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Evaluation of DOA Estimation Accuracy using Spectrum Width

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Abstract

In this paper, the evaluation method for DOA (Direction Of Arrival) estimation accuracy using the spectrum width is proposed, and its effectiveness is examined. It is numerically shown that the actual accuracy can be estimated by the proposed method. Moreover, computational resources can be saved because the number of trials of proposed method is decreased compared with conventional method. It is also shown that the error of the proposed method is reduced less than 0.1deg, in range of SNR = 0 to 20dB.

1. Introduction

In recent years, wireless communications are widely used. Researches on DOA estimation techniques have been investigated in order to minimize the effects of interferences on wireless communications[1]. In order to develop the accurate DOA estimation techniqus, it is necessary to properly evaluate the accuracy of the estimation. Namely evaluation method for the DOA estimation accuracy is important. Conventionally, DOA estimation accuracy is examined by comparing the direction of the spectrum peak and true direction of the source[2][3]. However, this evaluation method is sensitive to noise and disturbance. To obtain the correct DOA estimation accuracy, many trials are required, however, it is very difficult in experiments. Moreover, it spends a lot of computational resources in simulations.

In this paper, a novel evaluation method using a width of the MUSIC spectrum[4] is proposed. Effectiveness of proposed method is demonstrated by computational simulations.

2. Evaluation Method for DOA Estimation Accuracy using Spectrum Width

Figure 1(a) shows the outline of the conventional evaluation method for the estimation accuracy. In the method, the error ΔCo_e is obtained by comparing the true direction of source and the peak of the spectrum. However, many trials are required in this approach to grasp the average of error.

Figure 1(b) shows the concept of the proposed evaluation method. Generally, the spectrum peak tends to be sharp when the estimation accuracy is high, and loose when the estimation accuracy is low. In the proposed method, estimation accuracy is predicted from the width $\Delta \mathrm{Pr}_e$ of MUSIC spectrum. $\Delta \mathrm{Pr}_e$ is the width at the level of ΔSP which is lower than the spectrum peak. It is expected that the proposed method has high tolerance to noise or disturbance because it utilizes the width of the MUSIC spectrum.

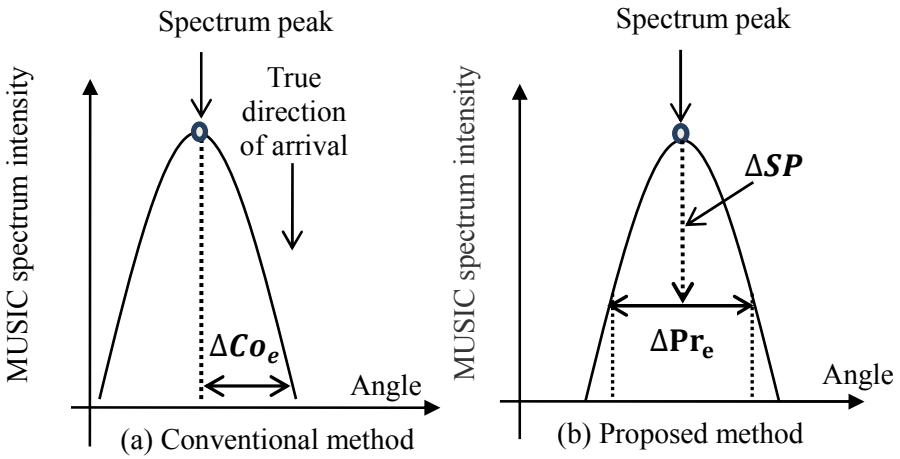

Figure 1: Estimation Accuracy Evaluation Method

3. Analysis Model

Figure 2 shows the the analysis model. Table 1 shows the analysis conditions. Array antennas used in the analysis. It is arranged the linear array that composed of 7 elements with 0.5λ of the element spacing is applied. Incoming wave is supposed to be plane wave. The direction of the incoming wave is 30 deg. SNR is 20 dB.

MUSIC method[4] is used for DOA estimation in the analysis. The DOA estimation accuracy is evaluated by using conventional method and proposed method.

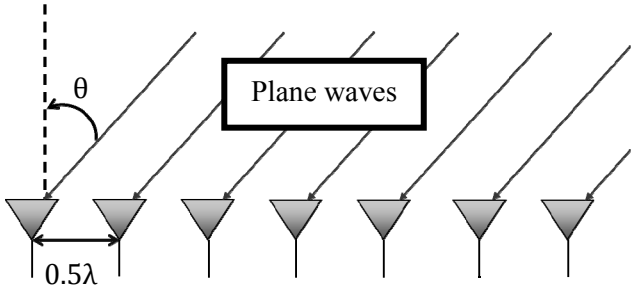

Figure 2: Analysis Model

Table 1: Analysis Conditions

Number of waves	1
Arrival angle θ [deg]	30
SNR [dB]	20
Number of trials	50
Number of array elements	7
Element spacing	0.5λ
Element arrangement	Linear array

4. Evaluation of DOA Estimation Accuracy by Proposed Method

4.1 Effect of Number of Trials on Estimation Accuracy

Figure 3 shows the effect of the number of trials on the accuracy evaluation. Here, ΔSP = 1.5dB, and SNR = 20dB. The number of the maximum trials is 50, and it was tried three times for different noise seed. The horizontal axis is the number of trials. The vertical axis is the estimation error. Solid line is averaged $\Delta \mathrm{Pr}_e$ that evaluated by the proposed method, and dashed line is averaged ΔCo_e that evaluated by the conventional method. The arrow in Fig.3 indicates the actual accuracy of MUSIC algorithm in this condition. It is desirable to achieve to this value with more few number of trials.

Figure 3 shows that the conventional method needs many trials to reach the actual accuracy. On the other hand, the proposed method can reach the actual accuracy in several trials.

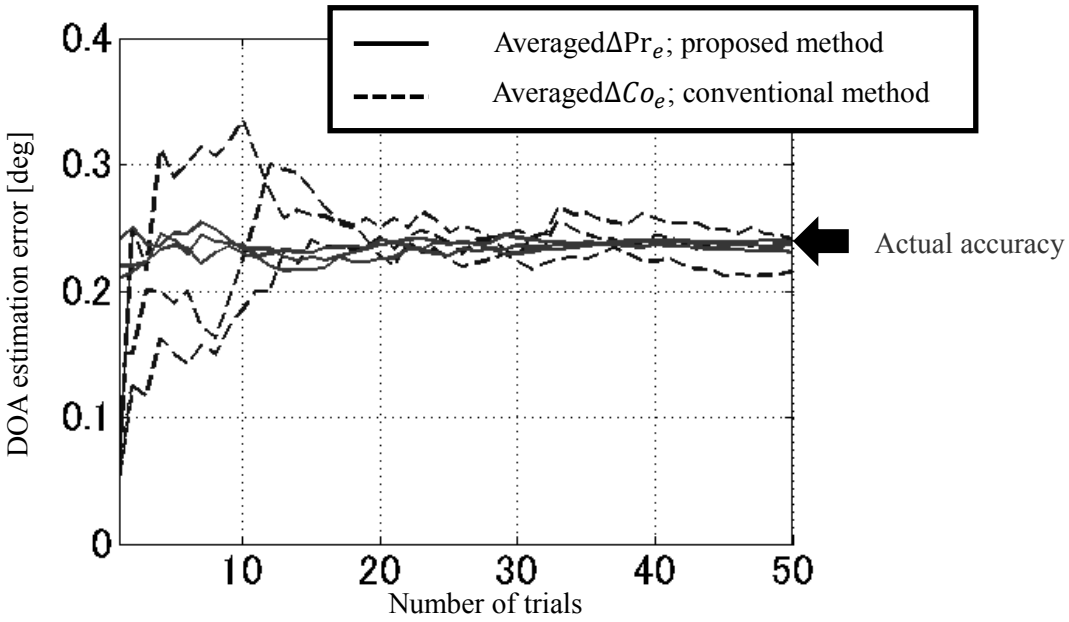

Figure 3 :Effect of Number of Trials on Estimation Error

4.2 Effect of SNR on Estimation Accuracy

Figure 4 shows the effect of SNR on the accuracy evaluation. The horizontal axis is SNR. The vertical axis is the estimation error of DOA. Here, ΔSP = 1.5dB, and number of trials is 50 times. Solid line and dashed line indicates averaged ΔPr_e and actual accuracy, respectively.

Figure 4 shows that the estimated accuracy by the proposed method is almost the same with the actual accuracy. It is also confirmed that the error between proposed method and actual accuracy increases as decreasing SNR. But, the error of the proposed method is reduced less than 0.1deg, in range of SNR = 0 to 20dB.

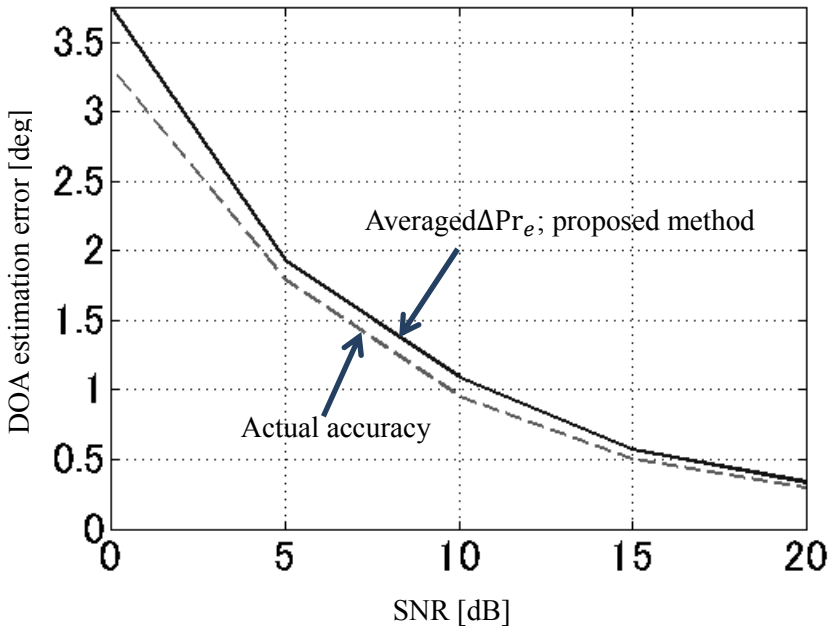

Figure 4: Effect of SNR on Estimation

4.3 Effect of Number of Array Element on Accuracy Estimation

Figure 5 shows the effect of number of array elements on the accuracy estimation. Here, ΔSP = 1.5dB, SNR = 20dB, and number of trials is 50 times. The horizontal axis is the actual accuracy and the vertical axis is averaged $\Delta \mathrm{Pr}_e$ that evaluated by the proposed method.

In Fig.5, all lines are increasing monotonically. In a word, the actual accuracy is grasped by the proposed method. In addition, the line of 7 elements is most similar to the actual accuracy in three lines. Since all lines are increasing monotonically, the actual accuracy can be estimated by the proposed method, but the ΔSP should be set at appropriate level for each element number.

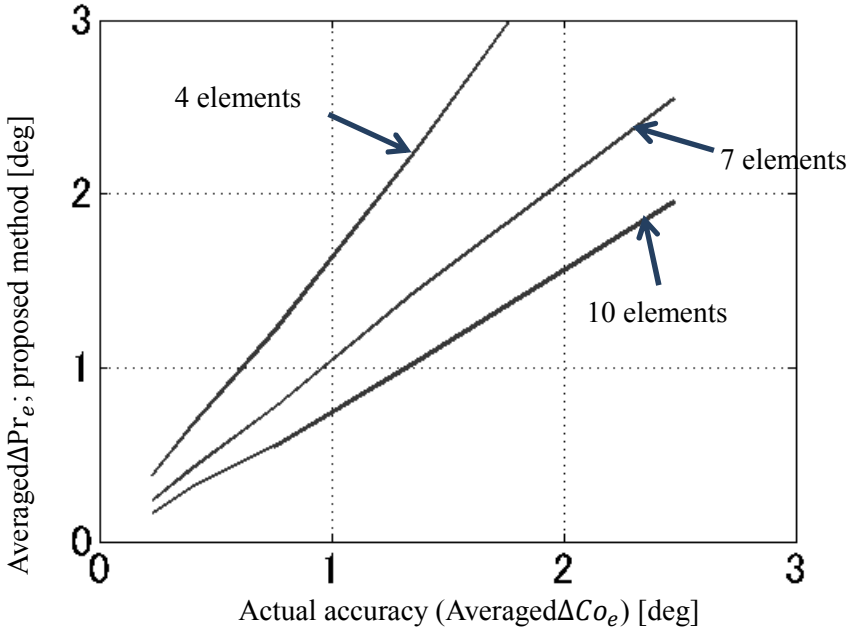

Figure 5: Effect of Number of Array Element on Accuracy Estimation

5. Conclusion

In order to evaluate the DOA estimation accuracy more simply, accuracy estimation method using the spectrum width was proposed, and effectiveness was examine. As a result, the evaluated accuracy by the proposed method was almost the same with the actual accuracy. Moreover, it was also shown that the proposed method could reach the actual accuracy in fewer trials compared with conventional method. It was found that the actual accuracy in any number of array element could be estimated by using the proposed method, but the ΔSP should be set at appropriate level.

It was also confirmed that the error of the proposed method was reduced less than 0.1deg, in range of SNR = 0 to 20dB.

References

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