ABSTRACT

In this paper Artificial Neural Network (ANN) is used for channel estimation in MIMO OFDM systems over AWGN fading channels. Neural Network is trained on the basis of pilots over the different layers using back propagation algorithm.

In OFDM system, pilots are used here in order to estimate the channel. Pattern of pilots must be able to match the channel behavior both in time and frequency domains. In this arrangement, the performance of the channel estimation is done through estimators based on obtaining weights and biases of ANN are carried out through MATLAB Simulation and coding. The performance of OFDM is evaluated on the basis of Bit Error Rate (BER). This technique is useful in achieving different parameters the high data rate, transmission capability with high bandwidth, efficiency and its compatibility to noise.

Keywords – MIMO OFDM, Back Propagation algorithm in Artificial Neural Network, Channel Estimators, pilots, data symbols, bit error rate, signal to noise ratio, Channel Impulse response.

I. INTRODUCTION

The communication systems have targets like to provide services that include video, voice and data with high speed and reliability. In the present era of high speed communication networks, Orthogonal Frequency Division Multiplexing (OFDM) has been introduced as key technologies for signal propagation and modulation techniques. This paper focused on multi-user access method, Orthogonal Frequency Division Multiple-Access (OFDMA). OFDM form of multicarrier modulation, it has recently been used widely in wireless communication systems due to its robustness to frequency selective fading, inter symbol interference (ISI) and high data rate transmission capability with high bandwidth efficiency. The transmitted signal is spread when it is transmitted through mobile radio channel. Bit Error Rate (BER) is reduced if time and frequency dispersive characteristics of channel are known the original bits can be recovered correctly. Multiple input multiple output (MIMO) communication system is itself as a technology can obtain high data rates by taking advantage of multipath signals. Both technologies (MIMO & OFDM) give number of advantages. combination of both systems can obtain next-generation (4th generation) of fixed and mobile wireless systems. Wireless channels are multipath fading channels, which causes ISI (inter symbol interference). For each path in wireless communication channel an independent path gain (or loss), independent path delay, and independent path phase shift will be there. The receiver must be provided with the channel estimator which contain the knowledge of CIR (Channel impulse response). For the channel estimation the sequence of bits must be unique for each transmitter. MIMO is multiple input and multiple output system which uses multiple transmit and receive antennas communicating in same frequency band which increases the capacity linearly of signals with the number minimum of transmit and receive antennas. An efficient MIMO-OFDM system is very much complex. OFDM uses a very large bandwidth in order to provide the diversity on the subcarrier. The result of this is the carriers being lost in the noise [1]. In order to improve performance of OFDM system under frequency selective channels; the channel estimation is necessary before demodulation of OFDM signals [2]. The channel estimation is a process of characterizing the effect of the transmission medium on the input signal.

In OFDM system there are several techniques for channel estimation [2-14]. Among these techniques; the Block Type Pilot based channel estimation technique is more popular. The Block type Pilot based
estimation techniques can use Least-Square (LS) method. The LS estimators have low complexity. In this paper, we used an artificial neural network (ANN) based on channel estimation technique which can be a substitute to Block type pilot based channel estimation technique for OFDM systems over AWGN fading channels. The Simulation results show that ANN based on channel estimator gives better results than without estimation of channels for OFDM systems over the AWGN fading channel.

II. FEED FORWARD ANN

An interconnected group of artificial neurons forms Artificial Neural Network (ANN). They uses a mathematical or computational model for information processing. In Feed Forward ANN is basically multilayer perceptron in which a network is divided into input layer, hidden layers and output layer. Each neurons have weight and biases. For feed forward as the structure is parallel, the input/output relationship is given by the equation as:

\[ Y = \Phi(WX+b) \]

where X is a N by 1 vector of inputs, W is an M by N vector of weights, b is an M by 1 vector of biases, and Y is the M by 1 vector of outputs. The operator \( \Phi(o) \) is the element-by-element activation function for each neuron. The architecture for Feed Forward ANN is as given below:

\[ \sum \]

\[ f \]

\[ \hat{y} \]

(Input layer) (Hidden layer) (Output layer)

Fig 1 – Architecture of Feed Forward ANN

In this paper we used neural network with 4 inputs in first layer and 3 hidden layers of neurons and 2 outputs in output layer.

The Normal ANN used usually uses Back propagation algorithm in feed forward networks as learning algorithm to update weights and biases of the network when inputs are applied to the network. The Back propagation has a tendency to stick at local minima or maxima. The training of neurons is done at the hidden layers by performing number of iterations. Also the performance evaluated for the system under consideration show delayed convergence.

III. System Diagram

A. System with Channel Estimation using ANN

The proposed system uses ANN with 4 pilots symbols and 48 data symbols for each of the data signal in two different channels. The pilots given as input to ANN were separated into real and imaginary part. The total inputs to ANN were 8 (4 real and 4 imaginary). The outputs of the ANN were again 8 (4 real and 4 imaginary). Single hidden layer was used with 14 Neurons containing 4 in first layer, 6 in second layer and 4 in third layer. The number of maximum iterations was 5000. The pilots were taken in the range \([0 \; 1]\). For training of the ANN these pilots with \(1e-03/48\) imaginary part were simulated for signal to noise ratio from 0 dB to 15 dB. The pilots received as an output were then stored and given as input to ANN separated into real and imaginary part.
The model used for training data symbols is shown below,

![Simulink model used for data pilots for training ANN](image1.png)

Figure 3 – Simulink model used for data pilots for training ANN

The system parameters used were,

Table 1 – System parameters

<table>
<thead>
<tr>
<th>Modulation</th>
<th>BPSK</th>
</tr>
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<tbody>
<tr>
<td>OFDM</td>
<td>64</td>
</tr>
<tr>
<td>Pilots</td>
<td>4</td>
</tr>
<tr>
<td>Data Symbols</td>
<td>48 (for each channel)</td>
</tr>
<tr>
<td>Code rate</td>
<td>¾</td>
</tr>
<tr>
<td>Frame Period</td>
<td>4e-04</td>
</tr>
<tr>
<td>Channel</td>
<td>AWGN</td>
</tr>
</tbody>
</table>

The total pilots transmitted were – 09.
[0 0.125 0.250 0.375 0.50 0.625 0.750 0.875 1].

Each pilot was simulated over SNR = 0 to 15 that is 16 times and the total period over which the system was simulated was 4e-04 that is for every pilot number of target pilots received was 5. The total combination for pilots used in 4 places was 24.

The System for channel Estimation using ANN

The figure 3 shows the actual model for 802.11a WLAN system using the ANN block to channel estimation. The ANN used in the system was trained online using MATLAB coding. The pilots transmitted were used as Targets and the received pilots were used as the inputs to the ANN. The ANN used has 3 layers excluding inputs and outputs [4 6 4].

![Total System showing ANN block for Channel Estimate and two data signals](image2.png)

Figure 4 – Total System showing ANN block for Channel Estimate and two data signals.

The main problem was to estimate the data symbols. After OFDM demodulation the pilots were grounded. The ANN was trained for 4+4=8 inputs (4 real and 4 imaginary). The training was done in such a manner that all 24 combinations for 4 pilots were considered and the system was simulated.

The 48 data symbols were broken into group of four and 12 such block of ANN were utilized for estimation of the data symbols. After estimation all the real and imaginary part was again combined and vertically concatenated to form 48 symbols and then fed to the receiver part of the system. The results were taken as comparison of two channels that is estimation of one channel and the another is without estimation of channel. The better results were obtained for the estimated channels. The results are shown in graph obtained after simulation through MATLAB.

RESULTS:

The graph shows the performance of the system with and without estimating the channel parameters. Comparative results obtained using this model. It shows that one channel without estimation and another with channel estimation.
IV. CONCLUSION

The performance of ANN for channel estimation for the OFDM based 802.11a WLAN using BPSK modulation with a code rate of ¾ was superior after channel estimation. The bit error rate is maximum for estimated channel as compared to channel without estimation.

REFERENCES


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Figure: MIMO-OFDM systems with NN based channel estimator & compensator [21]