Study and Analysis of Beamforming Algorithm between LMS and SMI

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Abstract—In the last ten years, intelligent antennas have played a beneficial role in developing and improving communication systems. The communication system is compellingly and authoritatively. It is requisite to increase the channel capacity and at the same time decrease the interference; smart Antennas are one of the best ways to improve the communication system by reducing interference between users and improving the Angle of Arrival (AOA). This paper analyzed and evaluated the Least mean square (LMS) and Sample matrix inversion (SMI) Through the effects of some matrix factors, the number of elements, and iterations in the algorithms. Through the results, the SMI solved the interference problem better than LMS with the less sidelobes number, using MATLAB to simulations the result.

Index Terms—Beamforming, block length, sample matrix inversion, convergence, adaptive

I. INTRODUCTION

The overall performance in mobile communication can be improved by using a smart antenna array, and the received signal at each antenna element is adaptively integrated using the smart signal processing unit [1], [2]. By producing a beam of radiation only along the direction of arrival of the signal (DOA), significant energy savings can be achieved using the smart antenna. Smart antenna technology can significantly improve the performance of the wireless system by increasing Signal quality, network capacity, and coverage area, as shown in Fig. 1.

A digital beamforming method using a smart antenna is shown. Signals are adaptively processed to take advantage of the spatial field of the mobile radio channel. Usually, the signals received from different antennas are multiplied by complex weights and then the weights are added adaptively [3].

In this paper, the smart antennas are constructed by comparing the LMS and MIS algorithms' effectiveness and efficiency with the same parameter and iteration [12].

Fig. 1. Beam formation of smart antenna [4].

II. LITERATURE SURVEY

[12] In this paper, the LMS / SMI algorithms' efficiency and accuracy were improved by merging the two
algorithms. The actual results from this merging were that the algorithm gave terrific results in efficiency and accuracy.

[7] Beamforming suppression implementation of discrete algorithms lower-median squares model matrix inversion and fewer iterative squares. In each case, the bit error rate is compared to the interference power level. The merging provided a significant improvement in the unit and nest weights of both algorithms. LMS SMI is minimized with a single device by sending only one item. The results showed that the process of combining the algorithms leads to a reduction in the single-bit error rate, and the SMI algorithm has been shown to outperform the LMS algorithm.

[6] In this research, all the LMS and SMI algorithms were compared using the same weights to determine their effectiveness in signal and interference. The SMI algorithm found instead of using weights, a time block was used to receive data, the effects of the method in terms of speed also exactitude better than the rest of the algorithms.

[13] In this paper, LMS technology was used, which is one of the most common methods used by all algorithms in creating adaptive beamforming (CGM) algorithms. It was found from the results that LMS technology is a technique that requires many iterations to produce the required packet, and this method is one of the undesirable weaknesses of each algorithm, such as Least Mean Square (LMS), Minimum Standard Mean Square (NLMS), and Recursive Least Square (RLS). Model Matrix Reflection (SMI), and the results proved that SMI is better than the rest of the algorithms in terms of performance. In contrast, the LMS algorithm is simple in performance and efficiency. We suggest that the process of improving the performance of algorithms should be combined with each other so that the results are more effective and perform better.

III. SMART ANTENNA

Van Atta introduced the term intelligent antennas in 1959 who wanted to describe the autonomous array [14]. The scientist Howells proposition the first technique for removing the sidelobe. While the technology is being used to remove the interference between users in this area, the current technology in antennas shows comprehensive progress in improving this field. Smart antennas contain more than one element of the antennas. The antennas are connected in terms of supply to manufacturing the beam directed to the desired user. UA all the elements are in line with each other. Many researchers consider smart antennas not that smart. It contains a digital signal processor matrix that processes complex signals, so it is considered a smart antenna system [15], [16]. In antennas, there are two types: firstly, a switched beam antenna, and secondly, an adaptive array antenna. The portable beam contains several different patterns and the second. The antenna systems detect signal strength, and one of these types is chosen, and the beam is transmitted between them and the position of the users. Smart antennas use a signal-processing algorithm to form a beam. The desired signal is automatically tracked, and the process of reasons is to reduce interference. At the same time, the (SA) gives the required signal while generating a blank signal to reduce signal interference between users. The basis for the configuration of the antennas is the DOA, the beam and the work of the antennas [17]. Searching for the user in all directions, collecting the received signals, and analysing the user's direction for the required signal and analysing the interference. The smart antennas depend on the selected DOA algorithms. [1], [14].

IV. ADAPTIVE BEAMFORMING ALGORITHMS

A. Least Mean Square (LMS)

The smart beam is formed by organizing and strengthening the desired source signals' weights and preventing interfering signals from unwanted sources. This algorithm is of interest in handling and complex calculations [16] as shown in figure 3. The LMS algorithm is one of the algorithms most used for its simplicity, it will not require scales, and the correlation is perfect with the rest of the algorithms because it does not need inverse algorithms. The LMS algorithm is one of the algorithms most used for its simplicity; it will not require scales, and the correlation with the rest of the algorithms does not require an inverse matrix [10].

![Fig. 3. Three elements with signal and interference](image)

Calculating and updating the regression of array weights used the iterative method; the LMS algorithm uses it [17]. It seems evident that successive weights vector corrections in the gradient vector's negative direction should ultimately result in the slightest mean square error. The
weights vector has reached its maximum value at this stage [18]. The array weights vector \( w \) is randomly initialized and then modified using the LMS equation in a standard LMS algorithm.

\[
w(n + 1) = w(n) + \mu x(n) e (n)
\]  

(1)

When \( w(n+1) \) denotes the vector parameters to be computed at iteration \((n+1)\) and \( \mu \) is the adaptive step size of the algorithm (LMS) is stable and positive, it could control the weights’ velocity by reducing the array error \( e(n) \) in the limiter’s\((n)\) as:

\[
e(n) = d(n) - y(n)
\]  

(2)

To ensure stability and convergence of the algorithms. The adaptive line size must be chosen from within the specified region. where \( d(n) \) is the reference signal and \( y(n) \) is the sensor array output signal as

\[
0 < \mu < 1/\lambda_{max}
\]  

(3)

The maximum value of the covariance matrix according to the place \( \lambda_{max} \) of the following equation [19].

\[
R = \sum_{n=1}^{K} X(n)x^{H}(n)
\]  

(4)

B. Sample Matrix Inversion

Another algorithm called SMI differed radically from the LMS algorithm in terms of operation because it does not deal with the matrix inverse directly [20]. The work of the SMI algorithm is by calculating the weights using the covariance matrix. The more samples of the received data, the weights are calculated with high accuracy to see the flowchart in Fig. 4. By calculating the weight of the algorithm using its predetermined value instead of the covariance matrix [7], it can get the required signal according to the equation

\[
R_{xx} (n) = \frac{1}{n} \sum_{n=0}^{n-1} x(n) \cdot x^{H}(n)
\]  

(5)

From the value of the vector to obtain a value according to the equation:

\[
r(n) = \frac{1}{n} \sum_{n=0}^{n-1} x(n) \cdot d(n)
\]  

(6)

From an SMI algorithm to calculate the rate of weights \( W_{SMI} = R_{xx}(n)^{-1} * r(n) \)  

(7)

The working environment for algorithms varies, and unexpectedly, the algorithm must adapt to this environment and form a high beam format. The LMS algorithm is less adaptive than the SMI algorithm.

V. RESULT

In this paper, the LMS algorithm is used in combination with the adaptive beam modulation technique and the SMI algorithm with Uniform Linear Array (ULA) and the elements (8). The \( \lambda \) is the wavelength spacing of elements with each other by 0.5\( \lambda \). The angle of Arrival (AOA) of Desired Signal is 30°, the interference signal is -60°. In Table I, the variables are defined in the simulation process using the MATLAB program in LMS algorithm they have six side lopes but they two of side lop have more 0.2 Array Factors this side lop not effect of the original signal but the bandwidth of signal is Wide see the Fig. 5. If increase the number of Antenna 16 with 14 side lop but two signals not effect, on the other hand the signal are narrow See the Fig. 6. The enhancement of antenna with 32 they have 33 side lop not affect the signal but have the tighten signal see the Fig. 7.

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Parameter Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>elements in the array</td>
<td>8</td>
</tr>
<tr>
<td>Block length</td>
<td>100</td>
</tr>
<tr>
<td>Space between element</td>
<td>0.5( \lambda )</td>
</tr>
<tr>
<td>desired signal</td>
<td>30</td>
</tr>
<tr>
<td>the interference</td>
<td>-60</td>
</tr>
<tr>
<td>Signal to noise</td>
<td>0.001</td>
</tr>
</tbody>
</table>

TABLE II: DIVERSITY OF ANTENNA ALGORITHMS

<table>
<thead>
<tr>
<th>Algorithm Name</th>
<th>Antenna element</th>
<th>Number of sides lop</th>
<th>Side lop rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMS</td>
<td>8</td>
<td>6</td>
<td>&gt;0.2</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>14</td>
<td>&gt;0.2</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>33</td>
<td>&gt;0.2</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>4</td>
<td>&gt;0.3</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>7</td>
<td>&gt;0.3</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>25</td>
<td>&gt;0.3</td>
</tr>
</tbody>
</table>
In SMI algorithm in the Fig. 8 they have 4 sidelobes without effect on the original signal further the signal is wide. In antenna with 16 elements they have 7 side lobes two side lopes more 0.3 this may be affecting the signal and the signal are direct to user because beam narrow see the Fig. 9. From antenna 32 element 25 sidelobes, the signal is narrower but no sidelobes in this signal see the Fig. 10.

The LMS is more than half the time to reach the desired signal and the results' effect due to the algorithm slowing.
The SMI algorithm does not need to be iterations but needs to block and get the desired signal. In the algorithm, the average value of the elements to give good results if the elements are small, such as 8 elements. The shape of the beam is narrow to the LMS algorithm, or if the results are extensive such as 16 elements, the results are excellent, but there are many sidelobes see the Table II. This method is also known as direct matrix inversion (DMI). A sample matrix is a matrix correlation time mean estimate, for which the matrix uses K-time samples.

VI. CONCLUSION

The algorithms LSM and SMI are approaching, analyzed, and compared. The algorithms are compared in terms of the effect of an antenna's elements on AOA variables. One of the results obtained in comparison between the two algorithms is that the beam width has been dramatically reduced. The SMI algorithm needed the time to reach the required signal, which proves that the SMI algorithm is better than the LMS algorithm in terms of speed. SMI algorithm is block dependent. One of the interests of SMI is that if the number of shots is defined and known, then the algorithm will give the value of the weights from the first time it repeated. However, there is a problem in the algorithm that we must invert the array is too large, and this causes complex equations and extensive calculations. Simulations were created with MATLAB to obtain results.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES


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