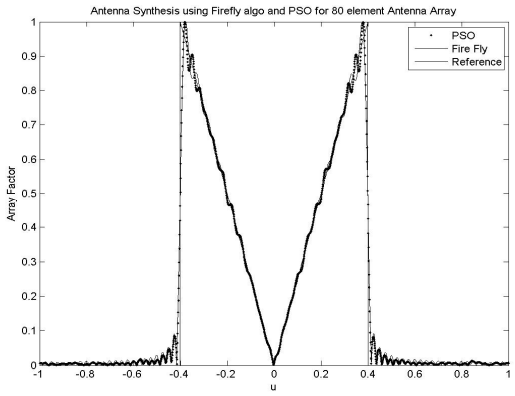

Figure 4. M-pattern for n=80 using PSO and Firefly algorithm

5. CONCLUSION

A unique technique for the generation of M shaped pattern was exhibited using PSO and Firefly algorithms. Both the algorithms have effectively generated the desired shape of M pattern for different dimensions of array antennas. Firefly has slight edge over PSO in generating M shaped pattern which effectively reduced the SLL. These techniques can be applied for pattern generation for different array configurations like circular array and planar array.

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