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Performance Improvement in Smart Antenna by Hybrid Algorithm

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Abstract: The development of mobile communication technology is making giant steps in commercial market of wireless communication. The smart antenna can be used to reduce the interference and improve the system performance. This paper presents analysis of simulation results for Direction of arrival estimation for smart antenna system. Smart antenna has to respond the variation in channel for optimized reception this is procured by use of DOA and beam forming algorithms. Algorithms like MUSIC (Multi Signal Classification), LMS (Least Mean Square) are limited by the number of users and low convergence speed in spite of the tedious mathematical calculations. This paper deals with the contrast of stochastic algorithms which are effective in design and operation of adaptive or smart antennas. In lime light of this paper and hybrid algorithm of artifial immune system (AIS) and particle swarm algorithm (PSO) paves the way for high convergence speed, channel capacity and resolution of adaptive linear array. The paper also compares the deferent factors proving the hybrid algorithm against the conventional algorithms. The comparison is in the respects of error and no of operations.

Keywords: Smart Antenna, DOA, Adaptive Algorithm, Particle Swarm Optimization, A I S.

I. Introduction

In the last few years mobile and wireless communication devices became part of once life. Vast use of these devices like cell phones and GPS receivers affected the bandwidth. One way to improve the capacity within the bandwidth is to use smart antenna or intelligent antenna. The challenge of next generation wireless communication systems comes from the fact that they will have to offer data rates in the hundreds of megabits per second. This requirement translates into the demand for wide frequency bands. The problem of overcoming spectrum limitation while delivering high data rate requirement can be achieved using smart antennas only. The adaptive antenna array is capable of automatically forming beams in the directions of the desired signals and steering nulls in the directions of the interfering signals.

Smart antenna processes signals arriving from different directions to detect desired signal direction of arrival DOA. Biased on the estimated DOA the beam former optimize antenna element weights such that the radiation pattern of the antenna array is adjusted to minimize a certain error function derived by the adaptive algorithm.Fig1.1 presents block diagram for Smart antenna system Let adaptive linear array antenna has M-elements as shown in fig 2.1 .Output signal is given by

$$\mathbf{y(n)= w^{H}(n)x(n)} \qquad \text{- - - - -(1.1)}$$

Where w(n)=weight vector: X(n)= input signal vector: $w^H(n)$=complex conjugate of w(n) The antenna receives a desired signal$S_0(n)$ and k interfering signals $S_K(n)$ with the presence of random noise N then

$$\mathbf{x(n)=S_0(n)a_0}+\sum_{k=1}^{K} S_k(n)\,\mathbf{a_k+N} \qquad \text{- - - -(1.2)}$$

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Where N=(m×1) matrix: a_k =steering vector of kth signal. The steering matrix for proposed antenna is given by $\beta = 2\pi / \lambda$ =wave number

$\lambda =$ wave length of the desired signal
$d =$ distance between two antenna elements
$\phi_k =$ Azemuth angle of k$_{th}$ signal

$$a_k = \begin{bmatrix} 1 \\ ej\beta\cos\phi k \\ ej2\beta\cos\phi k \\ \vdots \\ \vdots \\ . \\ ej(m-1)\beta\cos\phi k \end{bmatrix} \quad \text{-----(1.3)}$$

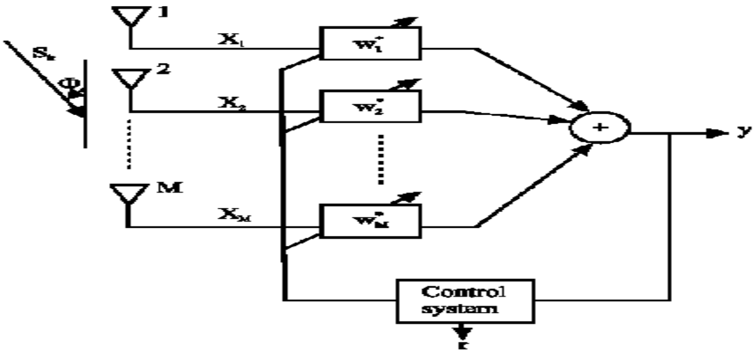
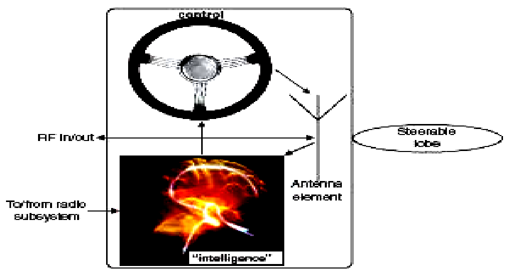


Fig 1.1 Simple Smart antenna

The dual purpose of a smart antenna system is to improve the signal quality of the radio-based System through more focused transmission of radio signals while enhancing capacity through increased frequency reuse. Smart antenna is a special application of antenna array , therefore in chapter we have explained the basic parameters related to an antenna array, which must be familiarized before going to Smart antennas.. It is the digital signal processing capability, along with the antennas, which make the system smart. In fact, in the 1970s and 1980s two special issues of the IEEE Transactions on Antennas and Propagation were devoted to adaptive antenna arrays and associated signal processing techniques. Particularly, the techniques have been used for many years in electronic warfare (EWF) as countermeasures to electronic jamming Smart antenna pattern improves system capacity, reducing sensitivity of non ideal be saviors, separates the received signals spatially [1]. Smart antenna have large number of applications [Liberty and Rapp port, 1999], WLAN, MLAN, satellite communication.

Particle swarm optimization [PSO] was invented by Kennedy and Earhart in the 1995. It is based on social behavior of birds PSO is similar to genetic algorithm. But it is much simpler. Recent trends incorporate this method in wireless applications owns to reduce complexity with mathematics. Different estimation and beam forming techniques are delta in section II.It deals with the basic concepts of DOA finding. In section III the proposed method of algorithm is dealt. It includes the flow chart and detail steps of algorithm. Section IV includes the results .comparative result of the convergence speed, capacity and resolution are given in different graphical reports. As conclusion section V is proposed to give the future scope including the conclusion. References are mentioned in the section VI.



1.2. Principle of a smart antenna system

II. DOA ESTIMATION METHODS

The methods used for operating adaptive antenna arrays can be broadly classified into deterministic and stochastic type. The deterministic methods include least square methods and fast Fourier transform methods. These methods are often computationally time consuming when the number of antenna elements is high. On other hand stochastic algorithms have some advantages over deterministic methods [9]. Many search techniques require much auxiliary information in order to work properly. In contrast, PSO requires only objective values associated with individual sting .unlike other methods, genetic algorithms use random choice as a tool guide. Particle swarm algorithm is different from more normal optimization and search procedures, like direct and indirect calculus based methods, enumerative schemes, random search algorithms etc, in fallowing ways: [2]

a. It works on coding of the parameter set, not the parameters themselves. It searches from a population of points, not a single point.

b. It uses objective function information, not the derivative or other auxiliary knowledge.

c. It uses probabilistic transition rules, not deterministic rules.

PSO require the natural parameter set of the optimization problem to be coded as a finite length string over some finite alphabet. Many search techniques require much auxiliary information in order to work properly. In contrast, genetic algorithm requires only objective function values associated with individual string. Unlike others, PSO use random choice as a tool to guide a search toward regions of the search space with likely improvement. In the last decades, two biological systems have provided a remarkable source of inspiration for the development of new types of algorithms: neural networks and evolutionary algorithms. In recent years, another biological inspired system has attracted the attention of researchers, the immune system (AIS) and its powerful information processing capabilities. The key features of the immune system are pattern recognition, feature extraction, diversity, learning, memory, Self-regulation, distributed detection, probabilistic detection, adaptability, specificity, etc…

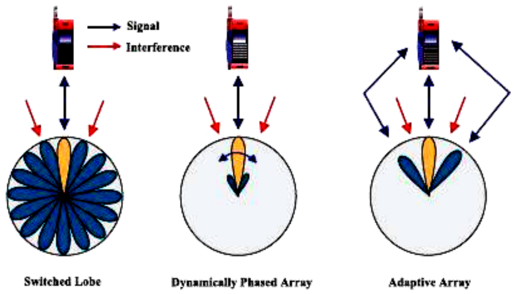


Fig 2.1 Different smart antenna concepts

Several theories and mathematical models have been proposed to explain the immunological phenomena. Those approaches include differential equation models, stochastic differential equation models, cellular-automata models, shape-space models, etc. The models based on the immune system principles, such as the Clonal Selection Theory [5, 6], the immune network model [9, 7], or the negative selection algorithm [8], have been finding increasing applications in science and engineering [10]: In this paper a hybridized technique of Genetic Algorithm and Artificial Immune system is proposed. This hybridization makes the system more robust and efficient. We have not implemented the RF end and created dummy signals which imitate the actual signals. When a signal impinges on the antenna array, it induces some phase in its elements. The phases that are induced on the next elements are the integral multiple of phase induced on the 1st element, as shown in figure2.2. Direction of Arrival estimation radiation pattern, this direction is the direction of arrival of the incoming signal For Beam forming once the current phases and magnitudes are calculated, radiation pattern is calculated by

$$\alpha_a(\theta) = \sum_{n=-N}^{N} \frac{I_n}{I_0} e^{jnkd\cos\theta} \qquad \text{---- 2.1}$$

In this equation I_n is the element current, I_o is the reference current, n is the iteration no., d is the inter-element spacing, k is the wave no. and theta corresponds to the spherical coordinate. Here I_n is calculated by

$$I_n = mag_n * e^{j\ phasen} \quad \text{-----2.2}$$

Now each chromosome in the population is tested to form this radiation pattern. Once the radiation pattern is calculated, direction of main beam is found. Difference is then taken between calculated DOA and direction of main beam due to each chromosome. This is graphically shown in figure, in this figure 7.2 actual, DOA is 20^0 but due to one chromosome beam is formed at 60^0. Here the difference is 40^0.

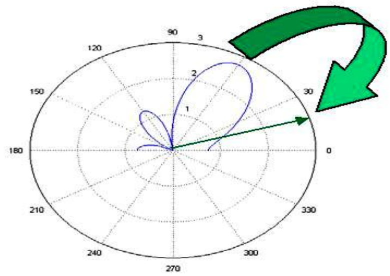


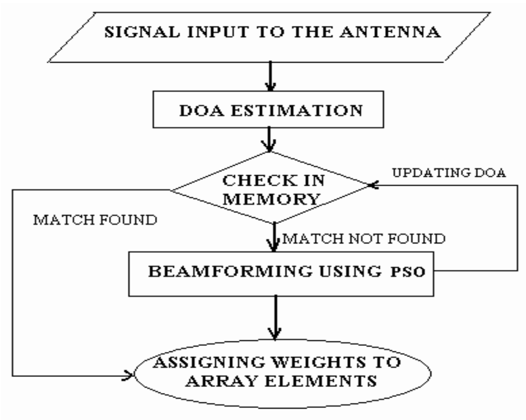
Figure2.2: Cost Function in Beam forming

Now this difference is calculated for all chromosomes in the population. This difference becomes the cost function for this population. In this case there are two cost functions; the other cost function is the magnitude of the radiate on pattern at the interference, which should be as low as possible. Now the convergence criterion will be such that the value of this optimization function should be less than a certain value. This is multi-objective optimization, we can simultaneously optimize many parameters, but again we have trade-off between processing Power and convergence criterion.

$$\text{Optimization function} = (\text{cost func } 1)^2 + (\text{cost func } 2)^2 \quad \text{--------2.3}$$

III. HYBRID ALGORITHM

In our proposed technique, first of all antenna senses its environment and receives the signal. Then it calculates its direction of arrival. Once its direction has been calculated, it matches its characteristics to that stored in memory, if a match is found then it immediately produces the stored response. If a match is not found it runs the algorithm in the routine manner as shown in Figure3.1.



Flow chart of Proposed Technique

Figure3.1

It is done in the same manner as in Artificial Immune System in corporate here. A signal that impinges on the array elements induces current in them. The magnitude of induced currents in the array elements will be same, but with a successive phase difference. We now multiply the induced currents with the weights (randomly assigned through pso) of the array elements and add them. This becomes the cost function which is to be maximized. This is done using the same steps of P S O algorithm i.e. natural selection, cross over and mutation. The new population thus formed is treated in the same manner. This process goes on until the algorithm is converged. Once it is converged, we select the best chromosome of the last population that gives us the optimized complex weights, giving us the direction of arrival of the user.

AIS scanning is performed i.e. match is found in the stored response in the memory. If the DOA is within the stored DOA estimates and magnitude at the interference is within a Specific margin then we can directly provide the stored weights to the array elements instead of running the entire algorithm again. In case a match is not found, then beam forming is done using PSO as explained earlier.

IV. Results

We have carried out the comparison of our proposed technique with already existing techniques, in terms of accuracy and no of operations involved. The graphical representation is as shown in fig 4.1.proposed hybrid algorithm has DOA estimation superior to the other estimation techniques like MUSIC and LMS algorithms in view of convergence speed and accuracy.

The Fig 4.2 shows the relative error of the estimation vs. no of generations (iterations) of proposed hybrid algorithm. Relative error of the proposed algorithm attains almost zero at 350 iterations. But other methods may converge at iterations of 500 minimum. The Fig 4.3 gives the power content of frequency vs angle of main lobe direction in degrees. The diagram is evident that hybrid algorithm can give resolution of 150.The direction of interest is 850 and direction of interference.

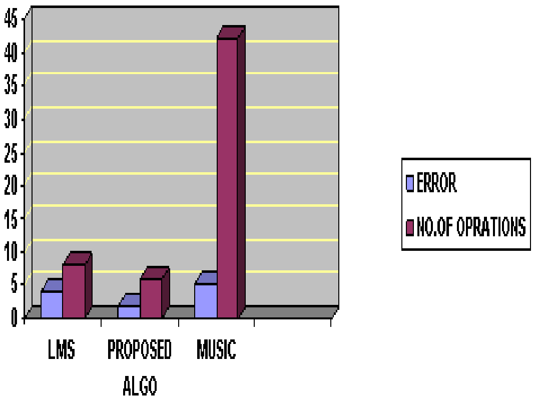


Fig.4.1

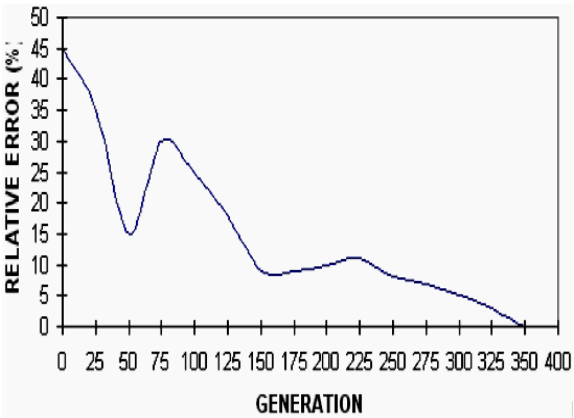


Fig.4.2

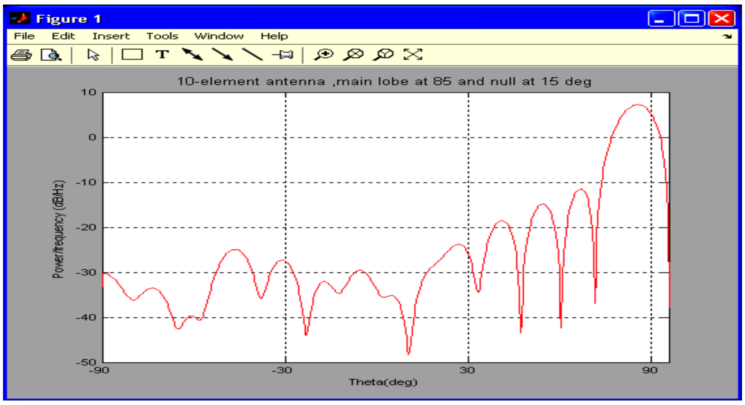


Fig.4.3

V. Conclusion

In the recent years, advancement in telecommunication technologies and the increasing demand of data rate has motivated the optimized use of frequency spectrum. One technique for the efficient usage of frequency is Smart Antenna system. Smart

Antennas are though developed using different algorithms, but the urge was felt for improving the technique to increase their efficiency. Therefore we humbly tried to present a new technique which tried to fulfil all the issues of smart antenna. In future we would definitely like someone to extend this work for the case of planar arrays designing. This technique may also be incorporated in Radar for scanning.

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