2P6-2

Proceedings of Symposium on Ultrasonic Electronics, Vol. 33 (2012) pp. 259-260
13-15 November, 2012

Time-Varying Underwater Acoustic Channel Characteristics in Shallow Water

HyunWook Moon[1], Woojoong Kim[1†], Jungsoo Park[2], and YoungJoong Yoon[1]
([1]Dept. of Electrical and Electronic Eng., Yonsei Univ.; [2]Agency for Defense Development, Korea)

1. Introduction

Underwater acoustic sensor networks (UW-ASNs) are interested increasingly since they have the potential to enable unexplored applications, such as an environmental monitoring, disaster prevention, a distributed tactical survaeillance, and so on[1)]. These applications are realized in shallow water with communication technology at high frequency bands. In this situation, an ocean is a dynamic medium such that the multi-paths with surface and bottom boundaries in shallow water have a random process. This time-varying underwater acoustic channel characteristic is very important in communication performance, however, few related work is investigated[2)]. Especially, the random process of surface/bottom bounce wave has a noncoherent component. Because this random and noncoherent component can not be modeled by theoretical method, a statistical approach has to be necessary to model the time-varying underwater acoustic channel.

in this study, we conduct an experiment at shallow water in Korea and analyze the random characteristic of multi-path waves. Then, the probability density function (pdf) is extracted for amplitude and phase of multi-paths to model the time-varying channel for underwater acoustic communication in shallow water.

2. Experimental Set-up and Environments

In order to analyze the time-varying underwater acoustic channel characteristics in shallow water, the experiment is performed at south sea of Korea in May, 2012, with an experiment set-up as shown in **Fig. 1**. This area has an about 45m water depth and is selected to consider shallow water. And the locations of transmitter and receiver are selected to take into account various scenarios in UW-ASNs. The wind speed, which influences on the random process of a surface bounce wave, is very important environment parameter. In **Fig. 2**, the wind speed profile is shown. The wind speed is measured at an interval of 1 minute and the pink box represents the experiment time. The wind speed has a variation from 5m/sec to 10m/sec.

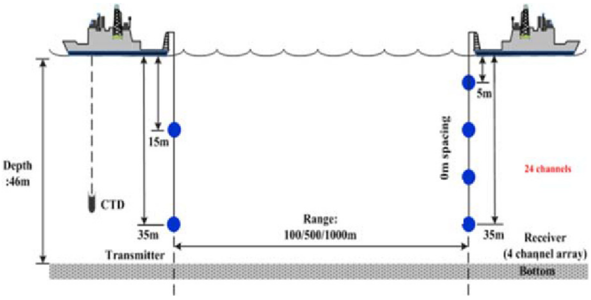


Fig. 1 Experiment scenario and set-up.

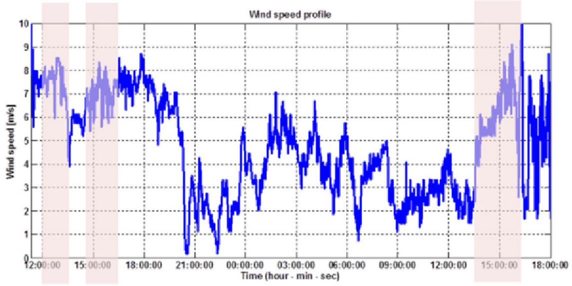


Fig. 2 Wind speed profile

3. Results of time-varying characteristics of multi-path in underwater acoustic channel

A linear frequency modulation (LFM) signal is used to extract the channel impulse response in the experiment. This LFM signal has 15kHz center frequency and 4kHz bandwidth. And a guard time between LFM signals is 255 milliseconds and sampling frequency is 150kHz.

Fig. 3 represents the measured channel impulse response at range 100m. As shown, the channel impulse response is composed by multi-path waves such as direct wave, surface bounce wave and bottom bounce wave, etc. Thus, the channel impulse response can be given by below equation.

$$h(t,\tau_i)=\sum_{i=1}^{N}A_i\exp(j2\pi f\tau_i+\phi_i) \qquad (1)$$

where A_i, τ_i, ϕ_i are an amplitude, a delay, and a phase, respectively.

---

mhw0329@yonsei.ac.kr

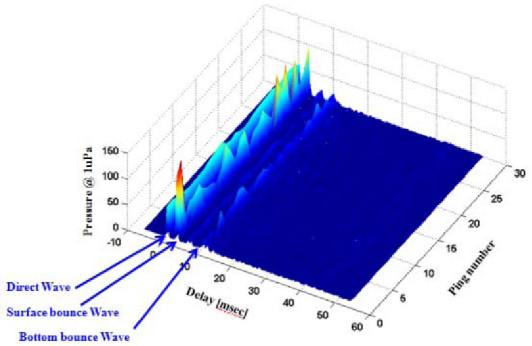
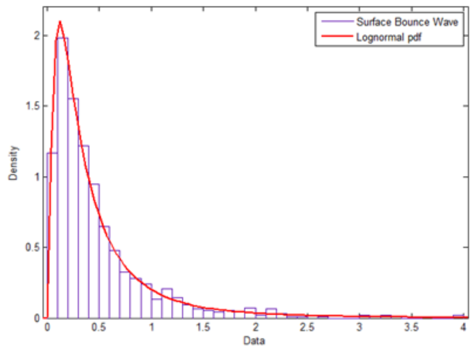
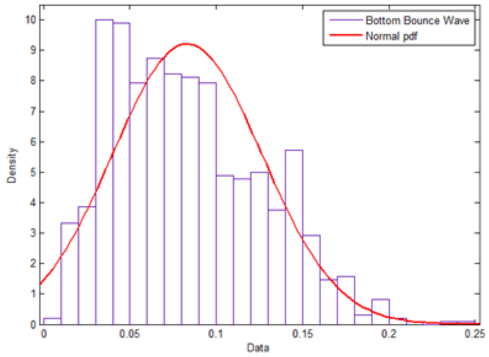


Fig. 3 The measured channel impulse response (Tx depth: 35m, Rx depth: 5m, Range: 100m)

As shown in equation (1), the amplitude, delay, and phase are important parameters to model the channel impulse response. Especially, the amplitude and phase have a random characteristic for the surface/bottom bounce wave and this causes the time-varying characteristics of underwater acoustic channel. Therefore, the pdf of amplitude and phase of surface/bottom bounce wave is extracted and analyzed by curve fitting as shown in **Fig. 4** and **Fig. 5**. As a result, the amplitude of the surface bounce wave has a log-normal distribution and that of bottom bounce wave has a normal distribution. And the phases of both waves have a uniform distribution.

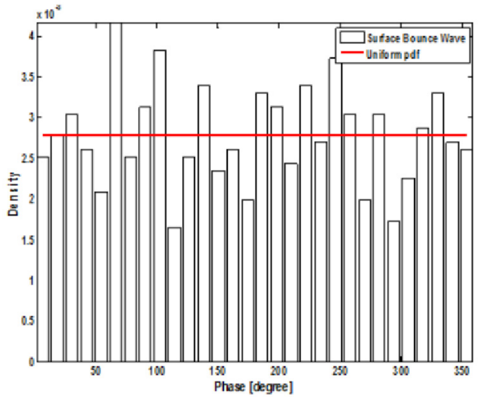


(a) Surface bounce wave

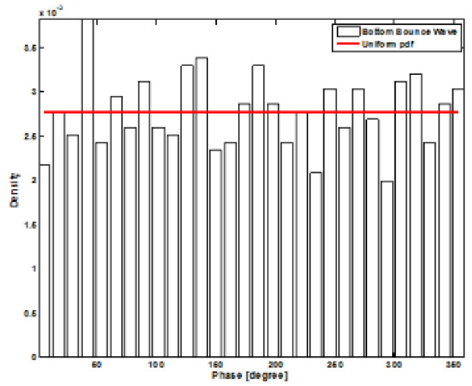


(b) Bottom bounce wave

Fig. 4 The pdf of amplitude for (a) surface bounce wave and (b) bottom bounce wave



(a) Surface bounce wave



(b) Bottom bounce wave

Fig. 5 The pdf of phase for (a) surface bounce wave and (b) bottom bounce wave

4. Summary and Conclusions

In this study, the statistical property of the surface/bottom bounce wave, which are dominant for the time-varying underwater acoustic channel characteristics in shallow water, is extracted and analyzed. Since this property is very important for the time-varying channel impulse response, this study be able to be useful with the various works related to the communication technology in shallow water.

Acknowledgment

This work was supported by Agency for Defense Development, Korea (UD100002KD)

References

1. P. Nicopolitidis, G.I. Papadimitriou and A.S. Pomportsis: IEEE J. Oceanic Eng. **35** (2010) 623.
2. T. Ebihara and K. Mizutani: Jpn. J. Appl. Phys. **51** (2012) 07GG04.