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Study on Underwater Multiple Acoustic Lens Performance Evaluation by Integral Projection
投影積分による複合水中音響レンズの性能評価の検討

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1. Introduction

For underwater imaging, we developed an underwater video camera[1]. The camera has a multiple acoustic lens (after here, lens), which are 280mm of apature and 1.33 of F-number[2]. But the lens diameter is too long to measure direct at our small tank[3].

Therefore, the lens was mounted on the camera which has a receiver array. The lens performance was measured by the receiver array, which is vertically-arranged 128 receivers whose shape are long and thin. That is, it is difficult to measure precise performance of the lens. Because the recievers are 1.7 mm spaced one-dimensional array. Then this paper reports that we studied the lens performance by integral projection method.

In addition, if you would like to see underwater video and/or photo images by the camera, please refer the 4th reference.

2. Derivation of Acoustic Pressure Distribution on Image Plate by Integral Projection

To reconstruct of a target image from the target projection is an integral projection method that is used commonly by CT scan.

Here, the object image replaces to an acoustic pressure distribution on a image plate. And we assumed that the acoustic pressure distribution is an deal following Eq;

$$P(r) = J_1(r)/r \qquad (1).$$

And a projection of the acoustic pressure distribution is

$$P(r) = \sin r/r \qquad (2).$$

Fourier transform of Eq. (2) is placed at all angles, then 2-D Fourier transform of it reconstructs an original acoustic pressure distribution. Additionally, Eq. (2) also shows integrate shape (Eq. (3)).

$$Si(r) = \Sigma_r\, p(r) \qquad (3).$$

Here, in this study, measured acoustic pressure corresponds to Eq. (3). If we analyze them along flamed and polka-dotted allows in Fig. 1, then we get a integral projection of the lens acoustic pressure distribution.

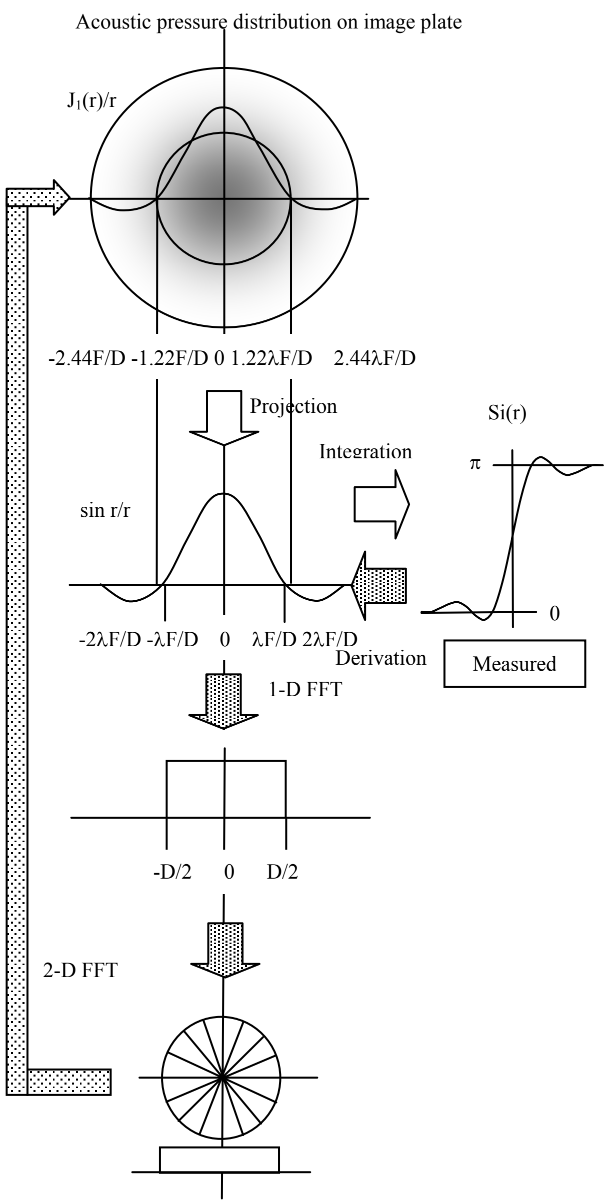

Fig.1 Acoustic pressure distribution on image plate by integral projection.

3. Multiple Lens and Measurement System

The multiple acoustic lens was composed from three lenses. A measurement system is shown in Fig.2. A source (RESON TC4034) transmitted burst wave at a frequency of 500 kHz, and the signal was received by the camera which put apart approximately 10 m from the source. The receiver array, which is vertically- arranged 128 receivers whose shape are long and thin. A tilt angle of the camera was able to be controlled. We measured it at each 0.1 degree between from 9.8 to 12.8 tilt angle.

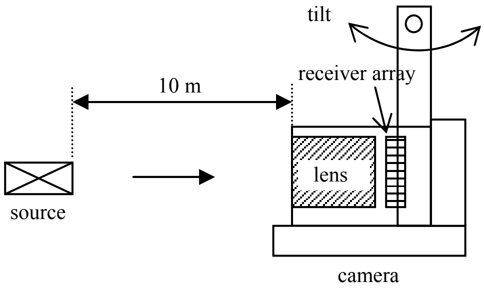

Fig.2 Measurement arrengement in a tank.

4. Results

We tried three ways. For comparison, the one was extremely simple that signals were received by each 128 receivers. Then it was acoustic pressure distribution on image plate shown in Fig. 3 described dotted line. The other one was signals were received by lower half part of receiver array, then those were integrated at each angle. Those data corresponded to Eq. (3) in Fig. 1. We differentiated it, the results shows in Fig. 3 described solid line. Dotted line dose not show a zero-point. Solid line showed ambiguously it. Both results were difficult to estimate the lens performance.

The third way is based on the integral projection. The data of solid line in Fig. 3 was analyzed along the flow chart in Fig.1, then a projection of acoustic pressure distribution on image plate shows in Fig. 4. From the result, a real diffraction limit of the lens is 1.07 deg. (one-side). On the other hand, a theoretical diffraction limit of the lens is 0.72 deg. (one-side). The width of real acoustic pressure distribution is 1.48 times as wide as ideal one. It means the real lens performance was lower than ideal.

5. Conclusion

We studied new technique based on integral projection method to evaluate an underwater multiple acoustic lens performance. Experimental acoustic pressure data were obtained in a tank, then

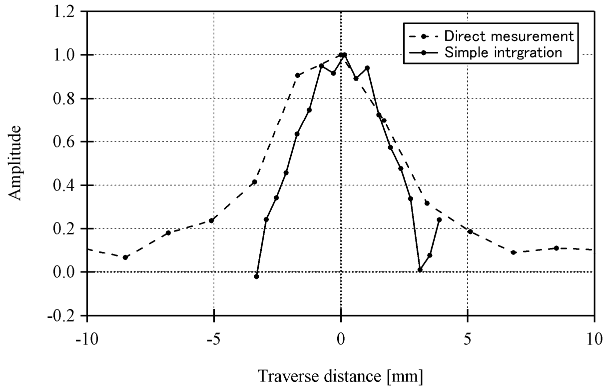

Fig.3 Comparison of simple measurement and integral signals.

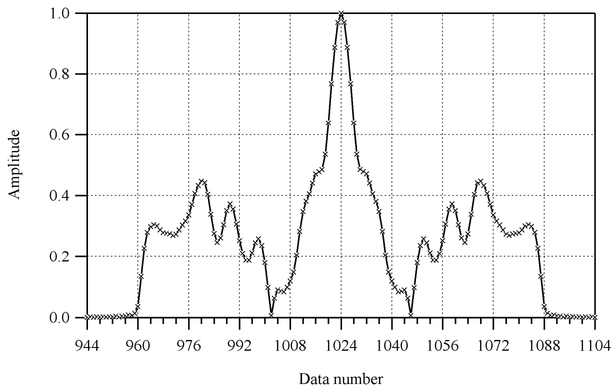

Fig. 4 Integral projection of the acoustic pressure distribution.

those data were analyzed. Our discussion concluded that the way is evaluating the lens performance.

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