IJCTA, 9(5), 2016, pp. 2333-2339

Design and Simulation of Smart Antenna System with a BTS Receiver

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ABSTRACT

Use of sensible antenna systems permits the network operators to extend the wireless network capability. Wireless networks are facing everyday increase in demands on their spectrum and infrastructure resources. Sensible antennas have emerged as doubtless a number one technology for achieving extremely economical networks that maximize capability and improve quality and coverage [1]. Networks area unit expected to expertise a vast increase within the traffic as a result of the augmented variety of users furthermore as high rate services and applications. Operation is divided into direction of arrival (DOA) estimation of 2 interference signals with associate ESPRIT and MUSIC rule, adaptive beam forming with a null beam former and regeneration of digital knowledge with comparator. This paper investigates and compares ESPRIT and MUSIC DOA estimation algorithms that are widely utilized in the smart antenna system [2]. The spectrum for ESPRIT and MUSIC rule, output radiation patterns and output valid digital knowledge of the Null beam former area units are premeditated.

Keywords: Smart antennas, ESPRIT, MUSIC, BTS receiver.

1. INTRODUCTION

Smart antennas area unit antenna arrays with good signal process algorithms which are used to establish the direction of arrival (DOA) of the signal. Smart antennas should not be confused with reconfigurable antennas, which have similar capabilities however area unit single component antennas and not antenna arrays [3]. The Smart antenna technology will considerably improve wireless system performance and political economy for a spread of potential users. Sensible antennas give most flexibility by enabling wireless network operators to vary antenna patterns to regulate to the dynamic traffic or RF conditions within the network. Such sensible antennas are wide utilized in wireless mobile communications as they will increase the data rate and coverage area. In adaptive array sensible antenna to find the specified signal, varied direction of arrival (DOA) estimation algorithms are used. In signal process literature, direction of arrival denotes the direction from that typically a propagating wave arrives using a set of sensors [4]. These set of sensing elements formed is referred to as a sensor array.DOA can be established by using two algorithms named as MUSIC and ESPRIT [5]. These algorithms offer high angular resolution and therefore they are explored a lot by varied parameters of antenna system.

In this system the direction of arrival of all the incoming signals as well as the busy signals are calculated by the Direction of Arrival algorithms [6]. The required user signal is known and separated from the remainder of the unwanted incoming signals. A beam is steered within the direction of the required signal and therefore the user is half-track as he moves whereas putting nulls [7] at busy signal directions by perpetually change the advanced weights and the resultant signal is transformed to the demodulator.

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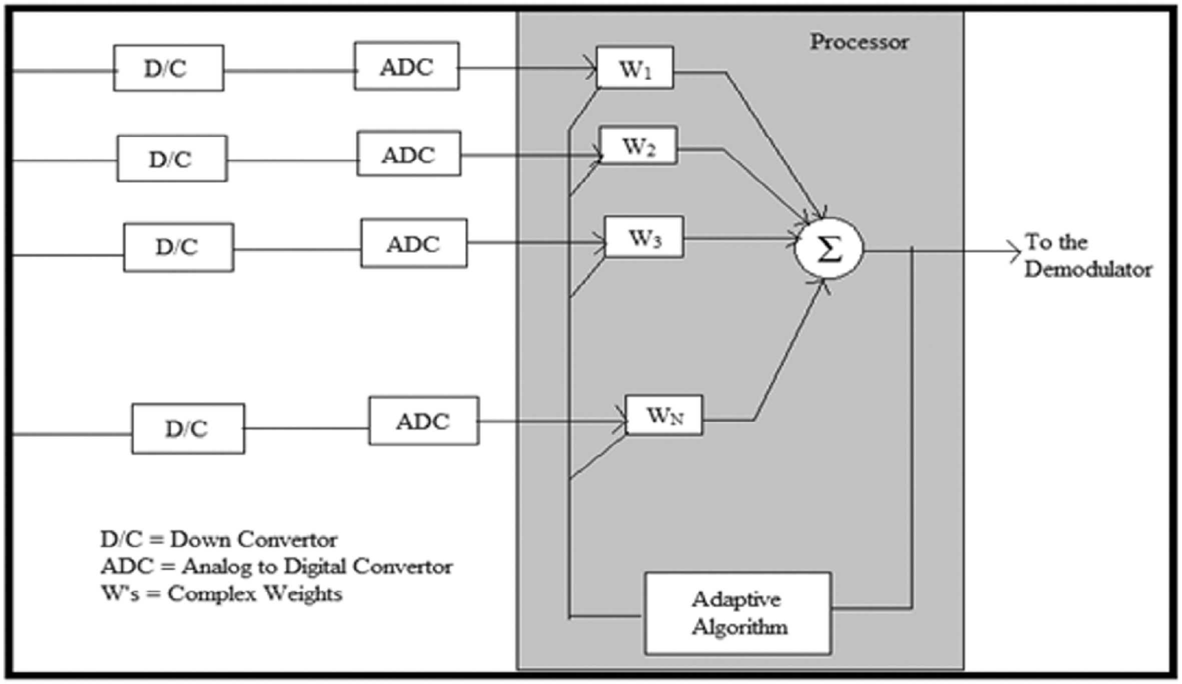

Figure 1: Adaptive array Smart Antenna

2. SMART ANTENNA BTS RECEIVER (UPLINK)

Smart antenna Base Transceiver station (BTS) uplink receiver depends on the estimation of the direction of arrival (DOA), Adaptive beam forming and signal regeneration [8].

2.1. Doa Estimation

In signal process literature, direction of arrival denotes the direction from which a propagating wave arrives at some extent. There are some subsequent conditions for a DOA which is represented as [9]:

- High accuracy significantly at low SNRs
- Low machine intensity
- Low memory
- Efficient for a pair of electro-acoustic transducer array with 4cm separation

The classification of DOA Algorithms [10] can be given as the following.

The topological space strategies like MUSIC and ESPRIT for direction of arrival (DOA) are based on the Eigen structure of the variance matrix.

2.1.1. Estimation of DOA using MUSIC Algorithm

MUSIC is a signifier that stands for Multiple Signal Classification. This approach may be a common high resolution eigen structure methodology [11]. MUSIC guarantees for the estimation of the amount of signals, the angles of arrival and the strength at which the waveform arrives. The signals which are incident could also be somewhat correlated to make a non-diagonal signal correlation matrix. However, underneath high signal correlation the normal MUSIC algorithmic rule breaks down and different strategies should be implemented to correct this weakness [12]. One should recognize in advance the amount of incoming signals or one should search the eigen values to work out the amount of incoming signals.

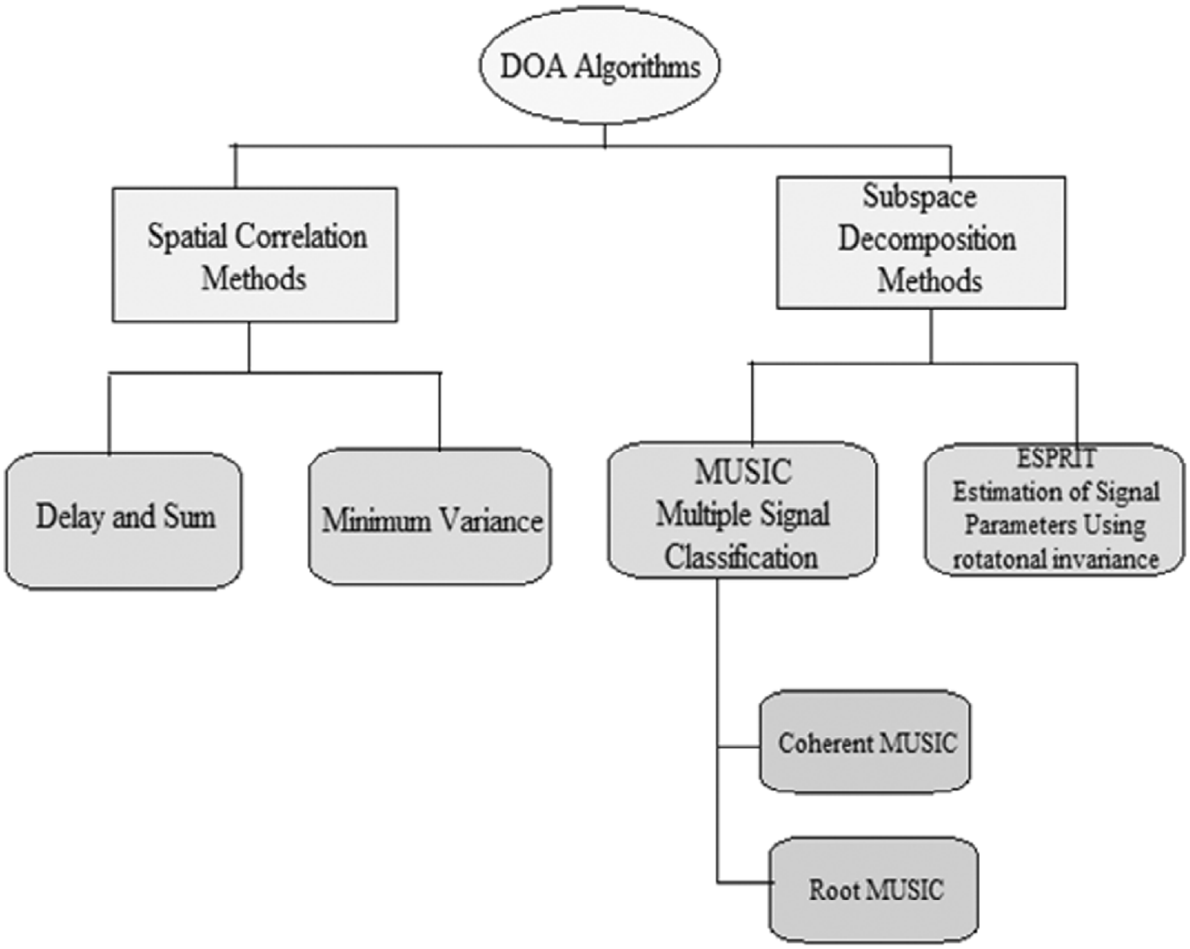

Figure 2: Flowchart representing the classifications of the DOA Algorithms

From an array matrix S, we will get U Eigen vectors related to the signals (X-Y). Then opt for the Eigen vectors related to the small Eigen values. Noise Eigen vectors mathematical space of order X * Y is made and is given as

$$E_x = [e\bar{1}\ e\bar{2}\ e\bar{3} \ldots\ldots\ldots\ldots\ldots e_{\bar{x}} = Y]$$

The noise mathematical space Eigen vectors is orthogonal to the array steering vectors .The pseudo-spectrum-a operate that offers a sign of the angle of arrival based mostly upon maxima versus angle for MUSIC is given by the following equation

$$P_{mu}(\theta) = \frac{1}{\left|\bar{a}(\theta)\bar{E}_x\bar{E}_x{}^H\bar{a}(\theta)\right|}$$

2.1.2. Estimation of DOA using ESPRIT Algorithm

ESPRIT is a new approach which stands for Estimation of Signal Parameter via Rotational Invariance Technique which is used to estimate the problems in the signal parameters. ESPRIT is comparable to MUSIC in that it explains the underlying model of data arrived. ESPRIT has several necessary advantages over MUSIC [13]. The ESPRIT or liveliness technique for DOA estimation was first proposed by Roy and Kailath. This formula is additional strong with relevancy array imperfections than MUSIC. Computation complexness and storage necessities area unit less than MUSIC because it does not involve extensive search throughout all doable steering vectors. But, it explores the move invariance property within the signal mathematical space created by 2 sub arrays derived from original array with a translation invariableness structure not like MUSIC.

The Angle-of-Arrival of the ESPRIT algorithm can be established as [13]

$$\Phi_k = \cos^{-1}[c(\arg(\Phi_k))/\beta\Delta X]$$

Where as Φ_k represents the value of the Eigen vectors

From the above discussion it can be stated as the ESPRIT eliminates the search procedure inherent in most DOA estimation strategies. ESPRIT produces the DOA estimation directly in terms of the Eigenvalues [14].

2.2. Adaptive Beamforming

Beam forming may be a signal process technique accustomed management the radial asymmetry of the transmission and reception of radio signals [15]. Adaptive beam forming may be an ordinarily utilized technique that enables system operation in associate degree interference environment by adaptively modifying the systems antenna pattern thus that nulls square measure generated within the angular locations of the interference sources. This approach is applicable to scenarios wherever multiple antenna components square measure individually weighted to supply a desired radial asymmetry pattern. A typical methodology of forming the adaptative weights is via the MVDR algorithmic rule, which implements one linear constraint that maintains unit gain within the bore sight direction

2.2.1. Null Beam Former

Null beam forming is a technique of spatial signal process by which the multiple antenna transmitters will null multiuser interference signals in wireless communications [16]. Null-Steering could be a technique of beam forming for narrowband signals generally to create higher use of the antenna arrays.

The null steering beam former adapts the antenna pattern to steer the most beam towards the required users and places nulls within the direction of officious users. Specifically, null steering may be a methodology of beam forming for narrow band signals where we would like to possess a straightforward method of compensating delays of receiving signals from specific supply at totally different elements of the antenna array. To achieve this goal, we may only add the weighted version of the signals with applicable weighted values [17]. We have a tendency to do that in such how that the frequency domain output of this weighted total produces a zero result. This methodology is named as null steering.

2.3. SIGNAL GENERATION

Applied null beam former rule place a main beam into the direction of the user and broad nulls into the directions of interfering signals [18]. For regeneration comparator is employed, which compare incoming knowledge signal with a threshold worth of 0.5 and manufacture valid digital output knowledge removing distortions.

3. SIMULATION RESULTS

For the purpose of simulation assuming $N = 4$ and $N = 8$ linear array elements with a signal to noise ratio per sample 20dB are assumed. The simulation is carried using MATLAB assuming wide bands. The operation is classified into three stages which are followed as the estimation of the spacial spectrum of MUSIC and ESPRIT, null beam former and finally the comparable digital outputs.

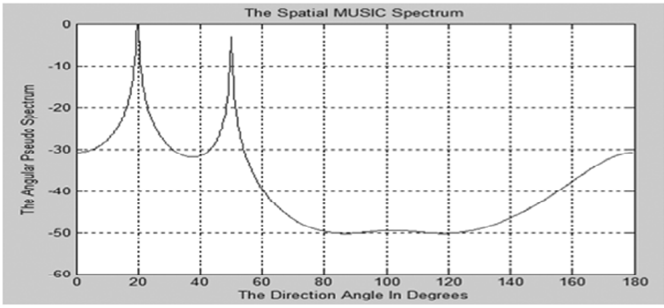

Figure 3: Represents the spatial MUSIC spectrum with peaks at 20^0 and 50^0

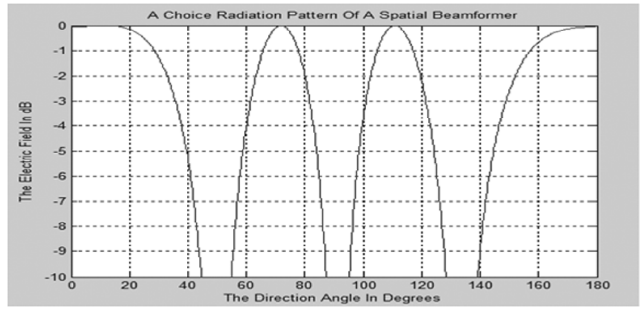

Figure 4: Represents the choice pattern of a spatial beam former

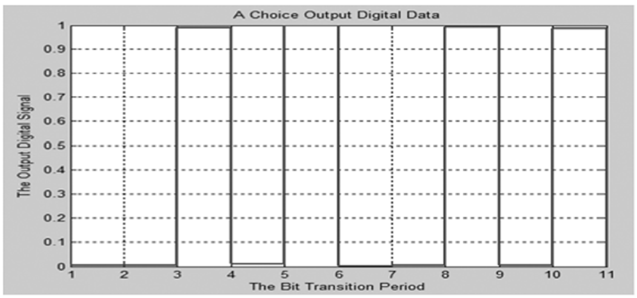

Figure 5: Represents the choice output digital data of 0010100101

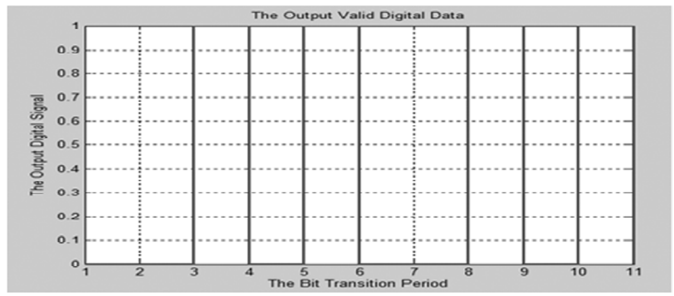

Figure 6: Represents the Valid output of the digital data

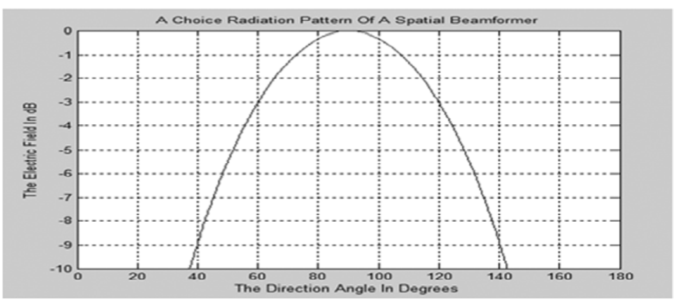

Figure 7: Represents a Choice of the Radiation Pattern for the Spacial Beam former

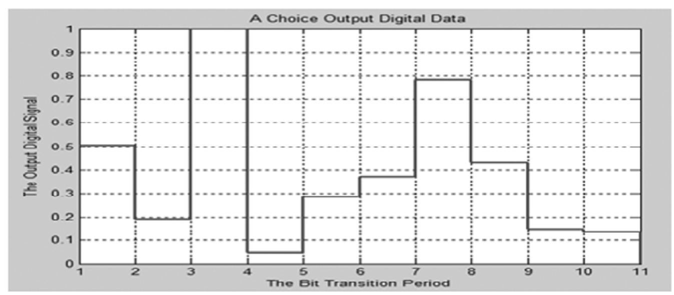

Figure 8: Represents the output choice of digital data of 1010111000

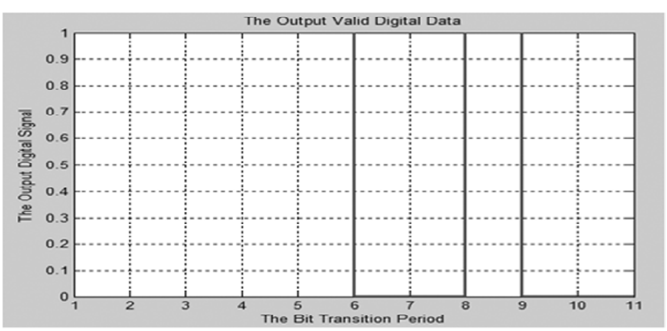

Figure 9: Represents the valid digital output data

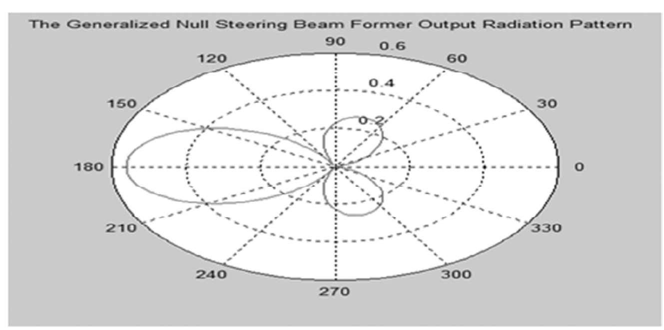

Figure 10: Represents the Output Radiation Pattern of a Generalized Null Steering Beam Former

4. CONCLUSION

This paper examines about the simulation and working of a sensible smart antenna BTS transmission uplink receiver. For beam forming with nulls in those directions, and the Null beam former is used to measure the specified weights. Authenticating bits of ten are formed with the help of the comparator. It is observed that the transmitted and recovered bits are same. In addition to this it is proved that the design of smart antenna with the usage of ESPRIT algorithm has several advantages over the design of smart antenna based on the MUSIC algorithm because it is less dependent on the array size. These results of numerical design and simulation are useful for the study and design of a smart antenna BTS receiver.

ACKNOWLEDGEMENT

We are thankful to our Head of the department Dr. P. C. Kishore Raja and our guide for his continuous support for the project especially during the data collection and fabrication. UG students M.Jahnavi, K.Divya Durga and Annam Sai Chaitanya closely worked on this project.

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