SOUND FIELD REPRODUCTION USING WAVE-FRONT SYNTHESIS BASED ON THE FOUR MICROPHONE MEASUREMENTS

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1.INTRODUCTION

In the 1st meeting, Yoshio Yamasaki and Takeshi Itow proposed the four microphone method. In the 2nd meeting, Yoshio Yamasaki reported the characteristic of European and Japanese halls using the four point microphone method.

And here, we talk about the method of the sound field reconstruction. The sound field reconstructed is compared to original one by the four microphone method.

To reproduce a sound field restrictedly, there are some methods, the binaural system, the transaural system using 2 or 3 loudspeakers to control 2 ear points, Kirchhoff-Helmholts Integral, and so on.

The binaural and transaural systems have some limitations, that is, we have to wear a headphone, or we cannot have to move any direction to fix the position of the ears. The Kirchhoff-Helmholtz Integral system has no limitation for listening, but numerous number of loudspeakers are needed.

Using an array of practical number of loudspeakers sound field is reconstrtlcted in a special anechoic chamber which is in the Chiba Institute of Technology. This anechoic chamber has 26 loudspeakers, which are placed behind the sound absorbing wedges on the wall. Each wall has 3 loudspeakers, while on the ceiling and on the floor 7 loudspeakers are mounted respectively.

And we were trying to reconstruct the sound field by these 26 loudspeakers in various methods, the directional impulse responses, the synthesized directional impulse responses using minimum phase.

2.THE FOUR MICROPHONE MEASUREMENTS

We proposed a method to grasp spatial information of sound fields from impulse responses measured at four points on the rectangular coordinate axes apart same distance from the origin. The positions and powers of direct and reflected sound sources or virtual image sources are estimated by correlation technique or intensity technique.

3.WAVE-FRONT SYNTHESIS

Our fundamentally theory is the Kirchhoff-Helmholtz Integral, that is based on the fact that an arbitrary sound field within an enclosed space can be determined by particle velocities and sound pressures on the surface of the space. The only restriction is that there are no sound sources within this space.

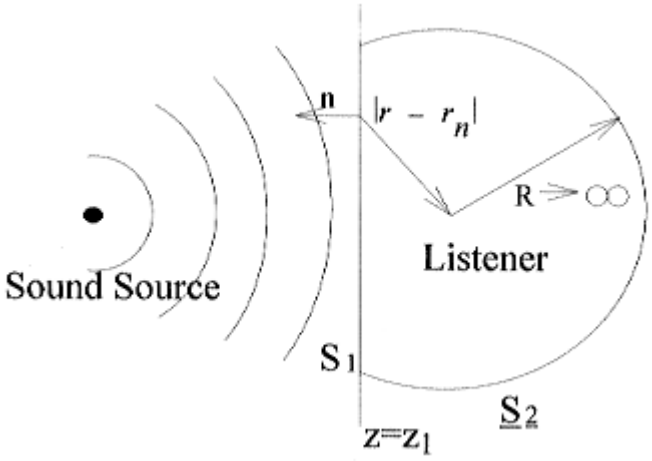


Fig.1 Kifchhoff-Helmholtz Integral

4.SIMPLIFY THE WAVE-FRONT SYNTHESIS

However, realization of this theory needs numerous number of monopole and dipole sources. For example, if we reproduce the sound up to about 1.7kHz, loudspeakers should be placed at 10 cm intervals. Therefore we reduce the number of loudspeakers, by using wave-front synthesis based on the idea of four point measurement.

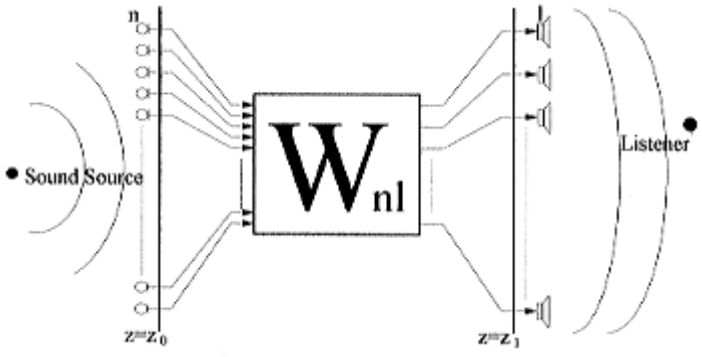


Fig.2 Simplify of wave front synthesis

Here we use the function W, where we splits the input sound pressure in n discrete levels on surface z_0. Then multiply the input by W ,and sums up these levels.

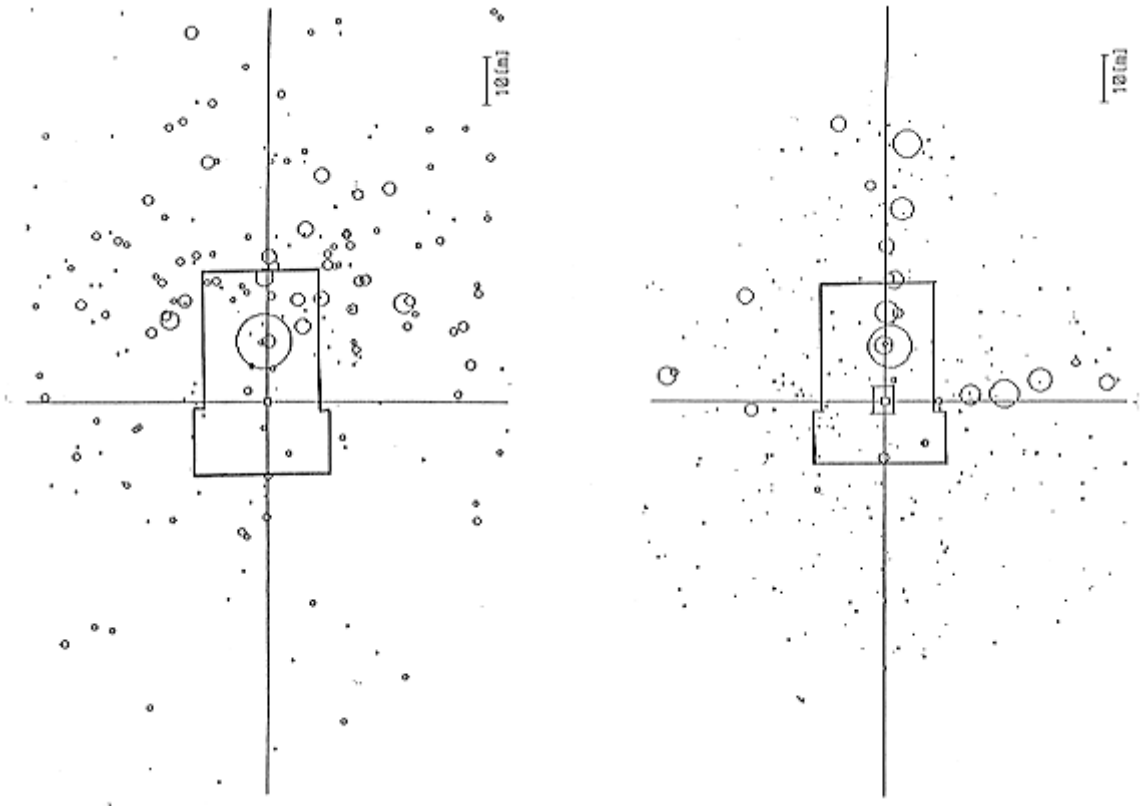
This W synthesizes wave-front approximately.

5.EXPERIMENT

An experiment was done with this technique by six loudspeakers of the front wall and of the right side wall. And single virtual image source is placed here.

We measured the distribution of the virtual image Sources in Aichi jut. Concert Hall.

This Figure shows the distribution of the virtual image sources. The center of the circle represents the estimated points of the virtual image Source, and the area of each circle represents the power of the corresponding source. The cross point of the two orthogonal lines is the observation point. The outlines of the concert hall are also shown.



a) Aichi Art concert hall (Real) b) Aichi Art concert hall (26 Speakers)

the distribution of cirtual image sources

This Figure shows the distribution of the virtual image sources of the reconstructed sound field.

The distribution is quit similar to the original one.

5.CONCLUSIONS

We propose the new method of sound field recontstruction by simplifying the wave-front synthesis. As compared to the directional impulse responses method, the sound image is localized between loudspeakers. However, in the reconstructed.sound field the number of virtual image sources slightly differ from original one. Since the number of loudspeakers were not enough.

In order to reduce number of loudspeakers, we will continue to optimize function W and the arrangement of the loudspeakers.

The four point microphone method is not only to be applied to real sound field analysis but also to can be applied to synthesized sound field evaluation.

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