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

Shuji Kudo*, Yasuhiro Oikawa*, Yoshio Yamasaki*
Waseda University, 3-4-1 Okubo, Shinjuku-ku, Tokyo
169, Japan
E-Mail: yamasaki@cfi.waseda.jp

1. 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.

The directional impulse responses were obtained by the distribution of virtual image source, which calculated by the four microphone measurements. Only by convoluting each the directional impulse response, the sound field reproduction is realized. Figure 1 shows the results of the four microphone measurements and the directional impulse responses obtained from it.

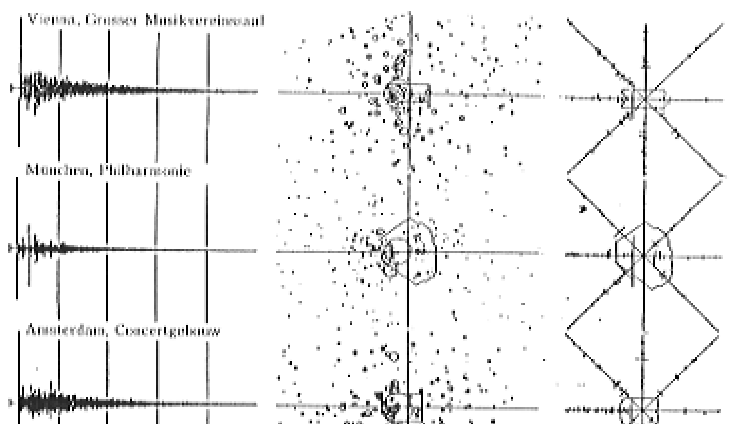

Fig.1 Results of the four microphone measurement

2. WAVE-FRONT SYNTHESIS

Our fundamentally theory is the Krchhoff-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 surihce of the space. The only restriction is that there are no sound sources within this

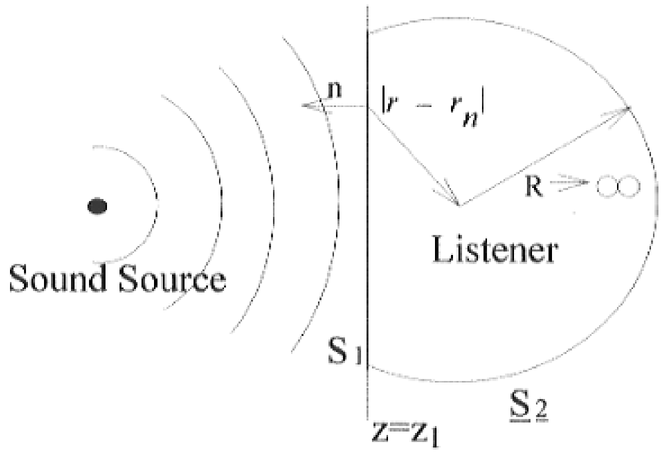

Fig.2 Kirchhoff-helmholtz Integral

3. 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.

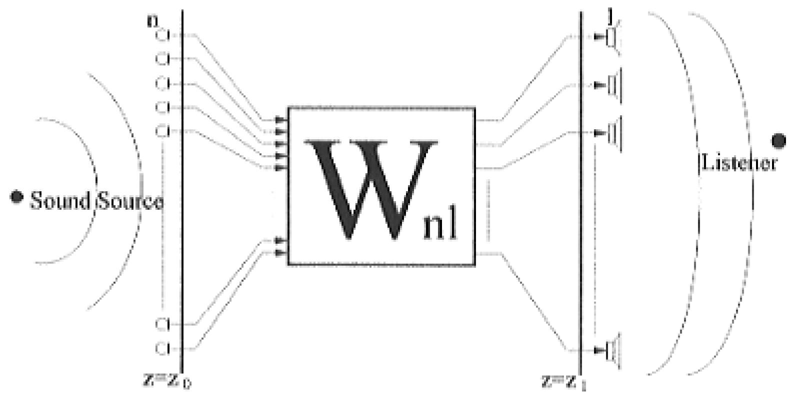

Fig.3 Simplify of wave front synthesis

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.

4. EXPERIMENT

An experiment was done with this technique by six loudspeakers of the front wall and of the right side wall. And the real time convolver was used.

We measured the distribution of the virtual image sources in Aichi Art Concert Hall.

Figure 4(a) 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.

Figure 4(b) shows the distribution of the virtual image sources of the reconstructed sound field. The distribution is quit similar to the original one.

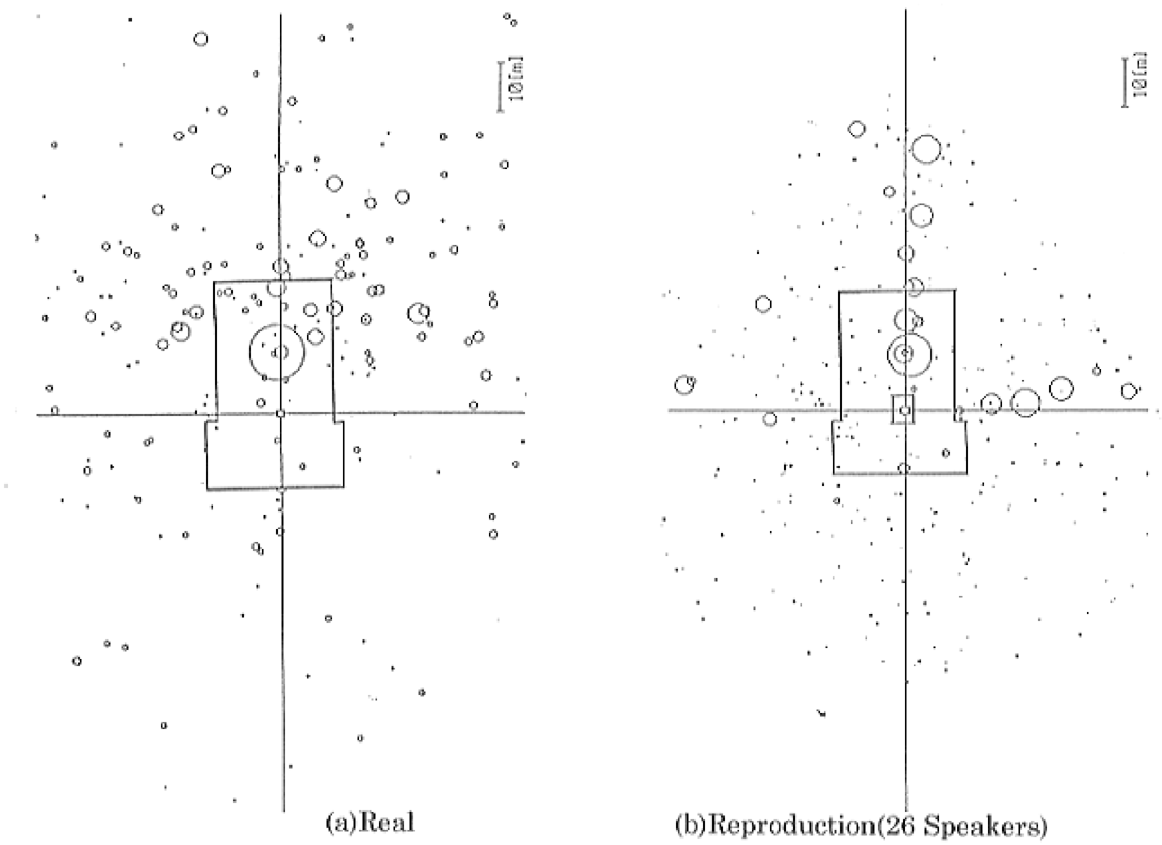

Fig.4 Distribution of virtual image sources

5. CONCLUSIONS

We propose the new method of sound field reconstruction 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 the 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.

RBFBRENCE

1) N.Aoshima, "Computer-generated pulse signal applied for sound measurement," J.Acoust.Soc.Am 69, 1484-1488(1981)

2) Y.Yamasaki and T.Itow, "Measurement of spatial information in sound field by closely located four point microphone method," J.Acoust.Soc,Jpn(E), 10, 101-110(1989)

3) A.J.Berkhout, D.de Vries and P.Vogel.Acoustic Control By Wave Field Synthesis", J.Acoust.Soc.Am.(1993)

4) A.J.Berkhout, Marinus M.Boone and Diemer de Vries "Generation Of Sound Fields Using Wave Fields Synthesis, An Overview", Active 95(1995)