

Post-Beamforming Third-Order Volterra Filter (ThOVF) for Pulse-Echo Ultrasonic Imaging

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Abstract: A ThOVF is applied to separate linear, quadratic, and cubic components from beamformed ultrasonic pulse-echo imaging data from nonlinear media. In the context of imaging ultrasound contrast agents (UCAs) infused in tissue media, the ThOVF offers the advantage of essentially complete separation of the nonlinear responses of the UCAs and tissues (since the latter rarely produces higher than a quadratic nonlinear response). We describe an SVD-based robust algorithm for estimating the coefficients of the ThOVF from beamformed data. In addition, experimental results from imaging of UCA in flow channels through tissue-mimicking phantoms demonstrate the advantage of this approach. We show imaging results with computed contrast-to-tissue ratio (CTR), histograms of UCA and tissue regions, and average spectra from UCA and tissue region. These results individually and collectively support the hypothesis that ThOVF is the appropriate model for complete separation of the nonlinear echoes from UCA and tissue.