EFFICIENT DIRECTION OF ARRIVAL ESTIMATION USING MIMO TECHNOLOGY

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ABSTRACT: The problem of estimating the bearing angles of multiple incident RF sources has always attracted the interests of researchers due to its innumerable practical applications in radar and sonar for source localization, and beam forming/steering in mobile communication. the practical significance of the DOA estimation problem demands real-time testing through actual hardware experiments for verification and validation of the methods, which includes more cost. But , in massive MIMO technologies more number of antennas are utilized. In order to apply for real time applications, need to consider more number of antenna elements. Whole Transmitter and receiver is designed with OFDM MIMO concept.

KEYWORDS: Direction of Arrival, lest mean square, Variable step size, Orthogonal frequency division multiplexing, Multiple input multiple out.

INTRODUCTION: The problem of estimating the bearing angles of multiple incident RF sources has always attracted the interests of researchers due to its innumerable practical applications in radar and sonar for sourc localization, and beam forming/steering in mobile communication. The existing literature in this area focuses primarily on fanding ways to improve the precision and reduce the complexity of the algorithms for DOA estimation [5]. The performance analysis of most of these methods is carried out through numerical simulations. However, the practical significance of the DOA estimation problem demands real-time testing through actual hardware experiments for verification and validation of the methods. In this context, we have recently proposed a QR-TLS method for DOA estimation in [6] and presented its experimental verification in [7].

A smart antenna system implementation for DOA estimation has appeared in [8, 9] where the authors present an FPGA implementation of a DOA estimation algorithm with emulated sources. Another work implements the DOA estimator on a software denied radio (SDR). The authors discuss a phase calibration scheme to avoid estimation errors due to phase in-coherence between the RF receivers and tested the proposed DOA estimator in microwave anechoic chamber. In [11], the authors present a comparative study of the performance of DOA estimation of the MUSIC, Root-MUSIC, and ESPRIT algorithms [12{14] for the case of uncorrelated RF signals. For experimental testing, they use a receiving system composed of a linear array of antennas and a network of ¯ve-port demodulators operating at 2.4 GHz. 0N E of the most popular algorithms in adaptive signal processing is the least mean square (LMS) algorithm of Widrow and Hoff [11. It has been extensively analyzed in the literature, and a large number of results on its steady state misadjustment and its tracking performance has been obtained [2]-[8]. The majority of these papers examine the LMS algorithm with a constant step size. The choice of the step size reflects a tradeoff between misadjustment and the speed of adaptation. In [l], approximate expressions were derived which showed that a small step size gives small misadjustment but also a longer convergence time constant. Subsequent works have discussed the issue of optimization of the step size or methods of varying the step size to improve performance [9], [lo]. It seems to us, however, that there is as yet no detailed analysis of avariable step size algorithm that is simple to implement and is capable of giving both fast tracking as well as small misadjustment . Wireless networks face ever-changing demands on their spectrum and infrastructure resources. Increased minutes of use, capacity-intensive data applications, and the steady growth of worldwide wireless subscribers mean carriers will have to find effective ways to accommodate increased wireless traffic in their networks. However, deploying new cell sites is not the most economical or efficient means of increasing capacity. Wireless carriers have begun to explore new ways to maximize the spectral efficiency of their networks and improve their return on investment [1].

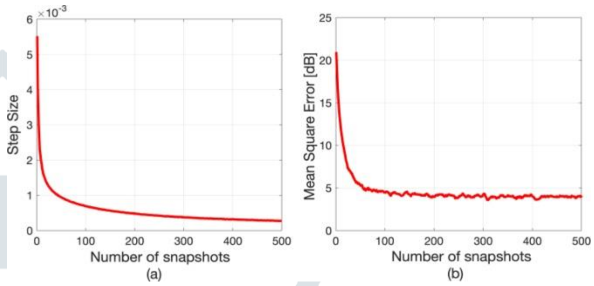
Smart antennas have emerged as one of the leading innovations for achieving highly efficient networks that maximize capacity and improve qualit and coverage. Smart antennas provide greater capacity and performance benefits than standard antennas because they can be used to customize and fine-tune antenna coverage patterns to the changing traffic or radio frequency (RF) conditions in a wireless network [1]. A smart antenna is a digital wireless communications antenna system that takes advantage of diversity effect a the source (transmitter), the destination (receiver), or both. Diversity effect involves the transmission and/or reception of multiple RF-waves to increase data speed and reduce th error rate.

In conventional wireless communications, a single antenna is used at the source, and another single antenna is used at the destination. Such systems are vulnerable to problems caused by multipath effects. When an electromagnetic field (EM field) is met withobstructions such as buildings the wavefronts are scattered,and thus they take many paths to reach the destination. The late arrival of scattered portions of the signal causes problems such as fading. In a digital communications system it can cause a reduction in data speed and an increase in the number of errors.

LITERATURE SURVEY:

It is well known that Chang proposed the original OFDM principles in 1966, and successfully achieved a patent in January of 1970. OFDM is a technique for transmitting data in parallel by using a large number of modulated sub-carriers. These sub-carriers divide the available bandwidth and are sufficiently separated in frequency so that they are orthogonal. The Orthogonality of the carriers means that each carrier has an integer number of cycles over a symbol period. In 1971, Weinstein and Ebert proposed a modified OFDM system [7] in which the discrete Fourier Transform (DFT) was applied to generate the orthogonal subcarriers waveforms instead of the banks of sinusoidal generators. Their scheme reduced the implementation complexity significantly, by making use of the inverse DFT (IDFT) modules and the digital-to-analog converters. In their proposed model, baseband signals were modulated by the IDFT in the transmitter and then demodulated by DFT in the receiver. Therefore, all the subcarriers were overlapped with others in the frequency domain, while the DFT modulation still assures their Orthogonality. Cyclic prefix (CP) or cyclic extension was first introduced by Peled and Ruiz in 1980 [8] for OFDM systems. In their scheme, conventional null guard interval is substituted by cyclic extension for fully-loaded OFDM modulation.

As a result, the Orthogonality among the subcarriers was guaranteed. With the trade-off of the transmitting energy efficiency, this new scheme can result in a phenomenal ISI (Inter Symbol Interference) reduction. Hence it has been adopted by the current IEEE standards. In 1980,Hirosaki introduced an equalization algorithm to suppress both inter symbol interference (ISI) and ICI [9], which may have resulted from a channel distortion, synchronization error, or phase error. In the meantime, Hirosaki also applied QAM modulation, pilot tone, and trellis coding techniques in his high-speed OFDM system, which operated in voice-band spectrum. In 1985, Cimini introduced a pilot-based method to reduce the interference emanating from the multipath and co-channels [10]. In the 1990s, OFDM



systems have been exploited for high data rate communications. In the IEEE 802.11 standard, the carrier frequency can go up as high as 2.4 GHz or 5 GHz. Researchers tend to pursue OFDM operating at even much higher frequencies nowadays. For example, the IEEE 802.16 standard proposes yet higher carrier frequencies ranging from 10 GHz to 60 GHz. However, one of the main disadvantages of OFDM is its sensitivity against carrier frequency offset which causes inter carrier interference (ICI).

DIRECTION OF ARRIVAL ESTIMATION:

In this section, the proposed DOA estimation method based on variable step size LMS algorithm is formulated.

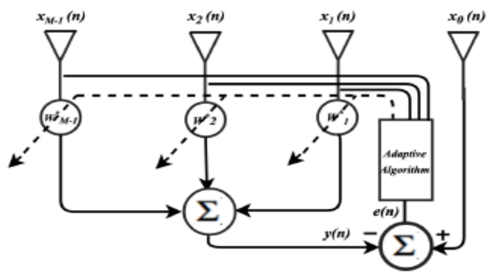


Fig-1: Linear Array antennas

The weight vectors for auxiliary elements [8] are calculated recursivelywith the variable step size which is expressed

$$\tilde{\mathbf{w}}(n+1)=\tilde{\mathbf{w}}(n)+\mu_{vss}(n)\tilde{\mathbf{x}}(n)e^*(n) \quad (5)$$

where $\mu_{VSS}(n)$ is the variable step size which is given by

$$\mu_{VSS}(n)=\alpha\xi_e^2(n)+\gamma\sigma_{\tilde{x}}^2(n) \quad (6)$$

where σ is a positive regularization factor bounded as 0 <α< 1/2 and γ is small positive steady-state parameter greater than zero.

$\xi_e^2(n) = 1/\sigma_e^2(n)$ (7)

$\sigma_e^2(n) = \sigma_e^2(n-1) + |e^2(n)|$ (8)

where $\sigma_e^2(n)$ is the cumulative sum of squared instantaneous error, e(n) is the instantaneous error which is calculated by

$e(n) = x_0(n) - w^H(n)x(n)\,\tilde{\mathbf{x}}^{\mathbf{H}}$ (9)

$\sigma_x^2(n)$ is the estimated signal power which is calculated by

$\sigma_x^2(n) = \frac{1}{\mathbf{xH}(n)x(n)}$ (10)

Fig-2(a),(b): Mean step size , Mean square error of the proposed method.

μVSS(n) should be less than μ_{max} for convergence of weight vector [8], where μ_{max} is an upper bound of step size which is given by

$0 < \mu VSS(n) < \mu_{max}$ (11)

where $\mu_{max} = 2/\lambda_{max}$, λ_{max} is the dominant eigenvalue of covariance matrix $R = E[x(n)x^H(n)]$, and approximately equal to signal power, i.e $\lambda_{max} \approx x(n)x^H(n)$Therefore, the upper bound of step size, μ_{max} can be calculated by

$\mu_{max} = \varepsilon \frac{2}{x(n)xH(n)}$ $0 < \varepsilon < 1$ (12)

where ε is a scaling factor. If the step size μVSS(n) is greater than μ_{max} then μVSS(n) is set to μ_{max} as given in the following expression, where μ_{max} is computed according to (12).

$$\mu_{VSS}(n) = \begin{cases} \mu_{max} & \text{if } \mu_{VSS}(n) > \mu_{max} \\ \mu_{VSS}(n) & \text{otherwise} \end{cases} \quad (13)$$

According to (6), the proposed method can choose step size adaptively as shown in Fig.2 (a). When $\xi_e^2(n)$ is large, the proposed method gets big step size which speeds up convergence. When it converges to the optimal solution, $\xi_e^2(n)$ approximately approaches to zero, resulting in a small step size μVSS $(n) \approx \gamma\sigma_{\tilde{x}}^2(n)$ which guarantees the stability and low mean square error of proposed method as shown in Fig.2 (b).

Further, to verify the validity of proposed method in terms of mean square error convergence, the following generalized condition should be satisfied

$$0 < \frac{E[\mu_{VSS}^2(\infty)]}{E[\mu_{VSS}(\infty)]} \leq \frac{2}{3\mathrm{tr}(\mathbf{R})} \quad (14)$$

where E[μVSS(∞)] and E[μ²VSS(∞)] are the steady-state values of mean step size E[μVSS(n)] and mean square step size E[μ²VSS(n)] respectively. After some mathematical derivations to (6), E[μVSS(∞)] and E[μ²VSS(∞)] are obtained

$$E[\mu_{VSS}(\infty)] \approx \gamma\sigma_{\tilde{\mathbf{x}}}^2(\infty) \quad (15)$$

$$E[\mu_{VSS}^2(\infty)] \approx (\gamma\sigma_{\tilde{\mathbf{x}}}^2(\infty))^2 \quad (16)$$

PROPOSED ARCHITECTURE:

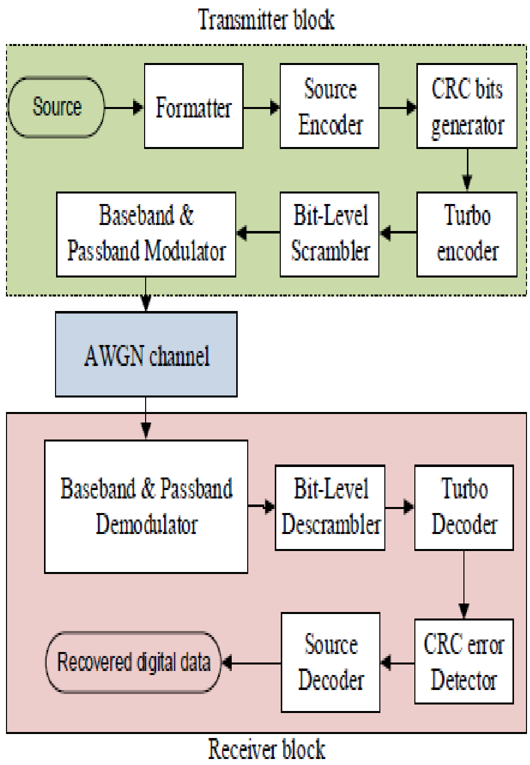


Fig-3: Proposed block

ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM):

Orthogonal Frequency Division Multiplexing (OFDM) is simply defined as a form of multicarrier modulation where the carrier spacing is carefully selected so that each sub carrier is orthogonal to the other sub carriers. Two signals are orthogonal if their dot product is zero. That is, if you take two signals multiply them together and if their integral over an interval is zero, then two signals are orthogonal in that interval. Orthogonality can be achieved by carefully selecting carrier spacing, such as letting the carrier spacing be equal to the reciprocal of the useful symbol period. As the sub carriers are orthogonal, the spectrum of each carrier has a null at the center frequency of each of the other carriers in the system. This results in no interference between the carriers, allowing them to be spaced as close as theoretically possible. The major advantages of OFDM are its ability to convert a frequency selective fading channel into several nearly flat fading channels and high spectral efficiency.

In this section, MIMO-OFDM transmission model in linear time-varying channels is introduced. The MIMO TDS-OFDM frame structure is also introduced as one of the possible frame structures that could be applied in our proposed approach for it can easily estimate linear time-varying channels.

MIMO OFDM:

TDS-OFDM adopts known sequences as the guard interval, serving the purpose of both channel estimation and synchronization [25]. MIMO TDS-OFDM uses pseudo-noise (PN) sequences as the guard interval. In time-varying channels, the channel estimation results from the PN sequences prior to and posteriori to the OFDM data block are put to estimate the channel variation model. In Figures, the frame structure and receiver structure of MIMO TDS-OFDM using the proposed ICI mitigation algorithm are illustrated.

$$\mathbf{Y} = (\mathbf{H} + \mathbf{A}\bar{\mathbf{B}})\mathbf{X} + \mathbf{V} = [\mathbf{H} \quad \mathbf{A}]\begin{bmatrix} \mathbf{I} \\ \bar{\mathbf{B}} \end{bmatrix}\mathbf{X} + \mathbf{V}$$

$$= [\mathbf{H} \quad \mathbf{A}]\tilde{\mathbf{X}} + \mathbf{V} = [\mathbf{H} \quad \mathbf{A}]\begin{bmatrix} \mathbf{X} \\ \mathbf{X}' \end{bmatrix} + \mathbf{V},$$

$$\mathbf{H} = \begin{bmatrix} \mathbf{H}_{1,1} & \mathbf{H}_{2,1} & \cdots & \mathbf{H}_{M,1} \\ \mathbf{H}_{1,2} & \mathbf{H}_{2,2} & \cdots & \mathbf{H}_{M,2} \\ \vdots & \vdots & & \vdots \\ \mathbf{H}_{1,N} & \mathbf{H}_{2,N} & \cdots & \mathbf{H}_{M,N} \end{bmatrix},$$

Fig-4: Receiver side of MIMO TDS-OFDM with ICI mitigation.

RESULT:

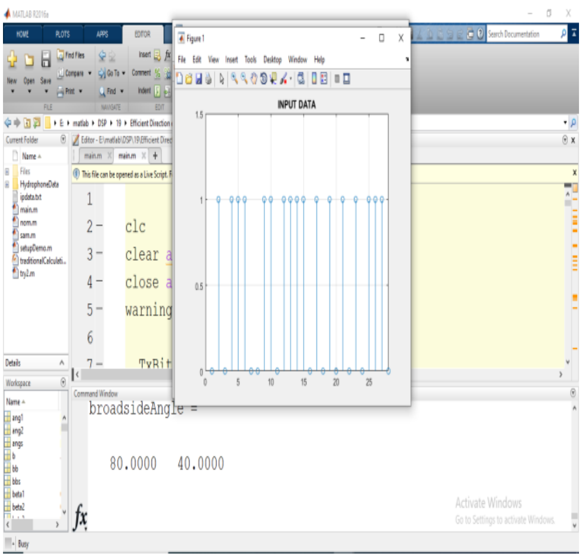


Fig-5(a): input data

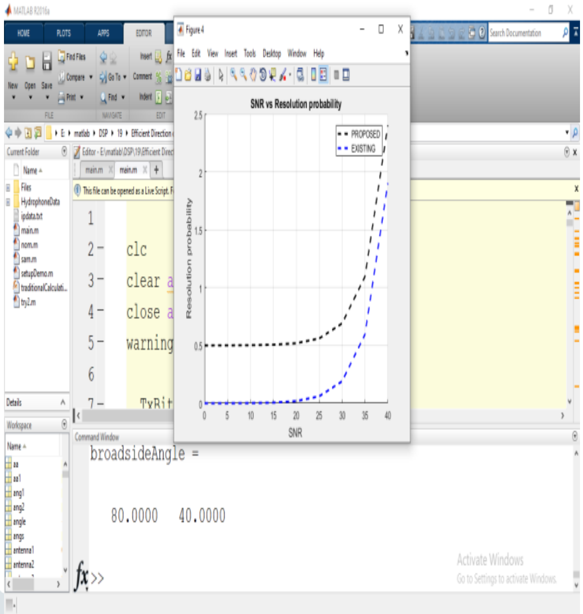


Fig-5(b): SNR vs Resolution probability

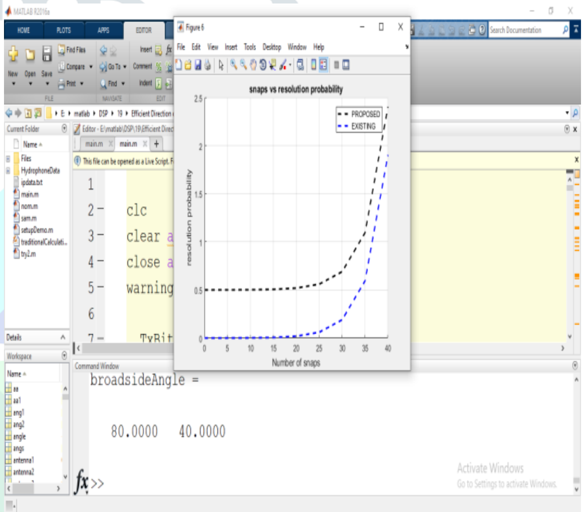


Fig-5(c): Snaps vs Resolution probability

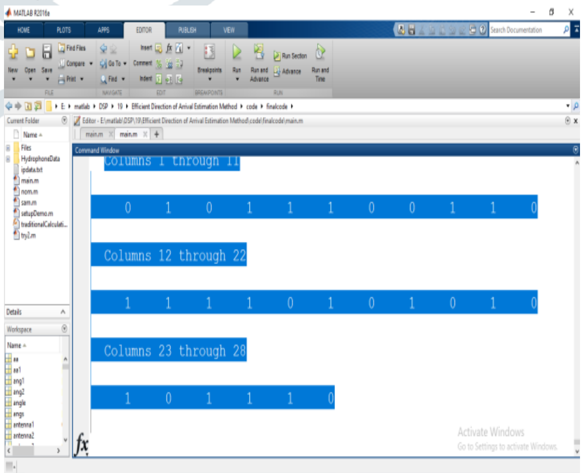


Fig-5(d): Final received data

CONCLUSION:

A direction of arrival (DOA) estimation method based on the variable step size LMS algorithm has been proposed. In this context, the performance of OFDM systems in the presence of frequency offset between the transmitter and the receiver has been studied in terms of the Carrier-to-Interference ratio (CIR) and the bit error rate (BER) performance . Inter-carrier interference (ICI) which results from the frequency offset degrades the performance of the OFDM system. Two methods were explored in this project for mitigation of the ICI. The ICI self-cancellation (SC) is proposed . Along with above all methodology turbo code is inserted and implemented for at most good signal o noise ratio.

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