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Comparative Studies of LMS and NLMS Algorithm for Adaptive Beam Forming System

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ABSTRACT

Smart antennas have been considered to be one of the most demanding communication technologies. It adapted as most demanding technology because of high-bit rate or high quality in broadband commercial wireless communication. Then most elementary solution would be to increase bandwidth; however, this becomes ever more challenging as the electromagnetic spectrum is becoming increasingly congested. Smart antenna systems provide opportunities for higher system capacity and improved quality of service. Direction-of-arrival (DOA) estimation is based on the LMS and NLMS algorithm for identifying the directions of the source signals incident on the sensor array comprising the smart antenna system. . This is done through smart-antenna arrays and the associated adaptive beamforming algorithms. Adaptive beam forming is achieved using this algorithm for directing the main beam towards the desired source signals and generating deep nulls in the directions of interfering signals. It has been found that NLMS performs better in many respects than LMS and so we propose NLMS to be used by mobile companies when they will use smart antenna. Our comparison and findings were simulated using MATLAB.
Keywords: Beamforming, DOA, LMS, NLMS algorithm.

I. INTRODUCTION

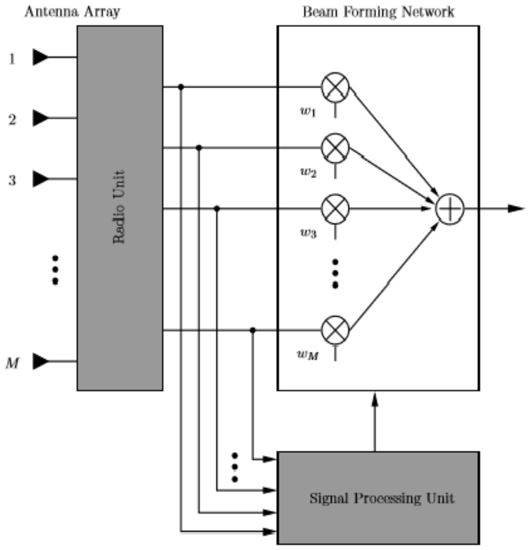
Smart antennas are also known as adaptive array antennas, multiple antennas and recently MIMO are antenna arrays with smart signal processing algorithms used to identify spatial signal signature such as the direction of arrival (DOA) of the signal. It is mainly used to calculate beamforming vectors, to track and locate the antenna beam on the mobile/target. Smart antenna is defined as an antenna array system that is aided by a processing system that processes the signals received by the array or transmitted by the array using suitable array algorithms to improve wireless system performance. Its array consists of a set of distributed antenna elements (dipoles, monopoles or directional antenna elements) arranged in certain geometry of desired signal strength and reduces the interference from other signals. Hence they can be viewed as a combination of regular or conventional antenna elements whose transmit or received signals are processed using smart algorithms.

The Smart antenna (SA) technology is gaining more and more interest in increasing the wireless network capacity [1] that helps to meet the demand for the subscriber growth and the high speed.

II. METHODS AND MATERIAL

The conventional base station antennas were Omnidirectional i.e. they used to radiate power in all direction, where there will be a waste of resources since power is radiated in all direction other than the desired user view of direction.

A smart antenna is an array of radiating antenna elements combined with digital signal processing to transmit and receive in the adaptive manner [2-6]. Adaptively in the sense, it automatically adjusts the directionality of its radiation pattern in response to the signal environment. They are also known as adaptive array antennas. Thus smart antennas can increase capacity of the channel, broadens range coverage, steer multiple beams to track many mobiles, compensates aperture distortion or reduce multipath fading and co-channel interference.



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The digital signal processor interprets the incoming signal information using antenna array elements, determines the complex weights (amplification and phase information) and multiplies these weights to each element output to optimize the array pattern. This optimization is based on particular criteria i.e. which minimizes the interference and maximizes the main beam gain at desired direction. Thus, for computing these optimum weights and updating them we have several adaptive beamforming algorithms. But we are interested in localizing the sources, so for this, we implement DoA estimating algorithms that are mainly based on the specific properties of desired signal covariance matrix. Thus the observation space is subdivided into 2 spaces, one is signal space and other is noise space.

LMS

One of the simplest algorithms that are commonly used to adapt the weights is the Least Mean Square algorithm (See Fig.2). The LMS algorithm is a low complexity algorithm that requires directing matrix inversion and no memory [3]. Moreover, it is an approximation of the steepest descent method using an estimator of the gradient instead of the actual value of the gradient, since computation of the actual value of the gradient is impossible because it would require knowledge of the incoming signals a prior. Therefore, the error can be defined as desired signal minus output of array weight The output response of the uniform linear array is given by

y(n) = w(n).x(n)…………...(1)

Where w is the complex weight vector and X is the received signal vector given. The complex weight vector w is obtained using an adaptive Beam forming algorithm. The least mean square algorithm is a gradient based approach in which an error, e (n) is formed as

e(n) = d(n) − y(n) ……………....(2)

Where d (n) denotes the sequence of reference or training symbols known a priori at the receiver at time n. This error signal e is used by the beamformer to adaptively adjust the complex weight vector w so that the mean squared error (MSE) is minimized. The choice of weights that minimize the MSE is such that the radiation pattern has a beam in the reference signal and that there are nulls in the radiation pattern in the direction of the interferers. The LMS algorithm is based on the steepest descent method which recursively computes an updates the sensor array weights vector w. It is reasonable that successive corrections to the weights vector in the direction of the negative of the gradient vector should eventually lead to minimum MSE, which point the weights vector assume its optimum value. In a standard LMS algorithm, the array weights vector w is initialized arbitrarily, and is then updated using the LMS equation given below

w(n+1)= w(n) +μ.x(n).e*(n)…………(3)

Where w (n + 1) denotes the weights vector to be computed at iteration n + 1 and μ is the LMS step size which is related to the rate of convergence. In order to ensure the stability and convergence of the algorithm, the adaptive step size should be chosen within the range specified as

$0<\mu<1/2\lambda max$

where λmax is the maximum Eigen value of the input correlation matrix.

NLMS

The normalized least-mean-square (NLMS) algorithm which is also known as the projection algorithm, is a useful method for adapting the coefficients of a finite-impulse response (FIR) filter for a number of signal processing and control applications. It can persist over a wide range of stepsizes. Theoretically, LMS method is the most basic method for calculating the weight vectors. However, in practice, an improved LMS method, the Normalized-LMS (NLMS) is used to achieve stable calculation and faster convergence. The NLMS algorithm can be formulated as a natural modification of the LMS algorithm based on stochastic gradient algorithm. Gradient noise amplification problem occurs in the standard form of LMS algorithm.

Normalized Least Mean Square Algorithm is an extension of the LMS algorithm being directly proportional to the input vector x(n), which overcomes the limitation of LMS algorithm. The stability problem occurs in LMS due to its weight vectors w(n+1).

In other words, the Normalized least mean squares filter (NLMS) is a variant of the LMS algorithm that solves this problem by normalizing with the power of the input.
$w(n+1)=w(n)+ \mu(n).x(n).e^*(n)$……….(5)

In the equation (5), the step size is given by

$\mu (n)= \mu \mid x \; n \mid 2$ ……………….(6)

where μ is a constant , the value of μ lies in between 0 and 2.

μ(n) is the normalized version of LMS (NLMS) because step size is divided by the norm of the input signal to avoid gradient noise amplification due to x(n).

III. CONCLUSION

Smart antenna technology will form a vital part of wireless communication. There are many benefits in using an adaptive antenna especially on handset like increased coverage, data rates, reduced intereference, increased in spectrum efficiencvy , which are beneficial to radio communication.From the analysis of both algorithms, it is concluded that the NLMS algorithm is much better as compared to LMS algorithm in the mobile communication, But the NLMS algorithm requires a minimum of one additional multiply, divide and addition as compared to LMS. The LMS algorithm is basic method for updating the weight vectors and NLMS is an improved LMS algorithm for fast convergence. The NLMS algorithm gives better convergence characteristics than the LMS algorithm, because it can reduce the increase of the noise by dividing the step size parameter by input vector power. So finally, we can say that the NLMS is more useful for mobile communication system.

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