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Adaptive Beamforming Scheme in Angle Diversity Receiver

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Abstract: Currently, a lot of researchers have studied adaptive beamforming which has become a trend for various wireless applications. These techniques are used as a spatial filter for receiving the desired signals coming from specific paths while suppressing unwanted interferences coming from different directions of arrival. The Least-Mean-Square (LMS) beamforming is widely used in various applications of adaptive filtering due to its simplicity and robustness. In this study, we discuss an LMS adaptive beamforming scheme for angle diversity receiver in which multipath signals are separately processed. We carry out the simulation to evaluate the performance of the scheme in terms of convergence speed.

Key words: Adaptive beamforming, LMS, angle diversity receiving, time delay estimation, multipath propagation, interference supression

INTRODUCTION

Spectral efficiency and reliability are limited by multipath fading, delay spread and co-channel interference in radio communication systems. In recent years, there are a lot of researches on angle diversity to combat the multipath fading in spatial domains. Especially, the performance of a radio communications systems can be enhanced by using smart antennas in various ways (Winters, 1998). Adaptive beamforming is one of the most important smart antenna techniques which can be widely utilized in the area of wireless communication.

The requirement of the wireless communication system is expected to get higher at an explosive rate in the near future. One of the possible solutions is to implement the adaptive beamforming system on the receiver side to satisfy the need for the future communication system (Le and Jeon, 2017). The LMS adaptive beamforming is essential to develop a high-capacity communications system due to the low computational complexity, fast convergence and stability (Al-Ardi *et al*., 2003). In the limitation of this study, we consider the microcell environment in which the signal propagates along multiple paths and has a broader angular spread. This characteristic helps to take advantage of angle diversity receiving (Cho *et al*., 2012; Paulraj and Papadias, 1997). In this study, we dicuss an LMS adaptive beamforming scheme for angle diversity receiver. We conduct a simulation to evaluate convergence speed and bit-error-rate performance (Islam *et al*., 2007).

MATERIALS AND METHODS

Adaptive beamforming scheme: In the beamforming system, the receiver gets a signal from a Uniform Linear Array (ULA) of L-elements. The received signal will be applied to an adaptive Beam Forming (BF) processor (Fig. 1). The output signal y of the BF processor is expressed as:

$$y = w^H \cdot x \tag{1}$$

Where:

x = The received signal vector
w = BF weights vector which is determined by using LMS adaptive BF algorithm

The error of the output is defined as:

$$e(k) = d(k) - w^H(k)x(k) \tag{2}$$

We use steepest descent method (Winters, 1998) to calculate BF weights vector:

$$w(k+1) = w(k) + \mu e^*(k)x(k) \tag{3}$$

where μ is the step-size parameter. In order to insure the stability of the adaptive BF system, the step-size parameter should be chosen under constraint (Winters, 1998):

$$0 \le \mu \le \frac{1}{2 \cdot \text{trace}[R]} \tag{4}$$

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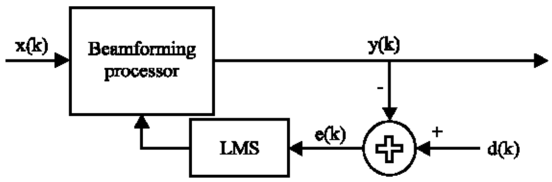

Fig. 1: An adaptive beamforming processor

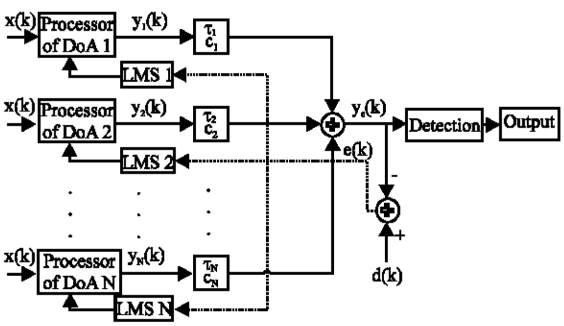

Fig. 2: LMS adaptive beamforming scheme in angle diversity receiver

with R presenting array correlation matrix:

$$R(k) = x(k)x^H(k) \quad (5)$$

Adaptive beamforming for angle diversity receiver: In angle diversity receiver, multipath signals are extracted by adaptive beamforming processors. In other words, each beamforming processor processes a signal which comes from practical direction. In this study, we discuss LMS adaptive beamforming scheme for angle diversity receiver which is illustrated in Fig. 2. Each array processor works as an LMS adaptive beamforming module. The output signals from processors are combined after adding proper time delays and combining coefficients (Cao and Pang, 2008). The main idea of our scheme is that all of the processors use the common error.

Let assume that, the desired signal propagates along N paths. The received signal at the uniform antenna array is forwarded to processors. After being processed by BF processors, the signals are combined:

$$y_c(k) = \sum_{i=1}^{N} c_i y_i(k) \quad (6)$$

The weights vector of the ith processor is modified as:

$$w_i(k+1) = w_i(k) + \mu_i e^*(k) w_i(k) \quad (7)$$

with the common error e(k) indicated as:

$$e(k) = d(k) - y_c(k) = d(k) - \sum_{i=1}^{N} c_i w_i^H(k) x(k+\tau_i) \quad (8)$$

$$0 \le \mu_i \le \frac{1}{2 \cdot \mathrm{trace}[R_i]} \quad (9)$$

Where:

c_i and τ_i = Combining coefficient and time delay of i-th path, respectively

μ_i = The step-size parameter of i-th path which is defined in equation

R_i = Presents array correlation matrix of i-th path

$$R_i = x(k+\tau_i) x^H(k+\tau_i) \quad (10)$$

Assuming that channel state information is known at the receiver side. Therefore, we can specify combining coefficient c_i and time delay τ_i for each path. In this study, we use maximum ratio combining to calculate the combining coefficient c_i (Lo, 1999).

RESULTS AND DISCUSSION

In this study, assuming that the main signals propagate along four paths which have angle of arrivals 20°, 0°, -20° and 40°. The receiver has ULA with the element spacing of λ/2. The ULA is connected to four parallel BF processors in order to process signals separately. In this simulation, we use BPSK modulation and 500 iterations. We carry out a simulation to figure out the difference in performance of utilizing common error feedback and individual error feedback. We denote that the scheme A is the scheme which uses individual error feedback and the scheme B is our scheme which uses common error feedback. Figure 3 shows that the convergence speed of scheme B is better than scheme A. In other words, using common error feedback can achieve stability faster than using individual one. Figure 4 indicates the Bit Error Rate (BER) performance when the system uses 200 iterations. The BER performance of scheme B is 4 dB better than scheme A at BER = 10^{-5}. Therefore, these results demonstrate clearly the advantage of the scheme B compared to the scheme A.

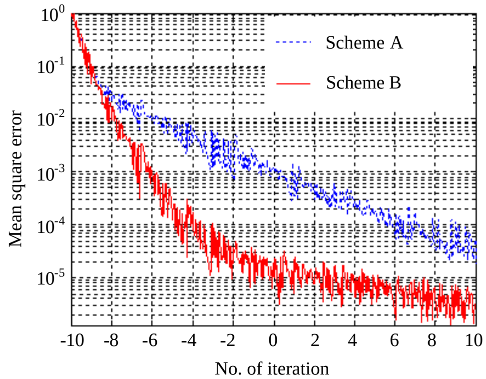

Fig. 3: Convergence speed of scheme A and B

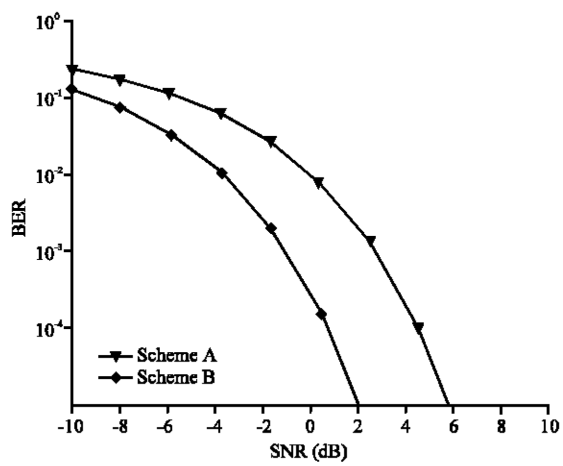

Fig. 4: BER performance at 200 iterations

CONCLUSION

In this study, we discuss using LMS adaptive beamforming scheme for angle diversity receiver. We also, investigate the using of common error feedback and individual error feedback in LMS adaptive beamforming scheme. The LMS scheme which uses common error feedback provides better performance compared to the scheme which uses individual one. The simulation result indicated that our scheme can achieve the stability and enhance the system performance of the angle diversity system.

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REFERENCES

Al-Ardi, E.M., R.M. Shubair and M.E. Al-Mualla, 2003. Performance evaluation of the LMS adaptive beamforming algorithm used in smart antenna systems. Proceedings of the IEEE 46th Midwest Symposium on Circuits and Systems Vol. 1, December 27-30, 2003, IEEE, Cairo, Egypt, pp: 432-435.

Cao, Z. and W. Pang, 2008. A joint processing method of angle diversity receiving and temporal equalization. Proceedings of the 10th International Conference on Advanced Communication Technology (ICACT'08) Vol. 2, February 17-20, 2008, IEEE, Gangwon-Do, South Korea, ISBN:978-89-5519-135-6, pp: 1293-1296.

Cho, J., I.K. Lee and J.S. Cha, 2012. MMSE based wiener-Hopf equation. Intl. J. Internet Broadcast. Commun., 4: 18-22.

Islam, R., F. Hafriz and M. Norfauzi, 2007. Adaptive beamforming with 16 element linear array using MaxSIR and MMSE algorithms. Proceedings of the IEEE International Conference on Telecommunications and Malaysia International Conference on Communications (ICT-MICC'07), May 14-17, 2007, IEEE, Penang, Malaysia, ISBN:978-1-4244-1093-4, pp: 165-170.

Le, V.A. and T. Jeon, 2017. An efficient adaptive beamforming with reduced training iterations. Proceedings of the 5th International Symposium on Advanced and Applied Convergence (ISAAC 2017), November 9-12, 2017, Dongguk University, Gyeongju, Koream, pp: 105-105.

Lo, T.K., 1999. Maximum ratio transmission. Proceedings of the IEEE International Conference on Communications (ICC'99) Vol. 2, June 6-10, 1999, IEEE, Vancouver, British Columbia, Canada, pp: 1310-1314.

Paulraj A.J. and C.B. Papadias, 1997. Space-time processing for wireless communications. IEEE Personal Signal Process. Magazine, 14: 49-83.

Winters, J.H., 1998. Smart antennas for wireless systems. IEEE Personal Commun., 5: 23-27.