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Time Reversal Simulation for Underwater Acoustic Communication

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1. Introduction

Acoustical time reversal mirror principles are described in review papers of M. Fink, the inventor of TRM, and his associates [1]. In Recent Choi carried out the study of the waveform and spatial focusing experiment [2].

In this paper it is considered the approach to predict TRM parameters based on the calculations of impulse response from underwater acoustic ray model(Bellhop) in shallow water.

Acoustic TRM(Time Reversal Mirror) is useful tool for sound focusing and sound source localization. TRM simulation is carried out to send the high acoustic energy to a sound source location in shallow water for underwater acoustic communication. An ideal TRM simulation is compared with the experimental simulation using the field data of shallow water in Korea.

2. Comparison of Simulation with Experiment

It is used the Bellhop acoustic ray model For simulation in shallow water condition for acoustic wave. It is extracted the impulse response from the acoustic propagation model. The source frequency is 200 Hz of Gaussian Envelop. Using the impulse response signals and time reversed signal from the Model, it can be got the TRM refocusing at source target position for underwater acoustic communication.

Figure 1 shows the source target signal (e), impulse response function (h) and received signal (s) estimated by acoustic model in shallow water condition. From the convolution of the impulse response and time reversed signal, we can get the focusing signal at target location.

Figure 2 shows the Schematic diagram of time reversal acoustic experiment in shallow water. We used three receivers(SRH) at depths of 10 m, 35 m and 60 m. Sound source is used a breaking bulb system at depth of 30 m. Maximum horizontal range is 10 km. Water temperature is measured by CTD as shown in Fig. 3.

Figure 4 shows the time reversal process using real signal with ocean experiment.

For TRM simulation, 3-elements hydrophone array are used as a re-emitted source at 0 m range. When the time reversed signal be re-emitted at hydrophone array position, we can simulate the spatial focusing effects at the position of source as shown in Figs 5~8. In here the source localization is not perfect because of TRM using a few numbers of hydrophones. Figure 9 shows a comparison for sound refocusing simulation about two source depth(10 m and 60 m) by time reversal technique at source target depth 30 m, 2.2 km range

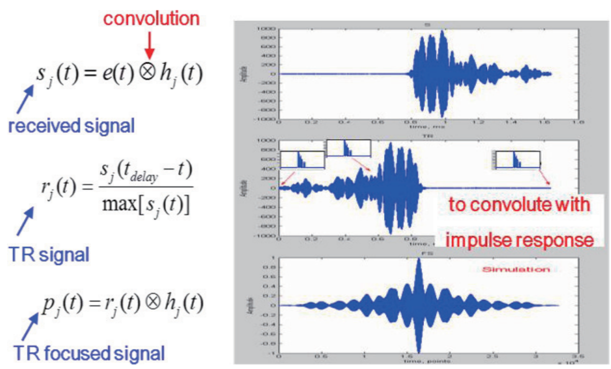

Fig.1. Principle of time reversal technique.

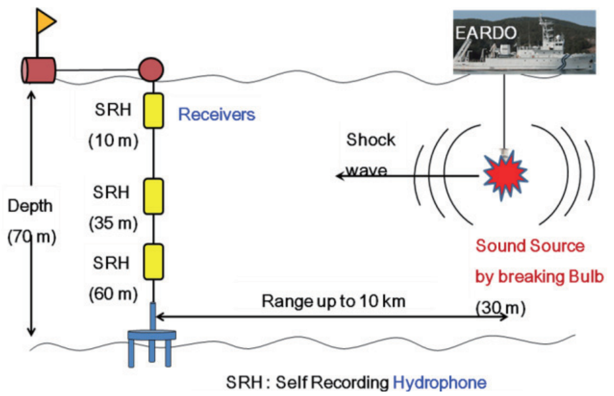

Fig. 2. Schematic diagram of time reversal acoustic experiment in shallow water.

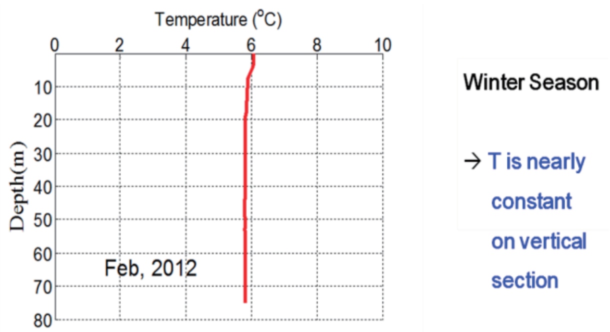

Fig. 3. Water temperature measured by CTD in shallow water.

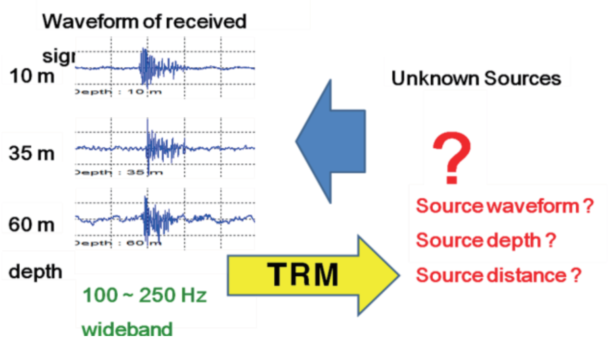

Fig. 4. Time reversal process using real signal with ocean experiment.

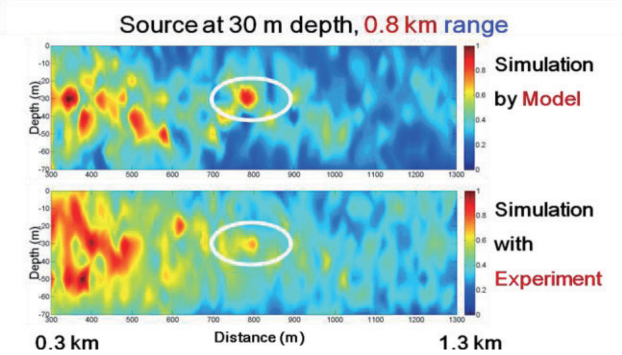

Fig. 5. Sound refocusing to source location by time reversal technique at source target depth 30 m, 0.8 km range.

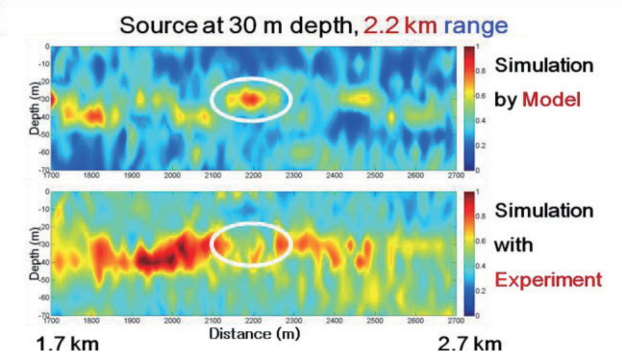

Fig. 6. Sound refocusing to source location by time reversal technique at source target depth 30 m, 2.2 km range.

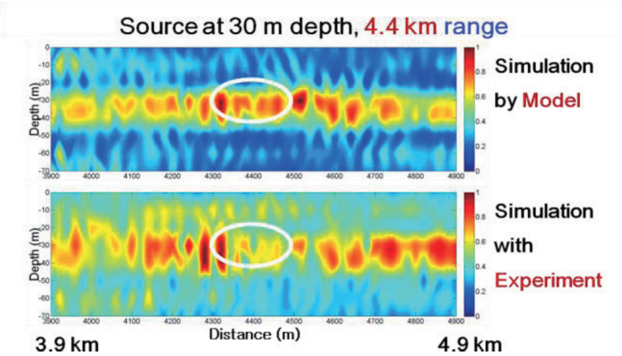

Fig. 7. Sound refocusing to source location by time reversal technique at source target depth 30 m, 4.4 km range.

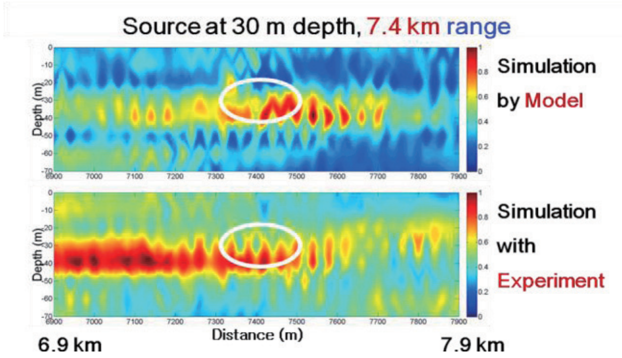

Fig. 8. Sound refocusing to source location by time reversal technique at source target depth 30 m, 7.4 km range.

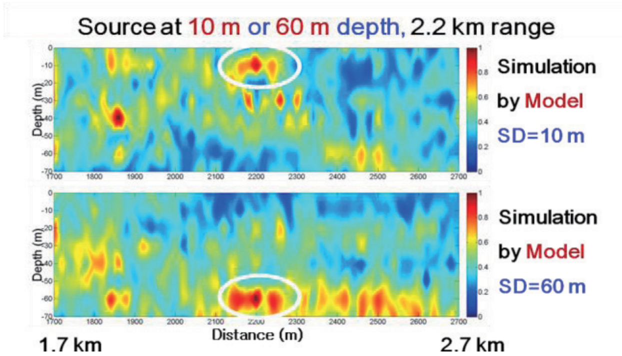

Fig. 9. Comparison for sound refocusing simulation about two source depth(10 m and 60 m) by time reversal technique at source target depth 30 m, 2.2 km range.

3. Conclusion

We simulate TRM focusing at the source location by time reversal algorithm. In result, the source localization can be built by TRM simulation using experimental signals for shallow water condition. But, the experimental simulation is not perfect as well as an ideal cases because of variation of real condition in shallow water.

Acknowledgment

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References

1. M. Fink, Time reversed acoustics, Scientific American, November (1999) 91-97.
2. B.K. Choi, B.C. Kim, A. Sutin, A. Sarvazyan, Ultrasonic focused waveform generation using time reversal acoustic focusing system, J. Mech. Sci. & Tech. 22 (2008), 699-707.