ANGULAR SPREAD ESTIMATION WITH EIGENVALUE DECOMPOSITION TECHNIQUE

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1. Introduction

Space Division Multiple Access (SDMA) is one of key technologies which are expected to enhance the channel capacity of the cellular system. Since the performance of SDMA technique depends on the angular spread of the propagation channel, it is very important to know the angular spread characteristics in the realistic environment. [1],[2]

In this paper, a method of the angular spread estimation with an array antenna is proposed. The proposed method is based on the eigenvalue decomposition technique, and is applicable to a base station (BS) of CDMA packet cellular system. Based on the proposed method, the angular spread characteristic is evaluated through the measurements with a 2GHz-band array antenna.

2. Estimation Method [3]

The distribution of eigenvalues, which are obtained by eigenvalue decomposition of covariance matrix for array output vector, is related with the propagation channel. When no scatters occur around a mobile terminal and only direct path wave comes from the direction of the mobile terminal, the value of maximum eigenvalue λ_1 corresponds to the total power of the received signal, and the other eigenvalues λ_i (i = 2, 3,..., K) are equal to 0. On the other hand, when scatters exist around a mobile terminal and mutipath waves arrives at BS with spreading the angle of arrival, the values of eigenvalues except the maximum eigenvalue increase as the angular spread. Therefore, we think that the angular spread of propagation channel can be estimated from the relative eigenvalues to the maximum eigenvalue. Figure 1 shows the relation between the angular spread σ_θ and the second eigenvalue λ_2 to the maximum eigenvalue λ_1. The curve is obtained by assuming that the angle profile $A(\theta)$ agrees with the Gaussian angular distribution with σ_θ as follows [4],

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$$A(\theta) = \frac{P}{\sqrt{2\pi}\sigma_\theta} \exp\left\{ -\frac{(\theta - \theta_0)^2}{2\sigma_\theta{}^2} \right\}, \quad (1)$$

where P and θ_0 indicate the power of the received signal and the direction of MS, respectively. Thus, by referring to Fig.1, the angular spread is estimated from λ_2/λ_1, which is obtained the covariance matrix of the array output vector.

3. Evaluation of the angular spread

3.1 Measurements

A circular array antenna with 12-elements shown in Fig.2 is employed for the base station. The array antenna was mounted on the top of a steel tower whose height is 50m from the ground level. The measurements were carried out at the base station over driving a vehicle having an MS on board around the base station. The course of the vehicles is within 2 km of the BS and located in suburban area where relatively low buildings whose height is lower than 20m fills up the area.

3.2 Results

Figure 3 shows the cumulative distribution of the angular spread. From the figure, the average of the angular spread was around 3 degree, and 90% of cumulative distribution of 90% was less than 6 degrees. Figure 4 shows the angular spread vs. the distance between the BS and MS. The distance was evaluated from the data of GPS receiver on the vehicle. From the figure, it seems that the average of the angular spread keeps 3 degree when the distance between a base station and a mobile terminal is more than 300m, although it increases when the distance between a base station and a mobile terminal is less than 300m.

4. Conclusions

We proposed a method of the angular spread estimation with an array antenna. The proposed method is applicable to a BS of CDMA packet cellular system, and real-time estimation of the angular spread is available while the communication link between BS and MS is maintained. Based on the proposed method, the angular spread characteristics were investigated through the measurements with 2GHz-band array antenna. We found that the 50% of the cumulative distribution was kept 3 degree when the distance between a base station and a mobile terminal is more than 300m. When the distance between BS and MS is less than 300m, the average of the angular spread is more than 3 degree.

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References

[1] T. Imai and S. Mori,"Path Characteristic of Temporal and Spatial Distribution in a Wideband Mobile Radio", Proc. of the 2002 IEICE General Conf., B-1-28, p.44, March 2002.

[2] J. S. Jeong, K. Sakaguchi, J. Takada and K. Araki," Joint Estimation of DOA and Angular Spread by Using ESPRI Algorithm", Proc. of the 2000 Communications Society Conf. of IEICE, no.B-1-34, p.34, Sept.2000.

[3] Y. Amano and T. Inoue and H. Shinonaga, "Angular spread estimation with Eigenvalue Decomposition Matrices Received at Array Antenna", Technical Report, AP2002-90,pp.63-67, Sept 2002.

[4] T. Inoue and Y. Karasawa, "Theoretical Analysis on the Performance of Optimal Combining for Multipath Waves Distributed in Spatial and Time Domains," IEICE Trans. Commun., vol.E83-B, no.7, pp.1426-1434, July 2000.

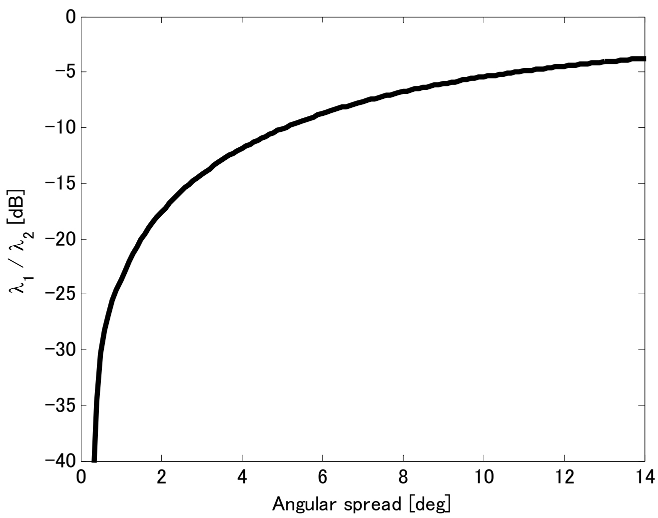

Fig. 1 The relation between λ_2/λ_1 and the angular spread.

Fig. 2　2GHz-band circular array antenna with 12 elements.

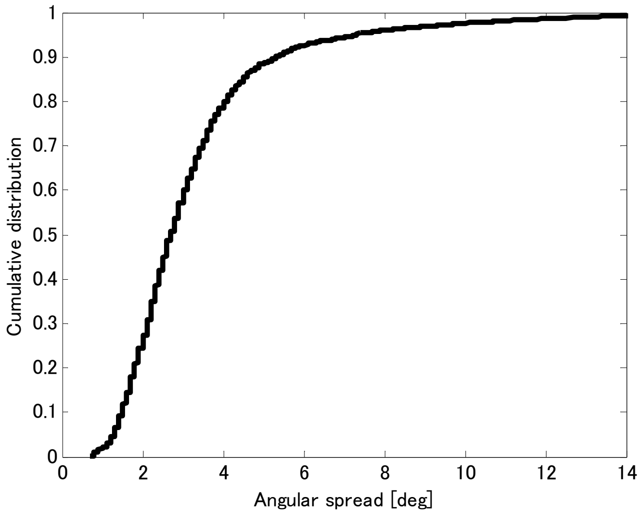

Fig. 3　Cumulative distribution of the angular spread.

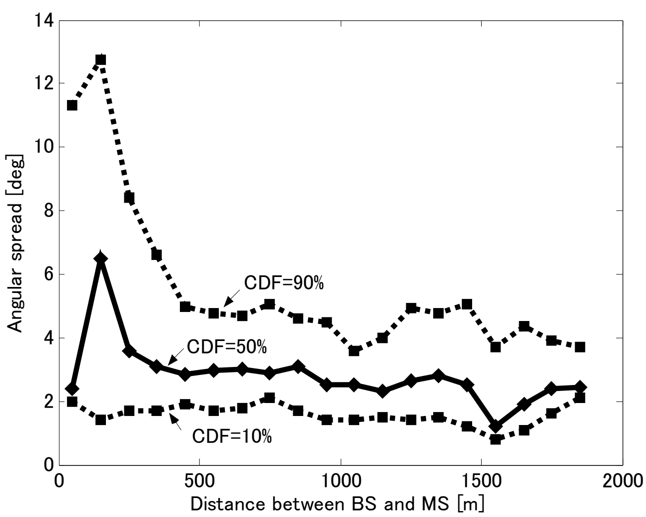

Fig. 4　Distance from the base station vs. angular spread.