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Applying Frequency Compound to Enhance Image Resolution of Single Integrated Irregular-Lens Oscillator

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1. Introduction

Ultrasound sensor has a free radiation and non-invasive feature that used in numerous applications. In medical application, an ultrasound imaging is used for diagnosing disease purpose by a doctor. Currently biopsy treatment is performed by removing a lesion or tumor from the human body and be observed under a standard microscope. The treatment makes an inconvenient situation to the patient. In this study, we apply ultrasound imaging for the biopsy treatment by applying in puncture microscopy type that enables to capture a small region of the human body. Therefore, the system should have features such as a small size, simple structure, and low-cost fabrication for widely mass useful purpose. The initial research in a puncture microscopy application was performed by [1].

Currently, beamforming technique is a famous method in generating an ultrasound imaging. It requires many sensors and complex system for generating an image [2][3]. For this reason, it is necessary to develop a simple structure that can conduct such application. Recently, structured ultrasound microscopy (SUM) was studied by employing single transducer [4][5]. Spatial coding was realized by the attached acoustic lens giving irregular aberrations to the transmitted and received waveform. It establishes a randomize wave propagation due to difference delay of transmission signal. We also applied frequency compound technique for increasing an image resolution to such system.

Table. 1 FEM Simulation parameters.

Parameters	Value
Number of mask patch	37
Randomized mask thickness	±0.837μm
Randomized mask width	0.2-0.3mm
Backing thickness	1.25mm
PZT thickness	0.12645mm
Center frequency of transmission signal	7MHz

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2. Method

The image model is defined by following equation.

$$Y = DX \qquad (1)$$

where Y represents set of echo signal and D is acoustic pressure in region of interest (ROI) with grid positions (x,y). The target image (X) was obtained by solving the linear equation of Eq. (1). The equation was applied to generate number of images with difference in frequency and angle of the transmission signal.

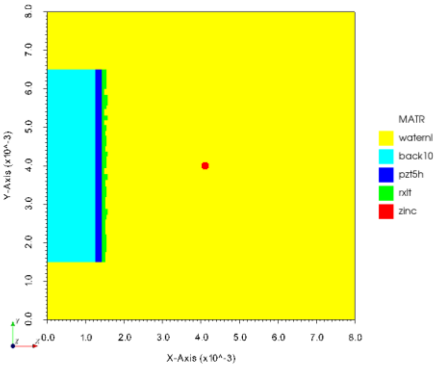
The constructed images was employed for enhancing the resolution of image target by applying frequency compound. The weight of frequency compound was computed by following equation.

$$W_F = \frac{R^{-1}1_L}{1_L{}^T R^{-1} 1_L} \qquad (2)$$

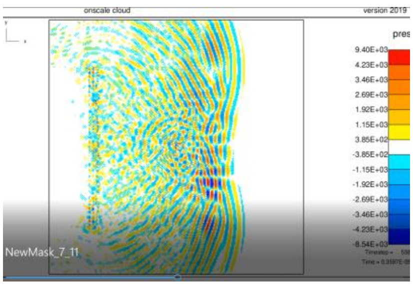
where R represents variance-covariance matrix.

3. Simulation Results and Discussion

The simulation model was conducted by Finite Element Method (FEM) OnScale. **Table 1** shows the parameters of simulation. The proposed model is shown in **Fig. 1(a)**. In this model, single transducer was used for transmitting a short pulse signal and receiving an echo with the same transducer from a target placed on the region of interest (ROI). In the system, irregular lens was placed in front of PZT for performing a randomized wave propagation due to its thickness. A snapshot of model simulation is depicted in **Fig. 1(b)**. In this study, two methods of frequency compound were applied for comparing the image resolution. Simple frequency compound was conducted by averaging of each pixel with difference frequency and angle of transmission signal.



(a)



(b)

Fig. 1 Simulation model; (a) proposed system consisting of single PZT with irregular mask; (b) snapshoot of simulation run by FEM.

The reconstructed image of simple frequency compound is shown in **Fig. 2**. The other method is weight frequency compound obtained by using **Eq. (2)** above. The clear difference of constructed image of both methods can be seen their amplitude profile as shown in **Fig. 3**. In order to integrate image with difference angles of transmission signal,

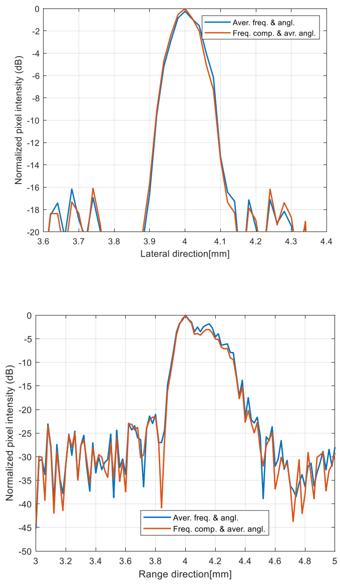
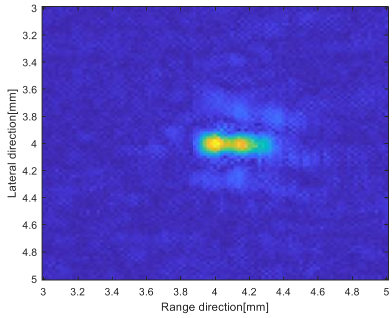
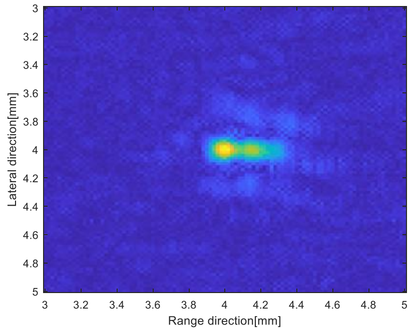


Fig. 3 Amplitude profile of simple frequency compound and weight frequency compound.



(a)



(b)

Fig. 2 Constructed images; (a) Simple frequency compound by averaging image pixel; (b). Applying weight frequency compound.

the averaging of each pixel was applied to it.

4. Conclusion and Future Works

We successful reconstructed ultrasound imaging of single PZT with irregular-lens. Resolution of target image improved by applying weight frequency compound compared to simple frequency compound. In the future, we will increase number of angles of transmission signal in order to enhance resolution in range direction.

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