



A hybridization approach of PSO and GSO algorithm for minimum-BER based multi-user detection in STBC-MIMO MC-CDMA systems

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Abstract

The usage of productive baseband receivers are portrayed by reasonable computational load is an urgent point in the advancement of transmission frameworks misusing assorted qualities in various spaces. Several research works have been published in the literature of space-time block codes multi-carrier code-division multiple-access (STBC MC-CDMA) Systems based on minimum conditional bit error rate Criterion. As like, in our previous paper, an efficient STBC communication system was performed using oppositional krill herd algorithm (OKHA). To overcome the drawbacks in the previous work, in this work we proposed a hybrid Particle swarm optimization (PSO) and group search optimization (GSO), called PSGSO based Multi-User Detection in STBC MC-CDMA Systems. In this paper, we use the Alamouti's STBC encoder for transmitting sequence and the channel estimation matrix is optimally evaluated using PSGSO algorithm. The simulation results show that the proposed algorithm is properly reducing the bit error rate (BER), symbol error rate (SER) and properly increase the spectral efficiency value compare to other techniques.

Keywords Gravitational search algorithm · Particle swarm optimization · STBC · Baseband receivers · CDMA system · Bit error rate

1 Introduction

The multi-carrier code-division multiple-access (MC-CDMA) system has been widely studied for future high-speed wireless communications in that it provides spectral efficiency and

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interference suppression capability [11]. The MC-CDMA system is developed using a combination of orthogonal frequency division multiplexing (OFDM) and CDMA. In a high data rate transmission system over frequency-selective fading channel, the inter symbol interferences (ISI) appear and cause severe degradation in the bit-error-rate (BER) due to multipath propagation [19]. The traditional Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA), as well as the orthogonal CDMA are orthogonal multiple access [15]. In wireless communication, how to efficiently utilize the system resources, such as frequency spectrum and power, and to provide high quality transmission, are the main challenges [21]. CDMA employs Analog to Digital (A/D) Converter in combination with spread spectrum technology MC-CDMA systems additionally employs multiple-input multiple-output (MIMO) techniques to increase the capacity of wireless link significantly by combining the advantages of spatial diversity which enable different users to share the available spectrum [24]. However, capacity of the system is limited by multiple access interference (MAI) from other users. By providing near-far resistance at the receiver and by utilizing known user spreading codes, multi-user detection (MUD) techniques emerged to overcome the inherent shortcomings of MAI [4].

Multisuser detection (MUD) in the context of various multicarrier CDMA schemes has been widely addressed and investigated in [17]. In the context of coherent multisuser detection, optimal performance can be achieved by ML detector [26]. The Interference suppression scheme considered in [23] is the bell laboratories layered space-time (BLAST) system which is mathematically akin to the decision feedback equalizer (DFE) [5]. DFE decisions are made in many different ways by using different MIMO receive algorithms. More specifically, non linear BLAST receiver combines a MIMO receive algorithm with ordered successive interference cancellation (OSIC) [20]. MIMO detectors including sphere decoder and several of its variants achieve near-maximum likelihood (ML) performance at the cost of high complexity. Other well known detectors including ZF (zero forcing), MMSE (minimum mean square error), and ZF-SIC (ZF with successive interference cancellation) detectors [12] are attractive from a complexity view point, but achieve relatively poor performance. For example, the ZF-SIC detector (i.e., the well known VBLAST detector with ordering [14]) does not achieve the full diversity in the system. The MMSE-SIC detector has been shown to achieve optimal performance.

MIMO systems is space-time (ST) signal processing [18] in which the time dimension is complemented with the spatial dimension inherent to the use of multiple spatially-distributed antennas. Commonly used ST coding schemes are ST-trellis codes and ST block codes (STBC) [10]. A well-known example of conceptually simple, computationally efficient and mathematically elegant STBC scheme has been proposed by Alamouti in [1]. STBC coding scheme has been proposed in [28] that is characterized by quasi-orthogonal characteristics in order to achieve full transmit diversity and linear decoding complexity in the presence of complex signal constellations. The very interesting and promising results yielded by MIMO and STBC techniques and the increasing importance of multicarrier modulations in new-generation cellular system design, suggested to researchers to mix together such two innovative technologies [7]. The claimed objective is to take advantages from STBC and multicarrier techniques in order to profitably combine diversity in different domains.

Nowadays, the mobile communication is an important process of communication. The combination of multiple antennas and multi-carrier code division multiple accesses (MC-CDMA) is a strong candidate for the downlink of future mobile communications. In this paper, we develop an efficient STBC MC-CDMA transmission System Based on Minimum

Conditional BER Criterion and hybrid PSGSO algorithm based channel estimation. Basically, our proposed work consists of two major processes, one is STBC encoder based signal transmission and PSGSO algorithm based channel estimation. The rest of the paper organized as follows: the recent research works is analyzed in Section 2 and the back ground of the proposed research algorithm is shows in Section 3. Section 4 shows the working principle of STBC encoder and Section 5 shows the channel estimation procedure. Section 6 shows the proposed methodology and Section 7 explains the performance of proposed method and the simulation results are shown. Finally, we end the paper with brief conclusions in Section 8.

2 Literature survey

Numerous works have been displayed in the literature for signal transmission in CDMA system. Here, we review some recent works related with CDMA system. Leandro D'Orazio et al. [9] have examined adaptive minimum-BER approach for multiuser detection in STBC-MIMO MC-CDMA systems, which is mainly focused on maximize the signal-to-noise plus interference ratio (SINR) at the output of the diversity combiner. Such a concept turns on the Minimum Mean Squared Error (MMSE) combining criterion. Moreover, Arifianto et al. [3] have introduced binary genetic algorithm assisted multiuser detector for STBC MC-CDMA, which is mainly focused on binary genetic algorithm in the detector. For the evaluation, simulated STBC MC-CDMA system over a frequency selective rayleigh fading channel. The receiver employs the binary genetic algorithm assisted MUD. For the purpose of comparison, STBC MC-CDMA receiver using equal gain combining (EGC) was simulated as well. Rather than, Vishnu Vardhan *et al.* [22] have explained low-complexity detector for large MIMO systems and multicarrier CDMA systems, which is mainly focused on low-complexity detector which achieves uncoded near-exponential diversity performance for hundreds of antennas (i.e., achieves near SISO AWGN performance in a large MIMO fading environment) with an average perbit complexity of just $O(N_t N_r)$, where N_t and N_r denote the number of transmit and receive antennas, respectively. Either than, Jung-Lang Yu et al. [27] have examined multiuser receivers for MC-CDMA MIMO systems with space-time block codes, which is mainly focused on forward-backward averaging technique and weighting analysis are then proposed for the blind constrained minimum output energy (CMOE), subspace-based and diagonal loading (DL)-based CMOE receivers. The forward-backward averaging technique, which uses twice the equivalent STBC blocks to design the multiuser receivers, reduces the bit-error-rate (BER) tremendously for the compared receivers.

Moreover, Prabagarane et al. [16] have introduced performance analysis of multicell multiuser MIMO MC DS/CDMA system with MMSE user-ordered SIC technique, which is mainly focused on co-channel interference (CCI) cancellation technique based on minimum mean square error (MMSE) user-ordered successive interference cancellation (UOSIC) for multi input multi output (MIMO) multicarrier (MC) direct sequence code division multiple access (DS/CDMA) system for multi cell setting. Though MC DS/CDMA possesses several advantages, interference limits the capacity of the system. Rather than, MouradBenyarou et al. [6] have examined multi-user-detection for multibeam-MIMO multi-carrier-Cdma systems with MMSE adaptive algorithm, which is mainly focused on multi-carrier code division multiple access (MC-CDMA) transmission has become a promising candidate for the new radio interfaces for mobile radio systems. Such systems increase the bit rate without consuming additional bandwidth. Furthermore, James Osuru and Naufal Mohamad Saad have

introduced error rate performance analysis of multiantenna MC DS-CDMA system over – frequency selective fading channels with arbitrary parameters, which is mainly focused on moment generating function (MGF) and probability density function (PDF) approaches, closed form expressions for average error probability of binary phase shift keying (BPSK), multilevel phase shift keying (MPSK), and square M-ary quadrature amplitude modulation (MQAM) schemes are derived and expressed in terms of Appell’s hypergeometric functions and Lauricella’s multivariate hypergeometric functions.

3 Hybrid PSGSO algorithm

The hybrid PSGSO algorithm consists of particle swarm optimization and group search optimization (PSGSO) algorithm. Here, at first we explain the individual algorithms. Then, we deeply explain the proposed Hybrid PSGSO algorithm.

3.1 Particle swarm optimization

The PSO algorithm was introduced by Kennedy & Eberhart in 1995 by the inspired of social behavior and movement dynamics of insects, birds and fish. It is a global gradient-less stochastic search method. PSO performance is comparable to genetic algorithms. This algorithm is successfully been applied to a wide variety of problems (Neural Networks, Structural opt, Shape topology opt.). The concept of PSO algorithm is to maintain multiple potential solutions at one time. During each iteration of the algorithm, each solution is evaluated by an objective function to determine its fitness value. Each solution is represented by a particle in the fitness landscape or search space. The particles “fly” or “swarm” through the search space to find the maximum value returned by the objective function shows in Table 1.

Position of individual particles updated using eq. (1):

$$x_k^i = x_k^i + v_k + 1^i \quad (1)$$

The velocity is calculated using eq. (2):

$$v_{k+1}^i = v_k^i + c_1 r_1 (p_k^i - x_k^i) + c_2 r_2 (p_k^g - x_k^i) \quad (2)$$

3.2 Group search optimization (GSO) algorithm

The GSO algorithm is firstly proposed by [13]. This algorithm works based on animal scanning mechanism and it employs producer-scrounger (PS) model and animal scanning

Table 1 PSO Algorithm parameters

variables	Description
x_k^i	Particle position
v_k^i	Particle velocity
P_k^i	Best “remembered” individual particle position
P_k^g	Best “remembered” swarm position
c_1, c_2	Cognitive and social parameters
r_1, r_2	Random numbers between 0 and 1

mechanism. Producer-scrounger model for designing optimum searching strategies was inspired by animal searching behavior and group living theory. It has usually led to the adoption of two foraging strategies within groups: 1) producing, searching for food; and 2) scrounging, joining resources uncovered by others. In order not to entrap in local minima, GSO also employs “ranger” foraging strategies. The population of the GSO algorithm is called a group and each individual in the population is called a member. There are three kinds of members in the group which is given below;

Producer: The producer performs producing strategies, searching for food sources and also at each iterations, the member who located the most promising resource is called producer.

Scrounger: The scrounger performs scrounging strategies, joining resources uncovered by others and also a number of member except producer in the group are selected as scroungers.

Ranger: The ranger employs random walks searching strategies for randomly distributed resources and also in a group except producer and scroungers is called rangers.

Recently, [8] suggested that the larger the group, the smaller the portion of informed individuals need to guide the group with better accuracy. Therefore, for accuracy and convenience of computation, we simplify the PS model by assuming that there is only one producer at each searching bout and remaining members are scroungers and rangers. It is also assumed that the producer, the scroungers and the rangers do not differ in relevant phenotypic characteristics. Therefore, they can switch between the three roles.

3.3 Hybrid PSGSO algorithm

The particle swarm optimization (PSO) algorithm is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. There is some disadvantages in PSO, the main disadvantage is particle swarm optimization (PSO) algorithm are that it is easy to fall into local optimum in high-dimensional space and has a low convergence rate in the iterative process. In the GSO algorithm also there is a drawback of having slow convergence, poor exploration and exploitation ability. By hybridized these two optimization algorithms, we assume that channel estimation performance will be increased and while, which will be helped to decrease the bit error rate [2]. In our work, PSO and GSO are joined and employed to optimal channel matrix generation process in signal transmission system.

4 STBC encoder

Space-time block encoder (STBC) are a establish version of Alamouti scheme but that have a similar key components. These codes are orthogonal and can accomplish full transmit differing qualities indicated by the quantity of transmit antennas. The data are built as a matrix which has its columns equal to the number of the transmit antennas and its rows equivalent to the quantity of the time slots to transmit the information. At the receiver side, the signals received initially joined and after that sent to the most maximum probability detector where the decision rules principles are connected. Space-time block codes were intended to accomplish the

maximum diversity order arrange for the given number of transmit and get receive antennas subject to the limitation of having a simple linear decoding algorithm. This has made space-time block codes an exceptionally well known and most generally utilized plan. Alamouti scheme is the premise of the Space Time Coding method. The mathematical explanation of the scheme with two transmitting and one receiving antennas is used. Using two transmit antennas and one receive antenna, the scheme provides the same diversity order as maximal-ratio receiver combining (MRRC) with one transmit antenna and two receive antennas. At the transmitter side a block of two symbols is taken from the source information and sent to the modulator.

4.1 Alamouti space-time encoder

The Alamouti space-time encoder takes the two modulated symbols called s_1 and s_2 makes encoding network S where the symbols $s_1(i-1)$ and $s_2(i)$ are mapped to two transmit antennas in two transmit time slots. The encoding matrix is given by:

$$s = \begin{bmatrix} s_1(i-1) & s_2(i) \\ -s_2(i)^* & s_1(i-1)^* \end{bmatrix} \quad (3)$$

The fading coefficients denoted by $h_1(t)$ and $h_2(t)$ are assumed constant across the two consecutive symbol transmission periods and they can be defined as:

$$h_1(t) = h_1(t+T) = |h_1|e^{j\theta_1} \quad (4)$$

$$h_2(t) = h_2(t+T) = |h_2|e^{j\theta_2} \quad (5)$$

The receiver receives r_1 and r_2 represents the two received signals over the two consecutive symbol periods for time t and $t+T$. The received signals can be expressed by:

$$\begin{bmatrix} R(i-1) \\ R(i) \end{bmatrix} = \begin{bmatrix} s_1(i-1) & s_2(i) \\ -s_2(i)^* & s_1(i-1)^* \end{bmatrix} \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix} = \begin{bmatrix} h_1s_1(i-1) + h_2s_2(i) + n_1(i-1) \\ -h_1s_2(i)^* + h_2s_1(i-1)^* + n_2(i) \end{bmatrix} \quad (6)$$

Where, $R(i-1)$ and $R(i)$ are $N \times 1$ vectors, $n_1(i-1)$ and $n_2(i)$ are the additive white Gaussian noise (AWGN) vector (all vector mechanism are independent and idensstically scattered with zero mean and variance σ^2), and h_1, h_2 are the $N \times N$ diagonal channel matrix. Here, the complex channel coefficient related to subcarrier and to the transmit antenna T_x .

5 Channel estimation using PSGSO algorithm

The signal is transmitted to the encoder and decoder there was a chance to error; so we using channel estimation in the system. By using channel estimation, we can detect the error and reduce the noise error. The channel estimation process is explained below;

Step 1: Solution encoding

Solution encoding is an important step for the optimization algorithm. In a realistic receiver, the channel matrices h_1 and h_2 are not deterministically known, but they should be replaced by their estimates h'_1 and h'_2 . Here, at first, we randomly assign the value of channel matrices h_1 and h_2 based the transmitted input signal. Here, at first we generate the search solution and head angle of each solution. The solution model is expressed in eq. (7).

$$I = (i_1, i_2, \dots, i_m) \tag{7}$$

The head angle of each individual is expressed by;

$$\phi_i = (\phi_1, \phi_2, \dots, \phi_m) \tag{8}$$

The search direction of the member based on head angle is expressed in (9).

$$U_i(\phi_1) = (u_1, u_2, \dots, u_m) \tag{9}$$

The search direction can be calculated from head angle by the use of polar and Cartesian coordinate’s transformation using (10), (11), (12).

$$u_{i1} = \prod_{p=1}^{n-1} \cos\phi_{i1} \tag{10}$$

$$u_{ij} = \sin\left(\phi_{i(j-1)}\right) \cdot \prod_{p=1}^{n-1} \cos(\phi_{ip}) \tag{11}$$

$$u_{in} = \sin\left(\phi_{i(n-1)}\right) \tag{12}$$

Step 2: Fitness calculation

The fitness calculation is important for selecting optimal solution. The fitness function is designed based on the channel matrices transmitting signals. In this paper, we adopted the MMSE channel estimate targeted to MIMO STBC system considers in [25].

$$\begin{aligned}
 FF_i &= O(\hat{h}_1, \hat{h}_2) \\
 &= \|R(i-1) - \hat{h}_1 c_{s1}(i-1) - \hat{h}_2 c_{s2}(i)\|^2 + \|R(i) + \hat{h}_1 c_{s2}(i)^* - \hat{h}_2 c_{s1}(i-1)^*\|^2 \tag{13}
 \end{aligned}$$

Step 3: Producer operator

The member with the top fitness of O_i is known as the producer and indicated as O_p . At first the producer scan the food sources (fitness) based on different angle such as zero degree, right hand side and left hand side.

(i) It carries out the scanning assignment at zero degree

$$O_z = O_p + \varepsilon_1 d_{max} U_p^i(\phi_i) \quad (14)$$

Where, d_{max} denotes the maximum search distance.

(ii) It accomplishes the scanning function at the right hand side hypercube

$$O_r = Z_p + \varepsilon_1 d_{max} U_p^i(\phi_i + \varepsilon_2 \Phi_{max/2}) \quad (15)$$

(iii) It executes the scanning task at the left hand side hypercube

$$O_l = O_p + \varepsilon_1 d_{max} U_p^i(\phi_i - \Phi_{max/2}) \quad (16)$$

Where, ε_1 points to a normally distributed randomnumber with zero mean and unity standard deviation and ε_2 stands for a uniformly distributed random sequence which has values within the range 0 and 1.

The maximum search angle Φ_{max} is effectively represented as:

$$\Phi_{max} = \frac{\pi}{c^2} \quad (17)$$

Now, the constant c can be furnished as:

$$C = \text{round}(\sqrt{n+1}) \quad (18)$$

Here, n corresponds to the dimension of the search space.

$$\therefore \Phi_{max} = \frac{\pi}{n+1} \quad (19)$$

The evaluation of maximum search distance d_{max} includes the ensuing equations.

$$d_{max} = \frac{\|d_u - d_L\|}{\sqrt{\sum_{i=1}^n (d_{ui} - d_{Li})^2}} \quad (20)$$

Here, d_{ui} and d_{Li} represent the upper and lower limits of the i th dimension, correspondingly.

The best location consisting of the most beneficial resource may be achieved by means of Eqs. (14), (15) and (16). The existing best location will give way for a new best location, if its existing resource is found to be inferior to that in the new location. Otherwise, the producer preserves its location and turns its head as per the head angle direction which is randomly produced by means of Eq. (21).

$$\phi^{i+1} = \phi^i + \varepsilon_2 \tau_{\max} \quad (21)$$

Here, τ_{\max} corresponds to the maximum turning angle which is evaluated with the help of the equation given below.

$$\tau_{\max} = \frac{\Phi_{\max}}{2} \quad (22)$$

When the producer is unable to identify a better position even after the completion of m iterations, its head would then assume its initial position as given in eq. (23).

$$\phi^{i+C} = \phi^i \quad (23)$$

Step 4: Scrounger operator

In all the iterations, many members other than the producer are selected and they are termed as scroungers. The scrounging action of the GSO generally includes the area copying task. During the S^{th} iteration, the function of area copying which the i^{th} scrounger carries out may be shaped as a movement to inch towards the producer in an intimate manner which is illustrated as:

$$O^{i+1} = Z_i + \varepsilon_3 o(O_p - I_i) \quad (24)$$

Here, o specifies the product which determines the product of the two vectors in an entry-wise manner and ε_3 denotes a uniform random sequence lying in the interval of (0, 1). The i^{th} scrounger continues to be in its searching task so as to make a selection of the superior chance for the purpose of linking.

Step 5: Ranger operator

The rangers are the residual members of the group, which have been relocated from their current location. They are competent to efficiently locate the resources by carrying out arbitrary walks or by means of an orchestrated searching process. The arbitrary talks are favored in cases, where the resources located are to be appropriately allocated. Both the head angle and the distance related to the ranger are created in an arbitrary manner.

$$d_i = c \cdot \varepsilon_1 \cdot d_{\max} \quad (25)$$

The arbitrary walk to a novel point may be illustrated as:

$$O^{i+1} = O_i + d_i U(\phi^{i+1}) \quad (26)$$

When the whole procedure comes to an end, the fitness of the modernized solution is estimated.

Step 6: PSO Updating

After the GSO operation is completed, in this work we further we update the solution using PSO algorithm. In PSO algorithm solution updation formula is given in eq. (27)

$$x_k^i = x_k^i + v_{k+1}^i \tag{27}$$

And the solution of velocity also calculated

$$v_{k+1}^i = wv_k^i + c_1r_1(p_k^i - x_k^i) + c_2r_2(p_k^g - x_k^i) \tag{28}$$

Step 7: Termination criteria

The process is continued until they get optimal solution otherwise it will stop the process. And the solution is which is holding the best fitness value is selected and it is specified as best channel matrix.

6 Proposed STBC MC-CDMA system for channel estimation

The main objective of this paper is to receive the signal without any noise. To reduce the noise present in the received signal, in this paper we utilized PSGSO algorithm. In this section we analyze the proposed method and the block diagram illustrate the method of the channel estimation and STBC encoder. The given procedures are bellow shows in Fig. 1:

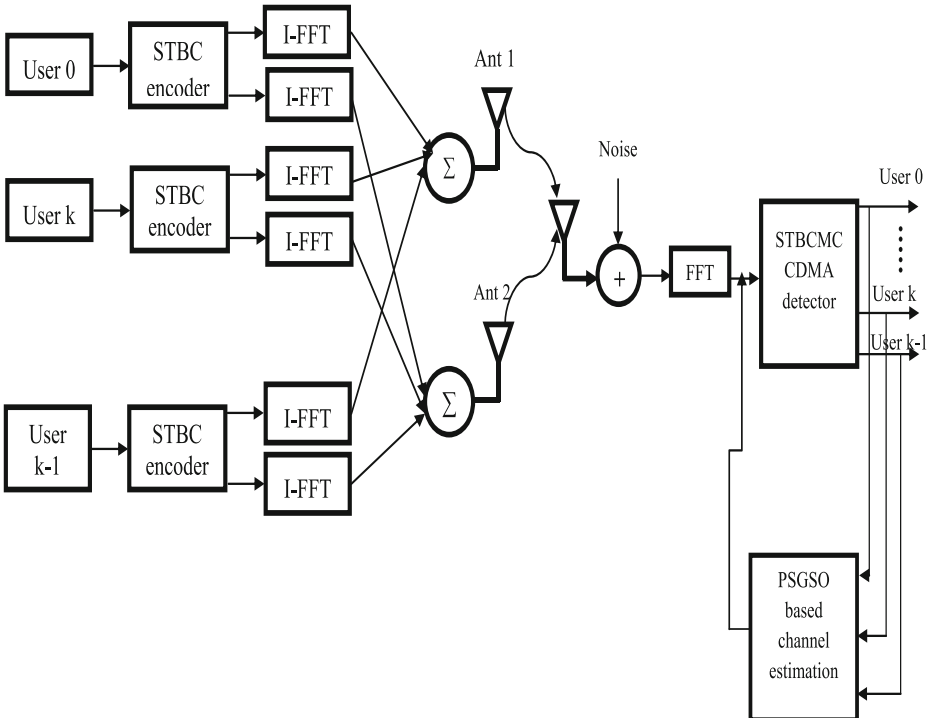


Fig. 1 Proposed STBC MC-CDMA channel estimation system

Step1: consider the Two consecutive data symbol of generic user $k(k = 0, \dots, k-1)$ $[s(i-1)s(i)]$ interconnected to the generic i^{th} modulation period ($i = 1, 3, \dots$) are mapped to two transmitting antennas according to the code matrix $\phi_p(i)$ by the equation

$$[\phi_p(i)] = \frac{1}{\sqrt{2}} \begin{bmatrix} s(i-1) & -s^*(i) \\ s(i) & s^*(i-1) \end{bmatrix} \quad (29)$$

The superscript operator (*) denotes the complex conjugate. The eq. (15) matrix represents the Alamouti's STB Cblock.

Step 2: The signals are transmitted to the STBC encoder. The encoder outputs are transmitted during two consecutive transmission periods, each one of duration equal to T. The first transmission period is $(i-1)T$.

Step 4: The two symbols $[s(i-1)s(i)]$ are vary by two separate Inverse Fast Fourier Transform- (IFFT-) based multicarrier transmitters using a unique Hadamard-Walsh sequence $c_k \wedge \{c_k(n) = 0, \dots, N-1\}$, where N is the number of subcarriers employed for spreading.

Step 5: At last, the RF-converted Multicarrier Spread Spectrum (MC-SS) signals are simultaneously transmitted by antenna 1 and antenna 2. The symbol $-s_p(i)$ is transmitted by antenna 1, and the symbol $s_p(i-1)$ is transmitted by antenna 2, respectively.

Step 7: Then the received signals are transformed into the FFT transformer based coherent de-multiplexing can be expressed as follows:

$$R_{-}(i-1) = h_1s_1(i-1) + h_2s_2(i) + n_1(i-1), R_{-}(i) = -h_1s_2^*(i) + h_2s_1^*(i-1) + n_2(i) \quad (30)$$

Step 8: The received signal is transfer to the STBC decoder and gets the signal without noise in the vector form using PSGSO algorithm. The pseudo code of proposed system is shown in Table 2.

7 Result and discussion

The proposed channel estimation in CDMA system is implemented in the MATLAB program, which was simulated in system specifications of 4 GB RAM and 3.2 GHz Intel i-5 processor. The evaluation metrics employed are SER (Symbol Error Rate) and BER (Bit Error Rate). The performances of the proposed channel estimation are evaluated by means of intensive simulation trials in a Rayleigh fading channel fixing the following parameters: Number of

Table 2 pseudo code of proposed STBC MC CDMA system.

<p>Input:</p> <p>Number of transmitting antenna T_x</p> <p>Number of receiving antenna R_x</p> <p>Input signals $s_1(i-1), s_2(i)$</p> <p>Parameters of GSO algorithm</p> <p>Parameters of PSO algorithm</p> <p>output:</p> <p>Received signals $R(i-1), R(i)$</p> <p>Assumption:</p> <p>Channel matrix h_1, h_2, Noise n_1, n_2, initial population I_i, fitness FF_i</p> <p>Initialization:</p> <p style="padding-left: 40px;">Initialize the position of the population $I_i = (i_i^1, i_i^2, \dots, i_i^d, \dots, i_i^n)$,</p> <p style="padding-left: 40px;">head angle ϕ_i of all members, search direction $U_i(\theta_i)$ of all members</p> <p>Start:</p> <p>Given the signal to the transmit antenna T_x</p> <p style="padding-left: 40px;">Transfer the signal to the STBC encoder</p> <p style="padding-left: 40px;">Decode the signal using STBC decoder</p> <p>If</p> <p>{</p> <p style="padding-left: 40px;">the received signal is noise; go for the channel estimation the received signal is</p> <p style="padding-left: 80px;">noise-free;</p> <p style="padding-left: 40px;">else</p> <p>stop the program</p> <p>}</p>
--

Channel estimation stage:

Generate the initial population $I_i, i = 1, 2, \dots, n$

Evaluate the fitness (FF_i) of the population

Set cycle to 1

Repeat:**Stage 1: for GSO**

While (the termination conditions are not met)

For each members i in the group do

Find new search solution

Choose Producer: Find the producer of the group.

Perform producing:

{

(i) Scan at three random points in the scanning field using eq. (14) to (16).

(ii) Move to the best point if it has a better resource, otherwise stay at the current position and turn the head to a new angle using eq. (21).

(iii) If a better area cannot be found then turn the head back to zero degree using eq. (23)

}

Perform scrounging:

Randomly select 80% from the rest members to perform scrounging.

Perform ranging:

{

For the rest members they will perform ranging:

To generate a random head angle using (9)

To choose a random distance I_i from the Gaussian distribution using (25)

Finally move to the new point using (26)

}

Check feasibility:

Check weather each member of the group violates the constraints. If it

It does, it will move back to the previous position to guarantee a feasible
solution.

end for

Set $k=k+1$;

end while

Stage 2: for PSO stage

while ($t \leq \max \text{imum iteration}$)

Select the n best solution from GSO

Update the velocity of each solution using eq.(27)

Update the position of each solution using eq. (28)

end while

Hybridization:

Combine GSO beset solution and PSO updated solution

Go for fitness calculation

Repeat

Select the best solution (channel matrix)

Output:

Noise free received signal

subcarriers is 8, transmission data rate is 1024Kb/s, coherence bandwidth of the channel 2.1 MHz, Doppler spread of the channel 100 Hz. To evaluate the proposed work, in this paper we used different configuration antenna sizes. Here, we carried out six types of result such as (i) $T_x = 1$, $R_x = 1$, user 2, subcarrier $S_x = 8$ (ii) $T_x = 2$, $R_x = 1$, user 2, subcarrier $S_x = 8$ (iii) $T_x = 3$, $R_x = 1$, user 2, $S_x = 8$, (iv) $T_x = 1$, $R_x = 1$, user 4, $S_x = 8$, (v) $T_x = 2$, $R_x = 1$, user 2, $S_x = 8$, (vi) $T_x = 3$, $R_x = 1$, user 4, $S_x = 8$.

7.1 Evaluation metrics

The evaluation of proposed MIMO MC-CDMA for STBC communication system using PSGSO based optimal channel estimation technique is carried out using the following metric as suggested by below equations,

Bit error rate: Bit Error Rate (BER) is defined as the rate at which errors occur in a transmission system. BER is the ratio of error bits received to the total bits sent.

Symbol error rate: Symbol Error Rate (SER) is defined as a number erroneously decoded information symbols (constellation points) divided by a total number of transmitted symbols.

Spectral efficiency: Spectrum efficiency refers to the information rate that can be transmitted over a given bandwidth in a specific communication system.

7.2 Performance evaluation

The main objective of proposed methodology is optimal channel estimation in MC-CDMA system. To improve the efficiency of the system in our work we choose the optimal channel using PSGSO algorithm. To encoding the transmitting signals, here we used Alamouti's space-time block coding. To evaluate the proposed work, in this paper we used different configuration antenna sizes. Here, we carried out six types of result such as (i) $T_x = 1$, $R_x = 1$, user 2, subcarrier $S_x = 8$ (ii) $T_x = 2$, $R_x = 1$, user 2, subcarrier $S_x = 8$ (iii) $T_x = 3$, $R_x = 1$, user 2, $S_x = 8$, (iv) $T_x = 1$, $R_x = 1$, user 4, $S_x = 8$, (v) $T_x = 2$, $R_x = 1$, user 2, $S_x = 8$, (vi) $T_x = 3$, $R_x = 1$, user 4, $S_x = 8$.

7.2.1 Case 1: User 4, $T_x = 1$, $R_x = 1$

Channel estimation is an important process for signal transmission. In this paper, we used multi user STBC CDMA transmission System for signal transmission while preserve minimum bit error rate using hybrid PSGSO algorithm. If the BER value is minimum means we obtain the noiseless signal. For experimentation, in this case we use $T_x = 1$, $R_x = 1$, $S_x = 8$ and user 4.

In MC-CDMA system, the noiseless signal transmission is an important process. To improve the quality of received signal, in this paper we used PSGSO algorithm for channel estimation. Figure 2 shows the performance of BER by varying SNR value using $T_x = 1$, $R_x = 1$, $S_x = 8$ and user 4. Here, the x-axis represents the SNR value and the y-axis represents the BER. In this, our proposed PSGSO algorithm based channel estimation in STBC MC CDMA system compared with other three algorithms such as Particle swarm optimization (PSO), group search optimization (GSO) and

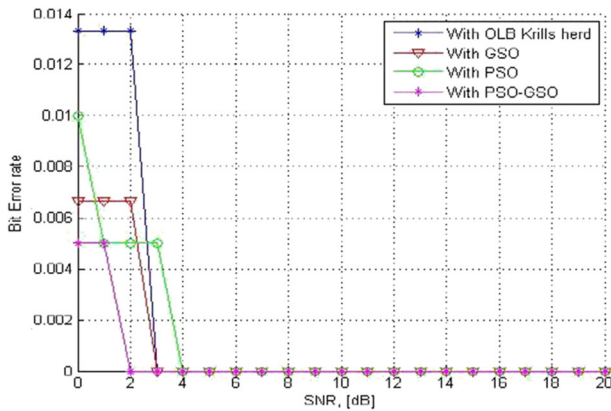


Fig. 2 BER vs. SNR plots of MC-CDMA system using $T_x = 1$, $R_x = 1$, $S_x = 8$ and user 4

oppositional krill herd algorithm (OKHA) based channel estimation. When analyze fig. 2, our proposed approach achieves the minimum BER of 0.005, which is 0.01 for using PSO algorithm, 0.0068 for using GSO algorithm and 0.013 for using OKHA algorithm. From the figure, we clearly understand our proposed algorithm obtain the minimum BER compare to other approaches. Moreover, fig. 3 shows the performance of spectral efficiency plot using $T_x = 1$, $R_x = 1$, $S_x = 8$ and user 4. if the transmission system is good means we obtain the maximum spectral efficiency. When analyzing fig. 3, our proposed approach achieves the maximum Spectral efficiency of 0.35 which is better than other methods. Similarly, Fig. 4 shows the performance of SER by varying SNR values.

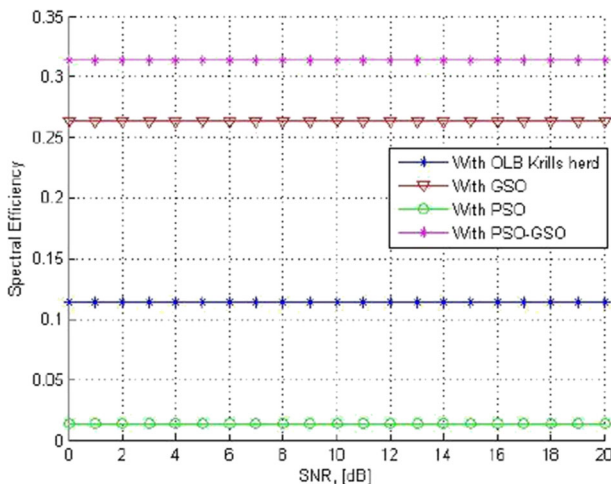


Fig. 3 SE vs. SNR plots of MC-CDMA system using $T_x = 1$, $R_x = 1$, $S_x = 8$ and user 4

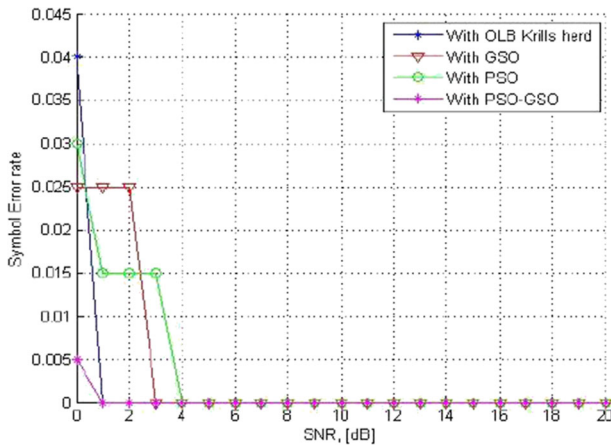


Fig. 4 SER vs. SNR plots of MC-CDMA system using Tx = 1, Rx = 1, Sx = 8 and user 4

7.2.2 Case 2: User 4, Tx = 2, Rx = 1

In this section, we explain the result obtained from proposed multi-user STBC MC-CDMA transmission System Based on Minimum Conditional BER Criterion and hybrid PSGSO algorithm assisted channel estimation using Tx = 2, Rx = 1, Sx = 8 and user 4. The most economic and advantageous Alamouti’s configuration considers two transmit antennas (installed at base station or access point) and a single antenna mounted at the receiver side.

The above fig. 5-7 shows the performance of STBC MC CDMA system for Tx = 2, Rx = 1, Sx = 8 and user 4 configuration. When analyze fig. 5, our proposed approach achieves the minimum BER of 0.005, which is 0.01 for using PSO algorithm, 0.012 for using GSO algorithm and 0.015 for using OKHA algorithm. Moreover, fig. 6 shows the performance of spectral efficiency plot using Tx = 1, Rx = 1, Sx = 8 and user 4. When analyzing fig. 5, our

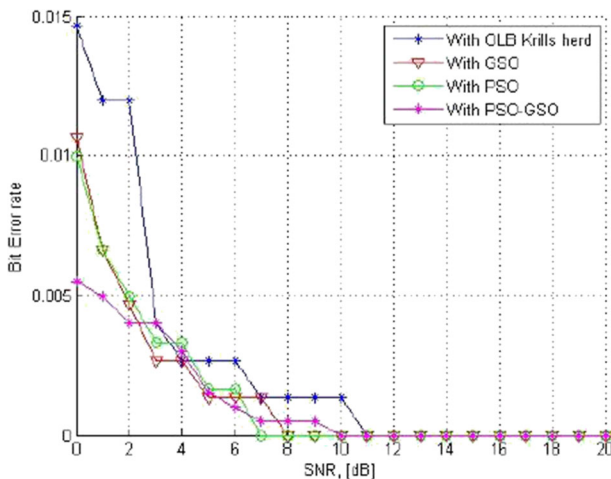


Fig. 5 BER vs. SNR plots for MC-CDMA system using Tx = 2, Rx = 1, Sx = 8 and user 4

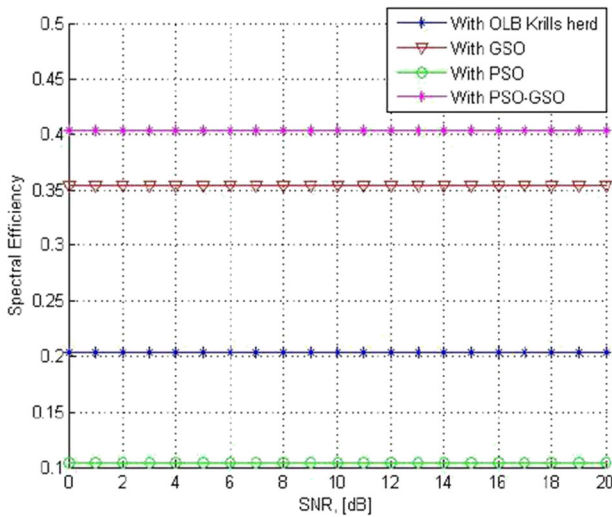


Fig. 6 SE vs. SNR plots for MC-CDMA system using Tx = 2, Rx = 1, Sx = 8 and user 4

proposed approach achieves the maximum Spectral efficiency of 0.4 which is 0.35 for using GSO algorithm, 0.2 for using OKH algorithm and 0.1 PSO. Similarly, Fig. 7 shows the performance of SER by varying SNR values. Here, our proposed approach obtains the minimum error rate of 0,017 which is very much low compare to other approach.

7.2.3 Case 3: User 4, Tx = 3, Rx = 1 and Sx = 8

In this section, the experimentation is carried out using Tx=3, Rx = 1, Sx = 8 and user=4. Here, we used only one receiver.

The above fig. 8 shows the performance of BER for MC-CDMA system using Tx = 3, Rx = 1, Sx = 8 and user 4. Here, our proposed approach achieves the minimum error rate of 0.006 for using PSGSO algorithm, 0.016 for using PSO algorithm, 0.008 for using GSO

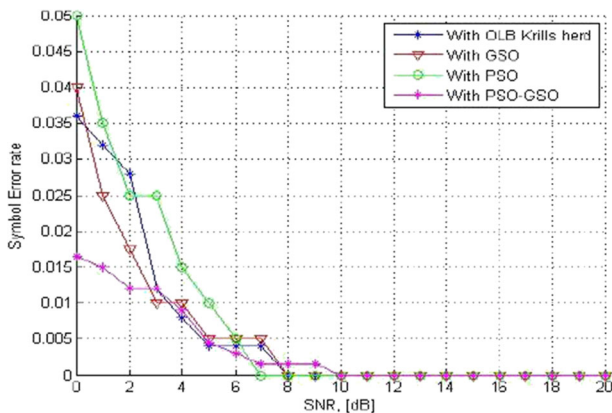


Fig. 7 SER vs. SNR plots for MC-CDMA system using Tx = 2, Rx = 1, Sx = 8 and user 4

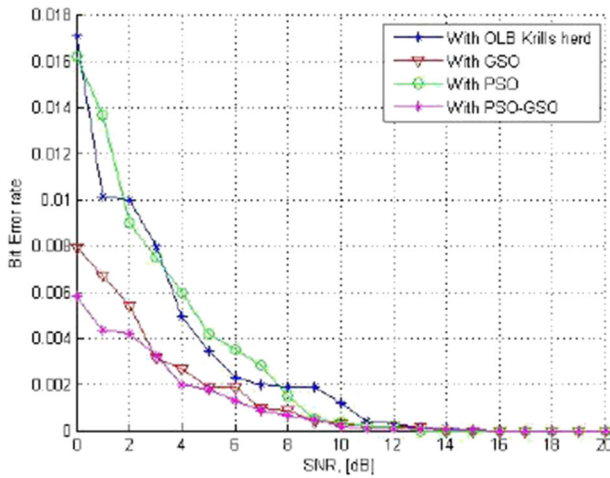


Fig. 8 BER vs. SNR plots for MC-CDMA system using $T_x = 3, R_x = 1, S_x = 8$ and user 4

algorithm and 0.017 for using OKHA algorithm. Similarly, fig. 9 shows the spectral efficiency of proposed method. Here, our proposed approach achieves the maximum spectral efficiency of 1.29. Additionally, fig. 9 shows the performance of SER plot by varying SNR value. When analyzing fig. 10, our proposed approach achieves the minimum error rate of 0.019.

7.2.4 Case 4: User 2, $T_x = 1, R_x = 1$ and $S_x = 8$

In this section, we explain the result obtained from proposed multi-user STBC MC-CDMA transmission System Based on Minimum Conditional BER Criterion and hybrid PSGSO algorithm assisted channel estimation using $T_x = 1, R_x = 1, S_x = 8$ and user 2.

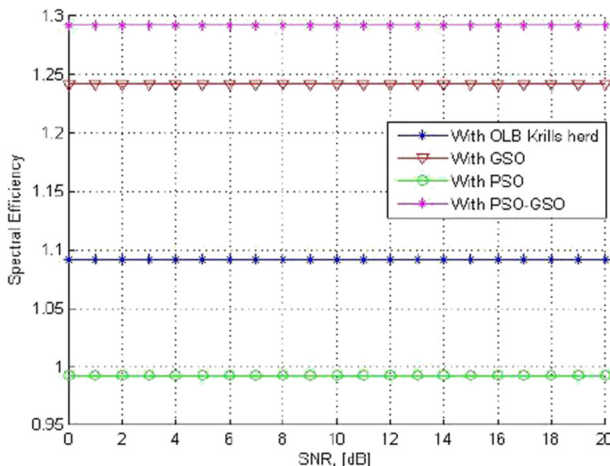


Fig. 9 SE vs. SNR plots for MC-CDMA system using $T_x = 3, R_x = 1, S_x = 8$ and user 4

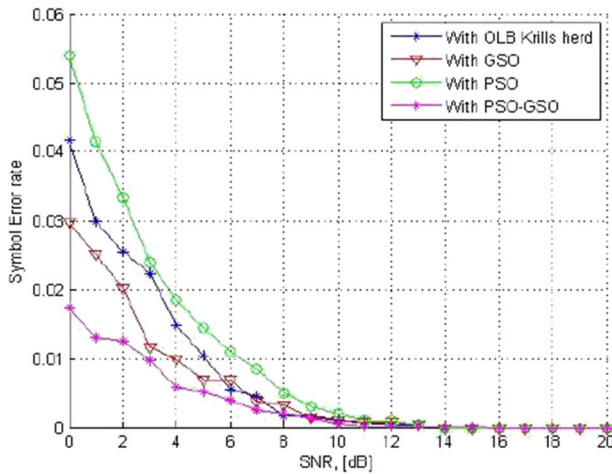


Fig. 10 SER vs. SNR plots for MC-CDMA system using $T_x = 3$, $R_x = 1$, $S_x = 8$ and user 4

The above fig. 11 shows the performance of BER for different method using $T_x = 1$, $R_x = 1$, $S_x = 8$ and user 2. The x-axis represents SNR value and y-axis represents the BER value. The graph shows, if the SNR value is increases means the BER value is gradually decreases. From the fig. 11, we clearly understand our proposed approach achieves the minimum error rate of 0.005. Figure 12 shows the Performance of SE vs. SNR for MC-CDMA system using $T_x = 1$, $R_x = 1$, $S_x = 8$ and user 2. Here, our proposed approach achieves the maximum SE of 0.33, which is 0.02 for using PSO algorithm, 0.12 for using OKHA and 0.26 for using GSO algorithm. Similarly, fig. 13 shows the Performance of SER vs. SNR for MC-CDMA system using $T_x = 1$, $R_x = 1$, $S_x = 8$ and user 2. Here, our proposed approach achieves the minimum error rate of 0,005, which very low compare to other approaches.

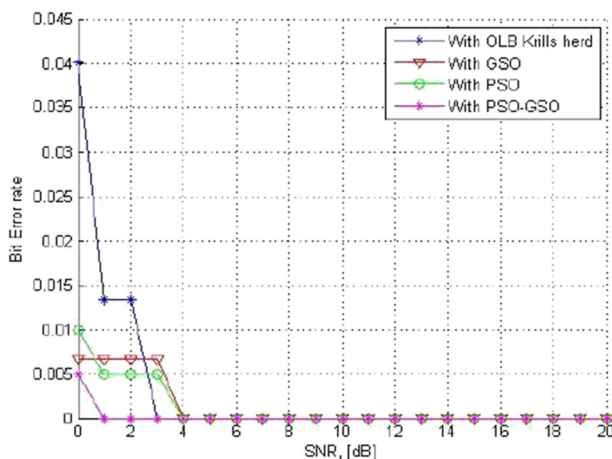


Fig. 11 BER vs. SNR plots for MC-CDMA system using $T_x = 1$, $R_x = 1$, $S_x = 8$ and user 2

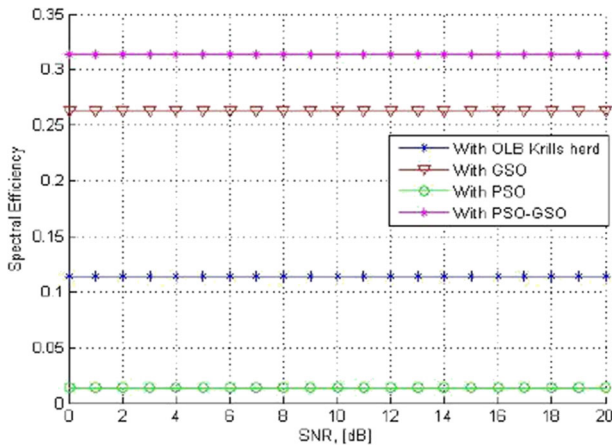


Fig. 12 SE vs. SNR plots for MC-CDMA system using Tx = 1, Rx = 1, Sx = 8 and user 2

7.2.5 Case 5: User 2, Tx = 2, Rx = 1 and Sx = 8

In this section, we Tx=2, Rx=1, Sx=8 and user 2 for STBC MC CDMA transmission system. Here, we compare our proposed work with OKHA, GSO algorithm based channel estimation, and PSO algorithm based channel estimation.

The above fig. 14, 15, 16 shows the performance of proposed system using the configuration of Tx=2, Rx=1, Sx=8 and user 2. When analyzing above figures, our proposed approach achieves the minimum BER 0.006of, minimum SER of0.015 and maximum SE of 0.4. From the results we clearly understand our proposed approach achieves the better performance compare to other approaches.

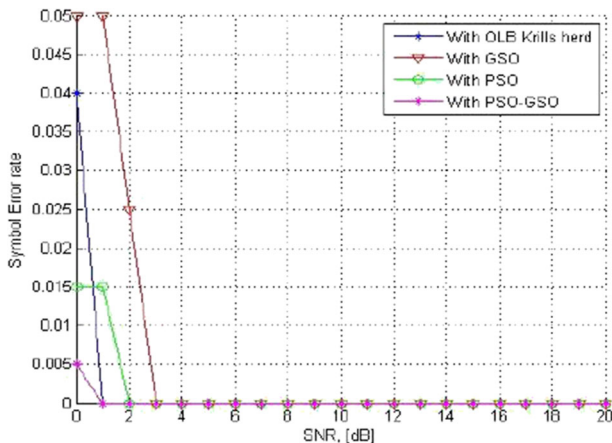


Fig. 13 SER vs. SNR plots for MC-CDMA system using Tx = 1, Rx = 1, Sx = 8 and user 2

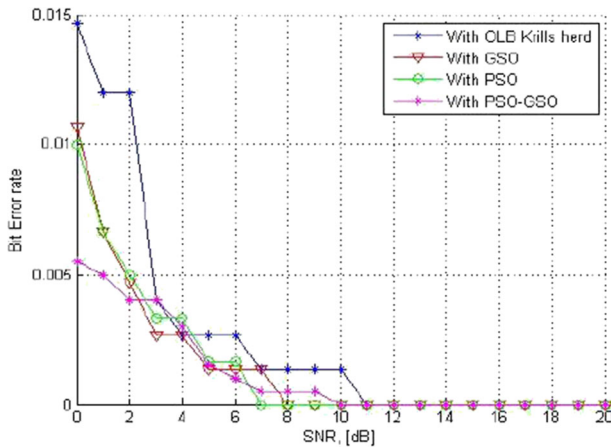


Fig. 14 BER vs. SNR plots for MC-CDMA system using $T_x = 3$, $R_x = 1$, $S_x = 8$ and user 4

7.2.6 Case 6: User 2, $T_x = 3, R_x = 1$ and $S_x = 8$

In this case, we utilize user 2, $T_x = 3$, $R_x = 1$ and $S_x = 8$ for our experimentation. Using PSGSO algorithm, we estimation the channel matrix value. Without channel estimation we can't properly receive the signal. In this section, we measure the SER, SE and BER value.

The above fig. 17 shows the performance of BER for different method using $T_x = 3$, $R_x = 1$, $S_x = 8$ and user 2. The x-axis represents SNR value and y-axis represents the BER value. The graph shows, if the SNR value is increases means the BER value is gradually decreases. From the fig. 17, we clearly understand our proposed approach achieves the minimum error rate of 0.006. Figure 18 shows the Performance of SE vs. SNR for MC-CDMA system using $T_x = 3$, $R_x = 1$, $S_x = 8$ and user 2. Here, our

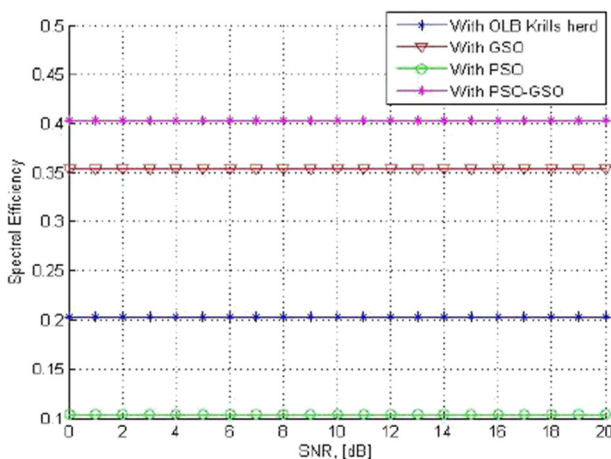


Fig. 15 SE vs. SNR plots for MC-CDMA system using $T_x = 2$, $R_x = 1$, $S_x = 8$ and user 2

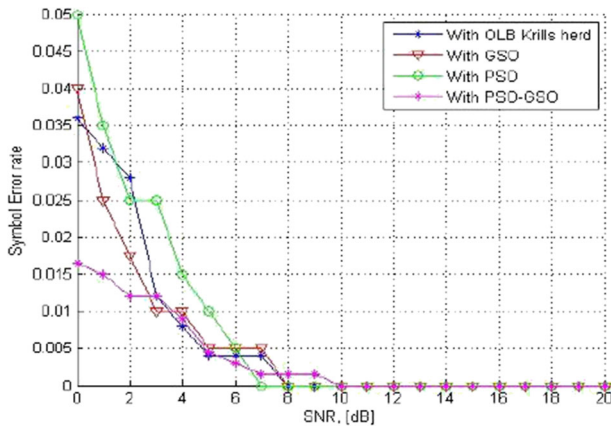


Fig. 16 BER vs. SNR plots for MC-CDMA system using Tx = 2, Rx = 1, Sx = 8 and user 2

proposed approach achieves the maximum SE of 1.29, which is 0.99 for using PSO algorithm, 1.1 for using OKHA and 1.25 for using GSO algorithm. Similarly, fig. 19 shows the Performance of SER vs. SNR for MC-CDMA system using Tx = 1, Rx = 1, Sx = 8 and user 2. Here, our proposed approach achieves the minimum error rate of 0,018, which very low compare to other approaches.

8 Conclusion

In this paper, we introduced and analyzed a novel PSGSO assisted MMSE channel estimation methodology for STBC MC-CDMA systems working in time-varying multipath fading channels. Here, the PSGSO algorithm overcomes the drawbacks of

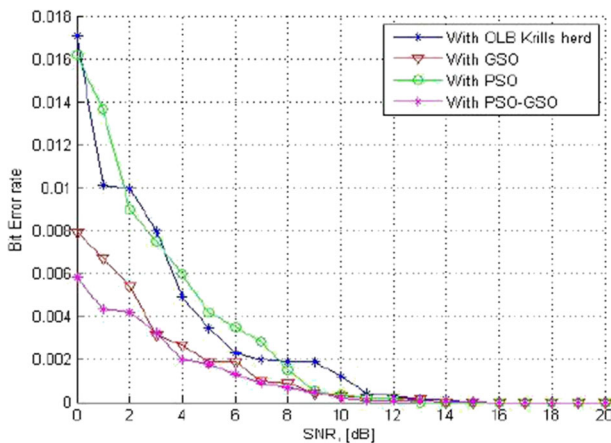


Fig. 17 BER vs. SNR plots for MC-CDMA system using Tx = 3, Rx = 1, Sx = 8 and user 2

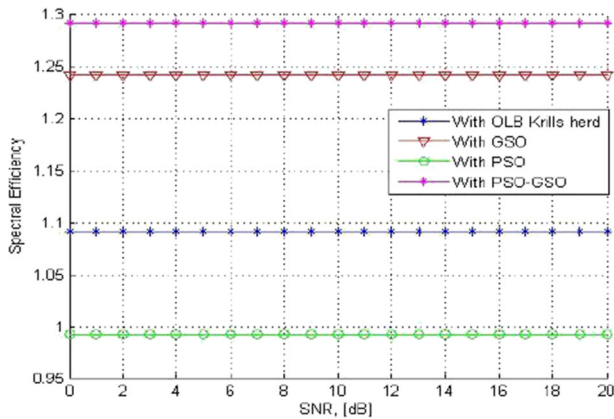


Fig. 18 SER vs. SNR plots for MC-CDMA system using $T_x = 3$, $R_x = 1$, $S_x = 8$ and user 2

individual PSO and GSO algorithms to achieve the optimal channel matrices. Further on, optimal channel matrices have been used to implement the canonical MMSE Multi User Detection. Simulation comparisons are conducted with the proposed algorithm, the PSO algorithm, GSO algorithm and OKH algorithm respectively. The system is evaluated based on different configurations. The results show that the proposed PSGSO algorithm is more efficient in terms of BER, SER, and Spectral efficiency.

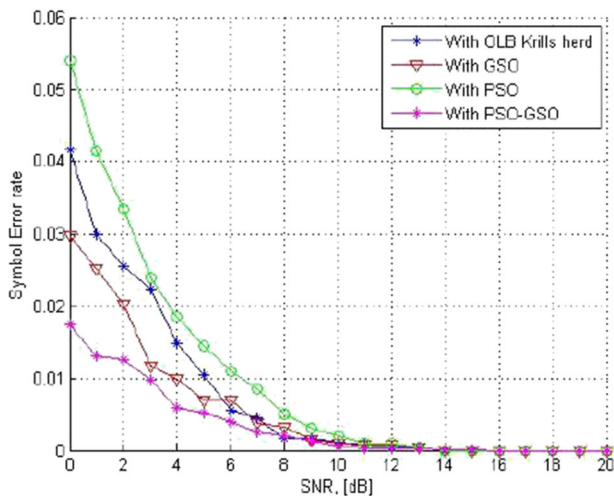


Fig. 19 SE vs. SNR plots for MC-CDMA system using $T_x = 3$, $R_x = 1$, $S_x = 8$ and user 2

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