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Proceedings of Symposium on Ultrasonic Electronics, Vol. 35 (2014) pp. 515-516
3-5 December, 2014

A Study for Improving SNR of Ultrasound Images using Amplitude and Phase Characteristics of Fundamental and Harmonic Components

基本波と高調波の振幅位相特性を考慮した超音波画像の SNR 改善手法の検討

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1. Introduction

Tissue harmonic imaging (THI) [1] is very usuful technique for improving quality of ultrasound image because THI has a high spatial resolution and less artifacts. However, the THI is susceptible to noise because intensity of second harmonic component is significantly lower than that of fundamental component.

To improve signal-to-noise ratio (SNR), a combination of THI and coded excitation has been investigated[2]. The coded THI uses a long coded signal, receives the reflected signals, and decodes a harmonic component of the signals. This method can easily improve its SNR.

A method of reducing noise in coded THI while maintaining the spatial resolution has also been proposed by Yamamura et. al [3]. This method stably estimates the auto-correlation function (ACF) of a second harmonic component using that of a fundamental component and uses the estimated signal as prior information for a posteriori (MAP) estimation. However, this method did not consider phase shift of harmonic component generated in passing through a medium[4,5].

In this study, a method that uses the MAP estimation with compensating the phase shift in coded THI, was proposed. To evaluate the method, in vitro experiment were conducted.

2. Method

Figure 1 illustrates the block diagram of the measurement system. A waveform was generated by an arbitrary waveform generator (Agilent, 33522A), amplified by a power amp (Thamway, U145-5046A, 100 W), and excited by a single transducer (Olympus, V312, center frequency 10 MHz, diameter 6.35 mm, focal length 42.5 mm) through a matching circuit (Thamway).

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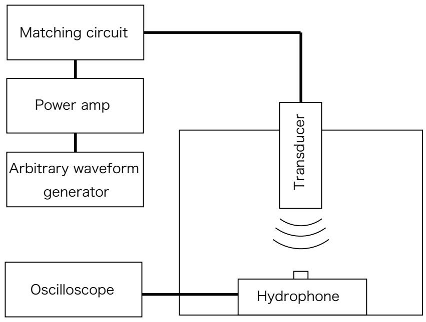

Fig.1 Block diagram of measurement system.

The excited ultrasound propagated water and was received by a hydrophone (ONDA, HMB- 0500, frequency 0.5–45 MHz) at distances of approximately 15–68 mm and digitized by a digital oscilloscope (Teledyne LeCroy, HDO4034, sampling time 2.5 GSa/s).

A linear up chirp was used as a transmitted signal. The starting frequency was 7 MHz, the final frequency was 13 MH, time duration was 10 μs, and the Hanning window was applied to the chirp signal. The value of the maximum negative pressure of excited chirp was approximately 0.2 MPa; therefore mechanical index was approximately 0.06.

Two matched filters decoded the obtained echo signal; one was the same as the transmitted chirp signal, and another was twice the frequency (14-26 MHz) and the same time duration (10 μs) chirp.

By regarding noise and signals as stochastic process, MAP method can be applied. The obtained second harmonic signal g is expressed as follows:

$$g = Ch + v, \quad (1)$$

where the diagonal terms of matrix C means a harmonic carrier signal, h is a second harmonic envelope signal, and v is the Gaussian white noise. The MAP estimator for the second harmonic imaging h_{THI} is expressed as follows:

$$h_{THI} = (\frac{1}{\sigma^2} C^T C + P R_h^{-1})^{-1} (\frac{1}{\sigma^2} C^T g + P R_h^{-1} h_m) \quad (2)$$

where σ is the standard deviation of v, the diagonal matrix P is attenuation characteristics of the harmonic echo, R_h is the variance-covariance matrix of h, and h_m is average of h.

3. Results

Figure 2 illustrates a waveform propagating a distance of approximately 22.5 mm, and its frequency spectrum. The envelopes of decoded waveforms using the waveform propagating a distance of approximately 22.5 mm, is shown in **Fig. 3**. Time difference between peaks of two envelopes with various propagation distances is shown in **Fig.4**. It is clear that the shift of peaks between decoded signals of fundamental and harmonic components occurs. **Figure 5** describes the envelopes of conventional and proposed signals.

4. Conclusion

In this study, a method that uses the MAP estimation with compensating the phase shift in coded THI, was proposed. Through *in vitro* experiments, it was shown that the proposed method had a potential to improve image quality.

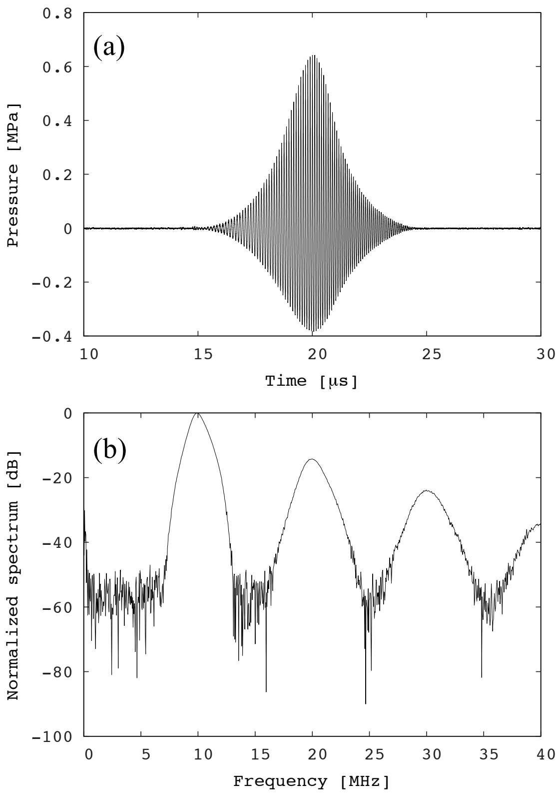

Fig.2 (a) A waveform propagating a distance of approximately 22.5 mm, and (b) its frequency domain.

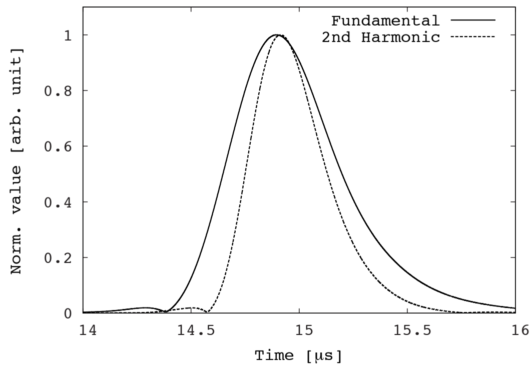

Fig.3 Envelopes of decoded waveform.

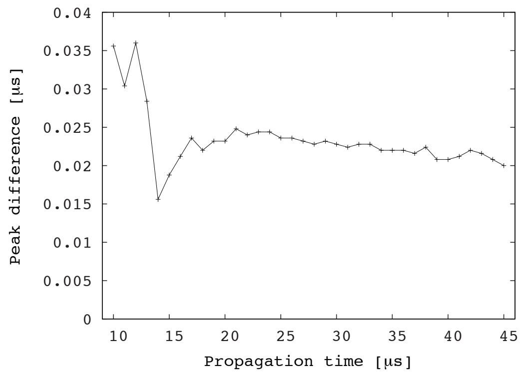

Fig4. Time difference between peaks of fundamental and harmonic components.

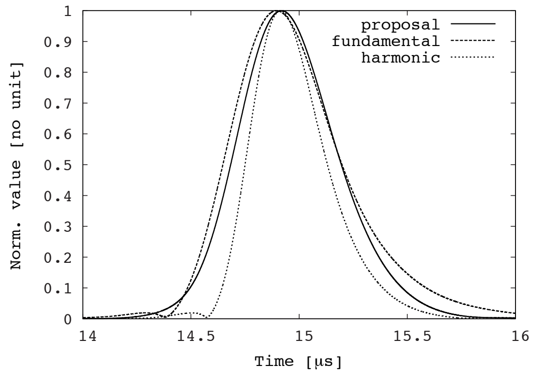

Fig.5 Envelopes of proposed (solid), fundamental (broken) and harmonic (dashed) signal.

Acknowledgment

This work was supported by JSPS KAKENHI Grant Number 24760318.

References

1. M.A.Averkiou, D.N.Roundhill and J.E.Powers: Proc. IEEE Ultrason. Symp., **2** (1997) 1561.
2. M. Tanabe, T. Yamamura, K. Okubo and N. Tagawa: Jpn. J. Appl. Phys. **49** (2010) 07HF15.
3. T. Yamamura, M. Tanabe, K. Okubo and N. Tagawa: Jpn. J. Appl. Phys. **51** (2012) 07GF01.
4. S. Saito and B.C. Kim: J. Acoust. Soc. Am. **82** (1987) 621.
5. S. Saito and H. Tanaka: J. Acoust. Soc. Jpn. (E) **11** (1990) 225.