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Channel Estimation of MC-CDMA aided with Evolutionary Algorithms

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ABSTRACT

Currently wireless communication has gained great demand. In order to satisfy current need of customer's, new technologies are required. Multi-Carrier Code Division Multiple Access (MC-CDMA) is one of the promising technologies for mobile radio communications. In this article MC-CDMA performance is evaluated by estimating the channel with the help of evolutionary algorithms. Block type pilot arrangement is used for estimating the channel with least square (LS) estimation algorithm. Matlab used for simulation.

Key words : Channel Estimation, Krill Herd Algorithm, MC-CDMA, PSO

1. INTRODUCTION

In radio communications, the signal strength fluctuates during travel in the free space because of presence of obstructions. The mobile radio system greatly depends on channel. To solve the issues arises in the system perfect information related to channel is necessary. Then the destination side data can be efficiently delivered. Equalization is the best procedure to get the knowledge about the medium between the source and receiver. Before equalizing the channel, receiver must estimate the channel state information [1]. Several procedures are needed for estimating the channel.

Using pilots in the system is one kind of procedure which satisfies the conditions. The data which can be used as pilot is added in the transmitted data and at the destination side it can be used to acquire the knowledge of required data. Pilot based strategy is known for both the devices. Pilot based strategy is called training based system. This procedure provides effective receiver design. But required more overhead.

For the problems which are not possible to solve using conventional methods optimization algorithms are more suitable. Many strategies are available in the literature. In the mobile radio system getting channel knowledge is most tough problem. So to solve this issue optimization algorithms are used in this article.

Several algorithms are in use in many applications. They are divided based on the procedures how they are evolved. One class of algorithm is flock intelligence based algorithm. Particle Swarm Optimization is most widespread algorithm in this set. Proposed by James Kennedy and Russell Eberhart in 1995 [2]. In this paper PSO optimization is used for estimating the channel. Differential evolution (DE) is a kind of optimization algorithm, proposed by Price and Storn [3]. It is a innovative population-based arbitrary search method. MC-CDMA system is furnished with DE in this article.

Other type of evolutionary algorithm is Krill Herd algorithm. This was first submitted by Gandomi and Alavi in 2012 [4]. This is a Biologically stimulated Optimization Algorithm. This algorithm is suggested to solve complicated optimization problems. This algorithm studies the steering behaviour of the krill groups. By taking the position of the krill single as well as in the group. In this paper KH is used for estimating the channel [5],[6].

In Section II, MC-CDMA system articulated. In section III, proposed channel predicting strategies conveyed. Section IV is about simulation results and in V section conclusions discussed.

2. SYSTEM MODEL

Multi-Carrier CDMA system block diagram is shown in Figure 1.

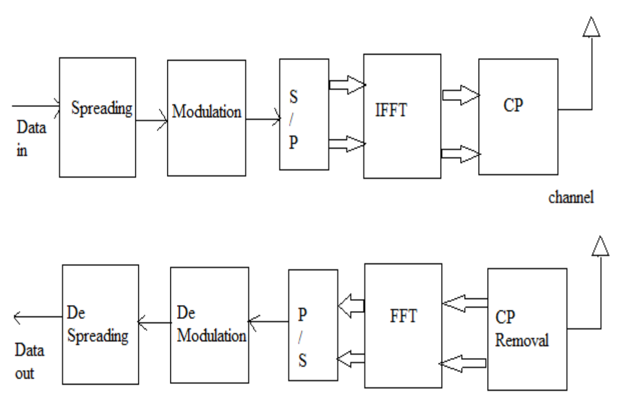

Figure 1: Block diagram of MC-CDMA system

Multi-Carrier CDMA system combines the characteristics CDMA and OFDM [7]. So that benefits of both techniques combinedly affects the overall system. In this scheme first, the data is spread, modulated and transmitted through multiple carriers, thus achieves multicarrier transmission. The critical problem in wireless systems is fading. Sending the information over several carriers is one biggest aid that resolves the problems. The data is parted into several narrowband streams in order that entire data will not be effected. does not affect the complete data.

As shown in the figure 1, the binary data is spread with Walsh Hadamard sequence, then it is modulated and passed through the IFFT block, then cyclical prefix is attached to minimize the disturbance. Then opposite action done at the receiver side to get the original data.

3. PROPOSED CHANNEL ESTIMATION

Various methods preferred for channel estimation. They are Least Square (LS), Minimum Mean Square Error (MMSE), Least mean square (LMS) etc. [8]. In this paper LS is used. LS method is one of the most uncomplicated methods for estimation and does not need any other channel related values.

Pilot based channel estimation is done by attaching pilot symbols in the initial data. Three kinds of pilot forms are available. They are block, comb and lattice pilot form. In this paper block kind pilot form is used. Block type pilots are shown in figure 2.

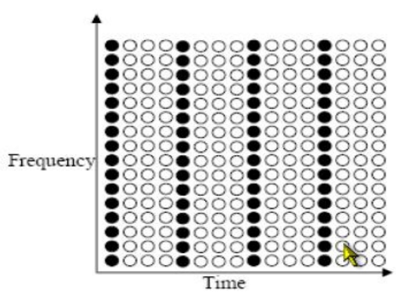

Figure 2: block type pilot arrangement

In this type pilot format pilot symbols are assigned to a specific block, they are sent cyclically in time-domain.

The least-square (LS) channel estimation method finds $\hat{H}$ by diminishing the below function.

$$J(\hat{H}) = \|Y - X\hat{H}\|^2 = Y^H Y - Y^H X\hat{H} - \hat{H}^H X^H Y + \hat{H}^H X^H X\hat{H} \quad (1)$$

By taking the derivative of the function

$$\frac{\partial J(\hat{H})}{\partial \hat{H}} = -2\,(X^H Y)^* + 2\,(X^H X\hat{H})^* = 0 \quad (2)$$

LS channel estimation as

$$\hat{H}_{LS} = (X^H X)^{-1} X^H Y = X^{-1} Y \quad (3)$$

LS channel estimate $\hat{H}_{LS}$ by $\widetilde{H_{LS}}[k]$, k=0,1,2,...N-1.

$\hat{H}_{LS}$ can be written for each subcarrier as

$$\hat{H}_{LS}[k] = \frac{Y[k]}{X[k]}, k = 0,1,2,\ldots N-1 \quad (4)$$

Chanel can be evaluated as follows

Step 1: Generating the user binary data and modulating with with modulation.

$$D_u[n] = D_0[n], D_1[n], D_2[n] \ldots.. D_N[n] \quad (5)$$

$$S[n] = 2 * D_u[n] - 1 \quad (6)$$

Where D[n] is the Uth user data and S[n] is the modulated data.

Step 2: Inserting the pilot symbols periodically to the modulated data and then spreading data with Walsh Hadamard sequence then adding with cyclic prefix.

$$P = p_1, p_2, p_3, \ldots p_m \quad (7)$$

m pilot symbols are inserted to the modulated data,

$$\text{Let } C_u = [C_0, C_1, C_2 \ldots C_k] \quad (8)$$

$$SP = D_u[n]'. C_u \quad (9)$$

C_u is the signature code of the user U, SP is the spread data

Step 3: Now the symbols are transmitted through multiple carriers along with cyclic prefix.

Step 4: Received data at the receiver is

$$Y[n] = H * G + Awgn \quad (10)$$

Awgn is the additive white Gaussian noise, H is the channel information and G is transmitted data and Y is the received data.

Step 5: Receiver evaluates the channel information with the aid of krill herd optimization process.

Step 6: Receiver arbitrarily generates the channel coefficients and chooses the best channel coefficient values, as per the finest fitness value calculated from the KH algorithm.

Step 7: Once the channel information is estimated, then the receiver estimates the transmitted data.

Step 8: Then the data is despread and demodulated.

Step 9: After step 8, BER is measured between transmitted and received data.

There are several optimization algorithms are used for channel estimation [9],[10].

A. Krill Herd based channel estimation:

Krill herd is a bio inspired Meta heuristic algorithm. There are several stages for calculation of fitness value.

krill herd algorithm steps are;

1. Restart of parameters
2. Fitness calculation
3. Motion calculation based on neighboring krills, foraging activity and random diffusion
4. Updating the krill positions
5. Once again calculating the fitness 6. Stop criteria.

B. PSO based channel estimation:

PSO is a stochastic optimization technique.
The steps for PSO are;

1. Initialization of parameters
2. Calculation of fitness
3. Velocity and position updating of particles
4. Again calculation of fitness values
5. Check the stop criteria

C. Differential Evolution based channel estimation:

The steps for DE algorithm are;

1. Start and compute fitness
2. If not ended then do
3. Mutation
4. Crossover
5. Selection
6. Stop

4. NUMERICAL RESULTS

In this section system is implemented with proposed algorithms. The simulation parameters are shown in tables. Walsh Hadamard codes used for spreading [11].

Table 1: MC-CDMA Simulation Parameters

Parameters	Value
Number of input bits	10000
Modulation	BPSK
Signature code	Walsh Hadamard
Spreading code length	8
Channel	Rayleigh
Channel estimation	KH, PSO, DE

Table 2: KH simulation parameters

Parameters	Value
Population size	10,20
Number of Iterations	10,30
w	[0,1]
N_{max}	0.01 m/s
V_f	0.02 m/s
D_{max}	0.005 m/s

Table 3: PSO simulation parameters

Parameters	Value
Population size	10,20
Number of Iterations	10,30
Cognitive coefficient	2
Social coefficient	2

Table 4: DE values

Parameters	Value
Population size	10,20
Number of Iterations	10,30
Mutation, crossover ratio	0.5

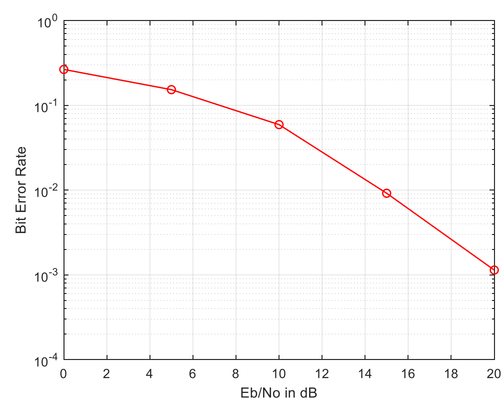

Figure 3: MC-CDMA system without optimization

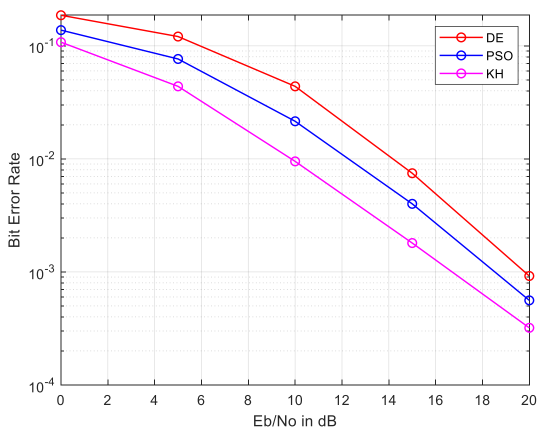

Figure 4: MC-CDMA system based on PSO, DE and KH

In figure 3, MC-CDMA system BER is measured without any optimization technique. In the figure 4, MC-CDMA system performance is evaluated with PSO, DE and KH algorithms. Analysis is given for SNR at 10 dB in table 1.

Table 1: Bit error rate table

Name of the algorithm	BER
Without optimization	0.059
DE	0.0438
PSO	0.0215
KH	0.0095

5. CONCLUSION

MC-CDMA system performance is estimated using KH algorithm and compared with PSO and DE algorithms in this article. System is also evaluated without optimization. The results are showing that KH algorithm is giving better performance.

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