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Title : Design and Development of Equalizer For Time Varying Channels

ABSTRACT : Wireless Communication is widely used for providing broadband communication services. The quality of any wireless link is based on its speed, reliability and range. Wireless channels are time dispersive, can't perform well at high bit rate and experiences a delay spread, due to the multipath fading effect. Delay spreading occurs due to the merging of two consecutive pulses due to low bit duration. This is popularly known as Inter Symbol Interference (ISI). At high bit rates, this problem is so severe, that it is difficult to recover the original bits at the receiver causing Bit Error Rate (BER). Therefore, the speed of any data communication system is mainly limited due to linear and non linear distortions introduced by the band limited nature of the channel. A process known as channel equalization is widely used to combat these distortions and to recover the received symbol noise free.

The global demand for wireless communication has grown rapidly since many decades and still continues to grow. Take the example of cellular phone which is growing with a rate of 40% annually. There were about 4 million users in 1988 worldwide, 123 million in 1995, 590 million in 2001 and to date it is more than 1000 million. Especially in the growing country like India there is immense potential market for digital wireless communication. According to one survey India is likely to have 314 million mobile internet users by end of 2018.All these need fast and reliable communication networks. These problems motivated us to study and design different types of equalizers. In view of the above discussions the objective of the present work is set as follows:

- To make a comprehensive study of fading channels and their effects so that an optimum equalizer can be designed.
- To study the performance of linear and DFE equalizer on fading channels.
- To design and study the performance of ANFIS based equalizer.
- To design an equalizer based on SCGNN for OFDM system.
- To develop an equalizer based on hybrid neuro fuzzy technique for MIMO-OFDM system.

Three models of fading channels are widely used for simulating a wireless communication system namely, two ray path, Rician and Rayleigh. Rayleigh fading channel which doesn't have any line of sight (LOS) path can model more accurately the wireless communication channels in metro cities. Decision Feedback Equalizer (DFE) performs better on the first two channels but shows poor performance on Rayleigh fading channel.

As the problem of time varying channel is non linear, a non linear equalizer can perform better. Non linear equalizer based on neural networks is in use since many decades but suffers from slow convergence rate and higher computational complexity. Hence, an algorithm based on Scale Conjugate Gradient Neural Network (SCGNN) is proposed for channel equalization, in which SCGNN is used to train feed forward neural network which is less complex. The

simulation results for this channel equalizer gives improved performance in terms of bit error rate.

Another way of dealing the problem of time varying channel is by the use of Fuzzy Logic. Many equalizers based on fuzzy If-then rule have been proposed in the literature. The fuzzy logic based system handle simultaneously the linguistic knowledge and numerical data that can be effectively used in mapping input output parameters. However the system response slows down with the increase in the number of fuzzy rules. A neural network is an excellent tool for modeling nonlinear system. If we club these two, we can get the advantage of modelling capabilities of Neural Network and input output mapping capabilities of fuzzy logic. A new algorithm based on integration of neural network and fuzzy system known as Adaptive Neuro Fuzzy Inference System (ANFIS) is proposed for channel equalization. Performance analysis has been done for different structures of ANFIS based equalizer.

MIMO-OFDM is the new emerging technology widely used in wireless channel which support high data rates to fulfill the need of wireless multimedia applications. But OFDM requires channel estimation and equalization. The previously proposed ANFIS equalizer is implemented on OFDM system and the result is compare with ideal and neural network based equalizer. Result shows that ANFIS based equalizer outperform the neural network based equalizer and gives a response very close to ideal one.

A Weighted Neuro Fuzzy Hybrid (WNFH) equalizer is developed for MIMO-OFDM system. This is based on a new equalization algorithm called Evolutionary Algorithm. In this proposed algorithm, a novel pilot designing scheme was constructed by combining the neural network and fuzzy system, through a weighted average formula in score level. Detailed simulation studies were carried out on the MATLAB 2013a simulator. The performance of the proposed equalizer was investigated on Rayleigh channel. After simulation the experimental results are compare with already existing algorithm proposed by Luca Ragini et.al and the results shows that there is a significant improvement using the proposed technique.

Finally the proposed algorithms are compared with the other algorithms proposed by other researchers. the results are summarized in the table given below:

SNR dB	BER NN (16)	BER CDFRNN (180)	BER VDFGA (181)	BER WNFH	BER ANFIS
5	0.3	0.25	0.2	0.1	0.08
10	0.15	0.095	0.09	0.06	0.02
15	0.05	0.07	0.04	0.02	0.007
20	0.01	0.06	0.017	0.008	0.002
25	0.009	0.05	0.012	0.002	0.0008

It is clear from the table that two of our proposed algorithms WNFH based equalizer and ANFIS based equalizer gives better performance when compared with the algorithm proposed by Luca Rugini et al (16), H.Q.Zhao et al [180] and Hosine Marabati et al (181). The Zhao trained the network by conventional method whereas Hosine used Genetic algorithm and in our algorithm we used GSO. All these three are based on neural network but GSO trained networks perform better.