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Application of MUSIC Algorithm for Adaptive Beamforming Smart Antenna

Laxmikant Bansod[1], Anoop Singh Bundela[2] , Amarjeet Ghosh[2], ,

[1]PG Scholar in Digital Communication, Vaishnavi Institute of Technology, Bhopal(MP), India
[2]Asst. Professor in Electronics Department, Vashnavi institute of Technology, Bhopal (MP), India
[3]Asst. Professor in Electronics Department, Vashnavi institute of Technology, Bhopal (MP), India

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Abstract – *The spatial spectrum expresses signal distribution in the space from all directions to the receiver. Hence, if one will get the signal's spatial spectrum, then the direction of arrival (DOA) may be obtained. As thus, spatial spectrum estimation is also known as DOA estimation. DOA technology analysis is vital in array signal processing, that is an interdisciplinary technology that develops speedily in recent years, particularly the direction of arrival with multiple signal sources, the estimation of coherent signal sources, and therefore the DOA estimation of broadband signals. Over the past few years, all types of algorithms which may be utilized in DOA estimation have created nice achievements, the foremost classic rule among which is Multiple Signal Classification (MUSIC). In this paper discuss the DOA estimation supported MUSIC algorithm.*

Key Words: Adaptive Beamforming, Smart antenna, DoA, BM, MUSIC, etc... …

1. INTRODUCTION

In view of explosive growth within the variety of digital cellular subscribers, service suppliers are getting progressively involved with the restricted capacities of their existing networks. This concern has led to the preparation of smart antenna systems throughout major metropolitan cellular markets. These smart antenna systems have usually utilized multi-beam technologies, which are shown, through in-depth analysis, simulation, and experimentation, to supply substantial performance enhancements in FDMA, TDMA and CDMA networks [3-7]. Multi-beam architectures for FDMA and TDMA systems give the straight-forward ability of the smart antenna to be enforced as a non-invasive add-on or appliqué to an existing cell website, while not major modifications or special interfaces.

In a cellular system, Omni-directional antennas have conventionally been used at base stations to boost the coverage space of the base stations however it additionally leads a gross wastage of power that in-fact is that the main reason for co-channel interference at neighboring base stations. The sectoring thought with diversity system exploits space diversity and ends up in improve reception by counteracting with negative effects of multipath fading. Adaptive / smart antenna technology represents the foremost advanced smart antenna approach so far. Employing a kind of new signal-processing algorithms, the accommodative system takes advantage of its ability to effectively find and track varied kinds of signals to dynamically minimize interference and maximize meant signal reception. Each adaptive / smart system commits to increase gain according to the situation of the user; however; solely the adaptive system provides optimum gain whereas at the same time identifying, tracking, and minimizing interfering signals. Signal and the cost function are minimized. This results in an optimum radiation pattern.

2. BACKGROUND

Wireless communication systems are confined in capability and performance because of numerous deteriorations, like multipath fading, interference and delay spread. Smart antenna has been advised for wireless systems to satisfy the demand for enhanced information rates and also the lack of restricted channel bandwidth [1]. Switched beam antenna arrays are a set of smart antennas that may enhance the capability of a cellular system. Antenna beam switch has been demonstrated as a technique of correcting the matter of imbalance across the network cell sites [2] and enhancing their capability. The implementation of butler matrix (BM) is that the key element of a switched beam smart antenna (SBSA) [3–7]. Rotmans lens demonstrated in [8] has a disadvantage of large size. An antenna array designed with BM beam forming is employed to get 4, 8 or 16 totally different mounted beams at different angles (although increase within the variety of beams suggests that increase in size).

Many analysis works on switched beam antenna are targeted on decreasing the scale by reducing the construction (branch line coupler) for BM beamforming. Others targeted on utilizing RF switches and microcontroller to make a reconfigurable antenna [9–12]. Application of improvement algorithms, like particle swarm optimization (PSO) and generic algorithmic program (GA) in switched beam array have additionally been demonstrated [1, 13].

One major challenge that several researchers are neglecting is the way to choose these mounted beams of SBSA to maximize its potency. SBSA attracted several analysis interests attributable to the price of implementing

full adaptive array smart antenna and increasing its potency can encourage the appliance to the next-generation wireless system. Siachalou et al. [14] used digital operation to work out that port of BM to show on, whereas [15] demonstrated the appliance of artificial system and negative choice algorithmic program on six sector antenna.

Neural networks are wont to solve several engineering issues [16]. A supervised learning algorithmic program supported the error correction learning rule is shapely and trained to know the connection between the position of the target within the coordinate angle and also the antenna beam that covers that position. No specific sort of signal has been thought of as that drained [17].

3. SYSTEM MODELING

Lets the number of signal sources *k (k=1, 2, and 3.....D)* to the antenna array, then the wave front of the signal $S_k(t)$ can be expresses as:

$$S_k(t) = s_k(t)exp\{j\omega_k(t)\} \quad [1]$$

Where, $s_k(t)$ is complex envelop of signal and $\omega_k(t)$ is the angular frequency of the signal. For t_i time required by the EM antenna the expression becomes

$$S_k(t-t_1) \approx S_k(t) \quad [2]$$

The delay in signal wave is

$$\left.\begin{aligned}\bar{s}_k(t-t_1) &= s_k(t-t_1)exp[j\omega_0(t-t_1)]\\ &= s_k(t)exp[j\omega_0(t-t_1)]\end{aligned}\right\} \quad [3]$$

For k^{th} signal source in space linear array at the moment *t* for the array element *m* (*m*=1, 2...*M*) is

$$a_k s_k(t)exp\left[-j(m-1)\frac{2\pi d\sin\theta_k}{\lambda}\right] \quad [4]$$

Where, a_k is impact of array element *m* for k^{th} value.

The output signal for m^{th} array element

$$x_m(t) = \sum_{k=1}^{D} s_k(t)exp\left[-j(m-1)\frac{d\sin\theta_k}{\lambda}\right] + n_m(t) \quad [5]$$

Where, $n_m(t)$ is measured noise in the signal.

The equation (5) can be written in MATRIX form as

$$X = AS + N \quad [6]$$

Where,

$$X = [x_1(t), x_2(t), \ldots\ldots\ldots x_m(t)]^T \quad [7]$$

$$S = [S_1(t), S_2(t), \ldots\ldots\ldots, S_D(t)]^T \quad [8]$$

$$\left.\begin{aligned}A &= [a(\theta_1), a(\theta_2)\ldots\ldots a(\theta_D)]^T\\ &= \begin{bmatrix} 1 & 1 & \ldots. & 1 \\ e^{-j\phi_1} & e^{-j\phi_2} & \ldots. & e^{-j\phi_D} \\ \ldots. & \ldots. & \ldots. & \ldots. \\ e^{-j(m-1)\phi_1} & e^{-j(m-1)\phi_2} & \ldots. & e^{-j(m-1)\phi_D} \end{bmatrix}\end{aligned}\right\} \quad [9]$$

4. MUSIC ALGORITHM

Multiple Signal Classification (MUSIC) algorithms were planned by Schmidt and his colleagues in 1979. It's created a replacement era for spatial spectrum estimation algorithms. The promotion of the structure algorithmic program characterized rise and development, and it's become a vital algorithmic program for theoretical system of spatial spectrum. Before this algorithmic program was conferred, some relevant algorithms directly processed information received from array covariance matrices. The essential plan of MUSIC algorithmic program is to conduct characteristic decomposition for the covariance matrix of any array output information, leading to a sign subspace orthogonal with a noise subspace such as the signal parts. Then these two orthogonal subspaces are used to represent a spectrum operation, be got although by spectral peak search and find direction of arrival (DOA) signals.

It is as a result of MUSIC algorithmic program encompasses a high resolution, accuracy and stability under bound conditions that it attracts an oversized variety of students to conduct in-depth research and analyses. In general, it has the following benefits when it is used to estimate a signal's DOA.

- The ability to simultaneously measure multiple signals.
- High precision measurement.
- High resolution for antenna beam signals.
- Applicable to short information circumstances.
- It can do real-time processing data when using high-speed processing technology

From the previous section the direction of signal source is giving by the rows of the matrix *A*.

If the noise matrix can be

$$E_n = [V_{d+1}, V_{D+2}, \ldots\ldots\ldots, V_M] \qquad [10]$$

For spatial spectrum $P_{MU}(\theta)$ defined as

$$P_{MU}(\theta) = \frac{1}{a^H(\theta) E_n E_n^H a(\theta)} = \frac{1}{\left\| E_n^H a(\theta) \right\|^2} \qquad [11]$$

Where, the denominator of the formula is an inner product of the signal vector and the noise matrix. When $a(\theta)$ is orthogonal with each column of E_n, the value of this denominator is zero, but because of the existence of the noise, it is actually a minimum. $P_{MU}(\theta)$ has a peak. By this formula, make θ change and estimate the arrival angle by finding the peak.

5. RESULTS

For implementation of the work let us assume there is a four element array antenna is used on 2GHz frequency with 0.75 meter apart. Here consider a narrowband signals which are uncorrelated or partial correlated. For authentication code first send 10 bits. The whole work is divided as discussed previous in three stages:

- Estimation of Angle of Arrival by MUSIC Algorithm
- Adaptive Beamforming
- Signal Regeneration

After running the simulation program in MATLAB the following results are obtain with two different phase angle of arrival of the signal at 30^0 and 150^0.

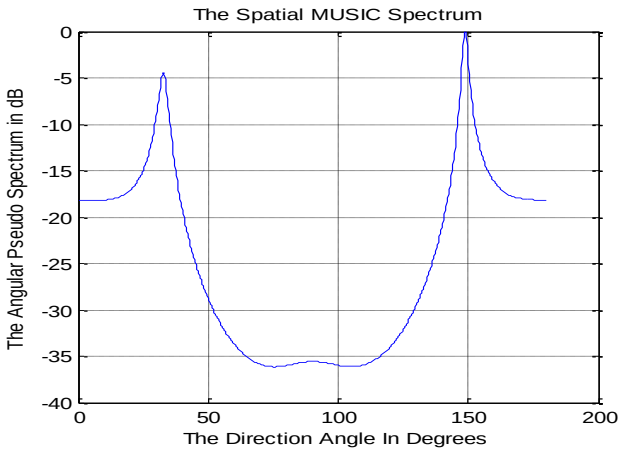

Fig. 1: Spatial MUSIC Spectrum for two different angles with 4 element array

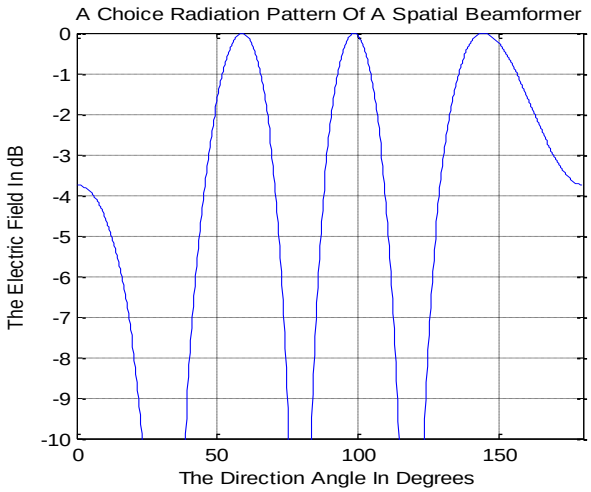

Fig 2: Choice of Radiation Pattern of Spatial Beamformer

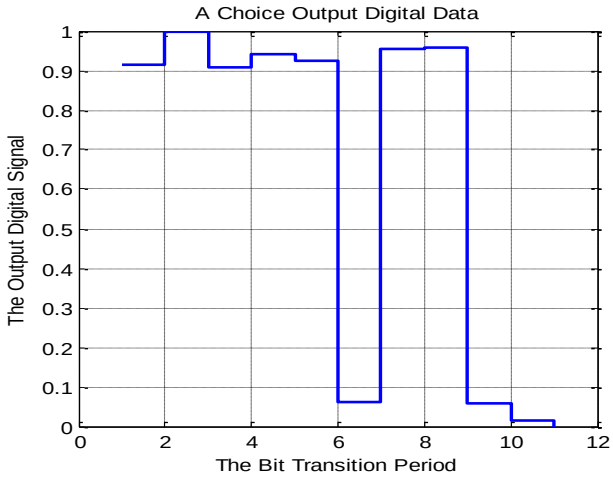

Fig 3: Choice of Output Digital Data

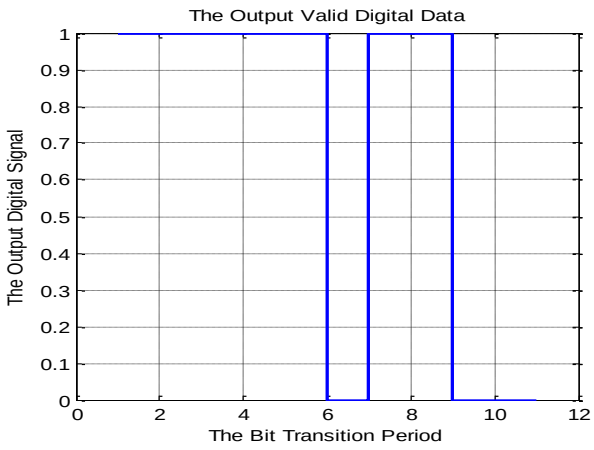

Fig 4: The Valid output data

6. CONCLUSION

The smart antenna is now a day's play major role in the advancement in wireless communication. The basic principle for growing interest in smart antenna system is the capacity increase and low power consumption. The DOA estimation plays an important role in array signal in the signal processing and has a wide range of application in smart antenna. The key to DOA estimation is to use an antenna signal array which is located in different spatial regions to receive signal from signal; sources in different direction. The use of DOA estimation algorithm has achieved useful results, which provide a theoretical and practical application.

This paper describes DOA estimation, spatial spectrum estimation and gives a mathematical model of DOA estimation with implementation of MUSIC algorithm (Multiple Signal Classification). The whole work is simulated in MATLAB software. From the simulation it is shows that MUSIC algorithm has a higher resolution over the smart antenna.

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