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A Study on Speckle Suppression by Stochastic Vibration of Ultrasound Transducer

超音波探触子の不規則振動を利用するスペックル抑圧に関する研究

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1. Background, Motivation and Objective

Diagnostic imaging by ultrasonic echo is widely used such as abdominal ultrasonography. In order to detect small tumors, we need to get more high-definition images. In this study, we propose a method to reduce noise in ultrasonic echo image. In particular, speckle pattern is generated by the interference of the reflected wave from small scattereres along the propagation path of transmitted ultrasonic beam. Speckle pattern is sometimes useful on the diagnosis. However, if the speckle pattern hides the targets required to be imaged, it has become one of major factors which degrade the image quality of ultrasound images.

Typical methods for speckle suppression can be categorized as the frequency compound method or the direction compound method. The first method, which uses several echoes measured in the different frequency bands, causes image distortion, if the reflection of the imaging target has a frequency dependent characteristic. The second method, which uses several echoes measured from the different beam directions, needs the movable scope for a transducer on the surface of an imaging target. On the other hand, realization of the mechanism of stochastic resonance (SR) in engineering has been variously studied [1,2]. SR can be viewed as a noise-induced enhancement of the response of a nonlinear system to a weak input signal, and naturally appears in many neural dynamics processes. In this study, we propose a new method based on SR to solve the problems of the conventional methods.

2. Method

In the method, the fluctuation of a speckle pattern is caused by placing a water layer between an imaging target and a transducer and vibrating a transducer toward the direction of transmitting and receiving. We assume here that there is no distortion of the imaging target, and such the distortion will be considered in the future work. To suppress only speckle and to preserve desired signals, a signal averaging should be applied to the observed multiple echoes after performing time shift of the echoes to compensate the transducer's vibration. The fluctuation of the speckle can be used also for the measurement of the transducer's vibration. In this study, for the purpose of confirming the degree of speckle's fluctuation, i.e., the ideal performance of the speckle suppression of our method, we use the exact values of the transducer's vibration known as the simulation data for the proper time shift of the echoes.

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3. Simulation

We confirmed the feasibility and the effectiveness of the proposed method through simulations using PZFlex, a standard code for FEM. **Fig. 1** describes the simulation model used in this study. We put a tumor in a liver tissue in the simulation model that assumes in the body.

In this simulation, sound velocity of water is 1500 m/s, density of water is 1000 g/cm^3, sound velocity of the liver tissue is 1567-1587 m/s, density of the liver tissue is 953～973 g/cm^3, sound velocity of the tumor is 1600 m/s and density of the tumor is 1000g/cm^3. Imaging area is shown in the **Fig. 1** with a red square.

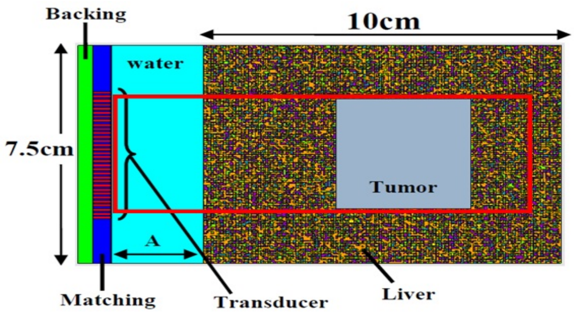

Fig. 1: Simulation model mimicking living body.

The ultrasonic transducer in **Fig. 1** consists of 32 elements of a PZT, and the focal point of it is 10 cm. An example of the transmitted signal is shown in

Fig. 2, and is the Hamming weighted pulse, which has a center frequency of 5 MHz and consists of 5 cycles. The amplitude voltage is 200V.

In this study, the distance between the transducer and the surface of a body is changed by vibrating a transducer, i.e. the thickness of the water layer (indicated with A in Fig. 1) is varied with the width of 1.0-2.5cm. Although the vibration pitch should be randomly changed for each transmitting and receiving in actually, in this study to simplify the simulation, we make the vibration pitch constant and the value of it is 0.1cm. Adittionally, since we assume that the thickness of the layer of water is known here, we can calculate the time-shift which is applied to the echo signals to compensate the transducer's vibration in advance using the sound velocity of the water. A lot of echo signals received by changing the transducer's position are averaged with the correct time shift to suppress speckle patterens.

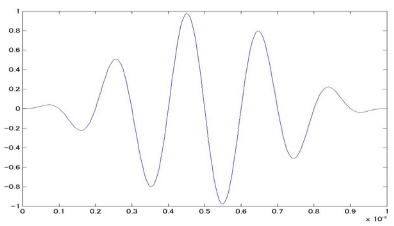

Fig. 2: Transmitted signal.

4. Results and discussion

By varying the vibration width, the performance of the speckle suppression was observed. As a result, we confirmed that, the wider the transducer is vibrated, the more strongly the speckle suppression is carried out. The RF echo signal obtained by our method is shown with the signal without speckle suppression in **Fig. 3**. Additionally, a decibel representation of the envelope signal corresponding to Fig. 3 is shown in **Fig. 4**. From these figures, we can clearly confirm the speckle pattern supplession.

5.Conclusion

In this study, we confirmed that the stochastic vibration of ultrasound transducer is available to the suppression of speckle patterns in principle. In the future work, we will examine the effectiveness of a random pitch of the transducer vibration instead of a constant pitch adopted in this study. Also, we are going to consider the automtic alignment of the echo data using the edge detection algorithm based on the stochastic resonance technique [2].

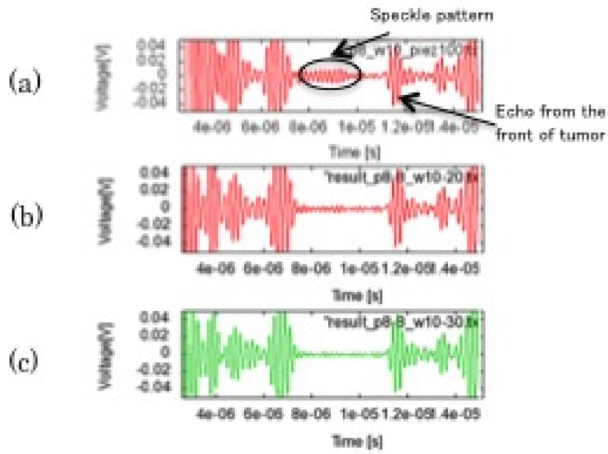

Fig. 3: RF echo signals before and after the proposed suppression; (a) without suppression, suppression result with the vibration width of (b) 1.0 cm and of (c) 2.0 cm.

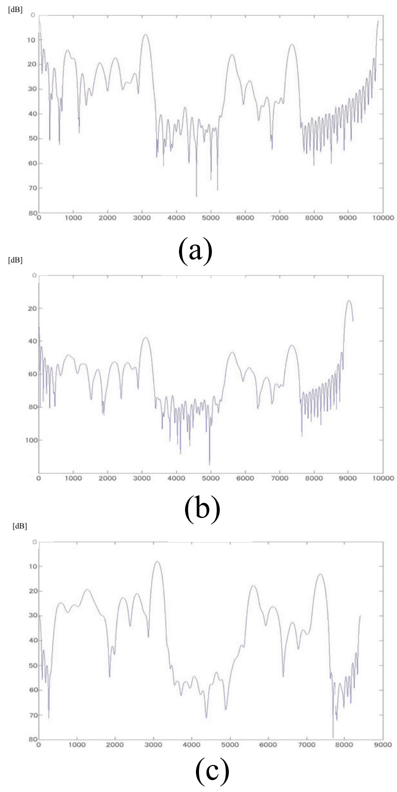

Fig. 4: Decibel representation of the envelopes corresponding to the RF echo signals in Fig. 3.

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References

1. M.-O. Hongler, Y. L. de Meneses, A. Beyeler, and J. Jacot: IEEE Trans. PAMI **25** (2003) 1051.
2. P. N. Prokopowicz and P. R. Cooper: *Int. Journal on Computer Vision* **16** (1995) 191.