Estimation of the source position by means of SAGE

#Sin'ya Aizawa[1],Yoshihiko Kuwahara[1], Makoto Tanaka[2], Takanori Uno[2], Kouji Ichikawa[2]
[1]Graduate School of Engineering, Shizuoka University
3-5-1 Johoku Naka Hamamatsu 432-8561 Japan tykuwab@ipc.shizuoka.ac.jp
[2] Engineering R&D Center, DENSO CORPORATION
1-1 Showa Kariya 448-8661 Japan

Abstract

We have examined location of coherent sources in the near field by means of the super resolution techniques. The multiple coherent sources of low frequency are located on the metal plane. We have confirmed that SAGE had estimated multiple coherent sources on the metal plane. Position estimation error was around 20-30 [cm].

Keyword : estimation of location, near field, coherent source, SAGE, MUSIC

1. Introduction

With concerns about such problems as environment and energy, people begin to use the hybrid vehicle and the electric vehicle that reduces the effects on the environment and the energy. These vehicles are installed with the Power Control Unit (PCU) that controls the power from the battery. PCU radiates strong undesired electromagnetic waves which influences on-board electronics. Nowadays, several kinds of antennas are installed on the vehicle. These antennas may receive the electromagnetic waves. In the future, with the advancement of information society, a lot of new communication devices will be installed in many vehicles. Therefore, we have to remove this noise effectively after pinpointing the location of source of noise generation. The radiation sources exist in the near-field. They may be coherent source of low frequency. Super resolution techniques like MUSIC and SAGE will be effective means to locate them accurately.

In this article we consider multiple sources on the metal to model signals propagating in the wire harness on the body. The frequency range is AM radio. MUSIC and SAGE are examined and compared.

2. Algorithm for location estimation

2.1 Steering vector of near-field

In this article, we focus on MUSIC and SAGE. MUSIC is based on the eigen-decomposition of the array correlation matrix [1]. And SAGE is a maximum likelihood estimation method [2]. These methods use antenna array responses (steering vector) to a source to find the arbitrary source in the search space.

Here, we use a minute dipole antenna as a source. The wavelength of the AM radio is 186[m]~560[m]. So, we must consider the near field signals for the measurement. In this case, the steering vector includes quasi-electrostatic field, induction field, and radiated field.

2.2MUSIC

MUSIC method is based on the eigen-decomposition method that uses eigenvalue and eigenvector of the array correlation matrix. In reference [3], multiple sources of non-coherent wave at 10[kHz] can be successfully located in the room. However, radiation from the harness of the vehicle will be treated as the coherent wave. Perhaps, we can’t estimate them by MUSIC. It is difficult to apply the spatial averaging for the near field case.

2.3SAGE

SAGE is a method of the maximum likelihood estimation. In SAGE, we must set the initial guess of the source position appropriately. If possible, it is better to know the number of the source. It is expected that we can estimate the multiple coherent source in the near field.

3. Propagation model

Here we use three kinds of simulation models. First is the free space model. Second, we think about the radiations from the harness. For simplicity, we first consider the minute dipole on a metal plate as shown in Fig.1. Then, we use the vehicle chassis model as shown in the Fig.2. The installation and location is the same as the metal plate model.

We analyzed the radio propagation by HFSS. The results for 1 and 2 sources of 1MHz are given in Fig.3. We use a linear array of three elements in the x-axis. Element interval is 1 [m]. We achieved the magnetic field at the positions. Here, the analysis area is a square area of 3 [m] on each side in the x-y plane.

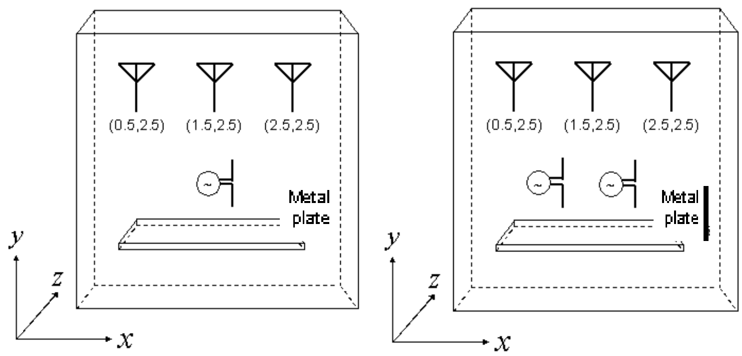


Fig.1: analytical model (left:1 wave source,right:2 wave sources)

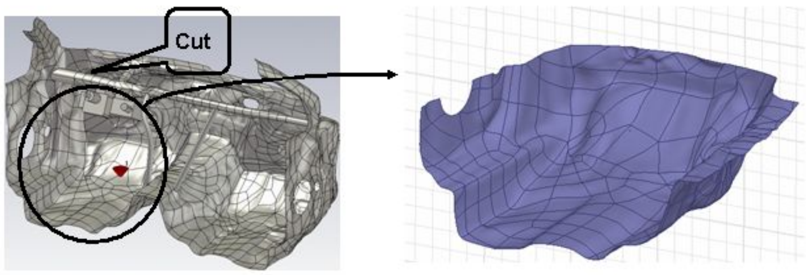


Fig.2: vehicle chassis model

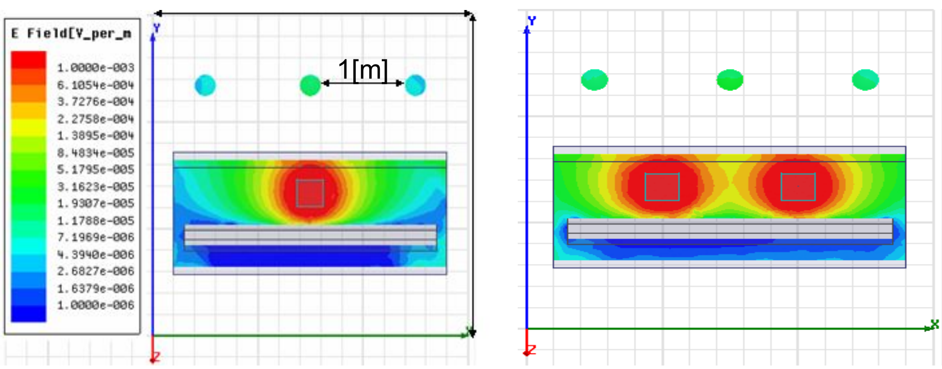


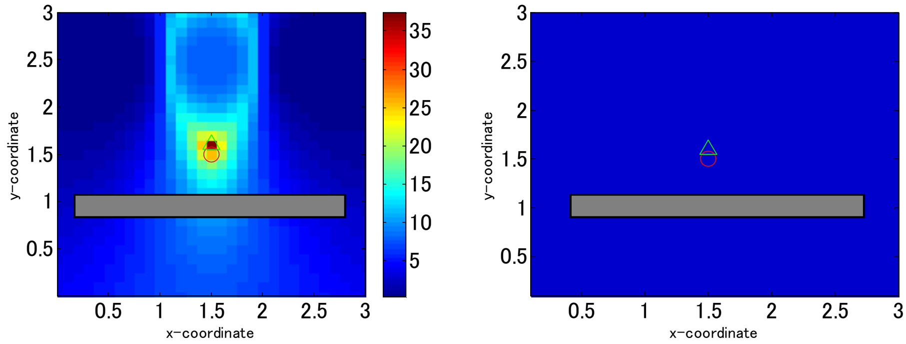
Fig.3: radiation pattern (left:1 wave source,right:2 wave sources)

The radiating field by the minute dipole in the free space was used for the steering vector

4. Location Results

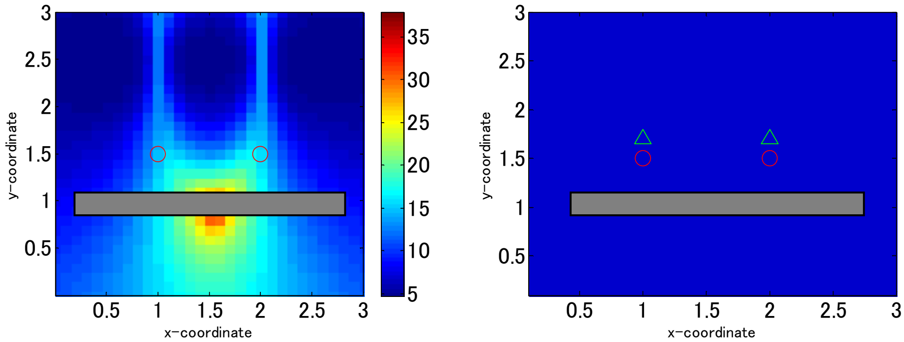
We demonstrate some examples of locating results. 1 or 2 sources are located on the metal plate as shown in Fig.4. ○ denotes the set position of the source. Δ denotes the estimated position by SAGE. In case of MUSIC, distribution of the cost function is overlapped. For 1 source, MUSIC and SAGE can estimate the position accurately. SAGE can estimate positions of 2 coherent sources while MUSIC cannot locate them.

1 wave source



MUSIC SAGE

2 wave sources



MUSIC SAGE

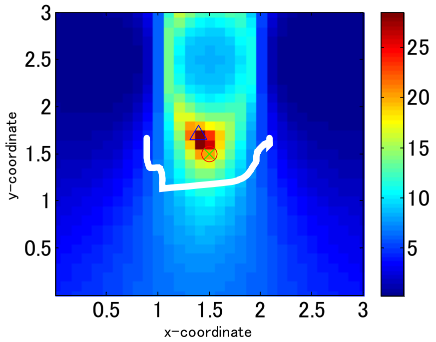
Fig.4:estimated result (left:1 wave source, right:2 wave sources)

Table1: Comparison of position estimation with or without metal plate

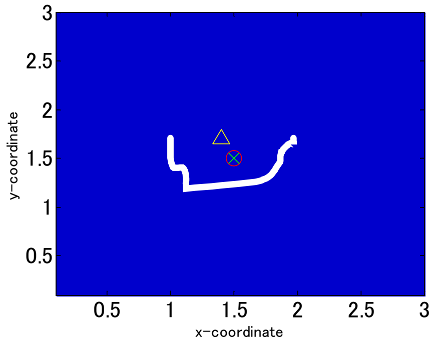
wave source	location estimation method	Set point [m]	estimated position [m]		error[cm]	
			free space	vehicle chassis	free space	vehicle chassis
1	MUSIC	(1.5,1.5)	(1.5,1.5)	(1.4,1.7)	0	22
	SAGE	(1.5,1.5)	(1.5,1.5)	(1.4,1.7)	0	22
2	SAGE	(1.3,1.5) (1.7,1.5)	(1.3,1.3) (1.7,1.4)	(1.3,1.8) (1.7,1.7)	20 10	30 20

Then, we have located 1 or 2 coherent sources on the complex vehicular chassis. The results are shown in Figure 5. Here, ○, ×, and △denote the set source, estimating result in the free space, and for the chassis model by SAGE. For 1 source, SAGE and MUSIC can locate it accurately. For 2 coherent sources, SAGE can locate them with the accuracy of 20-30cm. The estimated results are summarized in Table 1.

1 wave source

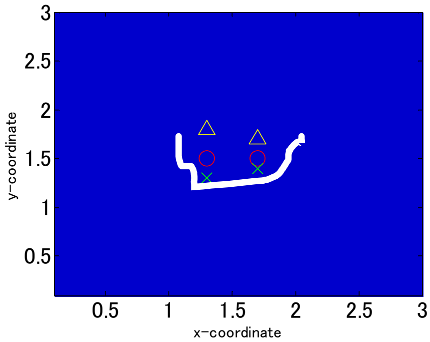


MUSIC



SAGE

2 wave source



SAGE

Fig.5: Comparison of position estimation with or without metal plate

5. Conclusion

We tried to locate 2 coherent sources of 1MHz with or without the metal plate by MUSIC and SAGE. MUSIC cannot locate 2 coherent sources in the near field while SAGE can locate them with the accuracy of 20-30[cm].

Through the examination, metal plate or complex chassis have serious influence of estimating performance. We are to examine the effect of reflection and its counterparts.

References

[1] R. O. Schmidt, Multiple Emitter Location and Signal Classification, IEEE Trans. Antennas and Propagat., Vol. AP-34, No.3, pp.276-280, 1986.

[2] J. A. Fessler and A. O. Hero, Space Alternating Generalized Expectation Maximization Algorithm, IEEE Trans. Signal Processing, Vol. 42, No.10, pp.2664-2677, 1994.

[3] Satoshi YAGITANI et.al., Localization of Low Frequency Electromagnatic Sources, IEICE Trans. Vol. J87-B, No.8, pp.1085-1093, 2004.