Adaptive Array for Interfering Signals Cancellation Based on Power Minimization Algorithm

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Abstract

Adaptive arrays have a widespread use in modern communications systems due to their beamforming, beam steering and interference mitigation abilities. Most commonly employed method of interference mitigation is to determine the direction of arrival (DOA) of the unwanted signal and place a null in its direction in the antenna’s radiation pattern. However, determining the DOA with a high precision, especially in the case of multiple interferers, can be a cumbersome task, requiring expensive, state-of-the-art hardware and sophisticated algorithms. In this work, we present a real-time, low-cost alternative to DOA-based interference mitigation, which uses a stochastic power minimization approach to cancel out interfering signals.

1 Introduction

Intentional or unintentional Electromagnetic interference in critical RF communication links has become a serious issue in today’s world of automation. Typically, antenna arrays are designed to identify direction of arrival (DOA) of these unwanted signals before nulling them through adaptively reconfiguration of the radiation pattern of the receiving array (see Figure 1). RF signals from various elements are first down converted to IF signals then digitized using ADCs to estimate the angle of arrival of the unwanted signals. In addition to the high cost of these ADCs and mixers, the process of determining the DOA is time consuming and, in most cases, does not allow for real-time operation.

2 Approach

As a low-cost alternative, and potentially a relatively faster option, power minimization design can be used to mitigate unwanted interference. This approach does not require any prior knowledge of the direction of the interfering signals and is suitable for scenarios where the power level of the wanted signal is known. The power minimization scheme [1] simply requires the ability to detect the total power incident on the receiver at any given time [2]; the minimization is triggered once the received power exceeds a specified threshold. In other words, summed RF signals are rectified, then the DC level is fed to microcontroller to stochastically optimize and the complex weights of the adaptive array to yield the desired radiation pattern characteristics.

3 Optimization Algorithm

There are various types of stochastic optimization algorithms that can be used to accomplish this task, including genetic algorithm (GA), particle swarm optimization (PSO) [3-6], ant colony (ACO), artificial immune system optimization (AIO), etc. Here, we utilize PSO for its simplicity and familiarity.

![Figure 1. Schematic of the wanted and unwanted received signals.](image-url)
Results

Figure 3a shows the measured radiation pattern of the quadrifilier helical antenna array (Figure 2) in reference mode. After introducing an unwanted signal incident from $\theta = -75^\circ$, the power minimization algorithm was triggered until the total received power was brought down to the acceptable threshold. As shown in Figure 3b, the measured radiation pattern shows a clear -25dB null in the direction of the interferer, while the boresight gain was only reduced by 0.75dB.

Conclusion

Power minimization algorithm implemented on fast FPGA based on stochastic optimization can lead to nulling of interfering signals with minimal latency. The low-cost approach can be easily extended to more than one interfering signal and its speed can be further accelerated using an SoC with a higher clock speed.

References


Figure 4. a) Radiation pattern before nulling, b) radiation pattern after introducing a null at -75$^\circ$ degrees, broadside gain dropped only by 0.75 dB, while the null depth is -25 dB.