Focusing Properties of Airborne Ultrasound Phased Array Using Time Reversal Method

時間反転法を利用した空中超音波フェーズドアレイの集束特性

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1. Introduction

We have studied non-destructive inspection using an airborne ultrasonic wave source scanning technique with an airborne ultrasound phased array(AUPA).

This study realizes a high-speed airborne ultrasonic wave source scanning by utilizing the high-speed focusing point movement of the AUPA.[1]

On the other hand, the AUPA has a problem that side lobes(SL) are generated. In addition, the AUPA a problem that deforms the sound wave focusing shape, along with the movement of the focusing point.

Here, there is time reversal method as a way to improve the above problem.[2]

In this study, we verified acoustic focusing and SL reduction using time reversal method by AUPA.

2. Focusing principle

Fig. 1 shows a schematic view of the use of time-reversal waves. The time-reversal wave is realized by the reception process and the transmitting process.

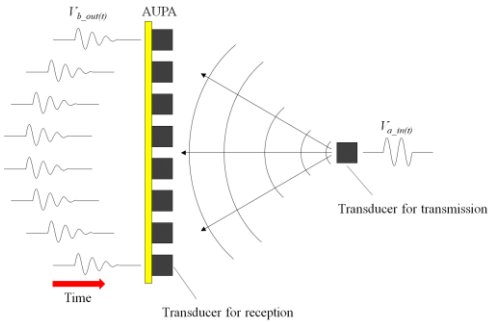
Fig. 1(a) shows the reception process. Sound waves are emitted from one ultrasound transducer (transmission). The sound waves are received by the AUPA having a plurality of transducers arranged. In addition, the signal received by each transducer is recorded as a received signal.

Next, Fig. 1(b) shows the transmitting process.

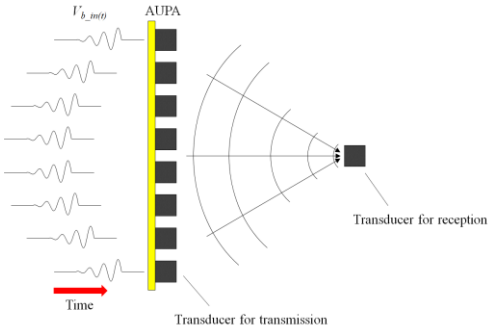
As shown Figure, in transmission process, the received signals recorded in the previous process are time-reversed and input to corresponding each transducers on AUPA. By the above process, the sound waves emitted from AUPA are focused on the point where the previous process transducer (transmission) was arranged.

3. Experimental apparatus and method

Fig. 2 shows the experimental device for the reception process. The device consists of AUPA,



(a) Reception process



(b) Transmission process

Fig. 1 schematic view of the use of time-reversal waves.

ultrasound transducer(UT1007-Z325R, SPL), A/D-Converter(USB-6356, NI), function generator(WF-1974, NF), and PC.

The experiment was performed according to the following procedure.

First, an input signal with an applied voltage of 20 V and a cycle number of 10 was input to the transducer, and a sound wave was emitted.

After that, the radiated sound waves were received by AUPA, and the received signal was recorded by a PC through an A/D converter(ADC). Here, the sampling frequency of the ADC was 350 kHz.

In this study, the distance between the transducer and AUPA was 100 mm.

Fig. 3 shows the experimental device for the transmitting process.

The device consists of AUPA, D/A converter(D-

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AC)(PX- Ie-6739, NI), 1/8 inch microphone(40DP, G.R.A.S.), measurement preamplifier(Type12AA, G.R.A.S.), precision stage(SG-SP46, SIGMA KO-KI), ADC(USB-6356, NI) and PC.

The experiment was performed according to the following procedure.

First, the time-reversal received waveform was input to the corresponding transducer and a sound wave was emitted.

Here, the sound pressure distribution of the radiated sound wave was measured by a microphone mounted on a precision stage.

The measurement range was 90 mm x 90 mm, and the measurement was performed in 2 mm steps. The distance between the microphone and AUPA was 100 mm. The sampling frequency of the D/A converter was 350 kHz. And the sampling frequency of the ADC was 1 MHz.

For the purpose of comparison, we also examined the sound wave focusing by phase control.

4. Experimental result

Fig. 4 shows the experimental results. The figures show the sound wave focusing result using the time-reversal wave and the sound wave focusing result using the phase control, respectively.

Both results are normalized by the maximum value of the amplitude of the sound pressure.

From the results, it can be confirmed that the periodicity of the SL is reduced in the time reversal method compared to the phase control. On the other hand, the focus diameter of the phase control is slightly smaller than that of the time reversal method. It is considered that this is the low waveform reproducibility due to the low sampling frequency of 350 kHz.

5.Conclusion

In this report, we investigated experimentally the acoustic focusing and SL reduction of AUPA using time-reversal wave. As a result, it was confirmed that SL regularity was reduced by using the time-reversal wave. However, it was confirmed that the focus diameter by the phase control was smaller than the time reversal method in terms of the sound wave focusing diameter.

Acknowledgment

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References

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2. Mathias Fink et al 2000 Rep. Prog. Phys. 63 1933

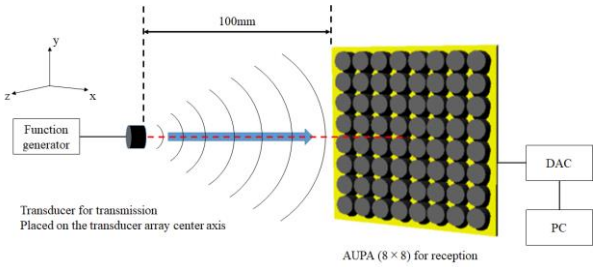


Fig. 2 experimental device (reception process).

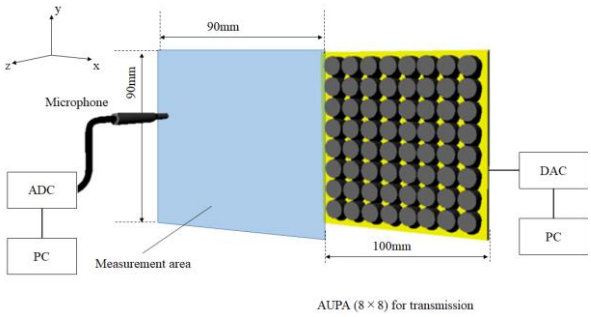
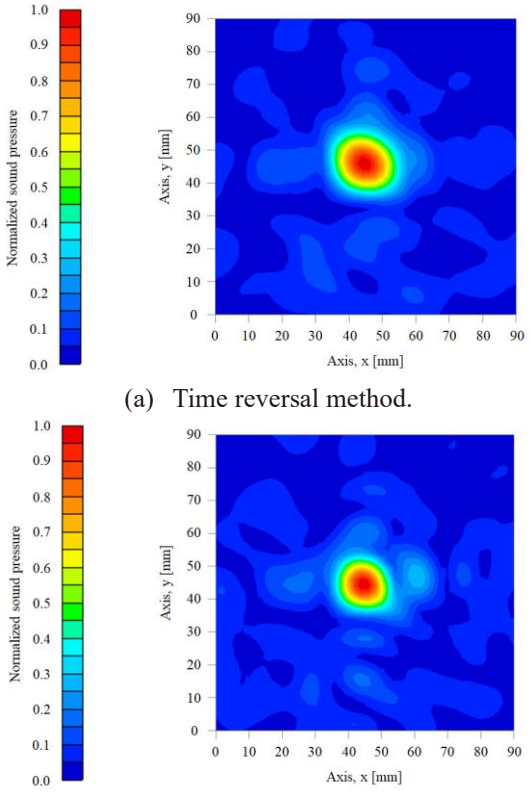


Fig. 3 experimental device (transmission process).



(a) Time reversal method.

(b) Phase control method.

Fig. 4 Sound pressure distribution around focus area.