Spatial coherence feedback for adaptive clutter filtering in color flow imaging

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Background, Motivation and Objective

Effective clutter filtering is critical for accurate velocity estimation in color flow imaging (CFI). Given the complex spatiotemporal dynamics of flow and clutter, filter selection can be a significant challenge. To this end, methods for adaptive down mixing and Eigen-based processing have been proposed to adapt filters based on tissue motion. In this study, we propose a novel adaptive filtering technique that relies on measured backscatter spatial coherence to optimally isolate flow from weakly coherent off-axis and reverberation clutter. This method avoids global assumptions about clutter amplitude and spectral content, making it broadly applicable to the dynamic imaging conditions encountered *in vivo*.

Statement of Contribution/Methods

In the proposed method, ensemble channel data are passed through a bank of IIR filters with varying cut-off frequencies. Local estimates of coherence for each filtered dataset are calculated via the slow-time average short-lag spatial coherence (SLSC) between channel signals. On a per-pixel basis, adaptive CFI is performed by selecting the filter that maximizes coherence and mapping its corresponding velocity estimate to the output image. We validate this technique in Field II using simulations of a 1-cm vessel with parabolic flow under varying levels of thermal noise, spatially incoherent clutter, and off-axis clutter from bulk tissue motion. We further demonstrate its application *in vivo* using hepatic CFI data with comparisons to matched images formed via fixed cut-off filtering and adaptive down mixing.

Results/Discussion

Analysis is presented for adaptive CFI implemented with a bank of 8 filters, including a no filter condition. Results show that the proposed method provides similar suppression of acoustic clutter and flash artifact as high order filters (Fig. a-b) without loss of accuracy in slow flow measurement (Fig. c). Across all simulated velocities and clutter levels, the adaptive filter closely matches or surpasses the performance of the best-case fixed cut-off filter. These improvements are illustrated in Fig. 1g, which shows simultaneous preservation of slow flow in vessel A with effective clutter rejection in vessel B – two features that are otherwise traded off when using fixed cut-off filters (Fig. 1e-f). Similar results are observed across all *in vivo* acquisitions (n=8) examined in this study.

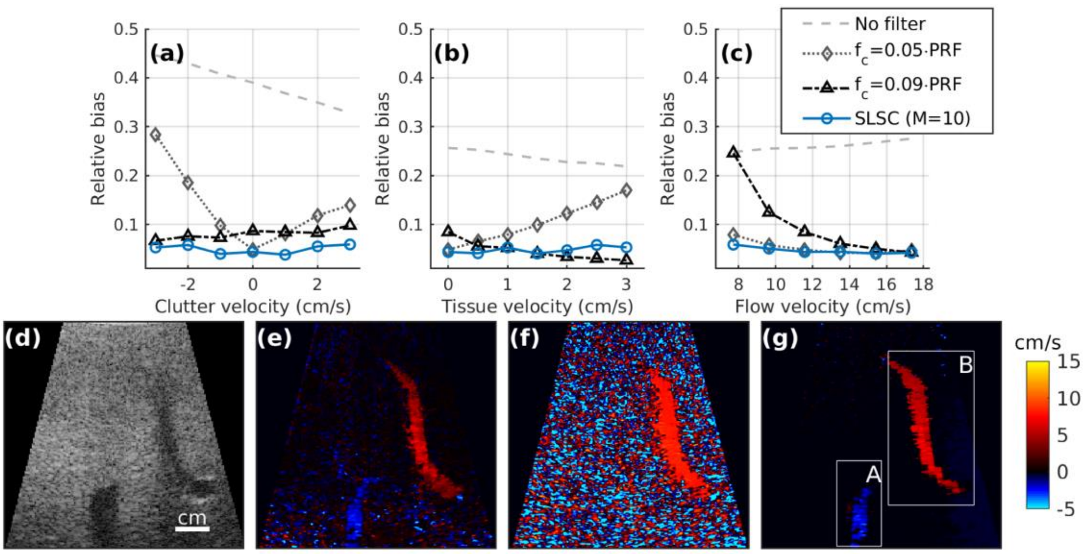

Figure 1: Velocity estimation bias with fixed cut-off filtering and coherence-based adaptive filtering for simulated parabolic flow with spatially incoherent clutter (a), bulk tissue motion (b), and varying peak velocity (c). Example B-mode (d) and CFI liver images formed using adaptive down mixing with fixed cut-off filtering at 0.05·PRF (e), 0.09·PRF (f), and coherence-based adaptive filtering with short-lag value M=10 (g).