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Enhancement in the performance of channel estimation for OFDM based system using bacterial foraging optimization and neural network

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***Abstract* - Orthogonal frequency division multiplexing (OFDM) is a multicarrier modulation technique used in various broadband systems and has ability to cope with severe channel conditions without complex equalization filters. The benefit of OFDM is spectral efficiency which measures the efficient use of bandwidth. This study combines feed forward back propagation neural network with bacterial foraging optimization (BFO) for the estimation of channel to improve the performance and convergence rate. Minimum mean square error (MMSE) algorithm is used for channel estimation. The performance of bit error rate (BER) and MSE with respect to signal to noise ratio (SNR) is observed.**

***Index Terms* - Channel estimation, OFDM, MMSE, neural network, BER, SNR.**

I. INTRODUCTION

Over the past two decades, the rapid development of wireless communication technology has brought great convenience to people's lives and work. The goal of next generation of mobile wireless communication system is to achieve ubiquitous, high-quality, high-speed mobile multimedia transmission. To achieve this goal, various new technologies are constantly being applied to mobile communication systems. Academia and industry have reached a consensus that OFDM is one of the most promising core technologies in new generation of wireless mobile communication system [9].

Applications of OFDM to wireless and mobile communications are currently under study. Although multicarrier transmission has several considerable drawbacks (such as high peak to average ratio and strict requirements on carrier synchronization), its advantages in lessening the severe effects of frequency selective fading without complex equalization are its attractive features. In order to obtain the high spectral efficiencies required by future data wireless systems, it is necessary to employ multilevel modulation with non constant amplitude (e.g., 16QAM). This implies the need for coherent receivers that are capable to track the variations of the fading channel.

Channel estimation is an important field of interest in wireless OFDM networks. When signal transmission takes place then due to various factors like multipath propagation, presence of objects etc. the signal strength gets reduced and gets spread into time and frequency domain [6]. So to reduce this effect there is need of channel impulse response (CIR) i.e need of filter. There are various methods of channel estimation which involves two type of techniques, blind and pilot type. Blind technique requires larger number of received symbol for extraction of statistical properties whereas pilot system involves insertion of training sequence comprising known data symbol (pilot) at the beginning of transmission for the initial estimation of channel.

The channel estimation (tracking) in OFDM systems is generally based on the use of pilot subcarriers in given positions of the frequency-time grid. For fast-varying channels (e.g., in mobile systems), no negligible fluctuations of the channel gains are expected between consecutive OFDM symbols (or even within each symbol) so that, in order to ensure an adequate tracking accuracy, it is advisable to place pilot subcarriers in each OFDM symbol.

Many investigators have recently explored various algorithms like Bhasker et al. [1] proposed an OFDM with equalizer namely Zero Forcing (ZF) and MMSE. Also utilization of modulation technique is done that provides good reliability. Zhao, Z. Peng, Z [2] proposed a pilot design scheme using convex optimization together with the cross-entropy optimization to minimize the mean square error (MSE). Cui and Tellambura [5] proposed different neural networks for implementation of channel estimation in OFDM.Radial basis function networks (RBFN), a type of neural network, has been applied to OFDM to solve the problem of channel estimation. Nawaz et al [13] studied and presented effectiveness of artificial neural network in channel estimation task. Chia-Hsin Cheng et al [17] proposed back propagation neural network for channel estimation and signal compensation. But in this work, the proposed algorithm will be based on BFO optimization method to optimize the effect of channel estimation.

The remainder of this paper is organized as follows: Section 2, presents the bacterial foraging optimization (BFO), Section 3 presents feed forward back propagation neural network and Section 4 and 5 presents simulation model and results, at the end paper is concluded.

II. BACTERIAL FORAGING OPTIMIZATION (BFO)

This technique is motivated by the foraging and Chemo tactic behaviors of bacteria, especially the Escherichia coli (E. coli). Locomotion can be achieved during the process of real bacteria foraging through the tensile flagella set. Flagella help an E.coli bacterium to fall or swim, that are two essential operations performed by a bacterium at the instance of foraging. When they revolve the flagella in the clockwise direction, every flagellum pulls over the cell. That results in moving of flagella separately and lastly the bacterium tumbles with smaller amount of tumbling, while in a damaging place it tumbles repeatedly to find a nutrient gradient. Stirring the flagella in the counter clockwise direction helps the bacterium to swim at a very speedy rate. In this bacteria undergoes chemo taxis, where they like to shift towards a nutrient gradient and shun harmful atmosphere. Usually the bacteria shift for a longer distance in a gracious situation. Figure 2 depicts how clockwise and anti-clockwise movements of a bacterium occur in a nutrient solution.

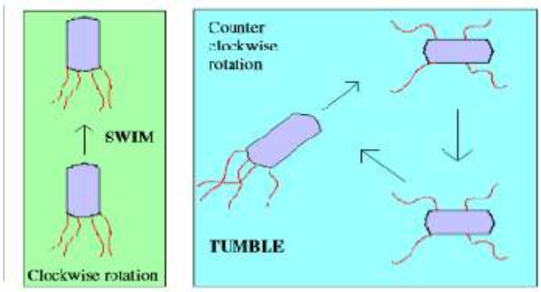

Figure 1 Swim and tumble of a bacterium

The BFO process can be divided into three parts namely a. chemo taxis b. reproduction and c. elimination and dispersal which is shown in figure 3.

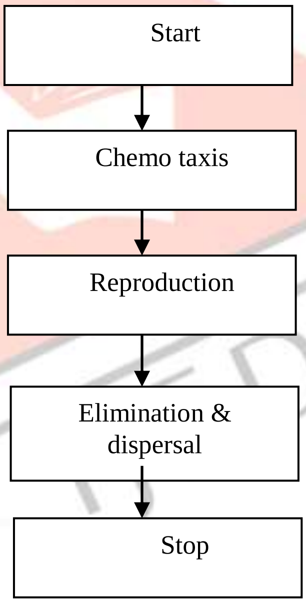

Figure 2 BFO process

Chemo taxis

It is the behavior of the bacteria in which it tries to avoid the deadly substance and then move forward to search nutrients by hiking towards high nutrient area

Reproduction

In reproduction when bacteria get sufficient amount of food its length increases in the presence of appropriate surroundings and then the bacteria break down from the middle to form an exact copy of itself.

Elimination

Elimination step is required to move to another direction. it involves dispersal which may place the bacteria near good food sources.

III. FEED FORWARD BACK PROPAGATION NEURAL NETWORK

Feed forward back propagation neural network consists of a series of layers: The first layer has a connection from the network input. Each subsequent layer has a connection from the previous layer. The final layer produces the network's output.

Feed forward back propagation neural network can be used for any kind of input to output mapping. A Feed forward back propagation neural network with one hidden layer and enough neurons in the hidden layer can fit any finite input-output mapping problem. Figure 4 represents the model of FFNN in which one input is taken after that in hidden layer 10 neurons are taken and at the end one output is observed.

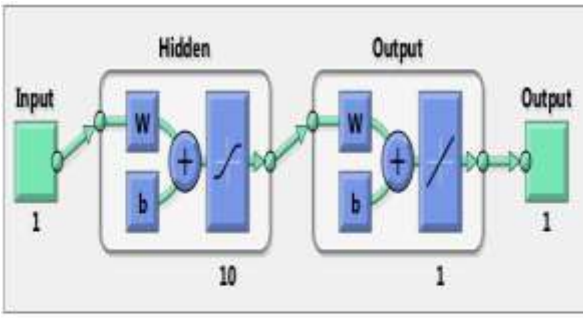

Figure 3 FFNN model

IV. SIMULATION MODEL

For estimation of channel in OFDM system for pilot based arrangement using QAM modulation evaluation has done in MATLAB. The steps involved in the work are:

Step 1. Random data is taken
Step 2. QAM modulation is done
Step 3. Modulated signal is obtained which is passed to serial to parallel converter.
Step 4. Modulated signal after parallelization is obtained.
Step 5. Pilot tone is inserted. The pilot symbols are used to correct the phase error and for data security using carrier frequency set and channel estimators.
Step 6. The obtained signal is optimized by bacterial foraging optimization and classified by feed forward back propagation neural network.
Step 7. Estimation is done by using minimum mean square error estimator.
Step 8. At last performance of two parameters are calculated i.e MSE and BER.

MSE: The mean-squared error (MSE) between two signals is
MSE=$(new\ data - old\ data)^2/length\ of\ data.$

BER: Total number of errors during transmission of data

V. SIMULATION RESULTS AND DISCUSSION

The simulation results for the performance of OFDM for QAM, using MATLAB. Various used parameters are: 96 bit of data is taken on which QAM modulation is done which is shown in figure 5.whuch is then passed to serial to parallel converter and is shown in figure 6 This parallel signal is modified by inserting pilot tone into the sequence which is represented in figure 7 Further one cyclic prefix guard interval is taken, Additive White Gaussian noise model is taken which is shown in table 1.Further for classification random data division is taken, and for training levenberg marquardt algorithm is chosen (figure 8) and the performance is measured in mean square error. For the results 50 iterations were chosen from which 3 to 4 epochs were converged.

TABLE 1SIMULATION TABLE

Parameters	**Values**
Data	96 bits
Type of Modulation	QAM
Guard Type	Cyclic prefix
Guard interval	One
Noise Model	AWGN

Optimization technique	BFO
Classification Method	FFBPNN
No. of iterations	50
Data division	random
Training Algorithm	Levenberg Marquardt

After the execution, two parameters MSE and BER with respect to SNR (which is taken in decibels are 0, 5,10,15,20) are calculated which are shown in figure 10 and 11. These results are compared with the GA-BP [17] and shown in table 2.

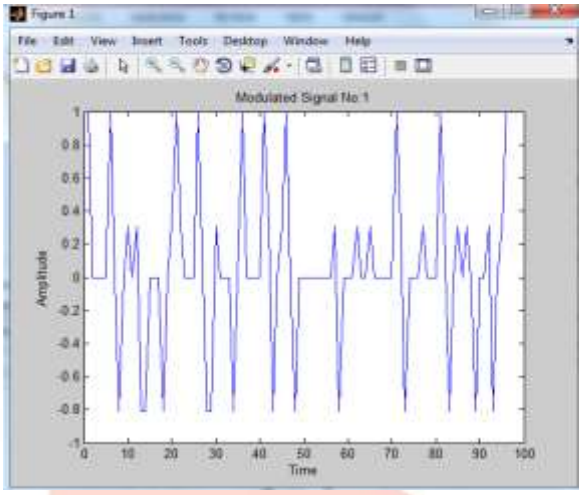

Figure 5 Modulated signal

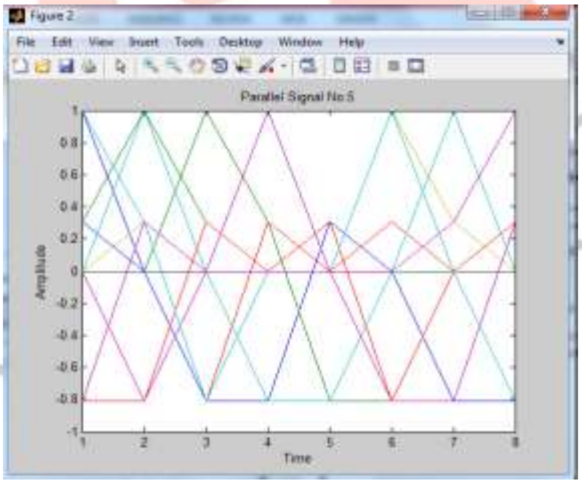

Figure 6 Modulated signal after parallelization

Figure 7 shows a graph of parallel signals in which the signal is transferred simultaneously at a time period of eight seconds.

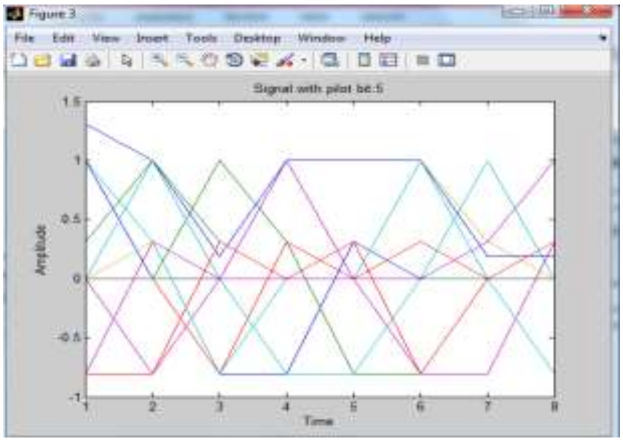

Figure 7 Modulated Signal with Pilot tone insertion

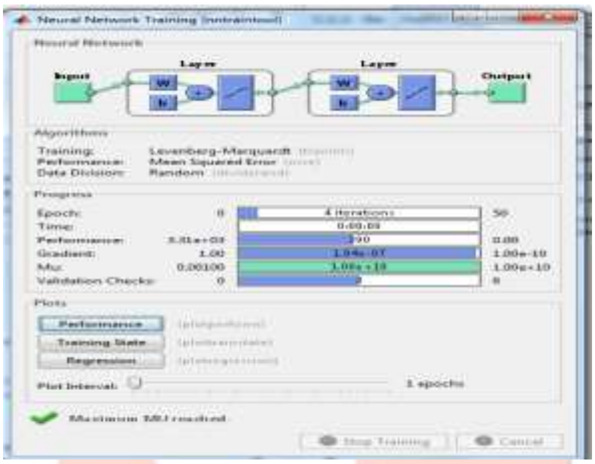

Figure 8 Convergence performance of modulated signal

The proposed system uses artificial neural network (ANN) with pilot symbols and data symbols for each of the data signal in channel. This system uses random data divisions, levenberg marquardt training, the number of maximum epochs are taken 50 and 6 validation checks. The best validation performance is found to be 430.7021 at epoch out of 3 epochs.

TABLE 2 Comparison of BER between proposed and GA-BP

Proposed Work		GA-BP [17]	
SNR	MSE	SNR	MSE
0	0.0023	5	0.4955
5	0.0027	10	0.2500
10	0.0063	15	0.1563
15	0.0083	20	0.0446
20	0.0098	25	0.0045

TABLE 3 Comparison of MSE between proposed and GA-BP

Proposed Work		GA-BP [17]	
SNR	BER	SNR	BER
0	0.1310	5	0.2455
5	0.0557	10	0.0759
10	0.0199	15	0.0357
15	0.0065	20	0.0089
20	0.0020	25	0.0045

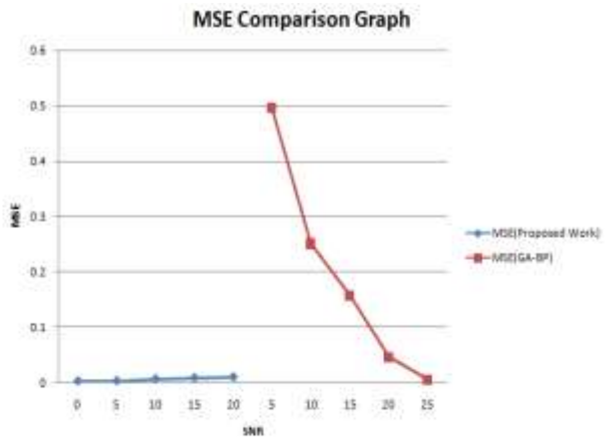

Figure 9 MSE verses SNR

Figure 9 shows the MSE for proposed work and GA-BP. From the graph it has been clearly seen that MSE is better for proposed work than compared work.its values has been shown in table 2. As after multiple iterations, the input data gradually becomes the target output via learning.

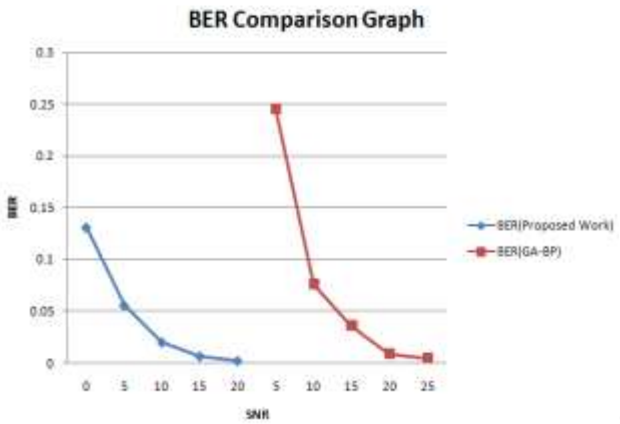

Figure 10 BER verses SNR

Figure 10 shows a graph that details the BER. From the graph it has been shown that obtained BER is .0020 for 20db SNR in case of proposed work and .0089 for GA-BP.The bit error rate is low for estimated channel.

VI. Conclusion

The proposed work showed the channel estimation based on pilot based arrangement. Channel estimation is the main area of focus in OFDM system This work has used MMSE algorithm to optimise the channel estimation. From the results of this work it has been concluded that BER and MSE value for QAM is better than normal OFDM system. The results demonstrate that the proposed approach is superior and provided good convergence rate. The proposed BFO and Feed forward backpropagation neural network achieved convergence within 3 to 4 iterations,compared to the 50 iterations.The current research work opens a lot of research areas for the future research workers . The future research workers can use a combination of ATST(advanced television system committe tuner) encoding technique with other encoding technique for the future betterment. In addition to that any other channel like Rayleigh channel can be sued for transmission.

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