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Synthetic Aperture Ultrasound Imaging using Coded-excitation and Harmonics Signal
波面符号化送信方式におけるハーモニックスイメージング

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1. Introduction

In the field of the clinical diagnosis, the ultrasound diagnosis device that observing the internal structure of the human body is spread In ultrasound images are included many speckle noise. The artifacts disturb to show structure of the human body definitely. To remove the artifacts, the harmonic imaging was researched.[1, 2] Because the pattern of the speckle noise is different for each images between using the fundamental wave and harmonic waves, the adding the intensity of fundamental image and each harmonic images reduce speckle noise.[3] This effect improves the dynamic range of ultrasound images.

The frequency compound method has been applied for the general B-mode ultrasound imaging, however the method is not applied for the coded-excitation ultrasound imaging system. Then, we research imaging the harmonic images and applying the frequency compound to the coded-excitation ultrasound imaging system.

2. Experimental

The condition of experiment is shown below. Transmit frequency is 1MHz, number of transmitter is32, and number of receiver is 29. The resonance frequency of transducer is 2.1MHz, and fractional bandwidth is 59.1%.

Here, we briefly introduce our imaging system. We have been developing an ultrasound imaging system adopting a combination of coded excitation and synthetic aperture focusing technique to image a three-dimensional image at high speed.[4-6] The system drives all the transmitters simultaneously with modulated waveforms using Walsh functions.

The object was a ball of a diameter of 30mm made with graphite powder and agar. Image volume size is 50mm×50mm×50mm. The distance of the center of image space and transducer was 110mm.

To obtain harmonics data, at first, the received echo is transformed to frequency domain by Fast Fourier Transform (FFT). Next, the echo signal is split into several harmonic bands and each harmonic images are reconstructed for each band using the transmitted code. We adopted the filter method; the frequency bands were as follows. The fundamental filter was 0.5MHz ~ 1.5MHz, the second harmonic filter was 1.5MHz ~ 2.5MHz, and the third harmonic filter was 2.5MHz ~ 3.5MHz, respectively.

3. Result and conclusion

Fig.1 shows the spectrum of the received echo calculated by Fourier transform. The third harmonic component can be recognized.

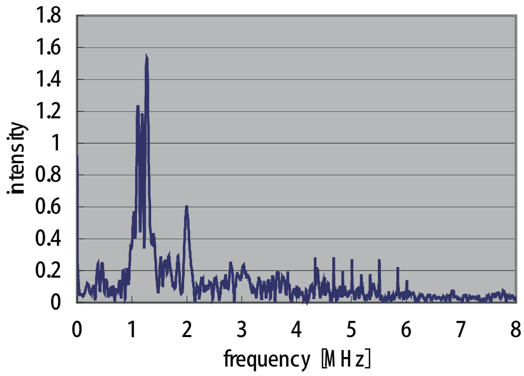


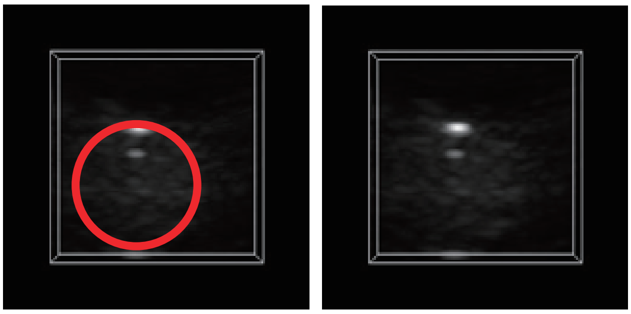
Fig.1 The spectrum of the received echo.

Fig.2 show the conventional (a), the fundamental (b), the second harmonic (c), and the third harmonic (d) images. The circle in (a) shows the circumference of the object. **Table.1** shows variance values normalized by average of the pixel intensity in the object.

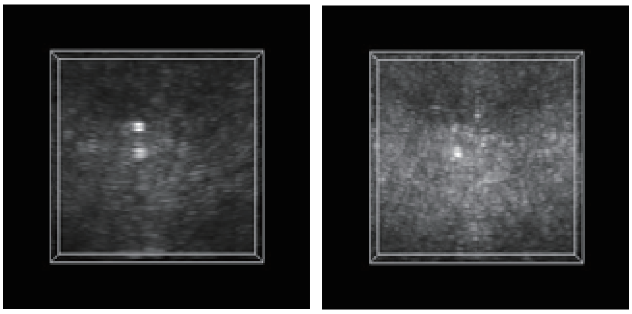
$$s^2 = \frac{1}{n}\sum_{i=1}^{n}\left(\bar{x} - x_i\right)^2 \qquad (1)$$

$$V_v = \frac{\sqrt{s^2}}{\bar{x}} \qquad (2)$$

where, n is the number of all pixels, $\bar{x}$ is average of the pixel intensity in the object.



(a).The conventional image (The circle shows the circumference of the object)　(b). The fundamental image



(b). The second harmonic image　(c). The third harmonic image

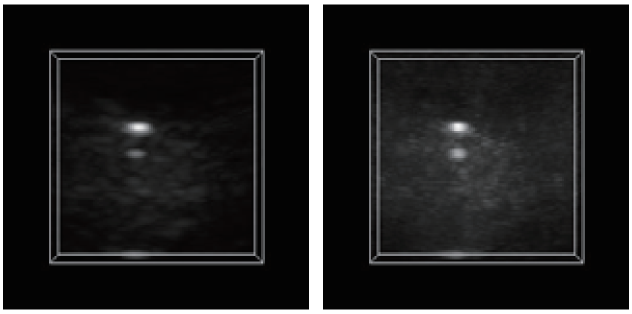
Fig.2 The fundamental image and harmonic images.

Table.1 Comparison of the variance value of the fundamental and harmonics.

Frequency ingredients	V_v
Fundamental	0.796
Second harmonic	0.577
Third harmonic	0.545

Fig.2 shows that the harmonic imaging succeeded in our imaging system. The second harmonic image shows the form of the object clearer than the fundamental image. But, even though the third harmonic image is low V_v, it is hard to observe the form of object, because the echo of the third harmonic is weak, and the whole image is smoothed.

Fig.3 shows conventional method image that was not split into harmonic bands (a) and the frequency compound image that adds the fundamental, the second harmonic and the third harmonic images with weighting (b). When the frequency compound image is constructed, intensities of harmonic images are multiplied by the weighting factor because harmonic images are weak signals. The multiplied rate of the fundamental, the second harmonic, and the third harmonic is $1:25:100$. **Table.2** shows comparison of the variance value of the conventional and the frequency compound method.



(a). The conventional method image　(b). The frequency compound image

Fig.3 The conventional method image and frequency compound image.

Table.2 Comparison of the variance value of the conventional and the frequency compound method.

Frequency ingredients	V_v
Conventional	0.793
Frequency compound	0.396

Fig.3 and Table.2 show that the frequency compound method improves the visibility of the object and smoothes brightness distribution than conventional method.

References

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