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Procedia Computer Science 93 (2016) 713 – 720

Procedia Computer Science

6th International Conference On Advances In Computing & Communications, ICACC 2016, 6-8 September 2016, Cochin, India

Robust Blind Beam formers for Smart Antenna System using Window Techniques

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Abstract

In this paper, we devised three efficient adaptive blind beamformers for smart antenna system based on popular constant modulus algorithm (CMA). Slow convergence rate of classical CMA limits its utilization in wireless communication applications where the channel conditions are rapidly changing. To overcome this problem, we firstly improved the convergence rate of CMA by making a step size adaptive. This makes CMA to converge within 10 iterations. Furthermore, to reduce the side lobe level (SLL), we applied three different windows namely; hanning, hamming and kaiser to the improved CMA and these algorithms are called as H-CMA, HW-CMA and KW-CMA respectively. Simulated results show that, KW-CMA has highest reduction in SLL as compared to H-CMA and HW-CMA. It has -80 dB peak SLL with an improvement of 70.89 dB for ten antenna elements than the conventional CMA for the same conditions. Hence the proposed algorithms exhibit fast convergence rate and reduced SLL. These key features make the smart antenna system robust and efficient and can be used in advanced wireless communication applications like radar, sonar and mobile communications.

Peer-review under responsibility of the Organizing Committee of ICACC 2016

Keywords: Beamforming; CMA; directivity; robust; sidelobe level; smart antenna

1. Introduction

Adaptive phase antennas are also called as "smart antennas", which have digital signal processing capabilities.

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Peer-review under responsibility of the Organizing Committee of ICACC 2016
doi:10.1016/j.procs.2016.07.274

Smart antennas are becoming popular now a day because of their unique features. When they used in wireless communication, can provide improved system capacities, increased frequency reuse, constant modulus restoration to phase modulated signals, multipath mitigation, blind adaptation, improved angle-of-arrival (AOA)
estimation and direction finding, higher permissible signal bandwidths, MIMO compatibility in both communications and radar and so on[1]. In the past decade, the wireless communications community recognized smart antennas as a core technology that would help existing systems overcome problems related to spectrum efficiency and provide a vehicle to achieve the ambitious requirements of next generation networks [2, 3]. The communication industries have already begun to develop smart antenna systems for commercial use and at the same time are working with standardization institutes around the world to produce smart antenna-friendly standards [4]. Recent research shows the use of smart antenna is one of the solutions for producing high directivity beamfomring for millimeter wave (mm) 5G and beyond networks [5, 6]. SLL is the main problem in radar and other communication systems which causes the wastage of energy [7]. SLL reduction and directivity are considered as most important applications of recent wireless communications. Many methods have been proposed for reducing SLL, but less research has been done for blind beamforming, which plays a vital role in multipath fading in mobile communications [8, 9]. The CMA[10] is the well known blind beamforming algorithm which does not require a reference radio signal. It depends on the signal properties (such as modulus or phase) to steer the main lobe [11]. They are suitable for mobile communications that produces low preambles.

In this paper, we propose three robust blind beamformers for smart antenna system using different window techniques. Figure 1 shows a uniform linear array (ULA) antenna configuration.

2. Array Signal Model

Let us consider a system model with ULA consisting of ‘M’ isotropic sensors. Let ‘m’ (m<M) be the unconstrained signal with frequency f impinging on ULA. Consider ‘d’ as element spacing between array elements which is λ/2. Here λ=c/f, where ‘c’ is the speed of light and f is the frequency of received signals. Consider dimension steering vector for directions $\theta(\theta_1, \theta_2, ..., \theta_m)$ in far fields and array observation vector can be modelled as :

$$\overset{*}{X}_k = s_r + a_r(\theta_r) + \sum_{i=1}^{M} s_i a(\theta_i) + n_k \quad (1)$$

Here, s_r & s_i are the required and interference signals respectively. θ_r & θ_i are the required and interference angles respectively. a_r & a_i are the required and interference steering vectors respectively. n_k is the complex noise vector and it is given by $n_k = [n_1, n_2\ ,..., n_m]^T$

The output of array vector can be expressed as: $y(k) = S^T(k)w = w^H S(k)$ (2)

Here $(\cdot)^T$ is the transpose and ‘w’ is the weight, which is given as: $w = [w_1, w_2 .... w_P]^T$

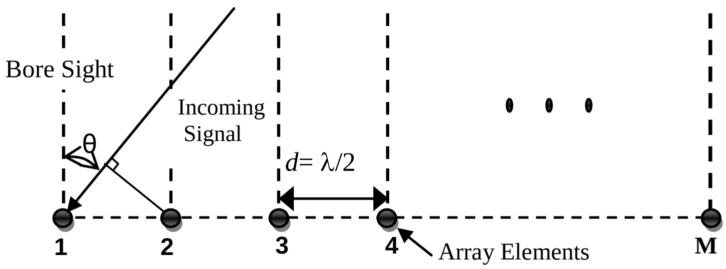

Fig.1. ULA Antenna Configuration[11]