Abstract—This paper aims to introduce the Ant hill colonization optimization algorithm (AHCOA) to the electromagnetics and antenna community. The ant hill is built by special species of ants known as formicas ants (also meadow ants, fire ants and harvester ants). AHCOA is a novel new nature inspired algorithm mimicking how the ants built and sustain the ant hill for their survival and sustenance for many years. This problem solves constrained and unconstrained optimization problems with wide capability in diverse fields. AHCOA is used by writing equations of volumetric analysis of the ant hill mould the manner in which the structure is architected. In this paper, we have shown how AHCOA is better than the previous paper on ant lion optimizer for controlling side lobe in antenna pattern synthesis in paper [1]. The potential of AHCOA in synthesizing and analyzing for \( d/\lambda \) varying from 1.1, 0.6, 0.5, 0.3 and 0.1 linear array is also illustrated. Antenna side lobe level minimization is compared with ant lion optimizer showing why AHCOA is better than the previously simulated ant lion optimizer for side lobe control. The results show why linear arrays are better synthesized for AHCOA then other algorithms used in planar arrays. This paper shows why AHCOA is a strong candidate for antenna optimization used in linear arrays.

Keywords—AHCOA, Fraun Hofer region, Fresnel region, Antenna Radiation, ant hill optimization, linear array.

I. INTRODUCTION

This paper introduces AHCOA to the electromagnetic and antenna community. In this paper there is a portrayal of AHCOA in antenna synthesis. This is a biologically evolved algorithm which is based on the smartness of the Formica ants in maintaining a separate department in the ant colony hill building i.e. building the ant hill, besides a separate department in ant hill cleaning, breeding and food collection. This architectural smartness of the ants is studied to show how we can find a novelty in their work in synthesizing our antenna which can function in a better way as compared to older algorithms in side lobe level (SLL) reduction. AHCOA is a new nature inspired algorithm which shows how we can synthesize a antenna based on these parameters.

II. Related work

There is a related work in this by [1] Prerana et.al in which she has shown about antenna side lobe reduction by using ant lion optimizer. In this they have multiplied the ant lion trap issue synthesis in evolving with a technique which can help optimize the antenna. There is a fitness function defined in
this algorithm which helps it in giving a random variable which can randomly process whether there will be a prey caught by the ant.

Figure: Ant lion trap for catching on prey based on fitness function

In the paper [19] they have spoken about natural selection in genetic algorithm which they termed as GABONST which synthesize a antenna to obtain nulls and side lobe level reduction.

III. Proposed Work

We know the angular field generation in the fraun hofer region is independent of the distance from the antenna. $2D^2/\lambda$ is the region understood to be greater than, when the dimension of a dipole or antenna is considered to be D, the region considered before is what far field region is considered to be from the antenna. How how does fraun hofer region work, it is more than large distance than the element of the antenna length, How can we better that region, where is the radiating energy wasted, How can we reduce radiation, the maximum possible length of fraun hofer region. We moreover signify that there is some force in the universe which has created its form, shapes, formation of location of stars and planets.. Connecting this to the formation of the celestial bodies we try to discuss the radiation pattern of the antennas. In the previous papers the ant lion optimizer was synthesized while this paper speaks about ant hill optimization.

Figure IV: Gravitational field following Kepler’s laws of motion.

For the fraun hofer region, the plot is given below as follows.
The Fresnel region concludes by interfering with the pattern of the antenna in the near field region, the magnetic field in the Fresnel region is one of the examples of Fresnel region. The Fraunhofer region has transverse vibration of the electric and magnetic fields of the magnetic field vector connecting it.

Figure V: Received power vs distance from the antenna.

The power radiated is never constant except in ideal antennas. The power radiated always decrease with distance.

Figure VI: The Fraun Hofer distance with distance from the antenna is given in the above figure. The farun hofer field or far field keeps on decreasing until it subsides to minimum and then fades away.

Moreover we emphasize on this unseen, invisible energy used in transmitting energy from one place to the other with the help of antennas. Similarly there is a force in the universe which has resulted in the formation of the complex design of the universe. If we can somehow devise an algorithm for the formation of the universes with these biologically inspired algorithms such as ant colonization, salp algorithm, particle swarm optimization, bat algorithm, and many more so there is a link and conjunction between the animals, plants and creatures and the formation and working of the universe. There are ants who go in straight lines, sometime co-circular, co-circles and more, they communicate with each other through their medium and lead to the formation of houses and cribs with their peculiar level of understanding. If we monitor these activities of the ants, the lion ants, swarms, dolphins, the bats, the bees and all the other animals and creatures understand them devise an algorithm for their working then maybe we can master of our nature, our work and our lives to be better than what it is today. So in our optimization we have tried to show some of the functions their convergence curves which show the minimization of the functions leading to the collapse of the function.
Can these lines of force of the antenna be applied to the field of gravitation of the universe, their formation and the location of the particles (stars and planets), can the biologically inspired algorithms be applied to the universe in devising the early history and formation of the universe, how we can explore the universe in a better way.

We can model the universe similar to the modelling of the earth as follows.

Figure VII: 2N symmetric Linear antenna array placed along the x axis

Can this algorithm of biologically inspired theorems be applied to the formation of the universe. The universe is divided by some invisible energy which we cannot pursue with normal senses and which keeps in working substantially. We try to picture it alike as a system of charged particles. Today we have softwares which can make this thing pursuable, the working of the universe, its early history, future and working. Today we have softwares like matlab which can show the working of functions, their plots, mathematical interpretation of functions, their detailed interpretation. We know that there is a sun and there are planets revolving around it due to gravitational magnetic forces interlinked, but moreover there are more forces linking all the particles from stars to asteroids in this entire universe, there can be an algorithm for asteroids revolving around the universe and how we can devise new problems in understanding such objects and preventing accidents on Earth to larger extent.

The ant Colonization algorithm can be studied in improving the directivity of the antenna by reducing the side lobes of the pattern thereby multiplying the functioning of the antenna. The ants perform various tasks such as movement for travelling from one place to the other, travelling for shelter, for communication, for shelter, for collecting food during the dry season and also building of their ant hills. So we try to simulate this ant colonization algorithm for improving the characteristics of the radiation pattern of the antenna. The antenna has various parameters such as beamwidth, the major being the first null beamwidth which is the angular separation between the two nulls. The half power beamwidth is the half of the maximum beamwidth of the antenna, that is the polarization of the electromagnetic radiation. So what we really have in this pattern of the ants is the collectiveness of the way they unite together to function. When any of the ants is attacked then they together try to dominate and attack and defend the others by their collective nature of functioning. Similar is the functioning of the bees when somebody tries to invade their space then they collectively try to sterilize the attack from the invader or attacker. The bees try to collect food from the pollinated flowers, in connection with the ants who move on the ant while the bees move on the flight motion. The ant lion colonization algorithm simulation looks like an inverted Bessel or a bowl function as shown in the figure below.
Figure VIII:

The convergence values for this function is given as:

| Iteration | Elite Fitness |
|-----------|---------------|
| 50        | 1058.4005     |
| 100       | 446.9132      |
| 150       | 277.3066      |
| 200       | 6.8822        |
| 250       | 4.5881        |
| 300       | 1.2675        |
| 350       | 0.68215       |
| 400       | 0.68215       |
| 450       | 0.68215       |
| 500       | 0.67371       |
| 550       | 0.44031       |
| 600       | 0.39565       |
| 650       | 0.39557       |
| 700       | 0.2234        |
| 750       | 0.2234        |
| 800       | 0.0082177     |
| 850       | 0.0032393     |
| 900       | 0.0032393     |
| 950       | 0.0021602     |
| 1000      | 0.0016601     |
| 1050      | 0.0016601     |
| 1100      | 0.0010171     |
| 1150      | 4.5236e-06    |
The ant working is a classic example of the functioning of a civilization. The civilization started initially from the forests when there were no houses or planned cities or towns or civilization (humans). So can this uncivilized civilization be applied to the functioning of the present antennas which are not correlated in their functioning. The present antenna operate by electric current which emit electromagnetic radiation by the process of emission of electromagnetic radiation. This electromagnetic radiation is distinctly intercepted from the two sources by the antennas by first null beamwidth. So how does this help? This process defines the functioning of the antennas which is used in bettering its main lobes by reducing unwanted radiation in unwanted direction.

How can we model such an antenna optimization?

Optimization of the antenna is very informal language, but this has been attempted multiple times by different ways, this is one such different way. Antenna side lobe is radiation in unwanted direction which is not essential and is always tried to be reduced by the manufacturer. The manufacturers are faced with the daunting task of preventing radiation waste and at the same time also providing maximum efficiency of the antenna. The ant colonization processed algorithm is one such algorithm used to enhance the main lobe and reduce the side lobes to maximum extent possible. The side lobes don’t transmit important information nor help in transmitting any information as we don’t want any radiation in that direction. The main lobes only help in progress of transmission and the user and manufacturer only wants the main lobes, the main lobes alone help in data communication in terms of digital communication. The digital communication subject works on the principle of digital data or binary data displayed in 1’s and 0’s. Digital communication consists of encoder and decoder at the basement of the physical layer holding onto the data link layer. How can we monitor all such things as a unit.

Monitoring these functions leads to the possibility of the antenna not radiating in unwanted direction. The function is defined for a location at X=-27, Y=50, and Z=1427 for the three coordinates. There was this function which was modified to obtain the tangential bowl function. The antenna radiation also goes out in a tangent, which is obtained by taking the slope of the function at the ends, which gives the tangential angle. This tangential function is obtained to model the antenna radiation going out from the antenna. Antenna electromagnetic radiation goes out at the speed of light, and travels in all directions.
from the antenna, the main lobe is where the radiation is and must be maximum while minimum in the side and back lobe direction.

While it is difficult to maintain uniformity in radiation, as the radiation is diverted in multiple directions and not always possible to maintain directivity. Directivity as defined as a term is very difficult to the earlier defined in books as directive gain, is defined as direction of the radiation in a given direction to the sum of direction of the radiation in all directions. The average radiation intensity is the sum over of power divided by 4pi.

Figure X:

![Convergence curve](image)

| Convergence curve |
|-------------------|
| Iteration# 1      | 182.0688 |
| Iteration# 2      | 152.7457 |
| Iteration# 3      | 38.2084  |
| Iteration# 4      | 38.2084  |
| Iteration# 5      | 38.2084  |
| Iteration# 6      | 38.2084  |
| Iteration# 7      | 3.3248   |
| Iteration# 8      | 3.3248   |
| Iteration# 9      | 3.3248   |
| Iteration# 10     | 3.3248   |
| Iteration# 11     | 1.5106   |
| Iteration# 12     | 1.5106   |
| Iteration# 13     | 1.5106   |
| Iteration# 14     | 1.5106   |
| Iteration# 15     | 1.5106   |

The convergence curve shows the fitness convergence of the function. This fitness convergence function shows how good or how fit the solution is with respect to the defined results.

We have iterated from 1 to 15 conjunction of results, the convergence of values from 182 to 1.5 shows a variance correlation of the function. The Fraun Hofer region of the antenna displays the effectiveness of the antenna in covering large distances.

Figure XI:
We obtained the far field plot as a step function for the proposed antenna. The far field or fraunhofer region of the antenna shows a gradual drop as a step function from 300 to 100 and so on for 29 GHz frequency. Dipole radiator has greater directivity due to greater intensity concentration than those directions where the concentration is in one direction or isotropic. We know that the directivity of an isotropic antenna is unity as radiation is diverted equally in all directions. Antennas play a vital role in receiving the energy in desired quantity and then transmitting it with maximum directivity. Another major thing to keep in mind is without increasing the size and dimensions of the antenna without increasing the size of the elements of the antenna is by using an assembly of elements in an electrical and geometrical arrangement. This new elements configuration is known as an antenna array. In most cases the geometrical arrangement and configuration is similar, but in some other cases it can be different. Individual elements can be in the form of straight inundating wires, spirals, bent wires and more shapes. When we are trying to calculate the vector addition of all the fields, it is the sum of addition of all the radiating elements. There is isolation of the elements then the radiating elements have a similar characteristics. Using antenna arrays improves the signal quality which is done without increasing the other parameters such as transmission power and transmission characteristics taken together. Smart antennas acquire some features of smartness in its operation by imbuing itself by the various processes of digital signal processing techniques. Digital signal processing techniques are widely used in antenna operation. These techniques have combined to form the smart antenna but we will not get in deep in this discussion. But what does the smartness in the actual sense mean is that the noisy signals can be filtered out to provide quality from interference and other deteriorating factors. They are in turn provided with improved gain. There has been an explosion today of land mobile devices due to the ever increasing trend of new technology arrival and discoveries and innovations in wireless communications.

Array beamforming is a technique we would like to emphasize in our paper which consists of and comes under array signal processing. There are almost like multiple antennas in a region and they have to be correlated to determine which is the best signal and which signal is adherent to requirement of the users. This is achieved by the process of correlation. Interference and unwanted noise is thrown out by filtering and keeping only what is necessarily required. We expect an array antenna to achieve all such things keeping in mind we want efficiency and clarity in terms of signal processing. So as mentioned in the earlier part of the paper we require the presence of certain radiation characteristics in the antenna such as nulls in certain directions, beamwidth should be quite low, besides low side and decaying minor lobes. Antenna synthesis is a method of achieving certain characteristics which otherwise would not be possible, leaving away certain things out, imbuing certain things to achieve a certain configuration of the setup.

The amount of power which is radiated or received by the antenna elements is directly proportional or dependent on the phase excitations or amplitude, which is with respect to all the elements of the to the origin of the coordinate system. So considering these things into picture there exist certain angles in the space which lead to the radiated signals or transmitted signals to be added constructively or destructively. The
regions of maximum radiation are the regions where the angles are in phase with each other, besides when they are not in phase results in zero radiation or we can consider zero reception. Where there is no reception or zero radiation it is referred to as null region.

When we discuss of adaptive beamforming which involves the changes in gain and phase of the signals which are inherited on various elements are altered before they are combined to adjust the gain of the array in a constructive way. This beamforming technique is a method of combining different elements with different weights to form beams of a particular characteristics. Beam pointing is the region which has the maximum influence of the antenna.

How our **algorithm** influences the **beamforming** pattern:

The patterns can be classified to obtain the signal to interference plus noise ratio(SINR), secondly the variance has to be minimized, thirdly steering towards desired signal, fourthly nulling the interference signals and finally to minimizing mean square error(MSE).

The ants move across trees, flowers, bulbs and seeds, they influence the beamforming technique in multiple ways. The first being how much of movement is done in seeds, which will be minimum hence directivity will be maximum for this case, secondly on bulbs and flowers there will be some kind of movement leading to slightly higher directivity in this case, thirdly and finally on trees the ants colonization algorithm will be maximum leading to highest directivity and minimum side and back lobe levels. The ants movement on the trees will be maximum time and hence the directivity in that scenario will be maximum and largest. Beamforming can be moulded into various types, as it involves antenna to antenna communication, and involves directivity of the antenna in a particular direction. This involves faster transmission and reduced loss in power and usage of broadcast energy. This beamforming technique enhances the performance of wireless networks in short ranges.

**Figure XII:**

Cost function can be modelled for ant algorithm which gives the cost function for shortest path region.

Ant colonization problem in solving classical communication problem.

Researchers and users of antennas are always facing the problem of antenna radiation loss, less radiation, not adhering to the required radiation for data transfer communication, besides there is large requirement of bandwidth and data for large distance and user communication. Today there are more than 15 billion users of mobile phone besides there is computers also functioning in parallel with this. There is a rapid need for bettering the technology used today for tomorrow as there is required need for large scale usage and need for low latency in communication. The zeta functions of representation of integral functions is one such kind of representation. We find what is cyclic group of order, as the ants follow a cyclic group sometimes revolving in their destination.
G is cyclic with order of $p$. Omega being a primitive $p$-th root of 1, Besides $R=\mathbb{Z}_p$, There is a ground based localization of function $Z(\text{zeta})$ at . Let J be an ideal function with respect to $R$, then J bar becomes its image in $R$ bar. The full nature of I of RG have the form.

$I=RG(\alpha, \beta) + (0, pJ)$, where $\alpha=(1-\omega)^k$.

There is the solomons result in Zeta function which is defined as

$$\zeta_{RG}(s)= (1-p^{-s} + p^{1-2s})/(1-p^{-s})^2$$

The previous function agrees with the above equation. The solomons function or conjecture is a second equation of Solomon referring to Zeta functions. We refer this to solve the classic problem in our paper.

Before we shift to cyclic zeta functions we need to refer to some primary classifications, of cyclic groups of order , $p^2$, I=when we try to calculate I bar, which is the image of I in RG, Inductive applications are used in our solutions.

$$RG=\mathbb{R}[\lambda]/(\lambda^p), \lambda=1-x, I=\lambda^k RG, 0<k<p$$

$R$ being the ring of algebraic integers in an algebraic number field, or a sequential completion of this field, $RG$ being the integral group ring of a finite group $G$, groups are collection of smaller entities. It is finitely generated and torsionfree, besides these terms form an important part in groups of ant colonization equations with respect to zeta functions. $I$, being the full ideal of $RG$, $I_1=f_1(I)$ being the full ideal of of the domain $S$ which is considered to be $S$. so $I_1=\alpha S$ where $\alpha=(1-\omega)^k$. The annihilator in $\alpha$ in $RG$ is the principal ideal. Ants are said to follow Zeta function similar to cyclic redundancy codes error detecting codes applications(accidental changes to binary data).

Figure XIV: Zeta function with grating beam, main lobe and side and minor lobes. There is a curve in the left hand of the side lobe in the figure which shows unprecedented finish with looping kind of curve without closing.
There is no one distinct formula, theorem or algorithm which can model all of these nature based biologically optimized algorithms, as there is change in their instincts in animals at every moments, but the most similar sequence can be modelled.

IV: Our concept

Ant hill structure building which can help synthesize our antenna:

The lion ant colonizer equation was used in the paper by prerana et.al in which they modify the antenna in such a way that side lobe reduction takes place to maximize directivity. In our research in this paper we are going to use the ant hill structure buildup which can help us in antenna directivity improvement.

The ant hill is a volumetric structure which the ants build with swallowing the soil and then building up the structure which is built up volumetrically. The volume equation is given by similar to a cube, rectangular structure together with a prism, pyramid and a right circular cone. Given as a conjunction or required summation of these volumetric measures as

\[ V = L \times W \times h \quad \text{Volume of Rectangular solid} \]
\[ V = B \times h \quad \text{Volume of prism} \]
\[ V = \frac{1}{3} B \times h \quad \text{Volume of pyramid} \]
\[ V = \frac{1}{3} \pi r^2 \times h \quad \text{Volume of right circular cone} \]

Ant hill Colonization optimization: Architecture by ants
The ants very architecturally build up the structure which can last for several years in all weathers and intruders without any problem. This AHCOA algorithm is very efficient in providing optimized solutions to linear antenna synthesis. The conventional optimization approach in calculus in finding the gradient of the equation and then equating it to zero to get the critical points. Then these critical points solutions give us the maximum or minimum value as per the function. This AHCOA provides a stochastic approach to find the best solution for a large diversity of the problem. The right circular cylinder is perfect structure for ant hill, though rectangular solid also exists. Prism and right circular cone is more contextual structure for this type of solid volumetric analysis. This kind of structure gives the ant hill more stability and balance as a whole with more area for the given space. There are sub inner right circular prism structures being built in sub layers inside the whole ant hill structure. This makes the ant hill have multiple structure with multiple layers built one inside the other in the ant hill. This makes it occupy more even space with space utilization algorithm.

1. It’s a 2 Dimensional arrangement.
2. We arrange the cells or small layers to attain the best arrangement.
3. There are sub mini inner layers inside each other in the overall structure.
4. The mini cells structure can be considered to be rectangular in shape, with multiple arrangements to obtain rectangular, prism, pyramidal or right circular cone structure in multiple repetitions.
5. The starting of the structure is assumed to start from top left.

Let's take some time to define bin packing algorithm:

It is an algorithm which can generalize our packing of ant hill in which cells of different sizes actualize sum to form the entire package of ant hill. It is done in such a way by ants to form layers but minimizing the actual number of bins or cells used for creating the structure. This bin packing can be linked to the creation of the universe as discussed in the start of this research paper. There are infinite cells formed by spaces in this universe leading from layers which form the occupying space. They also follow next fit(NF) packing algorithm is selecting the nest cell to fit in the context looking at infinitely minute scale.

The bin packing estimation is generalized as follows. A solution is optimal OPT if it has minimal K.

\[ K = \sum_{j=1}^{n} y_j \]

Subject to \( K >= 1 \),
\[ \sum_{i \in I} s(i) x_{ij} < B y_j \quad \forall j \in \{1, \ldots, n\} \]

\[ j^n = \sum_{i \in I} j = 1, \]

\[ y_j \in \{0, 1\} \]

\[ x_{ij} \in \{0, 1\} \]

Where \( y_j = 1 \) is bin \( j \) is used and \( x_{ij} = 1 \) if item \( i \) is put into bin \( j \).

By Looking at the bin packing algorithm applied to ant hill buildup we try to optimize for linear uniform array for the antenna problem.

**V. Experiments and Results:**

The radiation pattern for \( d/\lambda = 1.1 \) is obtained in a very peculiar manner as follows. The radiation pattern is

![Polar plot for the radiation pattern d/\lambda = 1.1](image)

Figure XIV: Radiation pattern for 10 element uniform array with \( d/\lambda = 1.1 \).
Figure XV: $d/\lambda=1.1$ plot of zenith angle showing normalized radiation pattern.

Figure XVI: Radiation pattern for $d/\lambda=1.1$ for 10 linear antenna array elements.

The above figure shows radiation pattern of 10 element $d/\lambda=1.1$ with 18 side lobes of proposed AHCOA algorithm.
Figure XVII: Uniform 10 element array with $d/\lambda = 0.6$

Figure XVIII: The figure shows fading side lobes not

Figure XIX: Radiation pattern for $d/\lambda = 0.6$ for uniformly excited 10 linear antenna elements for proposed AHCOA.
Figure XX: Radiation pattern for $d/\lambda = 0.5$

Figure XXI: AHCOA shown for fading side lobes. The AHCOA shows side lobes which are seen fading for $d/\lambda = 0.5$ whose radiation pattern was earlier simulated.
Figure XXII and XXIII and XXIV: Normalized far field pattern of uniformly excited 10 and 11 element linear array with $d/\lambda$ ratio of 0.5.

The three lines for side lobes of ant lion optimizer by Saxena et.al, proposed AHCOA and of ideal antenna which shows no side lobes. The proposed AHCOA is shown with minimum side lobes which are not visible after the first few.
The proposed ant hill algorithm has distinct fewer side lobes as compared to side lobes of ant lion optimizer.
The AHCOA for 10 element $d/\lambda=0.5$ showing 8 side lobes.

In this case the number of elements of linear array was increased to 11 for $d/\lambda=0.5$ which showed an increase in side lobes to 10.

Figure XXIV: Radiation pattern for 10 element uniform array $d/\lambda=0.3$

There are multiple parameters in antenna optimization such as directivity, polarization, bandwidth which influence the functioning of the antenna. We try to figure out in these optimization analysis the directivity enhancement of the antenna by side lobe level reduction.
Figure XXV: Minor fading side lobes scanned microscopically which were not seen in next figure.

![Normalized far field pattern of uniformly excited 11 element linear array with d/λ ratio of 0.3](image1)

The above figure showed a decrease of side lobes due to decrease of d/λ=0.3 value from 0.5.

Figure XXVI: Normalized far field pattern of uniformly excited 11 element linear array with d/λ ratio of 0.3

![Normalized far field pattern of uniformly excited 11 element linear array with d/λ ratio of 0.3](image2)
The figure above shows the maximum main lobe with minimum minor or side lobes. This signifies the improvement of the antenna in terms of the proposed algorithm.
Compared to the previous algorithms the proposed algorithm has shown considerable improvements in terms of the side lobes radiation pattern. As compared to ant lion optimizer the obtained pattern is as follows.

Figure XXVIII: For Ant lion optimizer algorithm for far field pattern of a 10 element with side lobe level of -40dB and d/λ ratio 0.5. The ant lion optimizer was synthesized to show the side lobes.
Figure XXIX: Normalized far field pattern of a 20 element ant lion optimizer with side lobe level of -40dB and d/λ ratio of 0.5.
Figure XXX: Normalized far field pattern of a 30 element of ant lion optimizer with side lobe level of -40dB and d/λ ratio of 0.5.
Figure XXXI: Normalized far field pattern of a 40 element of ant lion optimizer with side lobe level of -40dB and d/λ ratio of 0.5

Figure XXXII: Prerna et.al proposed comparison with PSO

Observations for ant lion optimizer algorithm comparing it with AHCOA: The above figure is taken from paper by Saxena et.al which propose radiation pattern for proposed ant lion optimizer, uniform linear array and for particle swarm optimization.
| No. of elements | F.N.B.W  |
|-----------------|----------|
| 10              | 42.22°   |
| 20              | 22.16°   |
| 30              | 18.1°    |
| 40              | 11.08°   |

Number of elements for ant lion optimizer

| No. of elements | No. of side lobes |
|-----------------|-------------------|
| 10 d/ $\lambda$=0.5 | 10                |
| 20 d/ $\lambda$=0.5 | 18                |
| 30 d/ $\lambda$=0.5 | 26                |
| 40 d/ $\lambda$=0.5 | 36                |

No. of elements for AHCOA:

| No. of elements | No. of side lobes |
|-----------------|-------------------|
| 10 d/ $\lambda$=1.1 | 18                |
| 10 d/ $\lambda$=0.6 | 10                |
| 10 d/ $\lambda$=0.5 | 8                 |
| 11 d/ $\lambda$=0.5 | 11                |
| 11 d/ $\lambda$=0.3 | 6                 |

Proposed by Saxena et.al[1]  14

Particle swarm optimization  7
Number of sidelobes in 10 element $d/\lambda=0.5$ for ant lion optimizer is 10 while there is a decrease to 8 in AHCOA. This shows a 20 percent decrease in side lobe numbers.
These are the six diagrams for varying $d/\lambda$. First figure is for $d/\lambda=1.1$ for ant lion optimization, second figure is for $d/\lambda=0.3$ for ant lion optimization, third figure is for $d/\lambda=0.5$ for ant lion optimization, fourth figure is $d/\lambda=0.5$ for proposed AHCOA, fifth figure is for proposed AHCOA $d/\lambda=0.6$ and sixth figure is $d/\lambda=1.1$ for proposed AHCOA with minimum side lobes and maximum grating.

The AHCOA algorithm was implemented and compared to ant lion optimizer for controlling side lobes of a linear antenna array. 42.22 degrees was the value of first null bandwidth of 10 element AHCOA, secondly 22.16° was obtained for FNBW for 20 element system, 18.1° value of FNBW was obtained for 30 element linear array of AHCOA finally for 40 element linear array of AHCOA a value of 11.08° was obtained. The AHCOA has better side lobe level for 10 element $d/\lambda=0.5$ which is 8 compared to ant lion optimizer which has 10 side lobes in summation. This shows a 20 percent decrease in side lobes in AHCOA algorithm as compared to ant lion optimizer. The ant lion optimizer for 10, 20, 30 and 40 element linear array for $d/\lambda=0.5$ the side lobes for the test bench was found out to be 10, 18, 26 and 36 respectively. In case of AHCOA $d/\lambda$ was varied from 1.1, 0.6, 0.5 and 0.3, the final side lobes was found to be 18 for 10 element $d/\lambda=1.1$, secondly for 10 element $d/\lambda=0.6$ the side lobes was found to be 10, thirdly for 10 element $d/\lambda=0.5$ the sidelobes was found to be reduced to 8 in terms of our calculated captured side lobes for the compared AHCOA with lion optimizer. When the elements was slightly increased to 11 and the values captured we obtain for $d/\lambda=0.5$ a value of 11 side lobes which is an increase in the number of side lobes, finally for 11 element $d/\lambda=0.3$ the obtained value of side lobes was reduced to 6, this showed a decrease in $d/\lambda$ value lowers the unwanted radiation by lowering the side lobes.

VI. Conclusion:

The Goal of this paper was to introduce AHCOA to the electromagnetic and antenna community. AHCOA is compared to Ant Lion Optimizer(ALO) in controlling the side lobe. The main advantage of AHCOA compared to Ant lion optimizer(ALO) is that there are small and less number of side lobes and it can be easily attenuated for antenna parameterization. The parameters also required to be adjusted as compared to other metaheuristic algorithms is very less. The elite functions generation for ant hill build up used in this paper proves to be very helpful in optimizing the antenna side lobes as the best ant is chosen for ant hill buildup job. There is a special ants species known as Formica Ants(also meadow ants, fire ants and harvester ants) which is involved in ant hill construction.

Optimized antenna radiation pattern was obtained for 10 element linear array antenna for AHCOA which was compared to ant lion optimizer(ALO) for suppression of peak Side lobe level as well as for side lobe level minimizations. Furthermore, AHCOA was compared to Ant lion optimizer(ALO) to obtain the optimized antenna positions in order to achieve the desired array pattern to obtain minimum side lobe level. Moreover, suppression of side lobes was obtained for directivity maximization.

AHCOA was compared for 10 element linear array for $d/\lambda=0.5$ and there was a 20 percent reduction in the number of side lobes. This metaheuristic approach was better as compared to Ant lion optimizer which was found to be harnessed for ant paths and various other adjustments in equations. The results indicate that AHCOA yields improved performance compared to Ant lion optimizer(ALO) and other metaheuristic algorithms. This demonstrates the variability and sustainability of AHCOA and how it can be used in electromagnetic and antenna community. Moreover, this ant hill algorithm can be used in any of the engineering optimization problems.

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