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Data Aided SNR Estimation for High Level Modulation Schemes in OFDM Systems

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Abstract:

Estimation of signal to noise ratio for the received signal is an important task in communication systems. The performance of existing non-data-aided (NDA) SNR estimation methods are substantially degraded for high level modulation scheme such as M-ary amplitude and phase shift keying (APSK) or quadrature amplitude modulation (QAM). In this paper, a novel approach for such estimation that uses zero point auto-correlation of received signal per block and auto cross-correlation of decision feedback signal in orthogonal frequency division multiplexing (OFDM) system. The performance of the method is verified qualitatively and they show a stable performance when compared with earlier methods when applied under higher modulation schemes.

I.INTRODUCTION:

Knowledge of the signal-to-noise ratio (SNR) is a requirement in many communication systems in order to perform efficient signal detection and/or link adaptation. A number of non-data-aided (NDA) SNR estimators, have been proposed for constant modulus (CM) constellations. Most of them, however, cannot be applied to non-CM constellations. Decision directed (DD) can be used by substituting the true transmitted symbols by the outputs of the decoder. Maximum likelihood estimator is one of DA estimator, and squared signal-to-noise variance (SNV), Although ML estimators provide good statistical performance, and they tend to be computationally intensive. Under a different classification, I/Q-based estimators make use of both the in-phase and quadrature components of the received signal, and thus require coherent detection; in contrast, envelope based (EVB) estimators only make use of the received signal magnitude, and thus can be applied even if the carrier phase has not been completely acquired.

The more signal has high modulation level, therefore, the more SNR estimation is difficult when we compare simple modulation signal such as binary phase shift keying (BPSK) with M-ary amplitude and phase shift keying quadrature amplitude modulation (QAM) modulation signal.Even if SNR estimation algorithm could apply efficiently to BPSK signal, there is much difficulty just as it is about high dimensional signal. There for a new estimator is required, for this a novel method is proposed in this paper.

II CORRELATION BASED SNR ESTIMATION:

Let the received signal be

$$y(n) = x(n) + w(n) \qquad (1)$$

Where x (n) is the original transmitted and w(n) be the Gaussian noise with zero mean and uncorrelated with the signal. The auto correlation of the measured data is given as

$$r_y(k,l) = r_x(k,l) + r_w(k,l) \qquad (2)$$

Let m=k-l then the above equation can be transformed as

$$r_y(m) = r_x(m) + r_w(m) \qquad (3)$$

Since the white Gaussian noise is a zeros mean which is un correlated resulting to

$$r_w(m) = \sigma^2 \zeta(m) \qquad (4)$$

Where σ^2 is the variance of the noise then the SNR of the received signal can be defined as

$$\rho = \frac{E[x(n)]^2}{\sigma^2} \qquad (5)$$

Let us consider that we transmitted symbols like {-a,a} with equal probability in to random/fading channel auto correlation value of transmitted and received signals are as follows

$$r_x(0) = E[x(n)x(n)^*] = 2a^2 = S \qquad (6)$$

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$$r_y(0) = E[y(n)y(n)^*] = S + N \qquad (7)$$

There for SNR based on auto correlation is given as

$$\hat{\rho} = \frac{S}{N} = \frac{r_x(0)}{r_y(0) - r_x(0)} \qquad (8)$$

Type II SNR estimation method estimates SNR using zero point correlation relation of received signal based on fourth moment with square of zero point auto/cross-correlation of transmit and receive signal. Zero point auto-/cross correlation are given as

$$r_x^2(0) = E[x(n)x^*(n)]^2 = S^2 \qquad (9)$$
$$r_y^2(0) = E[y(n)y^*(n)]^2 = (S + N)^2 \qquad (10)$$
$$r_{xy}^2(0) = E[x(n)y^*(n)]^2 = S(S + N) \qquad (11)$$

III SNR ESTIMATION IN OFDM SYSTEMS:

Data input into mapping block and modulate to complex data symbol such as QPSK or QAM. And, then, serial data stream converts to parallel data and this parallel data pass IFFT (inverse fast Fourier transform). Then, transmit signal of general OFDM (orthogonal frequency division multiplexing) is given by

$$x(t) = \sum_{k=0}^{K-1} X_k * e^{2\pi f_k t} = \sum_{k=0}^{K-1} X_k . e^{\frac{2\pi}{KT_s}kt} \qquad (13)$$

Where K is total sub-carrier number, Ts is symbol duration, frequency of sub-carrier is f_k=k/KTs, and t is n•Ts (n=0,…, K-1). Also, Xk is data symbol at k-th sub-carrier. To simplify analysis of system, communication channel assume to AWGN.

$$r(n) = x(n) \otimes h(n) + w(n) \qquad (14)$$

Considering AWGN channel to analyze mathematically, channel response h(n) equals to 1 and phase synchronization supposes to be perfect. After removing cyclic prefix, after FFT, the recovered output for the k-th subcarrier is as follows

$$Y_k = \frac{1}{\sqrt{K}} \sum_{n=K} r[n] . e^{-j\frac{2\pi}{K}kn} = X_k + N_k \qquad (15)$$

SNR estimation method of this paper requires zero point auto-correlation of transmitted and received signal in OFDM system. In this paper, we can calculate autocorrelation value of transmit signal using decision feedback signal. In OFDM system, auto-correlation of transmit signal with QPSK and QAM constellation is calculated as follows

$$r_x(0) = r_{x'}(0) = \frac{1}{K} \sum_{k=0}^{K-1} [X_k]^2 = 2, \ \forall QPSK \qquad (16)$$

For 16QAM signal

$$r_x(0) = \frac{1}{K}\left(\sum_{n_{c1}=1}^{N_{c1}} \left|X_{n_{c1}}\right|^2 + \sum_{n_{c2}=1}^{N_{c2}} \left|X_{n_{c2}}\right|^2 + \sum_{n_{c3}=1}^{N_{c3}} \left|X_{n_{c3}}\right|^2 + \sum_{n_{c4}=1}^{N_{c4}} \left|X_{n_{c4}}\right|^2 + \cdots\right) \qquad (17)$$

In this paper, we use auto-correlation value of decision feedback signal instead of transmit signal. In case SNR estimates through separated in-phase SNR based on fourth moment can calculate as auto-cross correlation relation of transmit and receive signal, and is derived as follows.

$$\frac{r_x^2(0)}{r_y^2(0) - 2r_{xy}^2(0) + r_x^2(0)} = \frac{S^2}{S^2 + N^2 - 2S^2 + S^2} = \left[\frac{S}{N}\right]^2 \qquad (12)$$

and quadrature signal, auto-correlation value of decision feedback signal with M-QAM constellation at receiver side is as follows.

For 16QAM signal,

$$r_x(0) \sum \begin{pmatrix} corrected \\ decision \\ signal \end{pmatrix}^2 + \sum \left(\overset{error}{\pm 1 \to \pm 3}\right)^2 - \sum \left(\overset{error}{\pm 3 \to \pm 1}\right)^2 \qquad (18)$$

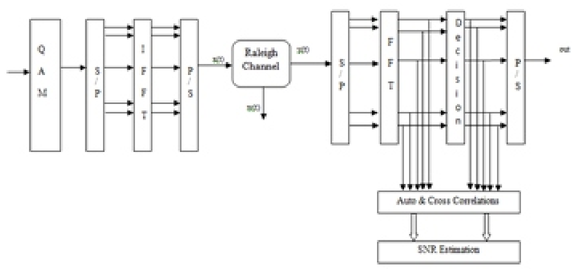

Fig1. Block diagram of Proposed Correlation based SNR Estimation

SNR estimation method Type 1 and Type 2 based on auto-correlation of decision feedback signal can be organized as follows.

$$\bar{\rho} = \frac{S}{N} = \frac{r_x(0) + \Delta r_x(0)}{r_y(0) - \{r_x(0) + \Delta r_x(0)\}}, \text{ for Type 1} \qquad (19)$$

$$\bar{\rho} = \sqrt{\frac{\{r_x(0) + \Delta r_x(0)\}^2}{r_Y^2(0) - 2r_{XY}^2 + \{r_X(0) + \Delta r_X(0)\}^2}}, \text{ for Type 2} \qquad (20)$$

Type 2 method estimates SNR using cross-correlation of decision feedback signal. So, in this case, error symbol X' has an effect to cross-correlation value and SNR estimation performance can be changed. If SNR estimation method based on correlation relation is used, system can benefit synchronization secure or offset estimation as well as SNR estimation.

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Type 2 SNR estimation method based on cross-correlation is given by

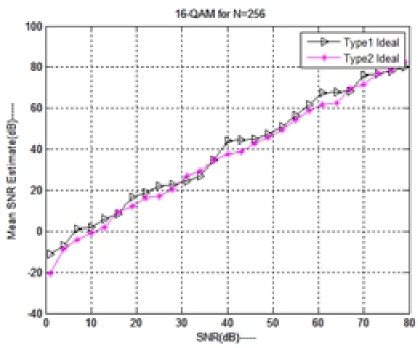
$$\tilde{\rho} = \sqrt{\frac{\{r_X(0)+\Delta r_X(0)\}^2}{r_Y^2(0)-2\{r_{XY}(0)+\Delta r_{XY}(0)\}^2+\{r_X(0)+\Delta r_X(0)\}^2}} \qquad (21)$$

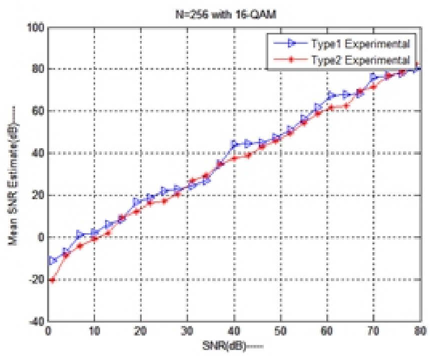
IV SIMULATION RESULTS:

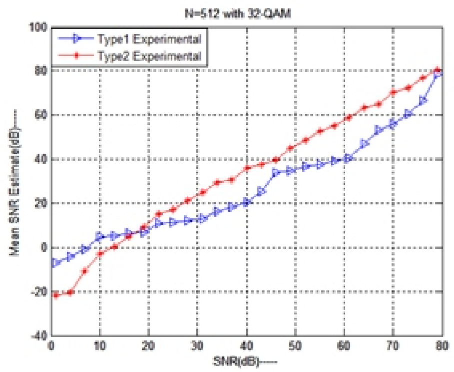
Fig. 2 shows mean SNR estimate performance of ideal and experimental value for proposed SNR estimation method in QAM-OFDM systems with M-ary and N=no. of data Points. Fig 2(a) and (b) shows that the SNR Performance of 16QAM-OFDM system with N=256.

In 16QAM or QPSK, proposed method is the same performance between ideal and experimental results because correlation relation of decision feedback signal doesn't change from transmit signal's one.

But the higher modulation level, estimation error is bigger. In Fig. 2, i.e. in case of 16QAM, proposed method shows about 0.5dB difference from ideal case because of correlation value with errors of decision feedback signal.







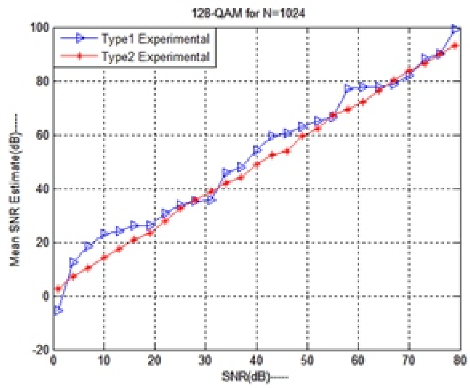


Fig2 Performance of SNR with different QAM

CONSLUSION and Future Work:

Here in this publishment we proposed a correlation relation-based approach that is amenable to practical implementation and significantly improves on previous estimators. Proposed method of this paper showed stable performance than previous SNR estimation method because this estimation method uses zero point auto-correlation of received signal per block and auto/cross- correlation of decision feedback

signal in OFDM system. Especially, Type 1 method had an estimation error under 2dB even though the signal for less than 0dB. Type 2 method has a NSER performance under 0.005 for more than 10dB SNR. Due to its simplicity and practicality, therefore, proposed method is an attractive choice, which recently proved competitive for also high level modulation techniques such as 32-QAM,64-QAM and also for 128-QAM. In future this may be extended for higher data rates with improved SNR and also we can use different types of channels to compare the SNR performance with each other.

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REFERENCES:

[1] T. A. Summers and S. G. Wilson, "SNR mismatch and online estimation in turbo decoding," IEEE Trans. Commun., vol. 46, pp. 421–423, Apr. 1998.

[2] T. S. Chung and A. J. Goldsmith, "Degrees of freedom in adaptive modulation: a unified view," IEEE Trans. Commun., vol. 49, pp. 1561– 1571, Sept. 2001.

[3] D. R. Pauluzzi and N. C. Beaulieu, "A comparison of SNR estimation techniques for the AWGN channel," IEEE Trans. Commun., vol. 48, pp. 1681–1691, Oct. 2000.

[4] P. Gao and C. Tepedelenlioglu, "SNR estimation for non constant modulus constellations," IEEE Trans. Signal Processing, vol. 53, pp. 865–870, Mar. 2005.

[5] Y. Chen and N. C. Beaulieu, "Maximum likelihood SNR estimators for digital receivers," in Proc. IEEE Pacific RIM Conf. Commun., Computers, Signal Processing, Aug. 2005, pp. 637–640.

[6] T. R. Benedict and T. T. Soong, "The joint estimation of signal and noise from the sum envelope," IEEE Trans. Inform. Theory, vol. 13, pp. 447–454, July 1967.

[7] W. Gappmair, "Cramér-Rao lower bound for non-data-aided SNR estimation of linear modulation schemes," IEEE Trans. Commun., vol. 56, pp. 689–693, May 2008.

[8] A. Papoulis, Probability, Random Variables, and Stochastic Processes. New York: McGraw-Hill, 1991.

[9] S. M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory. Upper Saddle River, NJ: Prentice-Hall, 1993.

[10] M. Abramowitz and I. A. Stegun, Handbook of Mathematical Functions. New York: Dover Publications, 1970.

[11] F. Gini, R. Reggiannini, and U. Mengali, "The modified Cramér-Rao bound in vector parameter estimation," IEEE Trans. Commun., vol. 46, pp. 52–60, Jan. 1998.

[12] M. Moeneclaey, "On the true and modified Cramér-Rao bounds for the estimation of a scalar parameter in the presence of nuisance parameters," IEEE Trans. Commun., vol. 46, pp. 1536–1544, Nov. 1998.

[13] N. S. Alagha, "Cramér-Rao bounds of SNR estimates for BPSK and QPSK modulated signals," IEEE Commun. Lett., vol. 5, pp. 10–12, Jan. 2001.

[14] L. L. Scharf, Statistical Signal Processing. Upper Saddle River, NJ: Prentice-Hall, 1990.

[15] R. López-Valcarce and C. Mosquera, "Sixth-order statistics-based non data-aided SNR estimation," IEEE Commun. Lett., vol. 11, pp. 351–353, Apr. 2007.

[16] T. K. Moon, "The expectation-maximization algorithm," IEEE Signal Processing Mag., vol. 13, pp. 47–60, Nov. 1996.

[17] A. Wiesel, J. Goldberg, and H. Messer, "Non-data-aided signal-to-noise ratio estimation," in Proc. Int. Conf. Commun., May 2002, pp. 197–201.

[18] N. Noels, V. Lottici, A. Dejonghe, H. Steendam, M. Moeneclaey, M. Luise, and L. Vandendorpe, "A theoretical framework for soft-information-based synchronization in iterative (turbo) receivers," EURASIP J. Wireless Commun. Networking, vol. 2005, no. 2, pp. 117– 129.

[19] CCITT Recommendation V.29, 9600 bit/s modem standardized for use on point-to-point 4-wire leased telephone-type circuits, 1988.

[20] EN 302 307 (V1.1.2), Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications. ETSI Standard, 2006.