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ASSESSMENT OF ADAPTIVE BEAM FORMING ALGORITHMS FOR UNIFORM LINEAR ARRAY

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ABSTRACT

The current wireless cellular base station antenna system employs switched beam technology with fixed radiation pattern. This technology suffers from its inefficiency to track the user and limited capacity. The alternative approaches called cell sectoring and cell splitting has the major problems like more handoffs, additional base station antennas etc. The Smart antenna technology which tracks the mobile user continuously by steering the main beam towards the user and at the same time forming nulls in the directions of the interfering signal. The development of smart antennas includes the design of antenna array and adjusting the incoming signal by changing the weights of the amplitude as well as phase using efficient Digital Signal processing algorithms. This adaptive array promises to provide optimal solution for the above said problems and enhance the capacity of the wireless cellular network capacity. This project mainly focuses on Adaptive beam forming algorithms such as LMS and LMS/SMI will be modified to identify the best one among those two Algorithms based on speed and accuracy for smart cellular communication base station antennas.

1. INTRODUCTION

In recent years there has been an explosive growth in the num ber of wireless users, particularly in the area of mobile communication. In future wireless mobile systems will be more sophisticated and more widespread. This growth has triggered an enormous demand not only for capacity but also better coverage and higher quality of service. Several new technologies have been explored and deployed in this regard to make effective use of the limited resources. One way to improve capacity is by using the concept of cellular technology, which involves dividing a large coverage zone into small hexagonal cells. Therefore, a single high power transmitter is replaced with many low power transmitters. Each cell is allocated a set of frequency channels that are different from those allocated to the neighboring cells. However the same set of frequencies can be reused by another cell as long as they are separated well enough not to cause interference. Since each of these cells reuses the frequency spectrum, a significant increase in capacity can be achieved. However personal wireless communications is getting more and more popular and is continuing to grow at an exponential rate. Therefore new technologies are required in the area of mobile communications to accommodate future capacity needs. Smart antennas or adaptive arrays those are dynamically able to adapt to the changing traffic requirements. Smart antennas, usually employed at the base station, radiate narrow beams to serve different users. As long as the users are well separated spatially the same frequency can be reused, even if the users are in the same cell.

2. SMART ANTENNAS

In mobile communication systems, capacity and performance are usually limited by two major impairments. They are multipath and co-channel interference. Multipath is a condition which arises when a transmitted signal undergoes reflection from various obstacles in the propagation environment. This gives rise to multiple signals arriving from different directions. Since the multipath signals follow different paths, they have different phases when they are arrive at the receiver. The result is degradation in signal quality when they are combined at the receiver due to the phase mismatch. Co-channel interference is the interference between two signals that operate at the same frequency. In cellular communication the interference is usually caused by a signal from a different cell occupying the same frequency band. Smart antenna is one of the most promising technologies that will enable a higher capacity in wireless networks by effectively reducing multipath and co-channel interference. This is achieved by focusing the radiation only in the desired direction and adjusting itself to changing traffic conditions or signal environments. Smart antennas employ a set of radiating elements arranged in the form of an array. The signals from these elements are combined to form a movable or switchable beam pattern that follows the desired user. In a Smart antenna system the arrays by themselves are not smart, it is the digital signal processing that makes them smart. The process of combining the signals and then focusing the radiation in a particular direction is often referred to as digital beam forming. The early smart antenna systems were designed for use in military applications to suppress interfering or jamming signals from the enemy. Since interference suppression was a feature in this system, this technology was borrowed to apply to personal wireless communications where interference was limiting the number of users that a network could handle. It is a major challenge to apply smart antenna technology to personal wireless communications since the traffic is denser.

3.ADAPTIVE BEAMFORMING

Adaptive Beam forming is a technique in which an array of antennas is exploited to achieve maximum reception in a specified direction by estimating the signal arrival from a desired direction (in the presence of noise) while signals of the same frequency from other directions are rejected. This is achieved by varying the weights of each of the sensors (antennas) used in the array. It basically uses the idea that, though the signals emanating from different transmitters occupy the same frequency channel, they still arrive from different directions. This spatial separation is exploited to separate the desired signal from the interfering signals. In adaptive beam forming the optimum weights are iteratively computed using complex algorithms based upon different criteria. Beam forming is generally accomplished by phasing the feed to each element of an array so that signals received or transmitted from all elements will be in phase in a particular direction. The phases (the inter element phase) and usually amplitudes are adjusted to optimize the received signal.

4.LMS ALGORITHM

The Least Mean Square (LMS) algorithm is an adaptive algorithm, which uses a gradient-based method of steepest decent. LMS algorithm uses the estimates of the gradient vector from the available data. LMS incorporates an iterative procedure that makes successive corrections to the weight vector in the direction of the negative of the gradient vector which eventually leads to the minimum mean square error.

As shown above the outputs of the individual sensors are linearly combined after being scaled using corresponding weights such that the antenna array pattern is optimized to have maximum possible gain in the direction of the desired signal and nulls in the direction of the interferers. The weights here will be computed using LMS algorithm based on Minimum Squared Error (MSE) criterion. Therefore the spatial filtering problem involves estimation of signal from the received signal by minimizing the error between the reference signal, which closely matches or has some extent of correlation with the desired signal estimate and the beam former output y(t) (equal to w*x(t)). This is a classical Weiner filtering problem for which the solution can be iteratively found using the LMS algorithm.

5.LMS WITH SMI INITIALIZATION ALGORITHM

A combination of two adaptive algorithms LMS and SMI is presented in this chapter. The simulation results are also provided to analyze the performance of the new combined algorithm. The previous discussions on LMS and SMI have provided us with an understanding of their advantages and disadvantages. In the combined algorithm the individual good aspects of both the algorithms are used. LMS is a simple algorithm and is well suited for continuous transmission systems since it is a continuously adaptive algorithm. However, it is not known for its convergence speed, which has prompted people to use other complicated algorithms such as the Recursive least square (RLS) algorithm. SMI on the other hand has a very fast convergence speed as discussed in the earlier chapter. The speedy convergence is achieved because they use inversion of matrices, which makes it very computationally intensive. Also, the SMI algorithm has a block adaptive approach for which it is required that the signal environment does not undergo significant change during the course of block acquisition. Therefore there is a need for an algorithm, which is simple to implement yet has a fast convergence rate and is not computationally intensive. The algorithm featured in this chapter is an attempt in achieving this goal and it will be referred to as the SMI/LMS algorithm. The SMI/LMS approach discussed here uses the merits of both the LMS and the SMI algorithm. In order to speed up convergence the initial weights are calculated by using the SMI algorithm.

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