Bayesian Equalizers literature Survey with Analytical comparison

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***Abstract*—Data transmissions rate is influenced communication system due to linear and non-linear distortion. Linear distortions occur in form of inter-symbol interference (ISI), co-channel interference (CCI) in the presence of additive white Gaussian noise. Amplifiers, modulator and demodulator subsystems are caused for Non-linear distortions along with nature of the medium. Different techniques are used to equalized and mitigate these effects.**

***Keywords*-Co-channel interference, Intersymbol interference, Bayesian equalizers, adaptive filters, fuzzy logic system.**

I. Introduction and Background

The demand for cellular mobile communication for users is to reduce cell size, increasing frequency reuse. With this rise in interference from the users of one cell to the users in another cell using the same frequency is called CCI. Also when the data transmitted through the channel in which each received pulse is affected somewhat by adjacent pulses. This is called Intersymbol interference (ISI). Intelligent allocation and reuse of channels throughout a coverage region in a cellular mobile communication system. The reuse of channel means reuse of frequency. In a given coverage area there are many cells that use the same set of frequencies. These cells are called co-channel cells, and the interference between signals from these cells is called CCI (co-channel interference).

An adaptive radial basis function (RBF) network is used to overcome CCI. After that an adaptive fractionally spaced decision feedback equalizer (DFE) is used to eliminate CCI in a multipath fading environment. A Bayesian DFE was used for CCI. Recently a fuzzy adaptive filter (FAF) type-1 is used to eliminate CCI.

Bayesian decision rule is based on a probability model whereas the fuzzy adaptive filter (FAF) based approach is model free. In model based statistical signal processing results will be good if the data according with the model, but may not be good if the data not according the model used.

Fuzzy sets allow us to handle linguistic uncertainties, as typified by the adage "words can mean different things to different people." Karnik and Mendel established a complete Type-2 fuzzy logic systems theory to handle linguistic and numerical uncertainties, Liang and Mendel proposed a type-2 FAF and applied it to time-varying channel equalization.

The equalizer present in the receiver should be capable of compensating ISI and CCI effects with limited computational complexity. We interpret in this paper that CCI as an uncertain disturbance added to the channel states. Theoretical analysis shows that the interpretation matched the reason of existence.

II. Literature Review

[2.1]. S. K. Patra and B. Mulgrew, "Fuzzy implementation of Bayesian equalizer in the presence of intersymbol and co-channel interference," *Proc. Inst. Elect. Eng.*, vol. 145, pp. 323–330, 1998.

In this paper the authors investigate the problem of channel equalization in the presence of co-channel interference (CCI), inter-symbol interference and additive white Gaussian noise.

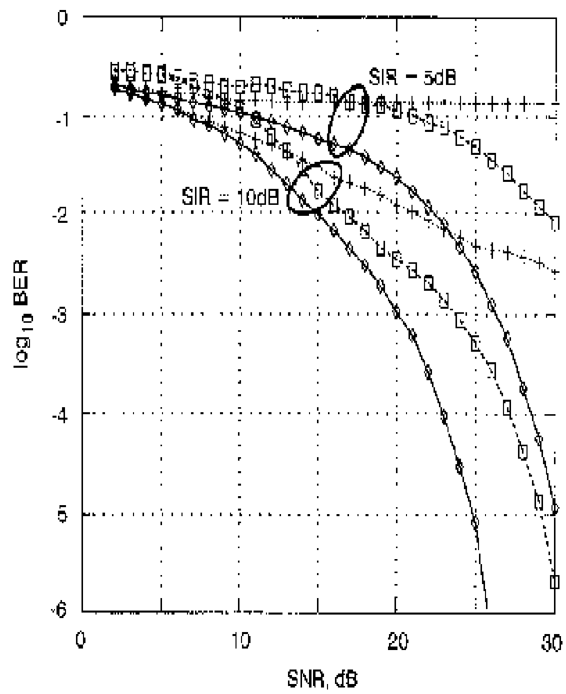

Fig: 1 BER performance for different equalizers under SIR=5, 10DB with channel, co-channel and with estimated channel and co-channel states ref [1].

Conclusion of this paper is the implementation of a new elegant fuzzy CCI_DFE which performs close to the optimal Bayesian CCI_DFE with reduction of computational complexity that fuzzy system is called type-1 fuzzy system.

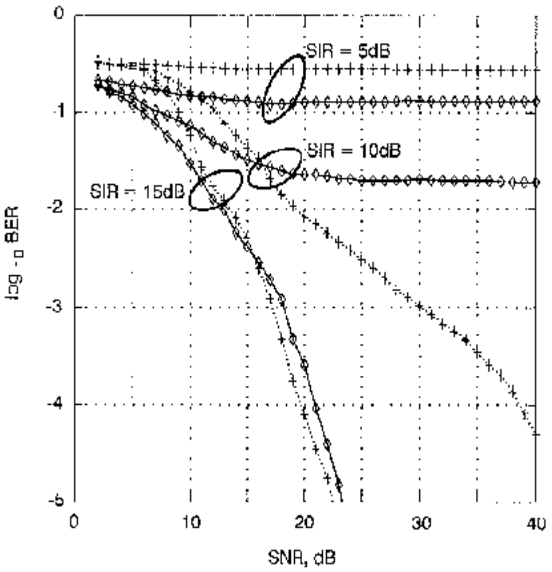

Fig: fuzzy CCI, DFE, BER performance with two co-channels. CCI=5, 10, 15dB with channel and co-channel.

[2.2]. Rahib H.Abiyev, Tayseer Al-shanableh, 'Neuro-Fuzzy Network for Adaptive Channel Equalization' IEEE MICAI'2006, $20.

In this paper authors presents the equalization of channel distortion by using neuro-fuzzy network. The structure and learning algorithm of neuro-fuzzy network have been described.

Conclusion of this paper is Classic equalizers do not performs well for time-varying channels. In the paper using recurrent neuro-fuzzy network structure the development of adaptive equalizer is carried out.

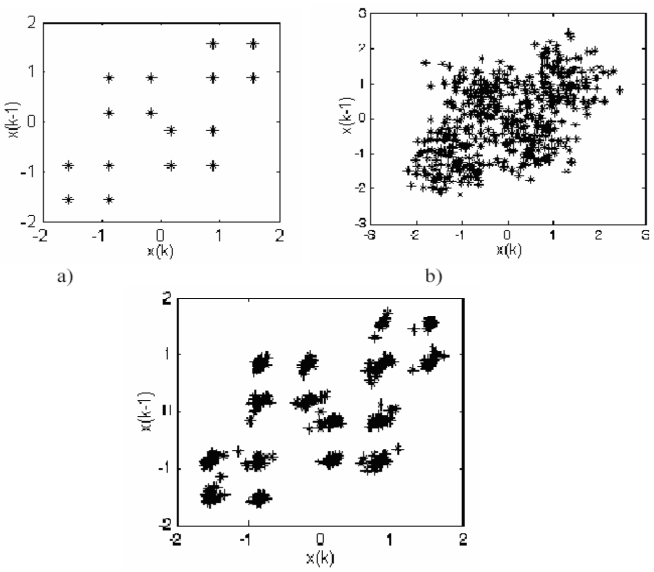

Fig: Channel states: a) noise free, b) with noise, c) after equalization

[2.3]. Amit Agarwal, S.N. Sur, R. Bera, 'Linear Vs Non-Linear Equalizer in Different Channel Condition', IJATER E-ICETT 2014, ISSN No: 2250-3536

In this paper authors present performance analysis of different equalization techniques such as minimum mean squared error (MMSE), Least Mean Square (LMS), Recursive Least Square (RLS), linear equalizers and MMSE-Decision Feedback equalizer (DFE), LMS-DFE, RLS-DFE non-linear equalizers in different channel conditions, in order to achieve optimal equalizer.

Conclusion of this paper deals with the details performance analysis of Non-linear equalizer and linear equalizer in different channel condition. Simulation result shows that the non-linear equalizer is better than linear equalizer in different channel condition.

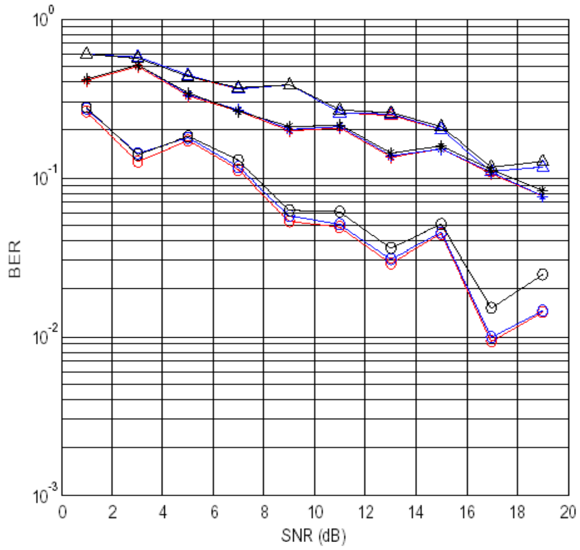

Fig: Linear equalizers in different channel condition.

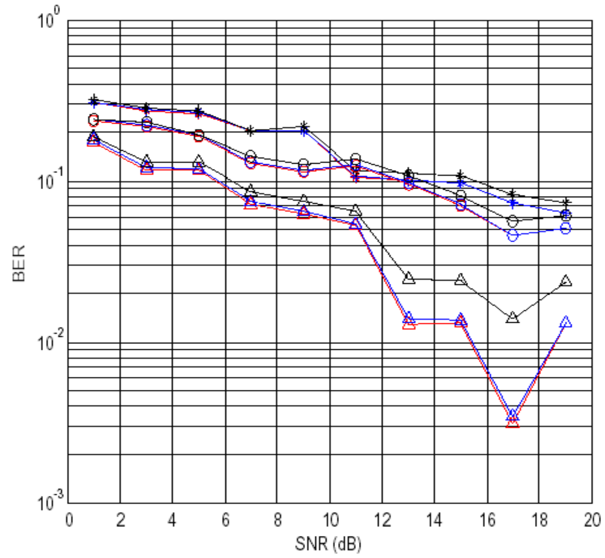

Fig: Non-Linear equalizers in different channel condition.

[2.4]. Qilian Liang and Jerry M. Mendel, Fellow IEEE, 'Overcoming Time-Varying Co-Channel Interference Using Type-2 Fuzzy Adaptive Filters', 2000, 1057-7130/00$10.00.

In this paper presents method for overcoming time-varying co-channel interference (CCI) using type-2 fuzzy adaptive filters (FAF).
Conclusion of this paper is applied type-2 FAF to eliminate co-channel interference in non-linear and time-varying channels. TE (transversal equalizer and DFE (decision feedback equalizer) structures were implemented for overcoming co-channel interferences.

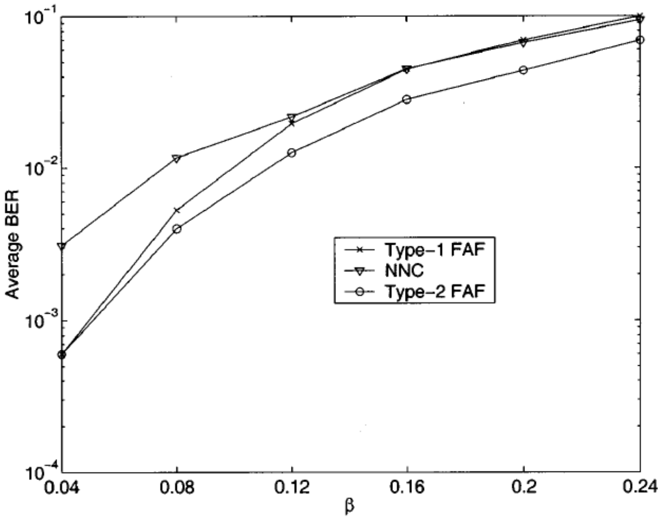

Fig: a) Average BER versus β when SIR=20dB

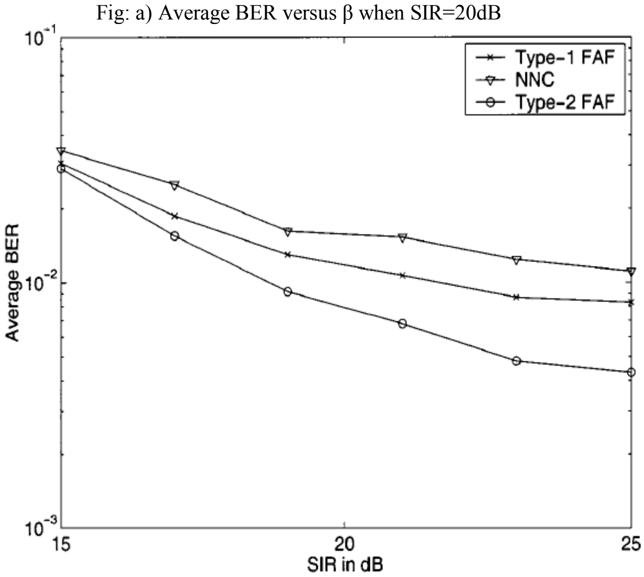

Fig: b) Average BER versus SIR when β=0.1

Fig: Average BER of type-1 FAF,NNC and type-2 FAF for 100MC realizations when SNR=25dB and the number of training prototypes is 289.

[5]. Luis Salamanca, Juan Jose Murillo-Fuentes, Fernando Perez Cruz, ‘Channel Decoding with Bayesian Equalizer’, arXiv: 1006.0795vl [cs.IT] 4 Jun 2010.

In this paper authors proposed a Bayesian equalizer that takes into consideration not only the uncertainty due to the noise in the channel, but also the uncertainty in the CSI (channel estate information) estimate, reducing the BER (bit error rate) after the LDPC (low density parity check) decoder.

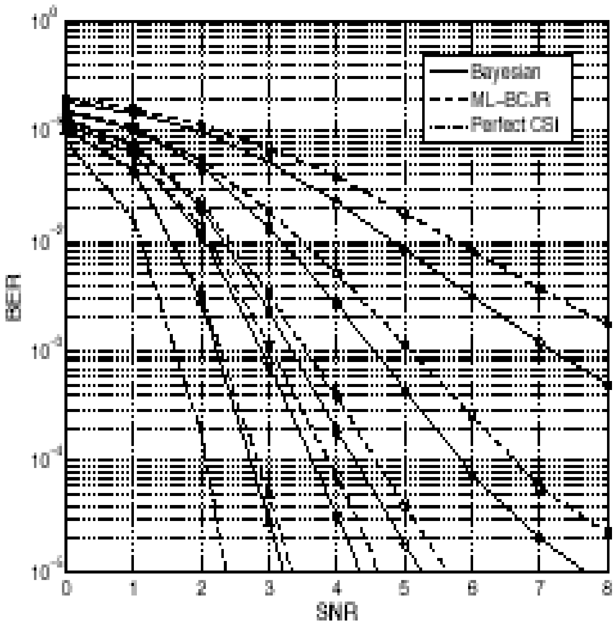

Fig: BER performance for Bayesian equalizer (solid lines) and ML BCJR (dashed line) after the decoder, for a channel with 6 taps and different lengths of the training sequence, n=15(o), n=25(), n=40(¤), n=50() and n=90(Δ). Dash-dotted line illustrates performance assuming perfect CSI.

III. Experimental Setup

A. *Features of Equalization*

Intersymbol interference is a form of distortion that causes symbols to overlap in Time-dispersive channels and become in distinguish by the receiver.

For example, in a multipath scattering environment, the receiver sees delayed versions of a symbol transmission, which can interfere with other symbol transmissions. An equalizer attempts to mitigate ISI and improve receiver performance.

B. *Linear equalizers is divided into categories:*

- Symbol-spaced equalizers
- Fractionally spaced equalizers (FSEs)
- Decision-feedback equalizers (DFEs)
- MLSE (Maximum Likelihood Sequence Estimation) equalizers that uses the Viterbi algorithm.

Linear and decision-feedback equalizers are adaptive equalizers that use an adaptive algorithm when operating.

For each of the adaptive equalizer classes listed above, this toolbox supports these adaptive algorithms:

- Least mean square (LMS)
- PiSigned LMS, including these types: sign LMS, signed regressor LMS, and sign-sign LMS
- Normalized LMS
- Variable-step-size LMS
- Recursive least squares (RLS)

In all cases, you specify information about the equalizer structure (such as the number of taps), the adaptive algorithm (such as the step size), and the signal constellation used by the modulator in your model. You also specify an initial set of weights for the taps of the equalizer; the block adaptively updates the weights throughout the simulation. For adaptive algorithms, the equalizer can adapt the weights in two modes: training mode and decision-directed mode.

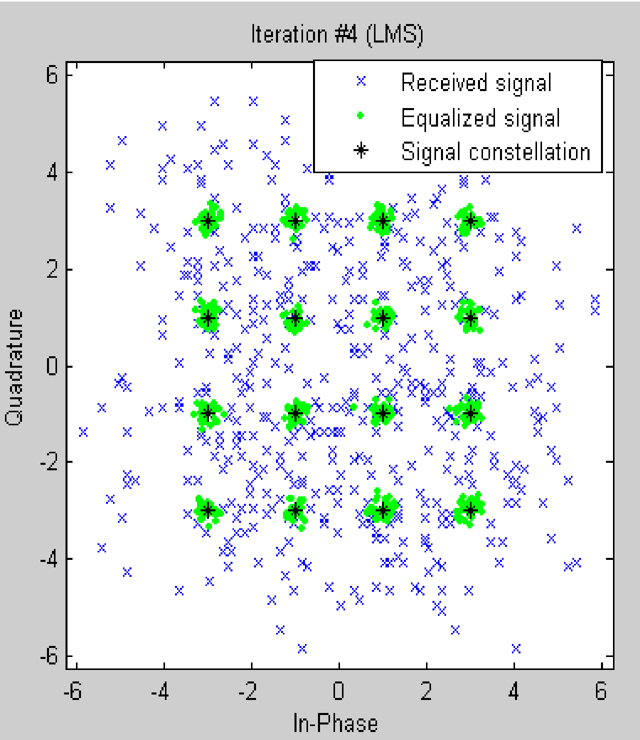

Fig: Plot equalized signal

Minimum Phase Channel: $1+0.5Z^{-1}$
Structure Network: 2-input nodes, 8-centre nodes and 1-Output nodes.
No. of training samples: 100
No. of testing samples: 100000
SNR in dB: 30

IV. Discussions

The key objective of the review paper is to develop novel artificial neural network equalizer (trained with linear, nonlinear) to reduce the linear and nonlinear distortion like ISI, CCI and burst noise interferences occurs in the communication channel and can provide minimum mean square error and bit-error-rate plot for extensive assortment of channel condition.

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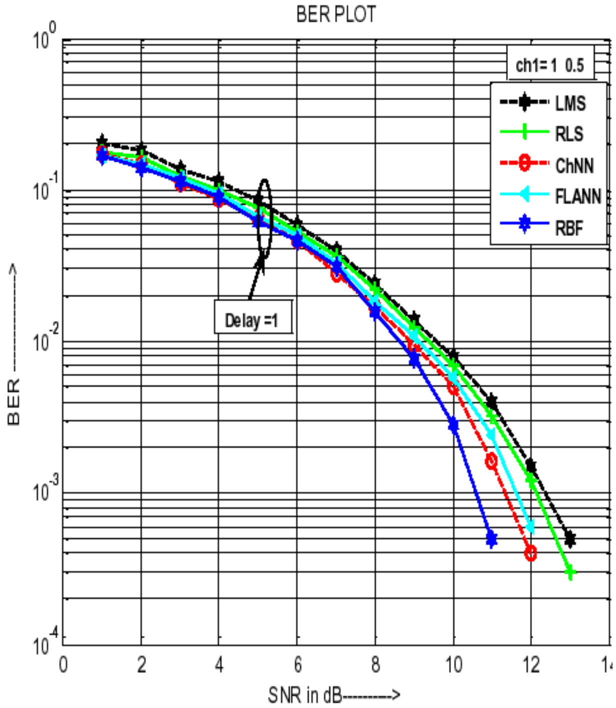

Fig: BER performance RBF equalizer compared chNN, FLANN, LMS, RLS equalizer for channel delay=1.

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