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# Signal feature extraction and detection for snapping shrimp noise

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## 1.Introduction

In UWA communication, OFDM is one of widely used communication methods for fast data transmission. Additive snapping shrimp noise(SSN) prohibits reliable UWA communication because of its impulsive signal features. For the reliable OFDM communication, the detection and mitigation of the SSN effect are needed[1~3].

Impulsive SSN signal contains from low to high frequencies and can be easly distingushed from the limited bandwidth communication signal by the frequencies. High pass filter was developed to extract the SSN from received communication signal and a hard threshold method was utilized to detect the SSN[1,2]. Since the hard threshold does not reflect the variation of background noise level, a constant false alarm rate(CFAR) was researched to automatically detect the SSNs from vaiable background noise level. A band stop filter had been developed to extract more impulsive SSN features than the high pass filter. However, these methods may not detect weak SSN because these methods are based on simple frequency filtering of the SSN, and may not precisely detect the SSN[3].

In this paper, a novel SSN detection is proposed by SSN feature extraction.The detection performance of the proposed method is presented and compared with the conventional SSN detection methods.

## 2. Snapping shrimp noise feature and detection method

The SSN is produced from popping bubbles when the claws of the snapping shrimp snap shut[3]. The sound patterns or signal features of the SSN can vary with the size of bubbles. Thus, it can be modelled by the size of bubbles. The relationship between sound pressure and the size of the bubble is found by Rayleigh-Plesset equation, which is written by following equation

$$P_s(r,t) = \frac{\rho R}{r}(2\dot{R} + \ddot{R}) \quad (1)$$

Where $R$ denotes the diameter of the bubble, and $\dot{R}$ and $\ddot{R}$ denote the first and second derivatives of $R$, respectively.

An example of the SSN by equation (1) is drawn in Fig. 1 (a) and a practical recorded SSN is also shown in Fig. 1 (b). As seen in Fig. 1(a) and (b), two figures show similar signal patterns which consists of a large peak and tail peaks with smaller amplitudes. These modelled SSNs can be utilized for basis functions which extract the existence of the SSN in the received UWA communication signal.

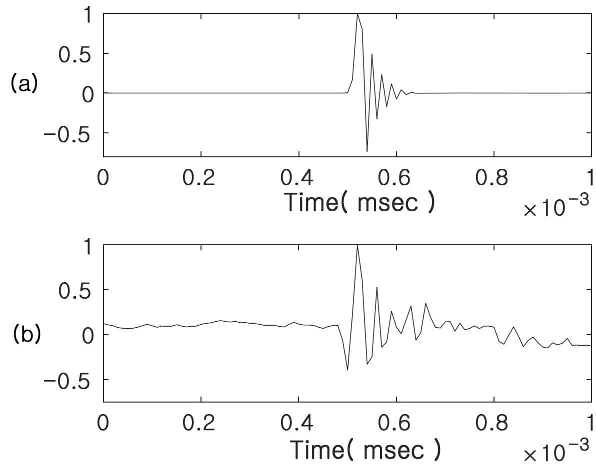


Fig. 1 Modelled SSN signal (a), actual recorded SSN (b)

In general, signal extraction method based on the correlation provides better performance than simple frequency filtering schemes. The correlation with the SSN extracts the degree of matching of the SSN in the received communication signal. Thus, even though the SSN is added with a small signal level, the correlation can extract the existence of the SSN.

In this paper, the SSN extraction and detection method is proposed. The proposed method extracts the SSN using the correlation with the modelled SSNs and detects the existence with a CFAR detector. First, in order to extract the SSN, several SSN models based on different sizes of bubbles are utilized. Since the proposed SSN extraction utilizes the correlation between some modelled SSNs and the received signals, the output of the correlation demonstrates the inner product output of the modelled SSN bases and effectively exhibits the existence of the SSN. If the SSNs exist in the received signal, the correlation shows large values, otherwise, small values. Second, based on the output of the correlator, the CFAR is utilized to automatically detect the existence of the SSN from the output of the correlator. The detail content of the CFAR is described in reference 3).

## 3. Experiment and results

The proposed SSN detection method is tested with simulated and practically recorded signals. To demonstrate the advantages of the proposed detection method, the detection performance of the conventional band stop filter methods are also tested since the band stop filter shows better detection performance than the high pass filter[3].

For the simulation, OFDM signal occupies a bandwidth of 15.25~17.75kHz, and AWGN noise is added with 7dB SNR. 10 SSNs are randomly added with 0, -2, 7dB power ratios to the OFDM with AWGN noise. The added SSN time locations are shown in **Fig. 2(a)** and the detection results of the SSN aredisplayed in **Fig. 2(b)**.

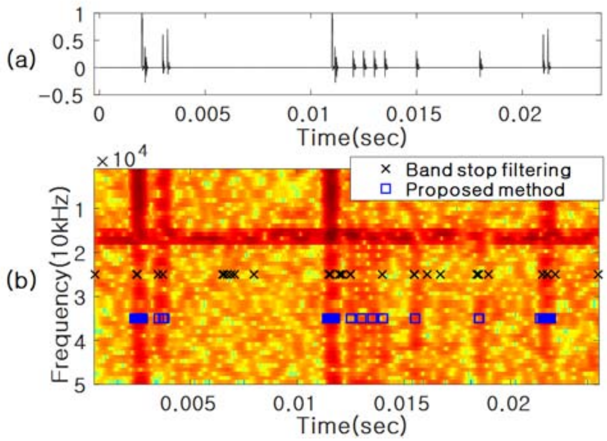


Fig. 3 Detection results of the SSN (a), SSN signal (b)

**Fig. 3(b)** shows the detection results of the proposed method and band stop filter method. The false alarm probability is set to be $5\times10^{-3}$ for all methods. Black × denotes the detection results of the band stop filtering and the blue rectangle denotes the detection results of the proposed method. In **Fig. 3(b)**, the band stop filter detects wrong time locations from 0.006sec to 0.007sec and 0.017sec, while the proposed method detects correctly without any errors. At 0.013sec, the band stop filter does not detect the existence of the SSN. However, the proposed method robustly detectsall SSNs. Thus, the proposed detection method exhibits better detection performance than the band stop filter.

For practical ocean experimental data test, SAVEX 15 data is utilized. **Fig. 4** demonstrates the SSN detection results of the proposed and the band stop filter methods. The false alarm rate is also set to be $5\times10^{-3}$ for all cases. In **Fig. 4**, the detection results of two methods are similar except 0.007sec and 0.016sec. The true existence cannot be determined, but the existence of the SSN at the time locations can be assumed by the frequency features of the spectrogram and hearing the recorded sound. The SSNs can be observed at 0.007sec and 0.016sec in **Fig. 4**. Thus, the proposed method provides better SSN detection performance than the band stop filter in the practical experiment data.

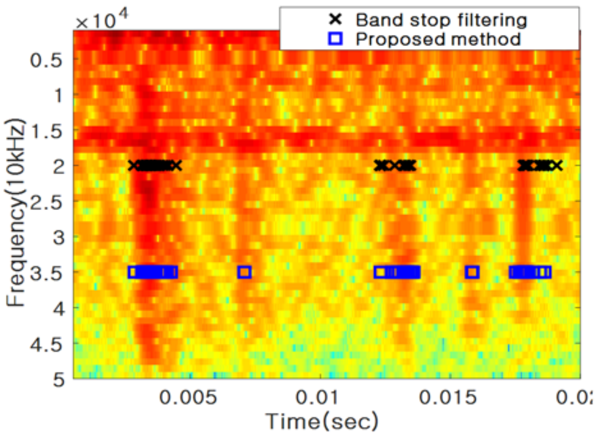


Fig. 4 SAVEX 15 SSN detection result

## 4. Conclusion

In this paper, we propose a method for extracting and detecting the SSNs in UWA communication signals. The proposed method extracts the SSNs using the correlation between the modelled SSNs and the received UWA communication signals, and detects the existence of the SSN using the CFAR detector. The detection performance is demonstrated by computer simulated data and practically recorded SAVEX 15 data. The proposed method exhibits better detection performance than the conventional band stop filter method.

**Acknowledgment**
This research was a part of the project titled "Development of Distributed Underwater Monitoring & control Networks," funded by the Ministry of Oceans and Fisheries, Republic of Korea.

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