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Basic Study on Image Degradation by Lateral Spatial Undersampling and Its Compensation

横方向空間間引きによる画像劣化とその補正に関する基礎検討

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1. Introduction

In medical ultrasound imaging, beamforming is a signal processing method to enhance the ultrasound signal in a specific direction, and the most popular method is delay-and-sum (DAS), which has been used for many years because of its low computational complexity. However, its image quality is to be improved.

Recently, a filtered delay multiply and sum (F-DMAS) method has been developed to overcome the problem [1]. However, the F-DMAS is more complex and expensive to calculate than DAS. This results in a lack of real-time imaging.

In this study, both uniform and Gaussian lateral undersampling [2] methods to reduce the number of elements with keeping receiving aperture are investigated. Furthermore, the impact of lateral undersampling on image quality is investigated.

2. Method

When transmitting, full aperture is used and the ultrasonic pulse is focused at a certain depth. When receiving, echoes are obtained from the elements according to two lateral undersampling schemes: an uniform and Gaussian decimations, as shown in **Fig. 1**. Subsequently, the DAS and F-DMAS are performed on the RF signal, respectively. The center of the Gaussian distribution is set at the center of the active receive aperture so that the entire aperture falls within the range of [-3σ, 3σ]. The sampling scheme is defined using the implicit formulation in a MATLAB (The MathWorks, Natick, MA, USA) library spot [3].

A simulation was performed in MATLAB by using the Field II simulator [4] In a phantom with 10 mm width and 55 mm depth, 30 point targets are placed in a regular space.

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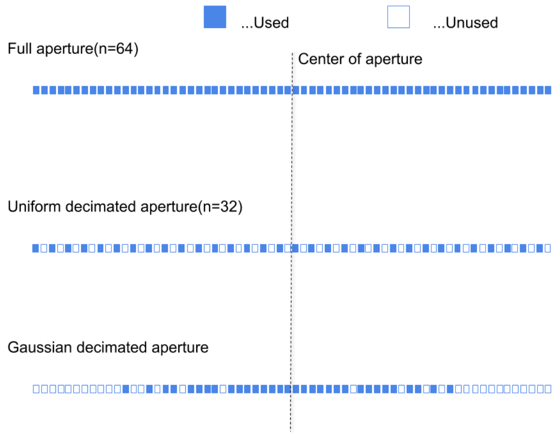


Fig. 1. Schematic diagram of proposed method. (a) Full aperture (number of reception n=64), (b) uniformly decimated aperture (n=32), (c) Gaussian decimated aperture (n=32).

A 192-element linear array is modeled with an element height of 3 mm, width of 170 μm, kerf of 30 μm (pitch = 200 μm) and a fixed elevation focus at 15 mm. Transmitted signal is a 2-cycle sinusoidal burst at center frequency of 12 MHz with Gaussian window. The sampling frequency is set to 100 MHz. A 64-element aperture is used for transmission and transmit focus is fixed at distance 15 mm. In the reception, 64 elements are used as full aperture. After receiving, some of those RF signals are decimated and discarded.

3. Results

Figure 2 shows B-mode images using various receiving methods and beamforming processing. It can be seen that each F-DAMAS image has better lateral resolution than that of the DAS image. Two-way normalized beampatterns at depth of 15 mm for DAS and F-DMAS are illustrated in **Fig. 3**. At the focal depth, there is no significant degradation with lateral undersampling. Using F-DMAS, the lateral resolution is improved with all types.

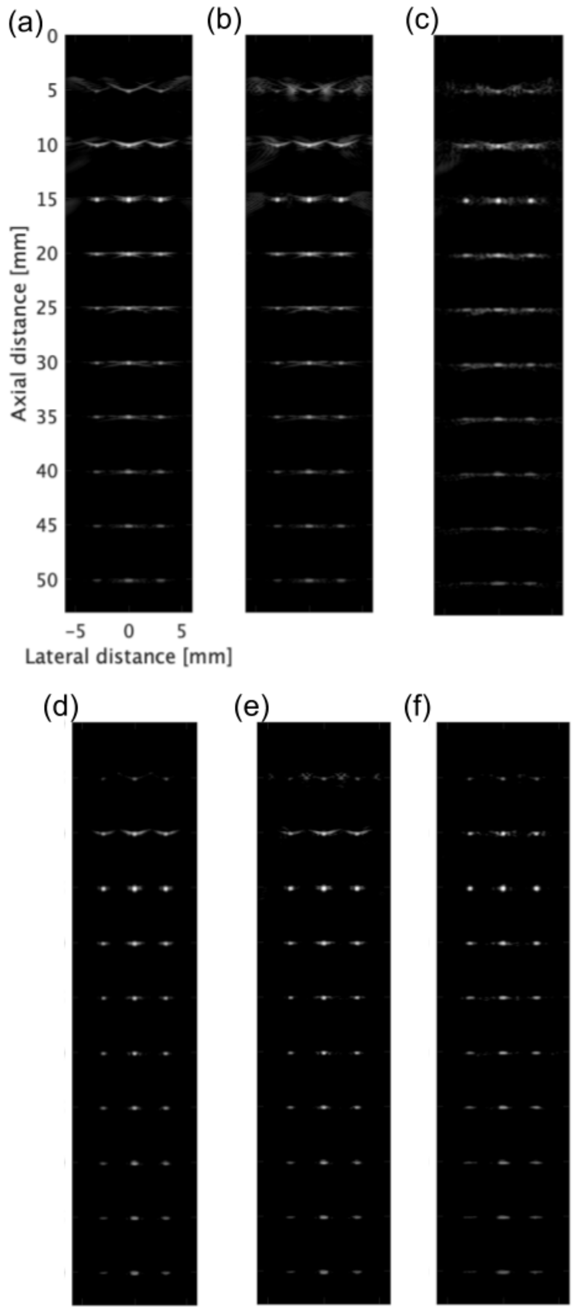
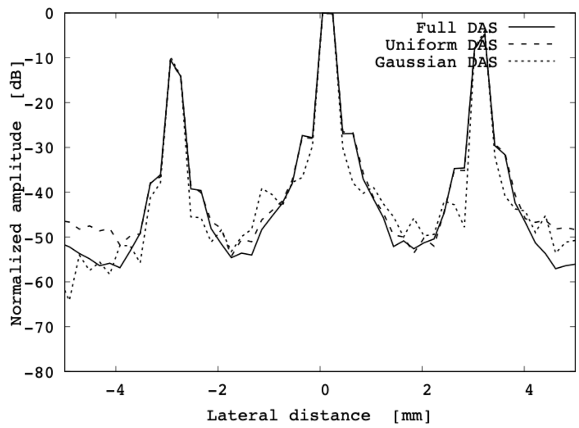
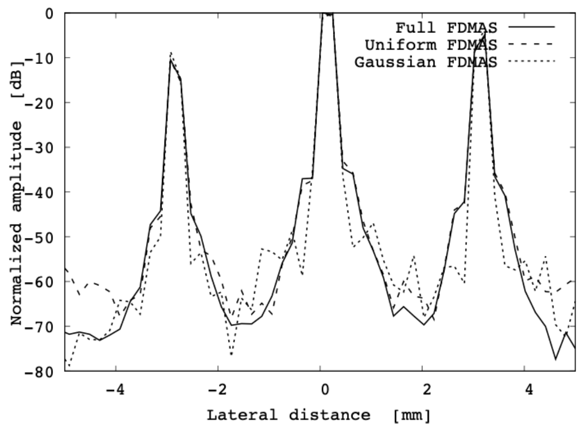


Fig. 2. B-mode images of 30 points scatterers. (a) Full aperture, DAS, (b) uniformly decimated, DAS, (c) Gaussian decimated, DAS, (d) full aperture, F-DMAS, (e) uniformly decimated, F-DMAS, and (f) Gaussian decimated F-DMAS.



(a)



(b)

Fig. 3. Two-way normalized beampatterns at depth of 15 mm for (a) DAS and (b) F-DMAS.

4. Conclusion

In this study, two beamforming techniques with two lateral undersampling schemes were performed. In future work, further investigation will be conducted.

Acknowledgment

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References

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