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PERFORMANCE ANALYSIS OF NORM-CONSTRAINED CMA ADAPTIVE ARRAY USING MEASURED DATA

Nobuo TSUKAMOTO Toshiyuki ASANO
Kentaro NISHIMORI Nobuyoshi KIKUMA Naoki INAGAKI
Department of Electrical and Computer Engineering
Nagoya Institute of Technology
Gokiso-cho, Showa-ku, Nagoya 466, Japan

1. Introduction

The CMA(Constant Modulus Algorithm) [1] adaptive array antenna has been developed as a sophisticated system capturing the constant modulus signals. Since the CMA does not require any prior knowledge on the desired signal, applying it to the mobile radio communications is confidently expected. Although the conventional discussion on the CMA adaptive array was mainly through computer simulation, currently some experimental results have been reported(e.g., [2]).

In this paper, we also carried out indoor experiments on the CMA adaptive array using a four-element planar array with an antenna element of a quarter wavelength monopole. The array received data in the experiments include effects of interelement mutual coupling and finite ground plane, and hence we can evaluate the performance of the CMA in more realistic situations.

Furthermore, the norm-constrained CMA is investigated here, which may provide higher SINR (Signal-to-Interference-plus-Noise Ratio) at the array output[3]. We show herein some experimental results in which the original and norm-constrained CMA are compared.

2. Principle of the CMA and Norm-constrained CMA

In an adaptive antenna array system, let $\boldsymbol{X}$ and $\boldsymbol{W}$ denote the input vector and weight vector, respectively. Then, the array output y is expressed as $y = \boldsymbol{X}^T\boldsymbol{W}^*$ in which the superscripts T and $*$ represent the transpose and complex conjugate, respectively. The CMA adaptive array works to eliminate the amplitude fluctuations of the array output signal due to the incidence of interferences. Therefore, the cost function to be minimized is normally represented as

$$Q_1(\boldsymbol{W}) = E\left[\left||y|^2 - \sigma^2\right|^2\right] \tag{1}$$

where σ is the amplitude of the array output signal expected in the absence of signal degradation.

Next, we introduce the constraint of weight norm into the CMA. The cost function of the norm-constrained CMA is described as follows:

$$Q_2(W) = E\left[\left||y|^2 - \sigma^2\right|^2\right] + \beta W^\dagger W \tag{2}$$

where β is a positive number for controlling weight norm constraint and the superscript $\dagger$ represents the complex conjugate transpose.

3. Experiments and Discussion

3.1 Four-element planar array antenna

We carried out some indoor experiments using a 1.5GHz-band, four-element planar array antenna which is shown in Fig.1. Figure 2 depicts the array patterns. Two theoretical array patterns are also shown in the figure, and one of them is a pattern employing ICT(Improved Circuit Theory) for considering the effect of interelement mutual coupling[4]. You can confirm that the experimental array pattern is affected by the mutual coupling.

3.2 Results of experiments

In the experiments, we deal with 2-wave radio environment in which an FM signal is used for the desired signal and a CW signal is generated as an interference. The carrier frequency of both signals is 1.5GHz.

First, we examine the performance of the CMA for the case where only the desired signal (FM) is incident from 0°. We let $\sigma = 0.5$ which is equal to the average amplitude of the antenna element outputs. We utilize the steepest descent method to iteratively update the weight vector and use 15 snapshots for one update. For the norm-constrained CMA, β is equal to $\sigma/1500$. The initial weight vector is set to $W_0 = [1, 0, 0, 0]^T$.

The array patterns after 273 iterations are given by Fig.3. Usually, the original CMA using eq.(1) does not change the array pattern from the initial one, because the FM signal always has the constant envelope properties. On the other hand, it is found from Fig.3 that the norm-constrained CMA attains higher SINR because of the lower sidelobes.

Next we discuss the performance in the 2-wave radio environment as shown in Table 1. The input SIR is nearly 0dB at the center antenna of the planar array. Figure 4 shows the array patterns of the original CMA and the norm-constrained CMA after convergence. You can find that the norm-constrained CMA forms a major lobe in the direction of the desired signal and steers the deeper null in the direction of the interference. Besides, the sidelobes of the norm-constrained CMA are reduced as a whole. It results in higher SINR at the array output.

Table 1: Radio environment in the case of 2 waves arriving

	Modulation scheme	Angle of arrival	Transmitting antenna
Wave 1	FM	−50°	horn
Wave 2	CW	50°	monopole

4. Conclusion

We have obtained the fundamental properties of the CMA adaptive array via indoor experiments. Also, it can be demonstrated by the experiments that the CMA adaptive array with the weight norm constraint provides lower sidelobes and higher SINR at the array output.

References

[1] J.R.Treichler and B.G.Agee, "A New Approach to Multipath Correction of Constant Modulus Signal", IEEE Trans. vol.ASSP-31, pp.459-472, April 1983.

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[4] N.Inagaki, "An Improved Circuit Theory of a Multielement Antenna", IEEE Trans AP-17, 2, pp.120-124, 1969.

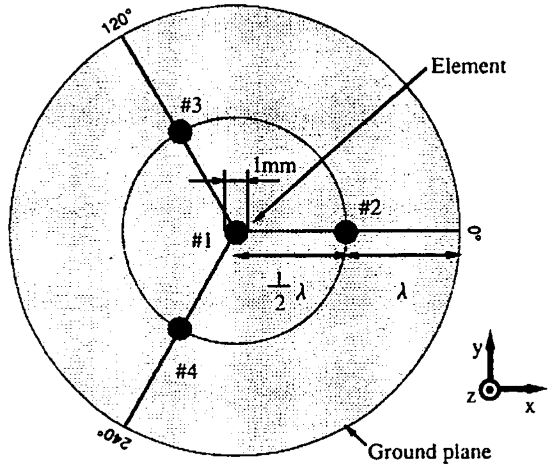

Figure 1: Configuration of a 4-element planar array at 1.5GHz band

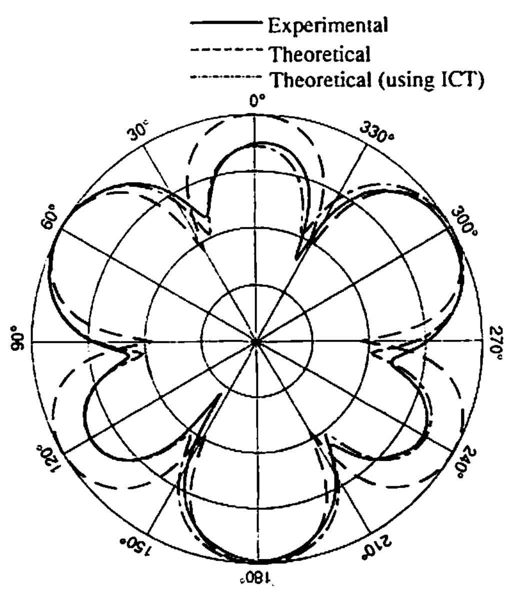

Figure 2: Array patterns obtained from experiments and theory [10dB/div] ($W = [1, 1, 1, 1]^T$)

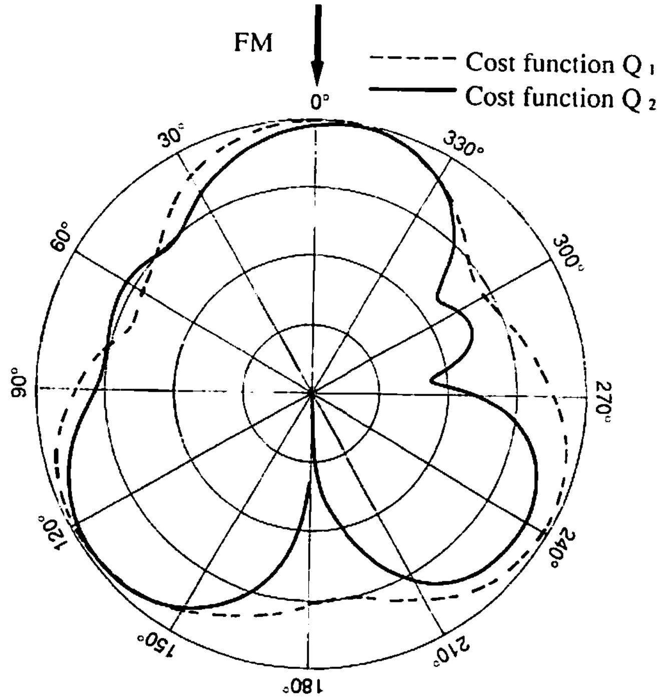

Figure 3: Adapted array patterns in the 1-wave radio environment [10dB/div] ($\sigma = 0.5$)

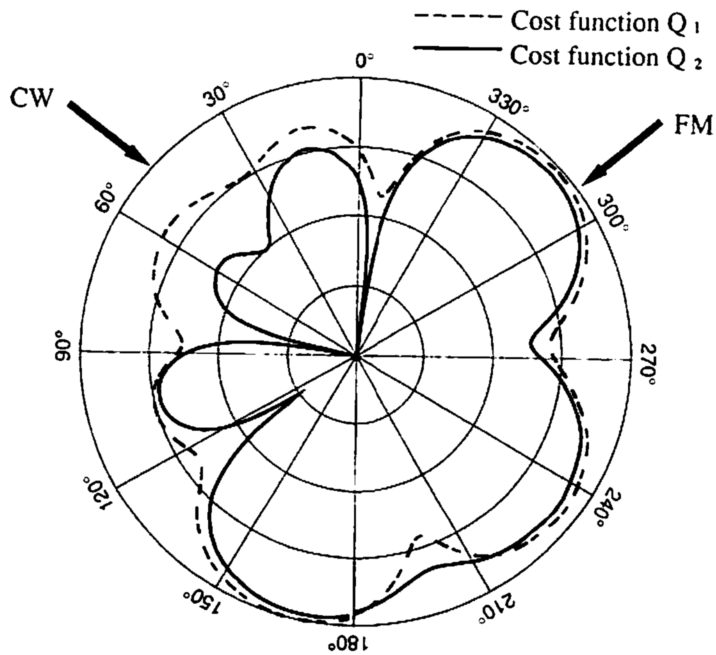

Figure 4: Adapted array patterns in the 2-wave radio environment [10dB/div] ($\sigma = 0.5$)