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Real-time sensitive hepatic vessel detection in high body mass index (BMI) patients from the spatial coherence of ultrasound: a clinical study

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Background and Motivation

Power Doppler (PD) imaging is a widely used technique for flow detection in clinics. However, its capability in flow detection is limited by noise sources, including thermal noise and reverberation noise. Patients with high BMI are often categorized as “difficult-to-image” by sonographers, because signal attenuation and reverberation are more severe among this population. Coherent flow power Doppler (CFPD) detects blood flow using the spatial coherence of ultrasound designed to suppress spatially incoherent noise; it provides an SNR improvement of approximately 5-7 dB compared to PD using the same conventional ensemble lengths (e.g. 8-16). We applied CFPD in a real-time in vivo study of high BMI patients undergoing abdominal ultrasound to evaluate the improvement in power Doppler image quality and vessel.

Statement of Contribution/Methods

We built a real-time CFPD imaging system based on a Verasonics Vantage 256 scanner and C5-2v transducer. The system captures the RF channel signals during a Doppler pulse sequence and passes these signals to a workstation for real-time software beamforming and image processing. Real-time beamforming and processing were implemented using CUDA C++ on a commercial GPU card. 12 high BMI patients undergoing abdominal ultrasound at Stanford Hospitals and Clinics were recruited to evaluate CFPD performance. In each subject, the liver vasculature was identified by a radiologist using the real-time CFPD display, and Doppler channel data was recorded over 1 second. The recorded data were processed off-line to produce power Doppler (PD) and CFPD images, and included noise-floor equalization to compare methods on an equal scale.

Results/Discussion

A frame rate of 20 fps is achieved for an imaging depth of 10 cm with an ensemble length of 8. Fig (a) shows an example of power Doppler (PD) and CFPD images produced from the same acquisition on one high BMI patient. Fig (b) shows the cross-section of signals indicated by the white line in (a). In (a) and (b), reverberation noise due to patient motion is present at 50-70 mm depth in the PD image, and is suppressed in the CFPD image. Fig (c) shows the Doppler SNR measured for all acquired images, and shows an average improvement of 6.4 dB with CFPD

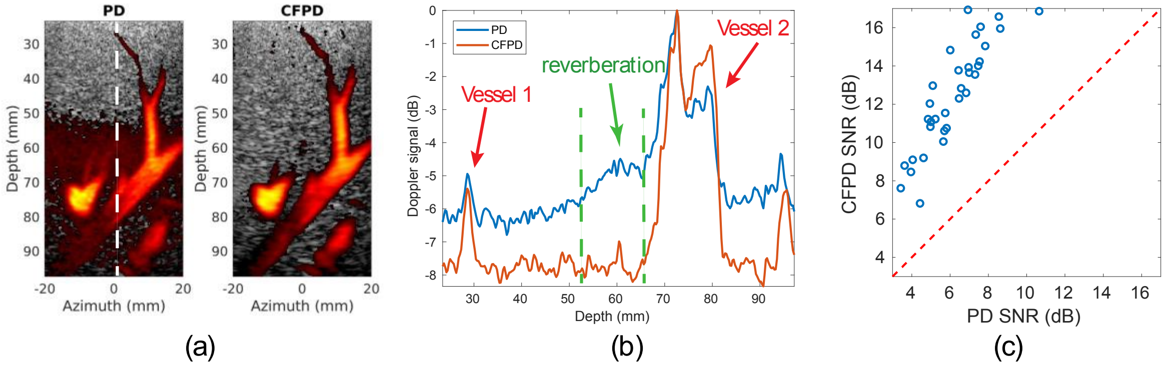

Figure **(a)** PD and CFPD image example of one high BMI patient that was difficult to image. The images are displayed with 30 dB dynamic range. Reverberation is present at 50-70 mm depth in the PD image and is suppressed in the CFPD image. **(b)** Axial cross-section of the images in (a). The location is indicated with white dashed line in the PD image. Reverberation can be seen near 60 mm depth in the PD image, and is completely suppressed in the CFPD image. **(c)** SNR measurement of the images collected on 12 patients. Each circle represents the measurement of the PD and CFPD images from one acquisition. In all cases, CFPD provides higher SNR than PD.