International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-3, January 2019

Optimization Driven Beam Forming in 2D Linear Array for MIMO Systems

P.N. Jayanthi, S. Ravishankar

Abstract— The advancements in the multimedia applications gained the attention of users and are considered as an important technique for wireless networks. Multiple Input Multiple Output (MIMO) systems depend on the wireless channels propagation. This work proposes a technique, named Exponential-Monarch Butterfly Optimization (Exponential-MBO), for initiating beamforming in 2D linear array under a MIMO system. The proposed Exponential-MBO algorithm is responsible for computing the optimal weights for the beamforming in the MIMO systems. At first, the preferred beam pattern attributes for the 2D array in the MIMO system are described using the initial beam patterns. Then, the fitness function of Exponential-MBO is derived to determine the pattern attributes in the required direction using the azimuth and the elevation beam pattern. The proposed Exponential-MBO algorithm determines the optimal weights for generating the patterns for beamforming in the MIMO system. The channel is estimated using the Least Square (LS) channel estimation method along with Quadrature Amplitude Modulation (QAM) multi-carrier modulation. The implementation of the proposed Exponential-MBO is in MATLAB, and its performance is evaluated by varying the channel. The proposed Exponential-MBO shows superior performance in terms of power gain and Bit Error Rate (BER).

Key words: MIMO-OFDM, Beamforming, Elevation beam pattern, Azimuth, QAM-multi-carrier

1. INTRODUCTION

Multiple-Input Multiple-Output (MIMO) systems are a well-known system that offers communication with high data rate and provide a better Quality of Service (QoS) [1]. The MIMO system achieved high data rate and improved QoS by adapting the special type of multiplexing, and diversity to exploit the spatial dimension using the multi-antenna system. The huge scale MIMO system has gained attention due to high energy efficiency and high spectral efficiency, in which the simplest linear precoder and detector attains outstanding performance [2]. MIMO system enhances the capacity of channel and accuracy of wireless communication by adapting multiple antenna pairs for initiating parallel data transmission. MIMO systems are considered as a key for next-generation cellular communication systems. Large MIMO system uses huge spatial degrees of freedom by adapting several antennas in the Base Station (BS) to facilitate inter-cell interference coordination in Multi-User (MU) communication [3][4]. In the MIMO system, diffused base stations share the channel state information of the users into the cluster and data symbols using backhaul links. Thus, joint downlink data transmission turns to be feasible. Moreover, the mutual design of downlink beams for spatial multiplexing, and intra-cluster interference is entirely excluded. The Network MIMO system is adapted to attain ultimate capacity limit in cellular networks [3]. Different research works adapted in past years gained lots of attention in the fields, such as array pattern synthesis, which is the development of antenna arrays that uses dynamic shaped radiation pattern with respect to the requirements [5]. The phase-only methods are considered as a significant method in synthesizing antenna arrays as phase shifters are utilized for controlling the direction of the main beam [6]. The antennas that operate using these requirements are known as smart antennas and the methods adapted for determining the suitable excitation weights that generate the required radiation pattern is known as adaptive beam forming methods. Various adaptive beam forcing methods are introduced in conventional antenna arrays for optimizing the steering ability of the main lobe and the nulls to modify the signal to noise ratio [5]. The beamforming technique is adapted to process the signal for controlling the directionality of the transmitting and receiving the radio signals [7]. The signal control is attained by distributing the element array such that the signals at distinct angle produce constructive interference, whereas the signal at other angles produces destructive interference. Beamforming is utilized in the transmission and reception stage for attaining spatial selectivity [8]. The beamforming technique contains an array processor that governs a beam to a particular direction by calculating a weighted sum of each sensor signals using a Finite Impulse Response (FIR) filter. The FIR is responsible for generating an output using frequencies of interest, which is a weighted sum of time samples. Thus, the filter is simpler for analyzing the beamformer as a frequency selective filter. The design of beamformer is capable of adapting the filtering techniques in any sensor array applications [9].

The antenna arrays offer beamforming gain for overcoming the high path loss and decrease the co-channel interference on the basis of directional beam. The beamforming can be adapted in the analog domain as well as digital domain. The digital beamforming offers multiple Radio Frequency (RF) chains using the components of each antenna. The digital beamforming is ineffective due to more power consumption and is expensive and has mixed-signal components, such as high-resolution Analog-to-Digital Converters (ADCs) for mm Wave communication systems having large antenna arrays.

Manuscript published on 30 January 2019.
***Correspondence Author(s)**
P.N. Jayanthi, Research Scholar, Dept. of Electronics and Communication Engineering, Rashtreeya Vidyaneekethan College of Engineering , Bengaluru, Karnataka, India
Dr.S Ravishankar, Professor, Dept.of Electronics and communication Engineering, Rashtreeya Vidyaneekethan College of Engineering , Bengaluru, Karnataka, India

The point to point application having high data rate provides cost effective analog beamforming using phased arrays that shape the output beams using a single RF chain. The optimized hyper beamforming technique, namely Social Emotional Optimization Algorithm (SEOA), is introduced for obtaining optimal hyper beam patterns of linear antenna arrays [8]. The 2D antenna array plane deploys multiple antenna elements as compared to previous multiple antenna systems for initiating wireless cellular communication using Full-Dimension MIMO (FD-MIMO) base station. The antenna elements are responsible for performing dynamic and adaptive precoding using multiple antennas. After precoding, the base station attains more directional transmissions in element domain and the azimuth simultaneously for a huge number of UE [10]. The robust reduced-rank method uses Joint Iterative Optimization (JIO) mechanisms in adaptive filters for designing the beamformer. This method is developed using the Minimum Variance (MV) criterion subject for responding to the array of Signal Of Interest(SO)I. It contains a bank, which consists of full rank adaptive filters that outlines the transformation matrix and adaptive reduced-rank filter, which activates the bank filters for evaluating the required signal [9]. The phase-only methods contain nonlinear optimization algorithms that are considered as a general method to estimate the signal. Genetic Algorithms (GAs) are broadly adapted in optimization problems, electromagnetic problems, and for synthesizing the antenna arrays [6].

There some existing techniques that contributes for the beamforming in MIMO. Two-dimensional Generalized Side lobe Canceller (2-D GSC), for constructing a signal blocking matrix. The 2-D adaptive beam formers were based on Linearly Constrained Minimum Variance (LCMV) criterion. However, in this as the computational complexity increases, the dimension of the 2D array is also increased simultaneously [7] . In [10] a 2D active antenna array is designed for Full dimension- Multiple-Input Multiple-Output (FD-MIMO) systems and were capable of supporting 32 antenna elements. The FD-MIMO system permits dynamic and adaptive precoding to be performed simultaneously to attain directional transmissions in azimuth and elevation domains for multiple users. Robust adaptive beam former design, for MIMO radar systems were designed . The required transmit-receive steering vector was evaluated by increasing the output power for correlation coefficient and to steer vector norm. The nonconvex problem was reformulated into Semi-Definite Programming (SDP) issues. The steps are repeated to address SDP issues, whose convergence is proved automatically. The interference covariance matrix is obtained using matrix rank-constrained minimization method. This method is highly efficient and provides improved accuracy, but the time taken for the execution is more [11].

This paper proposes a technique, named Exponential-MBO, for performing beamforming in 2D linear array in the MIMO system. Initially, the desired beam pattern attributes for the 2D array in MIMO systems are defined using the initial beam pattern. The proposed Exponential-MBO is used to calculate optimal beamforming vectors in MIMO systems. Then, the cost function is evaluated for deriving the pattern attributes along the desired direction using azimuth and elevation beam pattern. Based on the cost function, the proposed Exponential-MBO finds the vectors optimally for producing the patterns for initiating the beamforming in MIMO system and finally, the channel estimation is performed using least square error (LSE) method. LS channel estimation is adapted in this work due to its simplicity.

The major contribution of this paper is devising an optimization algorithm, namely Exponential-MBO, by incorporating Exponential Weighted Moving Average (EWMA) in Monarch Butterfly Optimization (MBO), for selecting the optimal beamforming vectors, to develop an effective beamforming approach in MIMO.

The organization of the paper is as follows: Section 2 deliberates the system model of MIMO systems and Section 3 describes the proposed Exponential-MBO designed newly for beamforming with suitable block diagram. Section 4 presents the experimental results attained through the proposed Exponential-MBO technique. Section 5 presents the conclusion and finally, references are listed in section 6.

II. SYSTEM MODEL OF MIMO-OFDM

In this section, the system model of MIMO for initiating the beamforming is elaborated. MIMO systems are described as the system that contains many transmitter antennas and many receiver antennas. The fundamental concept in MIMO systems is its capability to spin multipath propagation, which is a major issue in wireless communication among the users

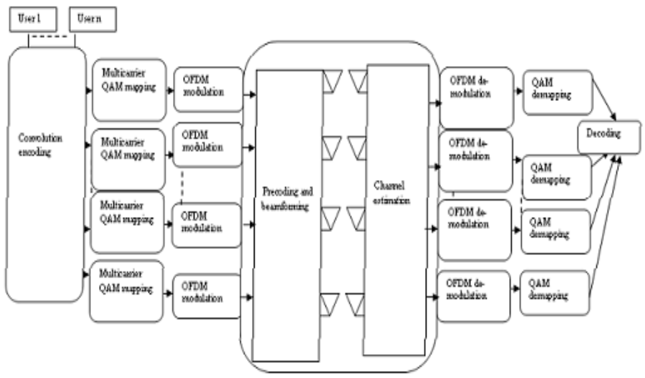


Figure 1. System model of beamforming under MIMO system

Figure 1 depicts the system model of beamforming under the MIMO-OFDM system. Initially, the source bit stream is encoded using convolution encoding. Once the encoding is completed, then the coded bit stream is mapped using QAM multicarrier mapping by OFDM modulator. The OFDM modulation converts a frequency-selective MIMO channel into parallel frequency-flat MIMO channels with improved spectrum efficiency. Quadrature Amplitude Modulation

(QAM) is a technique for integrating two Amplitude-Modulated (AM) signals into a single channel for increasing the bandwidth and is utilized for initiating mapping and demapping process in MIMO systems. Finally, the decoding is done using the bit streams for obtaining the essential information.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

constructing directional beams. Consider the MIMO system contains Q_T transmit antennas and Q_R receive antennas, which are further partitioned as K transmit sub arrays and L receive sub arrays. Here, each transmitting sub array contains G antenna and each receive sub array contains S antenna. Let I be the RF precode matrix, which is expressed as,

$$I = c \times m \tag{1}$$

where, c represents the beamforming vector, m is the transmitted signal vector and $m \in Z^{k \times 1}$. The MIMO techniques depend on the transmission characteristics of wireless channels. Let N be the received signal, represented as,

$$N = H \times I + k; N \in Z^{L \times 1} \tag{2}$$

where, H is the channel response, I is the RF precode matrix, and k is the noisy vector.

The RF precode matrix is represented as, $I = diag(c_0, c_1, \ldots, c_k, \ldots, c_{K-1}) \in Z^{Q_R \times Q}$ where c_k represents the beamforming vector for the k^{th} transmit sub array. The RF combined matrix is expressed as $V = diag(x_0, x_1, \ldots, x_l, \ldots, c_{L-1}) \in Z^{Q_R \times L}$, where x_l represents the combining vector for the l^{th} transmit subarray, $\tilde{H} = V^H HI$ denotes RF equivalent channel, $k \in Z^{Q_R \times 1}$ indicates additive white Gaussian noise vector, and $\tilde{k} = V^H k$ indicates equivalent noise vector.

Here, the channel matrix is given by,

$$H = [h_0, h_1, \ldots, h_w, \ldots, h_{Q_T - 1}] \tag{3}$$

$$\boxed{H = \begin{bmatrix} H_{0,0} & H_{0,1} & \cdots & H_{0,Q-1} \\ H_{1,0} & H_{1,1} & \cdots & H_{1,Q-1} \\ \vdots & \vdots & \ddots & \vdots \\ H_{L-1,0} & H_{L-1,1} & \cdots & H_{L-1,Q-1} \end{bmatrix}}$$

where,

$h_w = \left[\exp\left(\frac{y2\pi}{\mu} d_{0,w} \right), \exp\left(\frac{y2\pi}{\mu} d_{1,w} \right), \ldots, \exp\left(\frac{y2\pi}{\mu} d_{Q_R-1,w} \right) \right]^t$ and the sub matrix $H_{k,l}$ represents channel response from k^{th} transmit sub array to l^{th} receive sub array and is formulated as,

$$H_{k,l} = \begin{bmatrix} h_{kS,lG} & h_{kS,lG+1} & \cdots & h_{kS,lG+G-1} \\ h_{kS+1,lG} & h_{kS+1,lG+1} & \cdots & h_{kS+1,lG+G-1} \\ \vdots & \vdots & \ddots & \vdots \\ h_{kS+S-1,lG} & h_{kS+S-1,lG+1} & \cdots & h_{kS+S-1,lG+G-1} \end{bmatrix} \tag{4}$$

A.Least square channel estimation

MIMO systems with OFDM gains more attention for obtaining least square channels [13] on pilot subcarriers and to interpret channel gains on data subcarriers with respect to LS channel estimation. LS channel estimation is adapted in huge systems due to its simplicity. In LS channel estimation, the channel estimates are correlated using errors of channel estimation. Thus, the correlation linking estimates and estimation errors are used for initiating effective channel estimation. Based on the LS channel estimation technique [14], the individual channel impulse response is evaluated as,

$$\hat{h}_i = J^T m = h_i + (J^C J)^{-1} J^C k_i = h_i + J^T k_i \tag{5}$$

where, J^T indicates matrix pseudo-inverse, J^C denotes hermitian matrix, m represents signal tone vector of the transmitter, and k_i denotes additive white Gaussian noise.

The MSE of LS estimation is expressed as,

$$Y = \frac{1}{\ell G} \alpha \left\{ \| \hat{h}_i - h_i \|^2 \right\} \tag{6}$$

$$Y = \frac{1}{\ell G} \alpha \left\{ \| J^T k_i \|^2 \right\} \tag{7}$$

$$Y = \frac{1}{\ell G} \beta \left\{ \| J^T \alpha \{ k_i k_i^C \| J^{T^C} \right\} \tag{8}$$

where, $\beta(.)$ indicates trace operator, $\alpha(.)$ denotes expectation, ℓ represents length of channel impulse response, and h_i denote channel impulse response vector.

$$Y = \frac{1}{\ell G} \beta \left\{ (JJ^C)^{-1} \right\} \tag{9}$$

The minimum MSE is given by,

$$Y = \frac{\omega^2}{E} \tag{10}$$

where, denotes fixed power dedicate, represents noise variance.

III. PROPOSED EXPONENTIAL-MBO FOR BEAMFORMING IN 2D LINEAR ARRAY IN MIMO

This section describes the technique for beamforming in 2D linear array in a MIMO system using the proposed Exponential-MBO. Here, the required beam pattern attributes for the 2D array in the MIMO system are presented using the primary beam patterns.

Then, the fitness function is computed for each pattern using azimuth and the elevation beam pattern, and the function is solved using the proposed Exponential-MBO algorithm, which computes the optimal weights for generating optimal patterns for initiating the beamforming process in the MIMO systems, and lastly, the channels are estimated using the LS method.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

The proposed Exponential-MBO, which is the integration of EWMA in MBO, designed for selecting the optimal beamforming vectors is elaborated in this section. The purpose of beamforming is to use different signals and broadcast the signals at different antennas to ensure the stronger signal is disseminated in a specific direction. At first, the desired beam pattern attributes for the 2D array in the MIMO system are described using the initial beam pattern. The fitness function is computed with proposed Exponential-MBO to produce best solution to generate the beamforming patterns. The channel is estimated by LS method. The channel estimation algorithm generates pilot tones, which are known to receivers, are multiplexed with the data stream for estimating the channels. The purpose of estimating the channels is to gain knowledge of transmitted pilot symbols participated in the transmission. Figure 2 illustrates the block diagram of the proposed Exponential-MBO based beamforming technique.

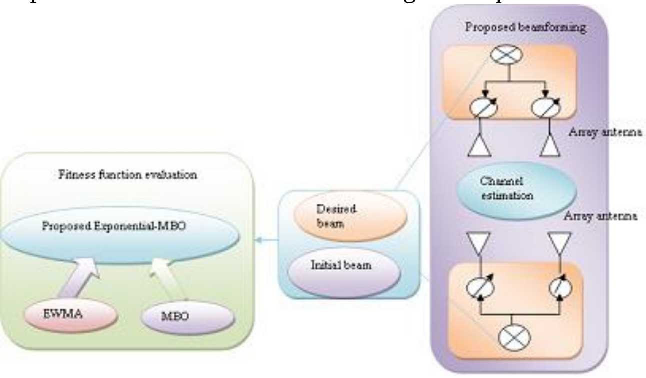


Figure 2. Block diagram of proposed Exponential-MBO based beamforming algorithm in MIMO-OFDM system

A. Formulation of Fitness to determine the optimal weights

The proposed technique makes use of the fitness function [12] to find the optimal weights for beamforming using a 2D linear array. Accordingly, the channel response and the beamforming vectors are selected to maximise the beamforming gain using the fitness function, which is represented as,

$$(\hat{c}_k) = max_c \; || c.F ||^2 \tag{12}$$

where, is the channel response and is the beamforming vector.

B. Solution Encoding

The solution of the algorithm is defined using solution representations. The purpose of solution representation is to determine the optimal weights to generate the patterns for beamforming in MIMO systems. The solution is encoded using the fitness function with a total of number of solutions, from which the optimal solution will be selected using the proposed Exponential-MBO algorithm. Each solution in the solution space has the size , as shown in figure 3. The fitness function is calculated based on the beamforming gain criterion. Proposed Exponential-MBO algorithm to obtain the optimal

c_0	c_1	c_2	$\cdots$	c_k	$\cdots$	c_{k-1}

Figure 3. Solution encoding of the proposed Exponential-MBO algorithm

C. Proposed Exponential-MBO algorithm

The proposed Exponential-MBO is developed by integrating EWMA into MBO for the beamforming. The proposed Exponential-MBO technique can determine the better function values on different benchmark problems and solves the real-world problem effectively. MBO [15] is inspired by the migration behavior of monarch butterflies. MBO is a meta-heuristic algorithm, which is well known for providing a trade-off between exploration and exploitation in meta-heuristic algorithms. MBO is an advanced metaheuristic technique that helps to solve the global optimization problems and shows superior performance while dealing with benchmark problems by evaluating with a number of unimodal and multimodal test functions and state-of-the-art techniques. In MBO, the population is initialized by the entire monarch butterflies in two lands. The child monarch butterfly is engendered by the migration operator from monarch butterflies in both lands. Then, the fitness of each monarch butterfly is calculated and the parent butterfly is replaced with the child monarch butterfly if it has better fitness than the parent. If the child monarch butterfly do not has the better fitness than that of the parent then, it is discarded from the population. In MBO, the position of the butterflies is updated in two ways, namely position update by migration operator and position update by adjusting parameter. MBO can execute a global search and local search and is more appropriate for parallel computation and provides a balance between diversification and intensification. The algorithm is simple to apply and has the ability to solve constrained and unconstrained algorithms based on the optimization techniques. Here, the position update executed using the adjusting operator is modified using EWMA. EWMA [16] is a control mechanism that is used to detect small shifts while processing the target values. The sampling interval is varied, which produces the information rapidly even though there is shifting and also, prevents the poor quality results. The EWMA is devised on the basis of the exponentially weighted moving average of current and previous observations. Hence,

the integration of EWMA and MBO is adapted in the proposed Exponential-MBO for selecting the optimal weights for initiating beamforming in MIMO systems.

I. Initialization

Initially, the set of solutions, algorithmic parameters and termination criterion are defined. The initialization of the solutions is represented as,

$$A = \{A_1, A_2, \ldots, A_p, \ldots, A_b\} \tag{13}$$

where, is the total number of solutions and .

II. Fitness Evaluation

The fitness is computed for individual solution using equation (12) to get the optimal solution. The solution providing maximum fitness value is considered as the best solution. The optimal solution is found at the last iteration as every solution craves to get the optimal position.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-3, January 2019

III. Update positions using EWMA in MBO

The MBO [15] is adapted to address various global optimization tasks. Here, the MBO is used to solve the meta-heuristic problems for improving the equations using the solution update of MBO. Thus, the update solution of MBO[19] is formulated using the equation given below

$$A_{p,q}(z+1) = A_{p,q}(z) + \eta \times (V_q - 0.5) \quad (14)$$

where, $A_{p,q}(z)$ represents the solution at iteration indicates the weighting factor, V_q represents walk step of butterfly .

The enhancement of certain parameters, such as randomness and stochastic behaviour, is possible by moving randomly in the search space, following levy flight. The movement of butterfly from one place to another on the basis of levy flight movement is given by,

$$V_q = Levy(A_q(z)) \quad (15)$$

where, $Levy(A_q(z))$ denotes the levy flight of q^{th} butterfly.

The weighting factor is represented as,

$$\eta = \frac{D_{\max}}{z^2} \quad (16)$$

where, $D_{\max}$ indicates max walk step, and indicates iteration.

According to the EMWA algorithm [16], the solution obtained at the current iteration depends on the runtime properties of current and previous iterations of the solutions. EWMA shows good performance for observations, which are not normally distributed or auto correlated. It is also used to attain more general cut-off values. Moreover, the utilization of EWMA in MBO improves the convergence of the algorithm. The position update in MBO based on the adjusting operator is given as,

$$A^E_{p,q}(z+1) = \lambda A_{p,q}(z) + (1-\lambda) A^E_{p,q}(z) \quad (17)$$

where, $A^E_{p,q}(z)$ denotes the solution obtained by EMWA at $(z)^{th}$ iteration, and denotes runtime properties.

$$A_{p,q}(z) = \frac{A^E_{p,q}(z+1) - (1-\lambda) A^E_{p,q}(z)}{\lambda} \quad (18)$$

The equation obtained by substituting equation (18) in equation (14) is given by,

$$A_{p,q}(z+1) = \frac{A^E_{p,q}(z+1) - (1-\lambda) A^E_{p,q}(z)}{\lambda} + \eta \times (V_q - 0.5) \quad (19)$$

IV) Termination

The steps from (II) to (IV) are repeated until the last iteration, $z_{\max}$, within which the best solution is obtained.

The pseudo code of the proposed Exponential-MBO for selecting optimal weights is given below in Table 1.

Table 1 Pseudo code for proposed Exponential-MBO

	Proposed Exponential-MBO
1	Input: Solution set A
2	Output: Best Solution $A_{p,q}(z+1)$
3	Begin
4	Initialize the solution
5	while $(z < z_{\max})$
6	for each solution Update V_q, η
7	Calculate the fitness using equation (12)
8	Update the position using equation (19)
9	$z = z + 1$
10	Choose the solution having maximum fitness as the best solution
11	end while
12	Return the best solution
13	Terminate

IV.SIMULATION RESULTS

The results of the proposed Exponential-MBO with the existing techniques are elaborated in this section. Together with this, the performance analysis of the proposed Exponential-MBO is evaluated with respect to power gain and Bit Error Rate (BER).

A. EXPERIMENTAL SETUP

The simulation of the proposed Exponential-MBO requires the MATLAB and the PC with certain system configurations. The entire simulation of the proposed Exponential-MBO is done in a PC with the 4GB RAM, Windows 10 OS, and the Intel I3 processor.

A.1 Comparative techniques

The comparative techniques utilized for analyzing the performance of proposed Exponential-MBO are Two-Dimensional

Generalized Sidelobe Canceller (2DGSC) [1], 2D Active Array Antenna [2], and MBO (Applied MBO [19] in the proposed technique instead of Exponential-MBO).

A.2 Performance analysis

The analysis of the proposed Exponential-MBO algorithm is based on distance between transmitter and receiver in terms of gain using Rayleigh channel, BER using Rayleigh channel, gain using the Rician channel, and BER using Rician channel. Here, the performance analysis is carried out by varying the values of SNR. Similarly, the performance analysis of proposed Exponential-MBO based on the number of transmitter for various channels is evaluated.

a) Analysis based on the distance between transmitter and receiver

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

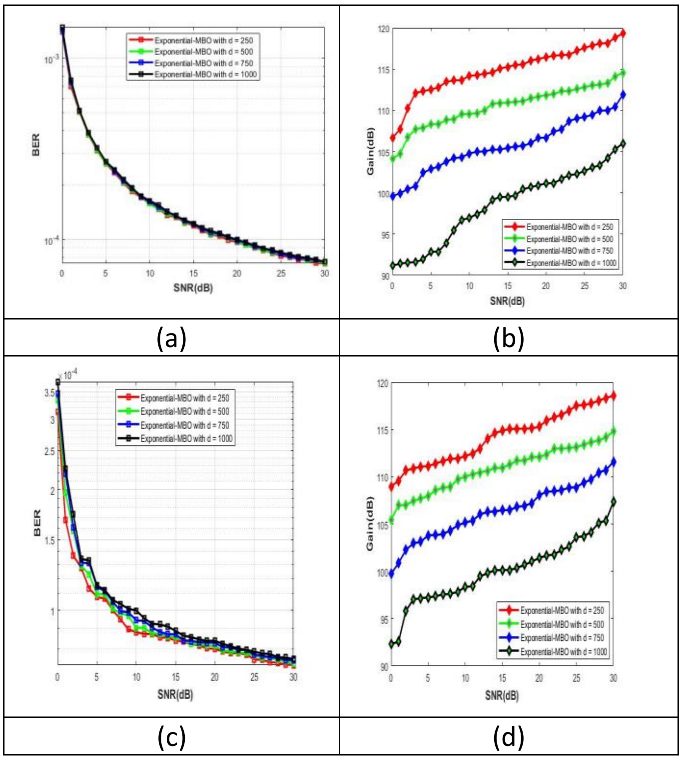


Figure 4 Performance analysis of proposed Exponential-MBO based on the distance between transmitter and receiver in terms of a) Gain using Rayleigh channel b) BER using Rayleigh channel c) Gain using Rician channel d) BER using Rician channel

Figure 4 depicts the performance analysis in terms of Gain and BER for the varying values of SNR using Rayleigh and Rician channels. Figure 4a depicts the analysis based on Gain values for varying SNR values ranging from 0 to 30 using the Rayleigh channel. Here, the distance between transmitter and receiver is denoted as d. When the SNR is 30dB, the Exponential-MBO with d=250 is 119.311dB, Exponential-MBO with d=500 is 114.536dB, Exponential-MBO with d=750 is 111.917dB, and Exponential-MBO with d=1000 is 105.998dB, respectively. Similarly, when the SNR is 25dB, the Exponential-MBO with d=250 is 117.573dB, Exponential-MBO with d=500 is 112.813dB, Exponential-MBO with d=750 is 109.182dB, and Exponential-MBO with d=1000 is 102.656dB, respectively. Figure 4b depicts the analysis based on BER parameter using a Rayleigh channel. When the SNR is 15dB, the Exponential-MBO with d=250 is 0.0001, Exponential-MBO with d=500 is 0.0001, Exponential-MBO with d=750 is 0.00012, and Exponential-MBO with d=1000 is 0.00012, respectively. Similarly, when the SNR is 5dB, the Exponential-MBO with d=250 is 0.000262, Exponential-MBO with d=500 is 0.000263, Exponential-MBO with d=750 is 0.000268, and Exponential-MBO with d=1000 is 0.000269, respectively. Figure 4c depicts the analysis based on Gain parameter using the Rician channel. When the SNR is 20dB, the Exponential-MBO with d=250 is 115.311dB, Exponential-MBO with d=500 is 112.122dB, Exponential-MBO with d=750 is 108.048dB, and Exponential-MBO with d=1000 is 101.434dB, respectively. Similarly, when the SNR is 5dB, the Exponential-MBO with d=250 is 111.126, Exponential-MBO with d=500 is 107.948dB, Exponential-MBO with d=750 is 103.814dB, and Exponential-MBO with d=1000 is 97.240dB respectively. Figure 4d depicts the analysis in terms of BER parameter using the Rician channel. When the SNR is 5dB, the Exponential-MBO with d=250 is 0.000107, Exponential-MBO with d=500 is 0.000109, Exponential-MBO with d=750 is 0.000114, and Exponential-MBO with d=1000 is 0.0001, respectively. Similarly, when the SNR is 7dB, the Exponential-MBO with d=250 is 0.000100, Exponential-MBO with d=500 is 0.000100, Exponential-MBO with d=750 is 0.000105, and Exponential-MBO with d=1000 is 0.000106respectively.

b) Analysis based on the number of transmitting antennas

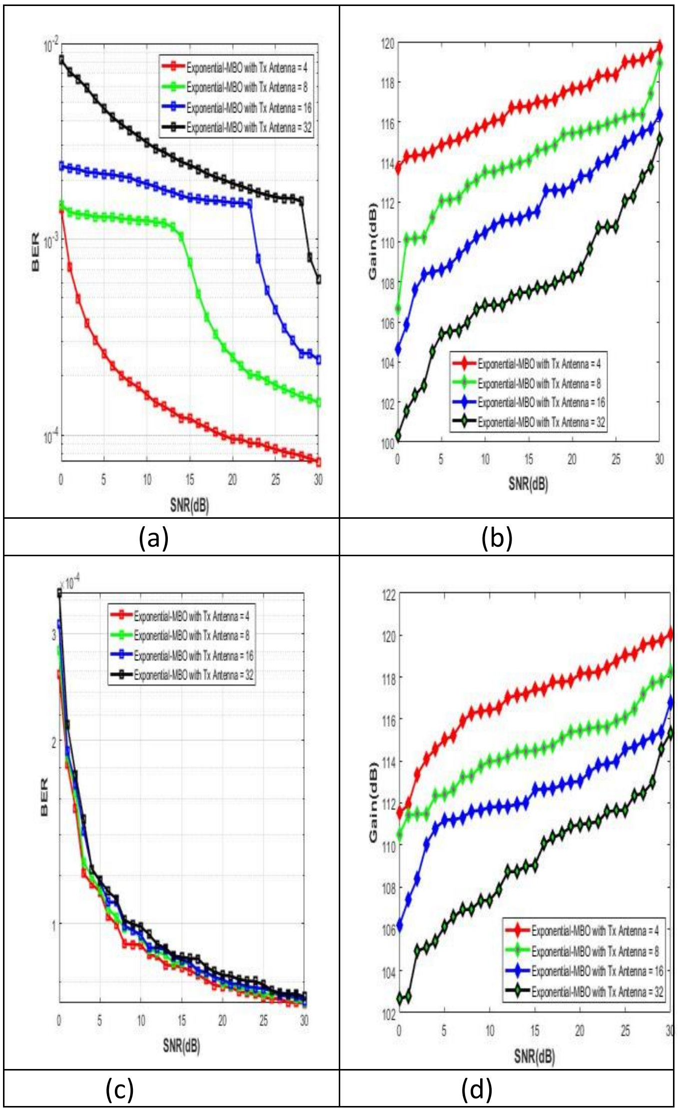


Figure 5 Performance analysis of proposed Exponential-MBO based on number of transmitter in terms of a) Gain using Rayleigh channel b) BER using Rayleigh channel c) Gain using Rician channel d) BER using Rician channel.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-3, January 2019

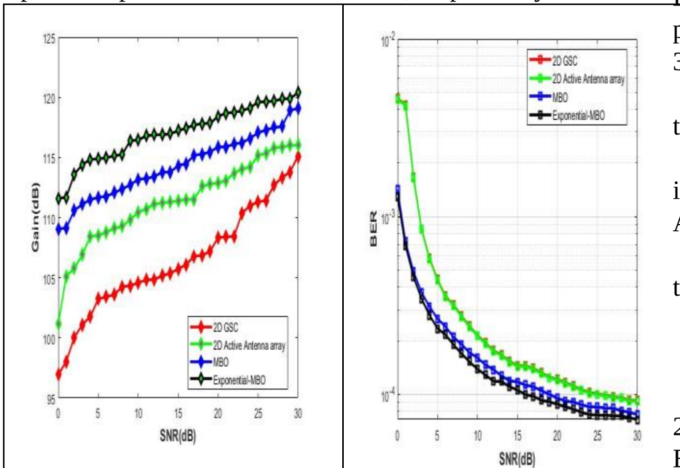
Figure 5 depicts the performance analysis in terms of Gain and BER for the varying values of SNR using Rayleigh and Rician channels. Figure 5a depicts the analysis based on Gain values for varying SNR values ranging from 0 to 30 using the Rayleigh channel. Here, the number of transmitter antennas is considered for the evaluation. Figure 5c depicts the analysis based on Gain parameter using the Rician channel.

A.3 Comparative Analysis

In this section, the analysis of the proposed Exponential-MBO with existing 2DGSC, 2D Active Array Antenna, MBO is carried out using Rayleigh and Rician channels with varying SNR values.

a) Using Rayleigh channel

The comparative analysis of existing, 2DGSC, 2D Active Array Antenna, MBO and proposed Exponential-MBO, in terms of power gain and BER is depicted in figure 6. The analysis in terms of power gain by varying the SNR for 2DGSC, 2D Active Array Antenna, MBO, and proposed Exponential-MBO with varying SNR is shown in figure 6a. When the SNR is 30dB, the corresponding gain values measured by 2DGSC is 115.109dB, 2D Active Array Antenna is 116.022dB, MBO is 119.083dB, and proposed Exponential-MBO is 120.384dB, respectively. Similarly, when the SNR value is 29dB, the corresponding gain values measured by 2DGSC is 113.791dB, 2D Active Array Antenna is 115.996dB, MBO is 118.902dB, and proposed Exponential-MBO is 119.889dB, respectively. Figure 6b presents the analysis based on BER parameter by varying the SNR. When the SNR is 0dB, the corresponding BER values computed by 2DGSC is 0.0046, 2D Active Array Antenna is 0.0045, MBO is 0.0042, and proposed Exponential-MBO is 0.00128, respectively. Likewise, when the SNR is 1dB, the corresponding BER values measured by 2DGSC is 0.0042, 2D Active Array Antenna is 0.0042, MBO is 0.00072, and proposed Exponential-MBO is 0.00068, respectively.



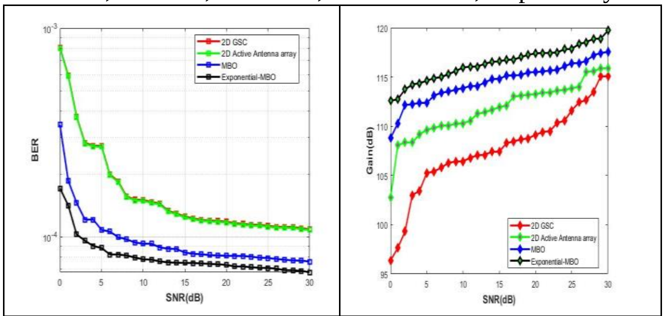
(a)	(b)

Figure 6. Analysis using Rayleigh channel based on a) Gain b) BER

B. Using Rician channel

Figure 7 presents the comparative analysis of existing 2DGSC, 2D Active Array Antenna, MBO, and proposed Exponential-MBO in terms of power gain and BER. Figure 7a depicts the analysis in terms of power gain by varying the SNR for existing 2DGSC, 2D Active Array Antenna, MBO, and proposed Exponential-MBO with varying SNR. When the SNR is 25dB, the corresponding gain values measured by 2DGSC, 2D Active Array Antenna, MBO, and proposed Exponential-MBO are 111.610dB, 113.842dB, 116.395dB, and 117.844dB, respectively. Similarly, when the SNR value is 20dB, the corresponding gain values measured by 2DGSC, 2D Active Array Antenna, MBO, and proposed Exponential-MBO are 109.119dB, 113.275dB, 115.489dB, and 117.405dB, respectively. The analysis based on BER parameter by varying the SNR is depicted in figure 7b. When the SNR is 5dB, the corresponding BER values computed by 2DGSC, 2D Active Array Antenna, MBO, and proposed

Exponential-MBO are 0.00027, 0.00027, 0.00010, and 8.85E-05, respectively. Likewise, when the SNR is 10dB, the corresponding BER values measured by 2DGSC, 2D Active Array Antenna, MBO, and proposed Exponential-MBO are 0.00015, 0.00014, 9.28E-05, and 7.81E-05, respectively.



(a)	(b)

Figure 7. Analysis using a Rician channel based on a) Gain b) BER

C. Comparative discussion

The comparative analysis of various techniques in terms of gain and BER is explained in this section. The maximum performance of the existing techniques, such as 2DGSC, 2D Active Array Antenna, MBO, and proposed Exponential-MBO is depicted in table 2 by comparing the performance attained for SNR values varying from 0 to 30dB.

- Proposed method reduces the BER 4.5% and improves the power gain by 33% with respect to 2DGSC
- Proposed method reduces the BER 3.75% and improves the power gain by 32.7% with respect to 2D Active Array Antenna.
- Proposed method reduces the BER 1.1% and improves the power gain by6.49% with respect to MBO

V. CONCLUSION

This work developed a technique for the beamforming in 2D linear array in a MIMO system using the proposed Exponential-MBO. The proposed Exponential-MBO algorithm calculates the optimal weights for the beamforming in the MIMO system. At first, the desired beam pattern attributes for the 2D array in the MIMO system are described using the initial beam pattern. Then, the objective function is designed to obtain the pattern attributes in the required "direction" using the azimuth and the elevation beam pattern.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

The fitness function is generated using the proposed Exponential-MBO algorithm that determines the optimal weights to produce the patterns for beamforming in the MIMO system. For the channel estimation, LS method is adapted. The performance is evaluated in terms of power gain and BER. Moreover, a comparative analysis is performed by comparing the performance of the proposed technique with that of existing techniques using channel models, like Rayleigh or Rician and by varying the antenna sizes and distance between antennas. Thus, the proposed Exponential-MBO shows superior performance in terms of power gain and BER

REFERENCES

1. PrabinaPattanayak and Preetam Kumar,"Quantized feedback scheduling for MIMO-OFDM broadcast networks with subcarrier clustering",Ad Hoc Networks,Vol :65,pp :26-37, October 2017.
2. Xin Xiong, Bin Jiang, Xiqi Gao, and Xiaohu You, "QoS Guaranteed User Scheduling and Pilot Assignment for Large-Scale MIMO-OFDM Systems", IEEE Transactions on Vehicular Technology ",Vol: 65, No: 8,pp: 6275 - 6289, August 2016.
3. Kianoush Hosseini, Wei Yuand Raviraj S. Adve,"Large-Scale MIMO versus Network MIMO forMulticell Interference Mitigation",IEEE Journal of Selected Topics in Signal Processing, Vol:8,no:5, pp:930-941.
4. Arin Minasian,Shahram Shahbaz Panahi and Raviraj S.,"Distributed Massive MIMO Systems withNon-Reciprocal Channels: Impacts and RobustBeamforming",IEEE Transactions on Communications,pp: 1-1,July 2018.
5. Said E. El-Khamy, Ahmed S. Eltrass and Huda F. El-Sayed,"Design of thinned fractal antenna arrays foradaptive beam forming and sidelobereduction", IET Microwaves, Antennas & Propagation :Vol: 12, no: 3, pp: 435 – 441,2018.
6. Boufeldja Kadri, MiloudBoussahla and Fethi Tarik Bendimerad,"Phase-Only Planar Antenna Array Synthesis with Fuzzy Genetic Algorithms",International Journal of Computer Science Issues, IJCSI, Vol:7, no:2, January 2010.
7. Ju-Hong Lee and Yung-Han Lee," Two-Dimensional Adaptive Array Beamforming With Multiple Beam Constraints Using a Generalized Sidelobe Canceller", IEEE Transactions on Signal Processing, Vol: 53, No: 9, pp: 3517 - 3529,Sept. 2005.
8. Gopi Ram, P. S. Pal, D. Mandal, R. Kar and Sakti Prasad Ghosal,"Social Emotional Optimization Algorithm forBeamforming of Linear Antenna Arrays",In proceedings of TENCON 2014 - 2014 Region 10 Conference,pp:1-5,IEEE.
9. Lei Wang,"Array Signal Processing Algorithmsfor Beamforming and Direction Finding", Doctoral dissertation, University of York.
10. IoannisTzanidis, Yang Li, Gary Xu,Ji-Yun Seol and JianZhong (Charlie) Zhang,"2D Active Antenna Array Design for FD-MIMO Systemand Antenna Virtualization Techniques", International Journal of Antennas and Propagation, 2015.
11. Junhui Qian , Zishu He, Wei Zhang, Yulong Huang, Ning Fu and Jonathon Chambers, "Robust adaptive beamforming for multiple-input multiple-output radar with spatial filtering techniques", Signal Processing,Vol:143, pp:152-160, February 2018.
12. Xue, C., He, S., Huang, Y., Wu, Y. and Yang, L., "An efficient beam-training scheme for the optimally designed subarray structure in mmWave LoS MIMO systems," EURASIP Journal on Wireless Communications and Networking, vol.1, pp.31, 2017.
13. Lee, S.J., "On the training of MIMO-OFDM channels with least square channel estimation and linear interpolation," IEEE Communications Letters, vol.12, no.2, 2008.
14. Seyman, M.N. and Taşpınar, N., "Pilot tones optimization using artificial bee colony algorithm for MIMO–OFDM systems," Wireless personal communications, vol.71, no.1, pp.151-163, 2013.
15. Gai-Ge Wang, Suash Deb, Zhihua Cui, "Monarch butterfly optimization", Neural Computing and Applications, pp. 1–20, May 2015.
16. Michael S. Saccucci , Raid W. Amin, and James M. Lucas,Exponentially weighted moving average control schemes with variable sampling intervals," Communications in Statistics - Simulation and Computation, vol. 21, no.3, pp. 627-657, 1992.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)