A NEW DIRECTIONAL CONSTRAINT ADAPTIVE ARRAY ANTENNA INSENSITIVE TO POINTING ERRORS

Masato Fujiwara and Naoki Inagaki
Electrical and Computer Engr. Dept.,Nagoya
Institute of Technology,Showa-ku,Nagoya,466,Japan

I. Introduction

In the adaptive array antenna based on the principle of minimizing the output power under directional constraint[1], the designer must know quite accurately the angle of arrival of the desired signal. In practice,however, there is usually some slight pointing error between the constraint direction and the actual desired signal direction. In such cases, small pointing errors result in large losses in the output signal to interference plus noise ratio(SINR). As the method to solve such pointing error problem, tamed adaptive array system have been proposed[2]. This system have aimed to reduce the sensitivity to pointing errors by adding the pseudonoise to the total output power.

In this paper, we propose a new system that is less sensitive to pointing errors than conventional systems and present the computational results of the steady state properties. We treat the case of narrowband signals for both the desired signal and interference.

II. Principle of the proposed system

This system aims to improve the output SINR when pointing errors exist by guaranteeing the response within some width (2Δ) centered on the constraint direction (θ_C)(Fig.1). Thus, the cost criterion is modified

$$\text{minimize}[\,\mathbb{W}^{\dagger}R_{xx}\mathbb{W}+\int_{2\Delta}(\mathbb{W}^{\dagger}C-\mathbb{H}^{\dagger})(C^{\dagger}\mathbb{W}-\mathbb{H})\,d(\sin\theta)\,] \tag{1}$$

$$\text{subject to}\quad \mathbb{W}^{\dagger}\mathbb{W}=M \tag{2}$$

where R_{xx} is the covariance matrix of input signals, C is the constraint matrix, $\mathbb{H}$ is the response vector, $\mathbb{W}$ is the steady state weight vector, and + denotes the complex conjugate transpose. The principle of this system is to approach the complex response of the signal arriving from the vicinity of the constraint direction ($\theta_C-\Delta \sim \theta_C+\Delta$) to a constant value as well as to minimize the total output power. Using (1) and (2), the optimum weight vector $\mathbb{W}opt$ is found by the method of a Lagrange multiplier as follows:

$$W_{opt}=[R_{xx}+\int_{2\Delta}(CC^{\dagger})\,d(\sin\theta)+\lambda I]^{-1}\int_{2\Delta}(C\,\mathbb{H})\,d(\sin\theta) \tag{3}$$

where λ is a Lagrange multiplier, and I is an identity matrix. Ordinarily, we substitute (3) into (2) to eliminate λ ,but in this case the equation becomes so complex that we adopt (3) without using (2). By suitable choice of λ , we can adjust adaptive ability in a given signal environment. In case the output SNR is used as a measure of array performance the optimum value of λ exists, which is approximated as

$$\lambda_{opt} \simeq -P_S N \tag{4}$$

where Ps is the average power of the desired signal on each element, and N is the number of elements.

III. Numerical results

A computer simulation was carried out on the new system, and the results were compared with those by conventional systems(directionally constrained adaptive array (DCAA) and tamed adaptive array (TAA)). The adaptive array system was assumed that antenna elements which had four-channel array were aligned linearly with the equal spacing of half wavelength and the element factor was isotropic and themal noise which had the equal power was generated on each element. The input SNR and the input INR are assumed to be 20(dB) and 40(dB),respectively, and the constraint direction and Δ are equal to 0 ° and 5 °,respectively. Fig. 2 shows the output SINR versus pointing errors when the direction of interference (θ_i)is equal to 60° . From these curves, we see that the new system is much less sensitive to pointing errors than conventional systems and it can obtain the faborable output SINR identical to that when no pointing errors exist even if the desired signal is incident from out of width (2 Δ) centered on θ_c. Fig. 3 shows the output SINR versus θ_i when the direction of the desired signal (θ_s) is equal to 10°. We can see that the performance of the new system is much better than others as long as interference is incident from the sidelobe area of the quiescent array. Fig. 4 shows the radiation pattern of the new system when θ_s=0°and θ_s=5 °. We see that the new system searchs the direction of the actual desired signal automatically even if pointing errors become large and the main beam of the array moves to follow its direction.

References

[1] K.Takao,M.Fujita,and T.Nishi:'An Adaptive Antenna under Directional Constraint,'IEEE Trans. Antennas Propagat.AP-24 ,No.5,pp.662-669 (1976).

[2] N.Kikuma and K.Takao:'Effects of Pointing Errors on the Tamed Adaptive Antenna under Directional Constraint ,'Technical Reports on Antennas and Propagat.,Inst.Electron. Commn.Eng.Jap.,Vol.AP84-32(1984).

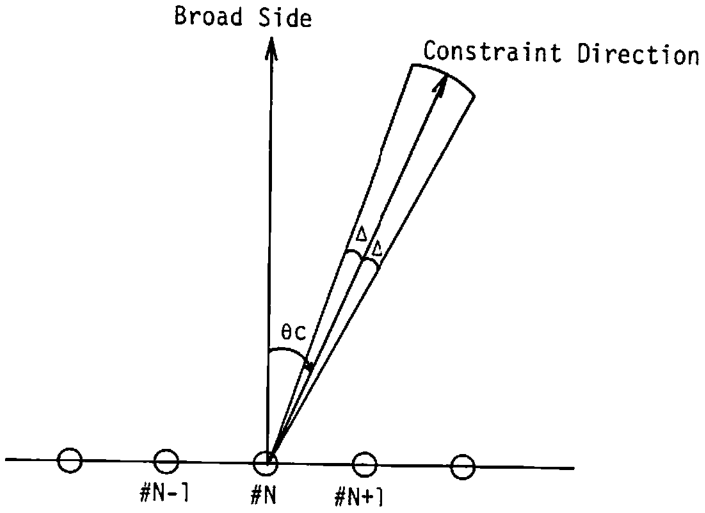

Fig.1 Uniformly spaced adaptive array

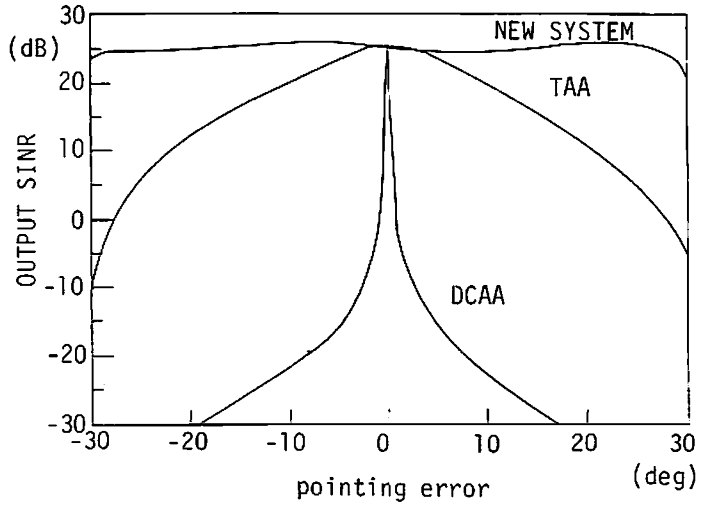

Fig.2 OUTPUT SINR versus pointing error

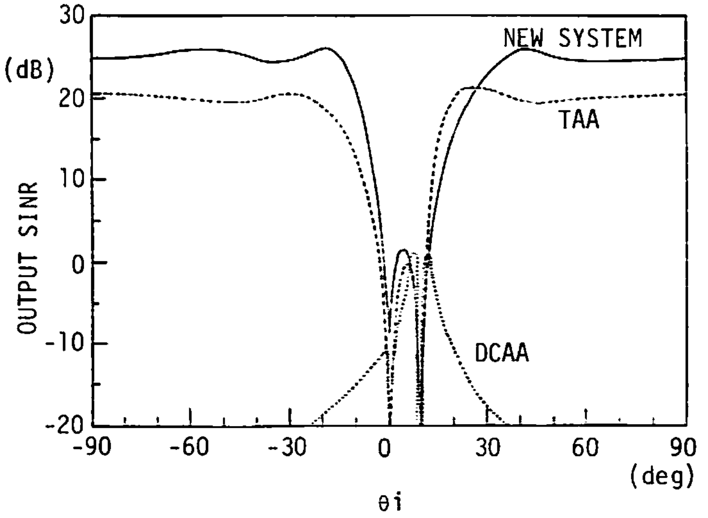

Fig.3 OUTPUT SINR versus the angle of arrival of interference

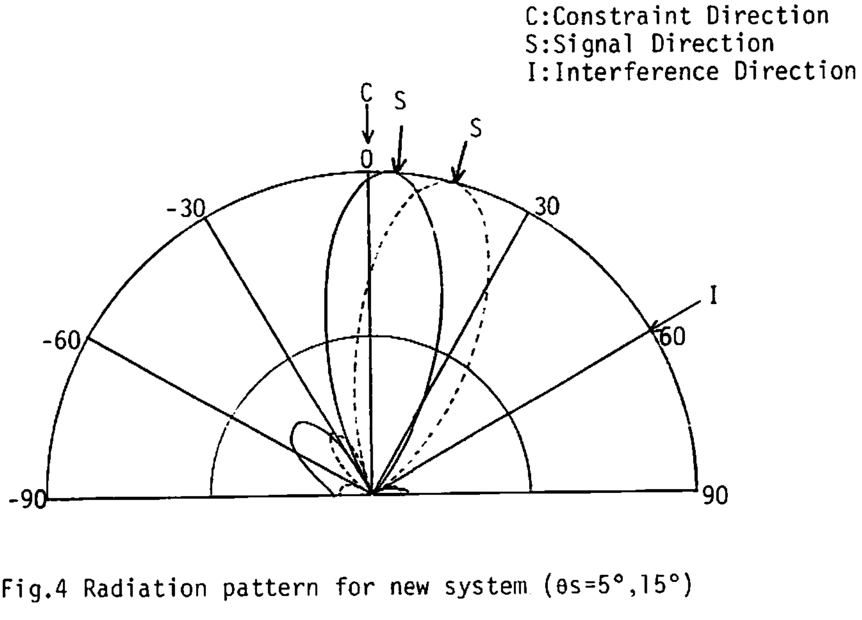

Fig.4 Radiation pattern for new system (θs=5°,15°)