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High Sensitive Beamforming for Change of Tissue Scattering Property

散乱特性変化に高感度な新規ビームフォーミング手法の検討

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1. Introduction

Ultrasound scattering property of tissue is one of promising parameters representing tissue characteristics, especially it is considered as a suitable parameter to observe aggregation of red blood cells or disorder structure of tumor cells. In HIFU (High Intensity Focused Ultrasound) treatment, a coagulation monitoring is essential tool to achieve precise control of treatment. Tissue scattering property is considered to be different between before and after coagulation. Therefore, monitoring of tissue scattering property is one of promising methods to detect coagulated lesion after of during the HIFU treatment. In previous studies, frequency responses in echo signals have been investigated to analyze scattering property [1-3].

Recently, programable beamformers were developed and it was commercially available. By using these beamformers, we can research new beamforming method as an alternative to a traditional “delay and sum” method. In this study, directivity of back scattered signals are investigated to analyze scattering property.

2. Method

An amplitude profile on an array element is representing of directivity of scattering echo. Therefore, we investigated a matrix echo intensity profile as shown in figure 1. N is a number of element in an imaging array. To obtain this matrix, a round-trip echo sequence as shown in figure 2 was proposed to analyze scattering property of a point scatter. In this figure, D is a diameter of the point scatter.

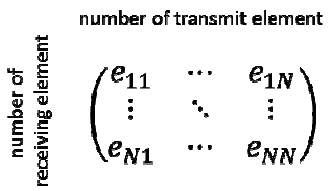

Fig.1 Scattering matrix

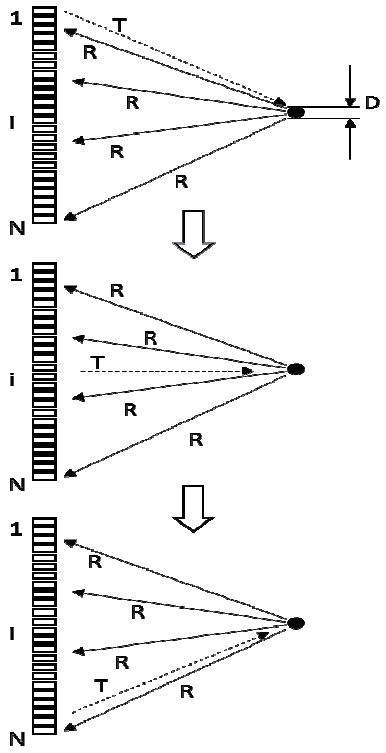

Fig.2 Estimation method of scattering matrix

In this study, scattering matrix obtained by an imaging array with the frequency of 7.5 MHz, the element number of 128, the element pitch of 0.2 mm was numerically calculated, under the condition of the distance between array and scatter was 30 mm. The diameters of point scatters were 20, 40, 80 and 160 mm. In continuous wave condition, the point scatters were divided to small elements and back scattered echoes from each elements in the point scatter were summed on the receiving element in the array.

3. Results and Discussion

Fig. 3 and 5 show calculated scattering matrices of single point scatter and multiple point scatters in the square area with the width of 0.5 mm, respectively. Fig. 4 and 6 show diagonal components of each case. Our proposed method has

high sensitivity to scatter size in the range from 20 to 160 (m. Since these sizes are in the order of cell size, this method has a potential for application to detect a change of tissue scattering properties. In future work, some spatial sampling method should be add to the proposed method.

4. Summary

A new ultrasound measurement method to detect directivity of target scatter based on scattering matirx was described. As results of preliminary research based on numerical calculation, proposed method has a sensitivity to the difference of point scatter size in the range from 20 to 160 μm.

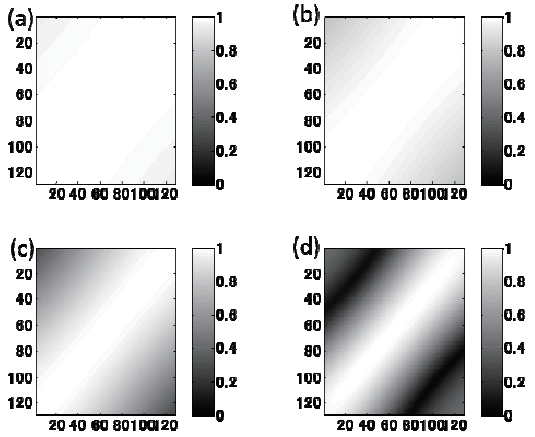

Fig.3 Scattering matrix from one point scatter with diameter of 20(a), 40(b), 80(c) and 160(d) μm

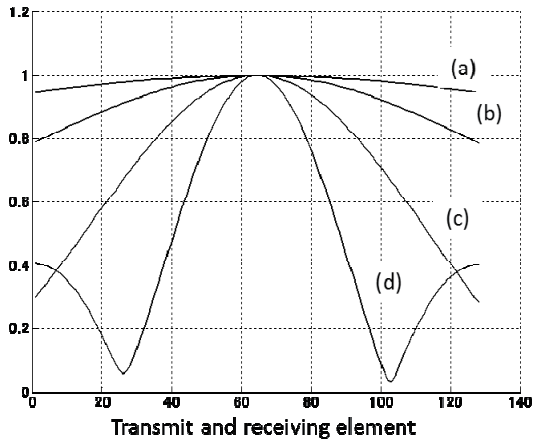

Fig.4 Diagonal component of scattering matrix from one point scatter with diameter of 20(a), 40(b), 80(c) and 160(d) (m

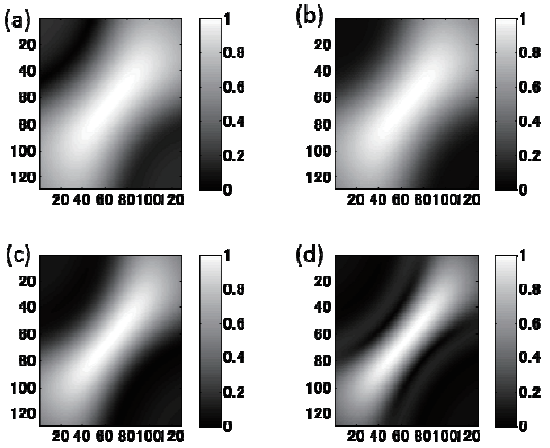

Fig.5 Scattering matrix from multiple point scatters with diameter of 20(a), 40(b), 80(c) and 160(d) μm

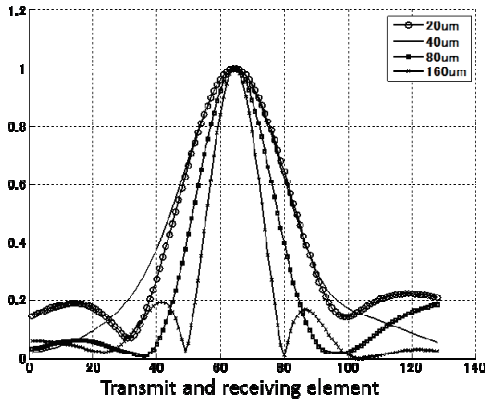

Fig.6 Diagonal component of scattering matrix from multiple point scatters

References

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