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Smart Antenna Investigations for Wireless Cellular Systems

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Abstract: The use of smart antennas in mobile radio communications cellular networks such as GSM network, to mitigate the fading effects and to increase the traffic capacity by exploiting the Spatial Division Multiple Access (SDMA) is actually of great interest. These intelligent antenna systems take advantages of both antenna and propagation technology. Smart antennas has the capability to reduce multipath interference as modeled in Rayleigh and Rician fading channel model, increase signal to noise ratio and introduce frequency reuse within a confined environment. The convenient base station antenna is 120° sectored. Although the implementation of smart antennas is mainly investigated on base stations, due in particular to obvious cumbersomeness reasons, it is still interesting to evaluate the smart antennas performance at the mobile level. The most important feature of a smart antenna is its beam forming capability. This technique can be used to increase the coverage of a particular area or data rate or the spectral efficiency of the system. In this paper different types of techniques are used for observing the behavior of the working of smart antennas. The amplitude or time delay (phase) of the signals received by all the antennas are modified then combined in such a manner as to improve reception of the desired signal.

Keywords: Smart Antenna, Beam forming, SDMA, Rayleigh Fading, Rician Fading

I. Introduction

A smart antenna is an array antenna composed of two or more antennas. The amplitude and time delay (phase) of the signals received by all the antennas are modified then combined in such a manner as to improve reception of the desired signal. Moreover, by concentrating the transmission energy in a specific direction, beam forming creates a signal that is orders of magnitude stronger than that of the signals in other directions. This technique can be used to increase the coverage of a particular data rate or the spectral efficiency of the system. The increased signal-to-noise ratio results in a larger gain in the direction of the user, and also provides better control of the distribution of spatial interference in the cell. Beam forming can be applied to the downlink and uplink. Smart antennas have gained great interest among researchers during recent years. Wireless operations are currently searching for new technologies to be implemented into the existing wireless communications infrastructures for capacity enhancement and quality improvement. Such research efforts will enable wireless carriers to boost the spectral efficiency of their networks so as to meet the explosive growth of wireless communications industry and take advantage of the huge market opportunity. Deployed at the base station of the existing wireless infra-structures, smart antennas are capable of bringing outstanding capacity improvement [1]. Until now, the investigation of smart antennas suitable for wireless communication systems has involved primarily uniform linear arrays (ULA). Different algorithms have been proposed for the estimation of the direction of arrivals (DOAs) of signals arriving to the array and several adaptive techniques have been examined for the shaping of the radiation pattern under different constraints imposed by the wireless environment. Furthermore, in the literature for adaptive antennas so far, little attention has been paid to other array topologies. Two key components of smart antenna technology examined here are direction of arrival (DOA) estimation and adaptive beamforming. With the former, it is feasible to determine the angles from which sources transmit signals towards an antenna array. With the latter, an antenna radiation pattern beam maximum can be simultaneously placed towards the intended user and ideally nulls can be placed towards directions of interfering signals.

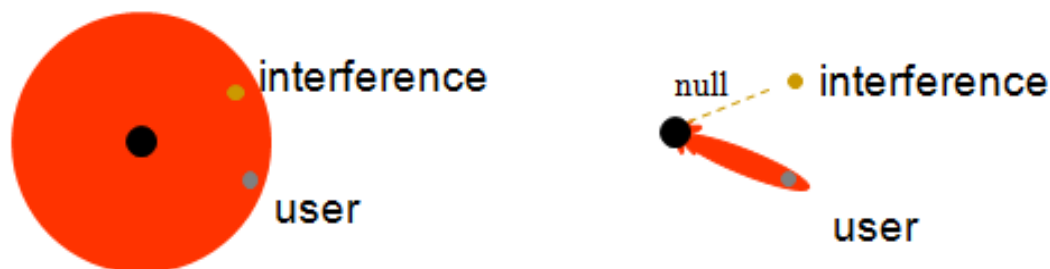


Fig. 1. Beamforming pattern of smart antenna and omni-directional

We consider the MUSIC algorithm for DOA estimation. Adaptive beamforming is achieved using the RLS algorithm.

II. Theory

There are two basic types of smart antennas. As shown in Fig. 2, the first type is the phased array or multibeam antenna, which consists of either a number of fixed beams with one beam turned on towards the desired signal or a single beam (formed by phase adjustment only) that is steered toward the desired signal. The other type is the adaptive antenna array as shown in Fig. 3, which is an array of multiple antenna elements, with the received signals weighted and combined to maximize the desired signal to interference plus noise power ratio[2]. This essentially puts a main beam in the direction of the desired signal and nulls in the direction of the interference. A smart antenna is therefore a phased or adaptive array that adjusts to the environment. That is, for the adaptive array, the beam pattern changes as the desired user and the interference move; and for the phased array the beam is steered or different beams are selected as the desired user moves[3].

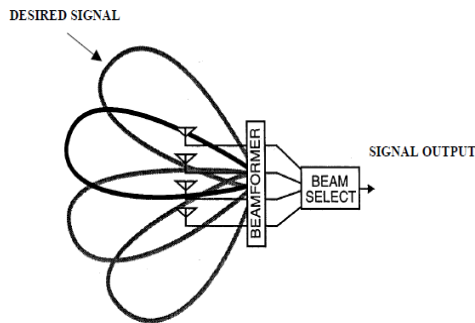


Fig.2- Phased Array

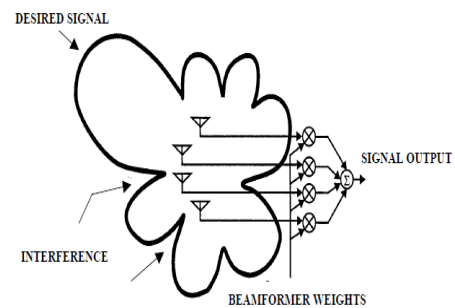
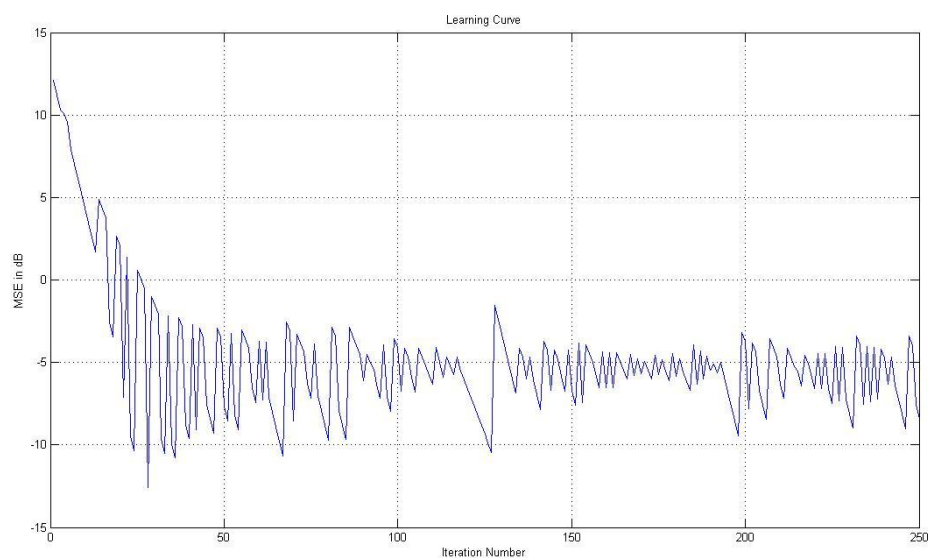


Fig. 3- Adaptive Array

The gain of a smart antenna is normally greater than that of an Omni-directional antenna. Also, when compared to an omni-directional antenna, smart antenna has higher reach ability i.e., a larger directional range. Beam forming is the term used to define the application of weights to the inputs of an array of antennas to steer the reception of the antenna array in a particular direction, called the look direction or the main lobe[4]. Beam forming techniques aims at enhancing the captured sound quality by using the diversity in the received signals of the microphone array depending on the location of the source and the hindrance. The two significant functions of smart antennas are Direction of Arrival and Adaptive Beam forming [5]. Adaptive beam forming systems uses an adaptive array processing for the creation of nulls in the direction of interference as well as powerful beams in the direction of desired use.

III. Results and Simulation



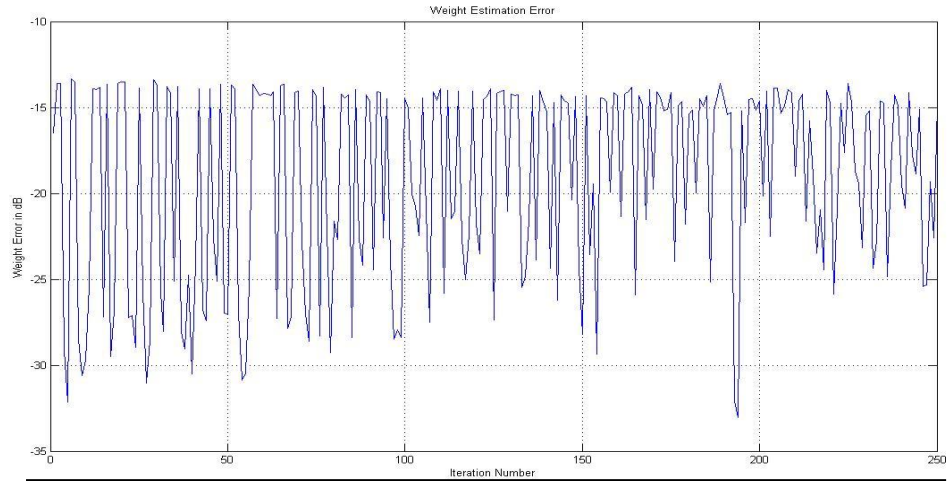


Fig. 4 Graphs showing the change in Mean Square Error and Weight Estimation error for a linear array of 3 elements without noise

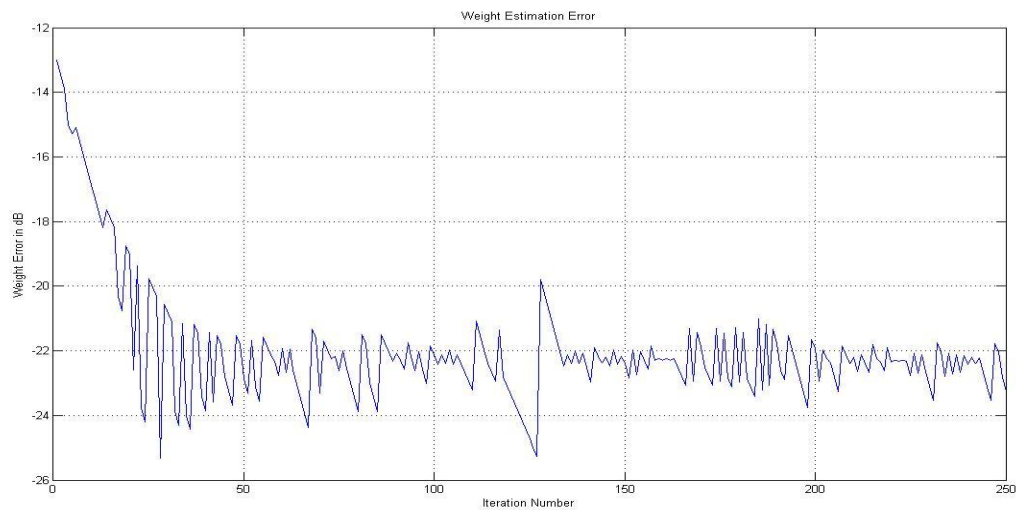
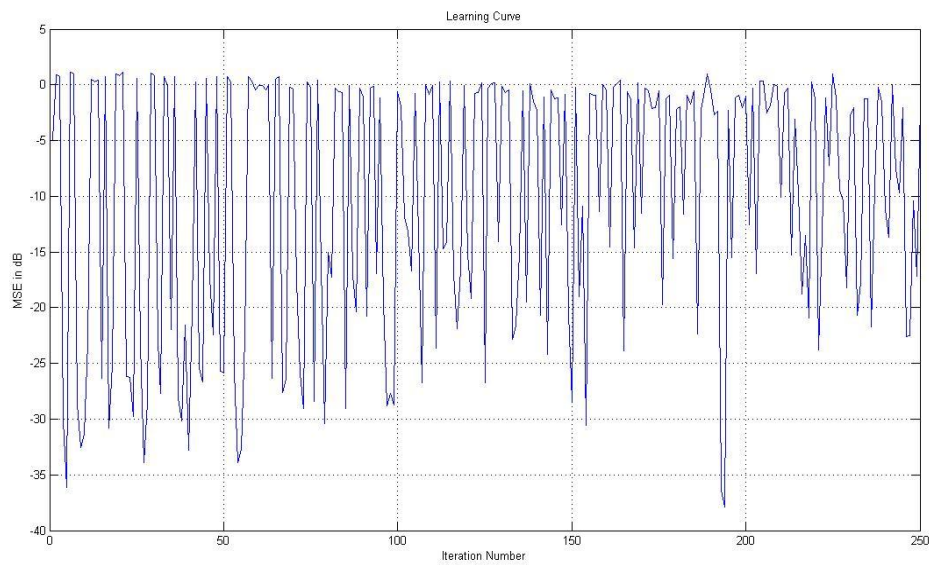


Fig.5 variations of MSE and weights error in the linear array of 3 elements with noise in environment

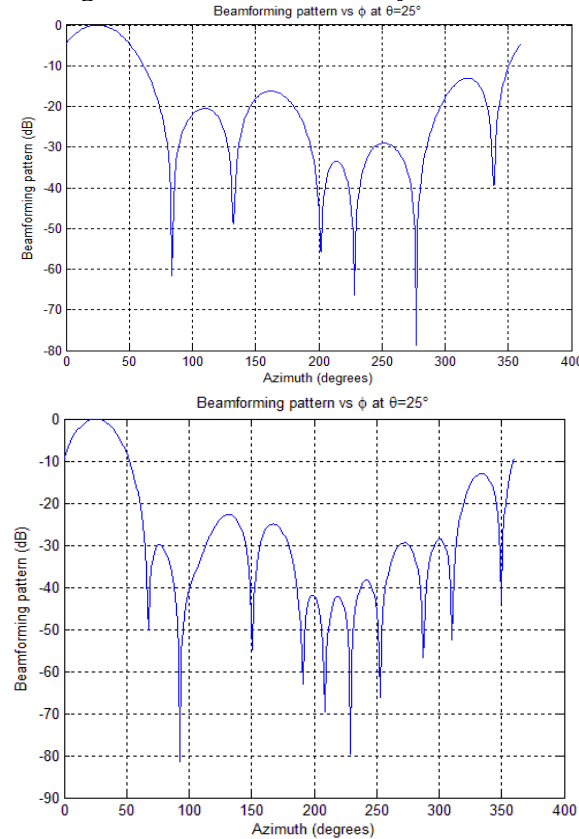


Fig.6. Amplitude responses of Planar Array (a) 6 X 6, (b) 8 X 8. Users at angle 25° and interferes at angle 45° .

From the graphs it is clear that the error in the outputs has been increased as noise is inserted in the ideal environment both the results show that the variations in the errors are very high. By changing the number of elements the results are further observed as more error prone. Planner array are designed, composing of rectangular patches. Planar arrays of 6×6 and 8×8 elements of rectangular micro strip patches having spacing between the elements $\lambda/2$. Designs are synthesized and analyzed using MATLAB 7.0, to observe the behavior of the array. SOI has magnitude of $0.5 + .5j$ and SNOI is complex conjugate of SOI. Theta and Phi for SOI is 25° whereas for SNOI is 45° . Beamforming Patterns are observed at azimuth angle of 25° . Responses of antenna array are shown in Fig. 2 and 3.

IV. Conclusion

The array factors are produced from complex weights using adaptive algorithm. Synthesized planar array of 8×8 is better in comparison to lesser number of radiating elements in array, i.e., 6×6 . But this modification has increases the cost and complexity of the designed antenna. These simulation results show that for this particular network for beamforming periods. Due to its narrower beam width; the main beam of the larger array can receive the signals-of-interest more accurately and rejects the more signals-not-of-interest.

References

- [1] M. Chryssomallis, "Smart Antennas", IEEE Antennas and Propagation Magazine, Vol. 42, No.3, pp. 129-136, June2000.
- [2] Frank Gross, "Smart Antenna for Wireless Communication" Mcgraw-hill, September 14,2005
- [3] A.O. Boukalov and S.G. Haggman, "System aspects of smart antenna technology in cellular wireless communications- an overview", Microwave Theory and Techniques, IEEE Transactionas on , vol. 48, pp. 919-929, 2000.
- [4] Xu Kai, Ji Hong, Le Guang-Xi, "An Improved Variable Step LMS Algorithm of The Adaptive Filter", Electrocircuit and System Transaction.2004,9(4):115-117
- [5] B.Widrow, P.E.Mantely,L.J.Griffiths, and B.B.Goode, "Adaptive Antenna Systems",Proc. IEEE, Vol.55,No.12, pp.2143-21559,Aug. 1967.
- [6] A.Alexiou and M. Haardt, "Smart Antenna technologies for future wireless systems: trends and challenges", Communications Magazine, IEEE, vol.42, pp. 90-97, 2004.
- [7] Y.T.Lo and S.W.Lee (Eds), "Antenna Handbook, Theory, Applications and Design", Chapter 11, pp. 49-52, Van Nostrand Reinhold Company, New York, 1998.