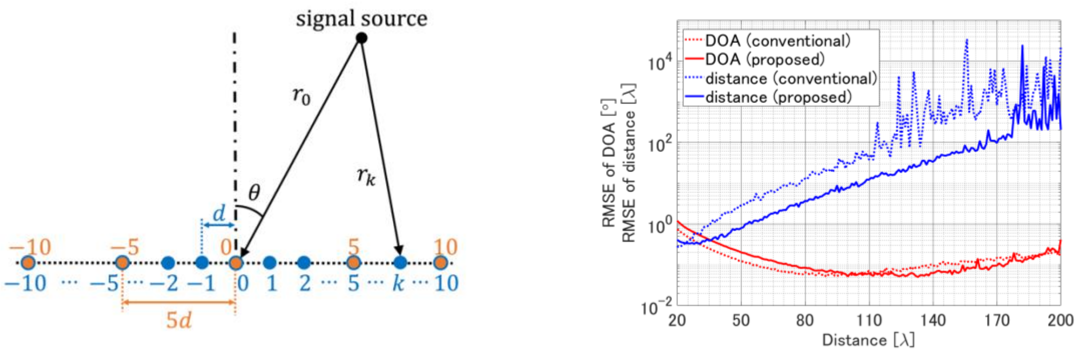
Numerical Analysis of Estimating Both DOA and Distance by Combined Use of ESPRIT Method and Near-Field DOA-Matrix Method

H. Matsubara(1), S. Kojima(1), N. Shinohara(1), and T. Mitani(1)
(1) Kyoto University, Gokasho, Uji, Kyoto, Japan, e-mail: hiroyuki_matsubara@rish.kyoto-u.ac.jp; seishiro_kojima@rish.kyoto-u.ac.jp; shino@rish.kyoto-u.ac.jp; mitani@rish.kyoto-u.ac.jp

In the Fresnel region, high-efficiency Microwave Power Transmission (MPT) needs to estimate not only a Direction of Arrival (DOA) of a pilot signal from a receiver but also a distance between the transmitter and the receiver. There have been many DOA estimation methods using a phased array antenna, such as ESPRIT method, which only estimates the DOA [1]. In the Fresnel region, the different signal model is needed because the antenna's radiation pattern depends on the distance. By using Near-Field DOA-Matrix method, both the direction and the distance can be estimated [1]. This has restriction that the element spacing is less than the quarter wavelength when estimating the DOA. It causes the difficulty of fabrication and increases the estimation error due to the mutual coupling with adjacent antenna elements. For overcoming this, we estimate the DOA with ESPRIT method, which needs that the element spacing is less than the half wavelength. Then we calculate the distance by using Near-Flied DOA-Matrix method.

We consider a uniform phased array antenna, having 21 elements, shown in Fig.1 (a). In ESPRIT method, we use an array antenna whose element spacing is $d = \lambda/2$ for the DOA estimation, λ is the wavelength. On the other hand, we use another array antenna whose elements spacing is $5d$ for estimating the distance. Fig.1 (b) shows the root mean square error (RMSE) of 100 times estimation of the DOA and the distance when the r_k is varied from 20λ to 200λ. Fig.1 (b) shows that the proposed method decreased the RMSE of the distance estimation than the conventional one. The RMSE of the DOA with the proposed method is as small as the one of the conventional method.

We realized the lower RMSE of the distance estimation with the proposed phased array antenna. We overcame the restriction of the elements spacing of Near-Field DOA Matrix method. We will suppress the mutual coupling with adjacent antenna elements.



(a) (b)

Figure 1.

(a) The proposed model of a uniform phased array antenna, where $d = \lambda/2$ is the element spacing, $\theta = 30°$ is the DOA, r_0 is the distance between the signal source and the center of the antenna, r_k is the distance between the source and the k-th elements. Each antenna element and the signal source is regarded as a point. (b) The simulation results of the RMSE of the DOA and the distance to the distance. Solid lines mean the results by the proposed method, and dotted lines mean the results by the conventional one. Red lines mean the RMSE of the DOA estimation, and blue lines mean the RMSE of the distance estimation.

References

[1] Ke Deng, Qinye Yin, and Huiming Wang, "Closed form parameters estimation for near field sources," *Circuits and Systems, 2007. ISCAS 2007. IEEE International Symposium on,* May 2007, pp. 3251-3254, doi: 10.1109/ISCAS.2007.378165.