2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

Virtual Receive Array Ultrasound Imaging for Grating-lobe Suppression

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***Abstract*— To suppress receive grating lobe artifacts we propose virtual receive elements with a reduced pitch size. A virtual RF data is created using physical RF data and plane-wave beamforming is performed with reduced pitch size.**

I. Introduction

In ultrasonic imaging, diverging beam transmission of linear transducer arrays often results in artifacts such as grating lobes. Aperture apodization [1] and spatial combination of steered receiving beams [2] are not sufficient to suppress receive grating lobes. Alternatively, reducing the pitch of linear transducers can suppress grating lobes, but there are physical limitations. Instead, we propose to overcome the physical limitations by "virtually" reducing the pitch size using *virtual receive elements*.

II. Methods

As shown in Fig. 1, physical elements (PEs) and virtual elements (VEs) are the same aperture size and have different pitch sizes (M>N). The PEs transmit (tx) and receive (rx) a 0° plane-wave once to produce radio-frequency (RF) data. In the RF data received from j^{th} PE, $RF_j(\alpha)$, the value at a particular location α, is the sum of values transmitted from all PEs and received from the j^{th} PE with a distance of α such that

$$\mathrm{RF}_j(\alpha) = \sum_{i=1}^{N} A_{i,j}(\alpha) \qquad (j = 1, \dots, N) \qquad (1)$$

where $A_{i,j}$ represents the intensity of the echo signal transmitted from i^{th} element and receive from j^{th} element. We assume that the values of $A_{i,j}$ and $A'_{i,k}$ are similar, and then VEs' RF data can be created by the PEs' RF data as follow:

$$\mathrm{RF'}_{j,k}(d_{j,k}) = \frac{L}{d_{j,k}} RF_j \quad (j = 1, \dots, N,\ \ k = 1, \dots, M) \ (2)$$

where $d_{j,k}$ represents the distance between j^{th} and k^{th} element. Finally, plane-wave beamforming is performed on the newly created RF data which utilizes VEs with reduced pitch size.

III. Results

In the Field-ii simulation, a 0° plane-wave with a center frequency 6.5MHz is transmitted once from a 128 elements linear transducer with a pitch size of λ. The VEs are L (half of the aperture size) away from the PEs and their pitch sizes are $\lambda/3$. As shown in Fig. 2, the proposed method of receiving three times smaller pitch sizes than the PEs method is superior at reducing the grating lobes at all point targets. The details are shown in Table 1.

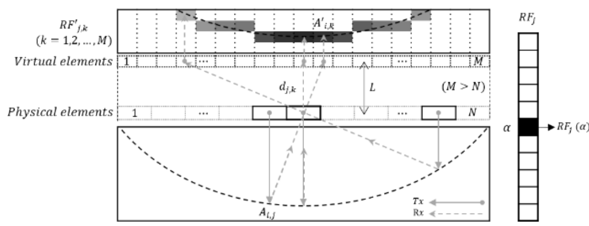

Figure 1. Configuration RF data in virtual receive elements.

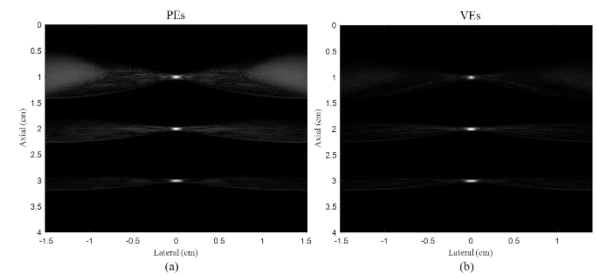

Figure 2. Beamforming image received from (a) PEs and (b) VEs.

TABLE I. Grating lobe and lateral resolution by points

Point 1 = 1cm Point 2 = 2cm Point 3 = 3cm	Grating Lobe (dB)			Lateral ***Res***. (at -6dB) (mm)		
	Point 1	***Point 2***	***Point 3***	***Point 1***	***Point 2***	***Point 3***
PEs	-34.44	-44.26	-48.98	0.0447	0.0496	0.0668
VEs	-46.84	-49.39	-49.38	0.0313	0.0467	0.0628

IV. Discussion & Conclusion

Reducing pitch size in virtual receive elements overcoming physical limitations is expected to improve ultrasound beamforming image quality.

Acknowledgment

This work was supported by the R&D program of MOTIE/KEIT (100076675, Development of MR Based High Intensity Focused Ultrasound Systems for Brain and Urinogenital Diseases)

References

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