ABSTRACT

The fundamental function of adaptive channel equalization is to compensate, eliminate or minimize distortion in a communication channel between a transmitter and a receiver. In this thesis, a Nonlinear Neuro Fuzzy Equalizer (NNFE) is proposed for the equalization of Quadrature Amplitude Modulation (QAM) signals in communication channels by improving the quality of complex signal transmission which eventually leads to more efficient communication. The presence of noise, intersymbol interference (ISI) and the time-varying characteristics of the communication channel necessitate the use of adaptive equalizers. A fuzzy adaptive filter is constructed from a set of fuzzy If-Then rules that change adaptively to minimize some criterion functions as new information becomes available. The fuzzy adaptive filter with the combination of neural networks is a significant type of adaptive equalizer which allows short training time of the equalizer, yields better results in terms of bit error rate (BER) and convergence rate with its efficient structure and design algorithms. The use of neuro-fuzzy equalizer in digital signal transmission allows decreasing the training time of the equalizer's parameters and decreasing the complexity of the network. Normalization method applied at the transmitter side of the communications system is utilized and nonlinear neuro-fuzzy equalizer (NNFE) is employed for the equalization of QAM signals.

The purpose of this thesis is to successfully equalize QAM signals that are distorted by noise and channel conditions when transmitted through a communications channel before being received by an equalizer at the end of the system. It's possible to reach fast and accurate equalizer output results with the aid of normalization technique in relatively small number of iterations. Convergence rate and BER performance comparisons have been carried out for 4-QAM and 16-QAM signals. The simulation results have revealed that the proposed nonlinear neuro-fuzzy equalizer (NNFE) can successfully minimize the errors and equalize both linear and nonlinear channels in addition to providing better convergence rate and improved BER performance for linear channel in severely noisy channel conditions.

Key words: Equalization, Quadrature Amplitude Modulation (QAM), bit error rate, nonlinear neuro-fuzzy equalizer, communications system, normalization.

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ABBREVIATIONS USED

AM	Amplitude Modulation
ANFIS	Adaptive Neuro-Fuzzy Inference System
ANN	Artificial Neural Network
AWGN	Additive White Gaussian Noise
BCH	Bose-Chaudhuri-Hocquenghem
BER	Bit Error Rate (Probability of Bit Error)
CMA	Constant Modulus Algorithm
COA	Center of Average
COG	Center of Gravity
CPU	Central Processing Unit
DCS	Digital Communications System
DFE	Decision Feedback Equalizer
DSB	Double Sideband
DSP	Digital Signal Processing
DVB	Digital Video Broadcasting
FBF	Feedback Filter
FFF	Feedforward Filter
FFNN	Feedforward Neural Network
FIR	Finite Impulse Response
FIS	Fuzzy Inference System
IMD	Intermodulation Distortion
ISDN	Integrated Services Digital Network
ISI	Intersymbol Interference
LMS	Least Mean Square
LTE	Linear Transversal Equalizer
MISO	Multi-Input Single Output
MLP	Multilayer Perceptron
MLSD	Maximum Likelihood Symbol Detection
MLSE	Maximum Likelihood Sequence Estimator
MMA	Multimodulus Algorithm
MMSE	Minimum Mean Square Error
MSE	Mean Square Error
MQAM	*M*-ary Quadrature Amplitude Modulation
NF	Nonlinear Function
NN	Neural Network
NNFE	Nonlinear Neuro-Fuzzy Equalizer
NNFN	Nonlinear Neuro-Fuzzy Network
NTSC	National Television Standards Committee (USA)
PSD	Power Spectral Density
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation

PAL	Phase Alternate Line (TV)
PAM	Pulse Amplitude Modulation
RBF	Radial Basis Function
RLS	Recursive Least Squares
RNN	Recurrent Neural Network
SISO	Single Input Single Output
SNR	Signal-to-Noise Ratio
TDMA	Time Division Multiple Access
TSK	Takagi-Sugeno-Kang
TV	Television

DECLARATION OF ORIGINALITY & CONTRIBUTION

The originality and contribution of the thesis include the followings:

- *Development of a Normalizer-based nonlinear neuro-fuzzy equalizer for the channel equalization of multilevel Quadrature Amplitude Modulation (QAM) signals ,*

- *The construction of the mathematical model of the neuro-fuzzy equalizer based on gradient-descent algorithm,*

- *Simulation, analysis and comparison of the results of the Normalizer-based equalizer for QAM signaling by using MATLAB programming language,*

The routine used to carry out literature research is an exception.

CHANNEL EQUALIZATION OF QUADRATURE AMPLITUDE MODULATION (QAM) SIGNALS USING A NEURO-FUZZY EQUALIZER

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