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A REVIEW ON A CONSTRUCTIVE SMART ANTENNA BEAMFORMING TECHNIQUE WITH SPATIAL DIVERSITY

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Abstract: Smart antenna have been achieving popularity now a days. The most important step in smart antenna is beamforming and the major advantage of beamforming is that phase shifting and array weighing can be performed on digital data rather than in hardware. These weights are used to steer the antenna array beam in the direction of interest, thereby enhancing SNR. Now in this review paper I studied that beamforming in smart antenna along with spatial diversity using fuzzy inference system and neural network was proposed. In this neural network and fuzzy inference system is trained by a dataset generated by genetic algorithm. The dataset is generated for angles individually and also for combinations of different angles. GA is one of optimizing technique works based on genetic concepts. In addition the proposed method increases the efficiency of the smart antenna. The comparative and analytical results prove the performance of the proposed method over the other existing methods.

I. INTRODUCTION

The recent advances in digital technology have made it possible and cost effective to implement smart antenna in wireless communication applications for improving overall system capacity, coverage, quality of reception etc. The smart antenna is an array of antenna elements followed by a sophisticated signal processor, which can adjust its own beam pattern in order to emphasize the signal of interest and to minimize the interfering signals[1].

Smart Antenna, also known as adaptive antenna, is capable of adapting its radiation pattern according to the surroundings. There are two main functions of smart antenna.

- Direction of arrival(DOA) Estimation
- Beamforming

DOA Estimation corresponds to finding the direction in which the desired user and the interference lie. Beamforming, on the other hand, corresponds to the formation of main beam in the direction of the desired user and placing nulls along the direction of interference. These two functions can be achieved through various algorithms. In paper[2] we use Genetic Algorithm. In fact, it is not the antenna which is smart, it is the algorithm behind the antenna which is smart. For the realization of smart antennas genetic algorithm is an optimization algorithm based upon two laws of Biology i.e. law of "Genetic Recombination" and "Natural Selection". Genetic algorithms combine survival of the fittest among string structures with a randomized information exchange. In every generation, a new set of strings is created using bits and pieces of the fittest of the old; an occasional good part is tried for good measure. They efficiently exploit information to speculate on new search points with expected improved performance. Smart antenna techniques can be separated into three broad categories: a) diversity b) beamforming, and c) MIMO (multiple input multiple output)[3].

The classical problem in array signal processing is to determine the location of an energy radiating planar source relative to the location of the array. We are interested in estimating the direction-of-arrival of a signal in the presence of noise and interfering signals. The antenna array filters data collected over a spatial spectrum much in the same manner that an FIR filter processes temporally sampled data. One such popular technique is the Multiple SIgnal Classification (MUSIC) algorithm[4]. However, new generation array signal processing techniques employ iterative evolutionary algorithms inspired from nature to estimate the location of energy radiators.

Adaptive beamforming is a powerful technique of enhancing a signal of interest while suppressing the interference signal and the noise at the output of an array of sensors. A smart antenna system combines multiple antenna elements with a signal- processing capability to optimize its radiation and or reception pattern automatically in response to the signal environment[5]. The main figure of merit for measuring the quality of digital signals is called Bit error rate (BER) which is the ratio of number of bits received in error versus total number of bits sent. An array beamformer is a processor used in conjunction with an array of sensors to provide versatile form of spatial filtering. The sensor array collects spatial samples of propagation wave fields, which are processed by the beamformer. An adaptive array system can be employed to automatically adjust its directional response to null then interferer and thereby enhancing the reception of the desired signal.

The two important categories are smart antennas. They are

A. Switched Beam Antennas

Switched beam antenna systems form multiple fixed beams with heightened sensitivity in particular directions. These antenna systems detect signal strength, choose from one of several predetermined, fixed beams, and switch from one beam to another as the mobile moves throughout the sector.

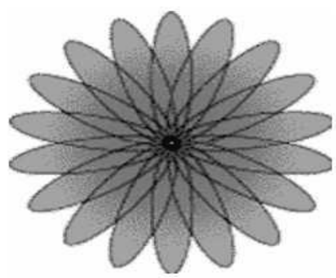

Fig.1 switched beam

B. Adaptive Array Antenna

Only a small portion of the power transmitted in an omni directional manner is actually received by the intended user, while at the same time the rest, the 'wasted' power causes harmful interference to other potential users as shown in Fig 2. Hence it is obvious that the omni directional power transmission is inefficient both in terms of power and capacity. Exploiting the adaptive antenna spatial filtering properties, it is possible to confine the radio energy associated with a given user to a small addressed volume, thus reducing the interference from others.

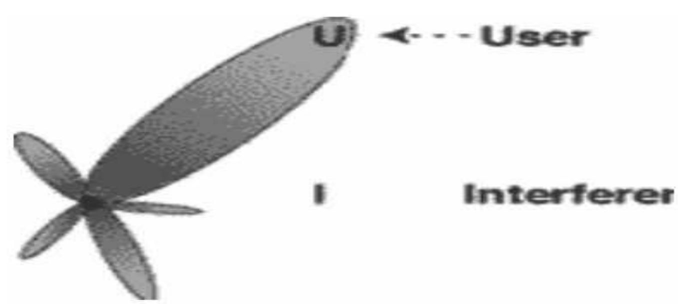

Fig.2 adaptive array

II. RELATED WORK

V.V. MANI[1] in 2007 proposed a smart antenna for impulse based UWB beamforming. This multi-element antenna combines received signals intelligently to collect desired UWB signal and to suppress UWB interference coming from other than the look direction of the antenna. In this paper genetic algorithm is used to determine the optimal weights of the antenna based on interference directions. In GA, the weights are represented as chromosomes on which genetic operators are shows M element antenna can suppress up to M-1 interferences and also the interference power decreases with increase in number of antenna elements. **Habib Awan[2]** in 2006 performed a work in which Smart antennas provide a smart solution to this problem by steering the beam power in the desired direction and pointing nulls in the undesired direction. In this paper author proposed an application of Genetic Algorithm towards the implementation of two important properties of Smart Antenna System which are the Direction of Arrival Detection and Beamforming. In this implementation, these are Estimation of Direction of Arrival of desired signal and interference, beamforming in the desired direction and null placing in the direction of interfering signals. **Konstantinos A. Gotis[3]** in 2009 A generic direction of arrival (DoA) estimation methodology is presented that is based on neural networks (NNs) and designed for a switched-beam system (SBS). The method incorporates the benefits of NNs and SBSs to achieve DoA estimation in a less complex and expensive way compared to the corresponding widely known super resolution algorithms. It is shown that a properly trained NN can accurately find the signal of interest (SoI) angle of arrival at the presence of a varying number of mobile users and a varying SoI to interference ratio. **Sumanta Bose[4]** in 2012 performed a work on array signal processing by using various algorithms. Array signal processing is one such application that has emerged as a promising technology for the fourth generation (4G) wireless communication network. It is widely used in smart antenna technology for estimating direction-of-arrival (DOA) and beam-forming. In the recent past it has evolved massively delivering enhanced performance by utilizing algorithms in nature: Artificial Neural Network (ANN), Genetic Algorithm (GA), Particle Swarm Optimization (PSO). This paper discusses the algorithms and analyses the performance of the stated optimization techniques. **K. Meena alias Jeyanthi[5]** in 2009 worked on adaptive algorithm with interference suppression. In this Modeling and simulation of uniform linear array using Matrix Inversion Normalized Least Mean Square (MI-NLMS) adaptive beam forming with minimum Bit Error Rate (BER) is developed for smart antenna applications. The algorithm have the advantage of both block adaptation and sample by sample techniques which shows that the performance of block adaptation and normalization of Least Mean Square (LMS) improves the system capacity and minimize bit error rate (BER) upto 10-4 for the signal to noise ratio of 13 dB's. The Quadrature amplitude modulation (QAM) allows us to send more bits per symbol to achieve higher throughput and to overcome fading and other interferences. The simulation is done in MATLAB. Adaptive beamforming allows several attractive features. **Mohammed Ali Hussain[6]** in 2010 performed a work on the use of smart antennas in ad hoc network. The capacity of ad hoc networks can be severely limited due to interference constraints. One way of using improving the overall capacity of ad hoc networks is by the use of smart antennas. Smart antennas allow the energy to be transmitted or received in a particular direction as opposed to disseminating energy in all directions. This helps in achieving significant spatial re-use and thereby increasing the capacity of the network. **J. Rugamba[7]** in 2004 proposed a work in which The research has shown the following; that with use of smart antennas, reduction in outage probability from 1 to 0.001 meant less co-channel interference is experienced even when frequencies have to tightly be reused in high traffic areas. **Ch. Santhi Rani[8]** in 2009 proposed a paper in which made a use of LMS and RLS algorithms for smart antenna in a w-cdma

mobile communication environment. This article focuses on adaptive beam forming approach based on smart antennas and adaptive algorithms used to compute the complex weights like Least Mean Square (LMS) and Recursive Least Squares (RLS) algorithms. The convergence speed of the LMS algorithm depends on the eigen values of the array correlation matrix. In an environment yielding an array correlation matrix with large eigen values spread the algorithm converges with a slow speed. This problem is solved with the RLS algorithm by replacing the gradient step size μ with a gain matrix. The simulation results were provided to understand the convergence, stability, and the method of the adaptation of the algorithm. The results obtained from the simulations showed that the LMS had poor convergence compared to RLS, and the RLS algorithm is the most efficient and LMS is the slowest.
Here we studied various research papers related to smart antenna beamforming and their results are concluded as follow in table given below.

Author(s)	Year	Paper name	Technique used	Results
V. V. Mani and Ranjan Bose	2007	Genetic algorithm based smart antenna design for UWB beamforming	Genetic algorithms for UWB beamforming	Suppress interference coming from the look direction, M antenna suppress M-1 interference
Habib Awan, Khurrum Abdullah and M. Faryad	2005	Implementing smart antenna system using genetic algorithm and artificial immune system	Genetic algorithm and artificial immune system	Successfully catered for two users by adjusting the radiation pattern, it have also incorporates the artificial immune system I n the form of memory to make this technique fast
Konstantinos A. Gotsis, Katherine Siakavara, and John N. Sahalos	2009	On the direction of arrival (DoA) estimation for a switched-beam antenna system using neural networks	Switched beam system using neural network	Set of seven beams, produced by the cosine illumination of the antenna elements, provides significantly better results compared to the set of eight orthogonal beams produced by the uniform illumination, The configuration is very robust and adaptable to the DOA estimation case
Sumanta Bose , Prabu. K and D. Sriram Kumar	2012	Array signal processing and optimization using algorithms in nature	Array signal processing and optimization using	Artificial neural network- interpolate data into high

			different algorithms	dimensions, does not need initial estimate of the direction of the source, substantial reduction in the CPU time need to estimate DOA. Genetic algorithm-performance of GA-based ML method is superior to music, computing time is less as compared to music
K. Meena alias Jeyanthi, Dr. A. P. Kabilan	2011	A simple adaptive beamforming algorithm with interference suppression	Matrix inversion normalized least mean(MI-NLMS)	Improves the system capacity by suppressing co channel interference, 14 db gain improvement, and significant improvement in bit error rate.
Mohammed Ali Hussain, P.Suresh Varma, K. Satya Rajesh, Hussain Basha Pathan, Leela Madhav Sarraju	2010	Use of smart antennas in AD HOC networks	Smart antenna in ad-hoc network using medium access control protocol	Avoidance of hidden terminal problems, ensure that the schedule respects the half duplex nature of the communication
J.Rugamba, Prof. L.W. Snyman, A. Kurien, and D. Chatelain	2004	Viability of using intelligent (smart) antenna system in GSM cellular networks	Adaptive beamforming	Reduction in outage probability, less transmitted power due to smart antenna high gain
Ch. Santhi Rani, P. V. Subbaiah, K. Chennakesava Reddy and S. Sudha Rani	2009	LMS and RLS algorithms for smart antennas in a WCDMA mobile communication environment	LMS and RMS algorithms	Lms has poor convergence compared to RLS algorithm and the RLS algorithm is the more efficient and LMS is the slowest.
T. S. Ghouse Basha, P. V. Sridevi, M. N. Giri Prasad	2011	Enhancement in Gain and Interference of Smart Antennas Using Two Stage Genetic Algorithm by	Two stage genetic algorithm	Gain increased, interference decreased, improved performance

		Implementing it on Beam Forming		

III. RESULTS AND CONCLUSIONS

In this review various methods and techniques that are being used for beamforming in smart antenna are evaluated. A comparative study is made of various techniques. After evaluation of
well-known techniques it is clearly shown the various methods which perform beamforming in smart antenna efficiently and provides accurate results. In this study, FIS and NN are used for beam forming in smart antenna with spatial diversity. In the proposed method, GA is used for generating a training dataset and using this dataset, the fuzzy logic and NN is trained. The proposed method is implemented in MATLAB and tested by giving different angles as input to the system. The computational time of the proposed method is compared with beam forming without spatial diversity and from the results obtained it is clear that the proposed method is better than beam forming without spatial diversity and also the proposed method at input angle 0 and 180 is compared with the LMS algorithm. From the comparison result with LMS algorithm, it is clear that the proposed method has very low side lobes when compared with LMS algorithm, because of the reduction in side lobes it is clear that, using the proposed method the interference is very low. This work will be extended for new algorithm for brain direction of estimation which will provide more efficient results than existing methods in near future. Computational time will also be considered to compare this technique efficiently.

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