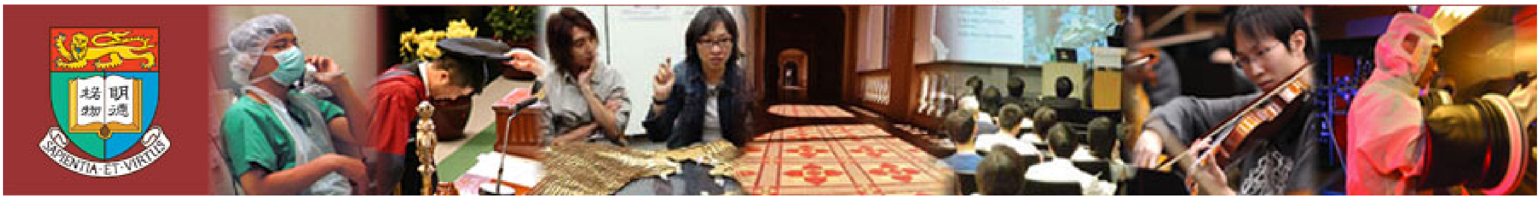

Title	Anthropomorphic flow phantom design using stereolithography: a novel approach based on direct fabrication of thin-walled compliant vessels
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The performance of the proposed ACR method was compared with conventional clutter rejection methods, i.e., static (ST) and down-mixing (DM), using a commonly-used flow signal-to-clutter ratio (SCR). From the phantom experiments, the ACR method provided 4.0 dB and 3.4 dB improvements in SCR over the ST and DM methods where the 3rd-order IIR filter with projection initialization is used. The consistent results were obtained with the in vivo experiments as shown in Fig. 1 where the color Doppler images with frequency estimates without power thresholding obtained from three methods are visualized. In ACR, as shown in Fig. 1(d), six clutter filters were dynamically selected depending on the varying clutter characteristics. The improvement in SCR from the ACR method is 4.5 dB and 3.3 dB, compared to the ST and DM methods. These results indicate that the proposed ACR based on spectral decomposition and tissue acceleration can improve image quality in ultrasound color Doppler imaging by effectively removing the clutter.

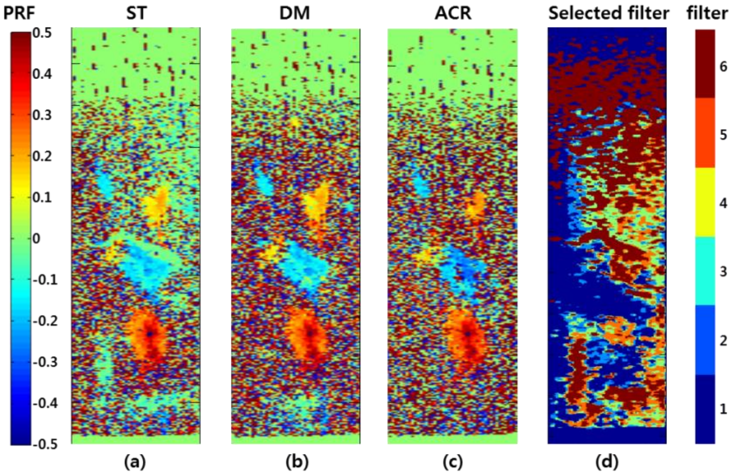

Figure1. Color Doppler image with velocity estimates form the (a) ST, (b) DM and (c) ACR methods and (d) selected clutter filter for ACR

IUS1-PC2-3

Anthropomorphic Flow Phantom Design Using Stereolithography: A Novel Approach Based on Direct Fabrication of Thin-Walled Compliant Vessels

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Background, Motivation and Objective

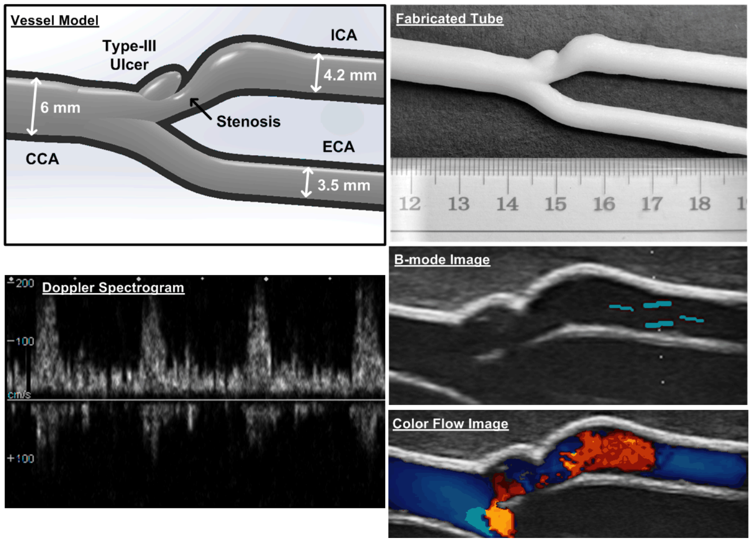
Anatomically realistic flow phantoms are essential tools for vascular ultrasound investigations. They are conventionally developed using investment casting; however, this technique is known to require skilled craftsmanship, and it is difficult to incorporate multiple pathological features into the phantom's vessel geometry. In this work, we seek to devise a new phantom design framework that can efficiently produce complex vessel models resembling diseased arteries. Stereolithography is proposed here as a direct way of fabricating thin-walled compliant vessels.

Statement of Contribution/Methods

Anthropomorphic vessel geometries were first drafted in SolidWorks. Carotid bifurcation models were developed for demonstration; we designed thin-walled (0.8 mm thick) vessels that concurrently possessed two diseased vascular conditions: 1) eccentric stenosis (50%), and 2) plaque ulceration (Types I/III). Vessel tubes were fabricated using a stereolithography machine with build resolutions of 16 um and 42 um respectively for layer thickness and along each layer plane. To produce elastic vessels, a compliant photopolymer was used. Each thin-walled vessel was coupled to an agar tissue mimicking material, and it was connected to a Shelley gear pump. To analyze their operational performance, Doppler ultrasound and color flow imaging were performed using a SonixTouch scanner (scan freq: 5 MHz). Material characterization was also performed via uniaxial load testing (for elastic modulus estimation) and insertion-loss pulse transmission measurements (for acoustic speed and attenuation).

Results/Discussion

Our phantoms were found to yield Doppler spectrograms with significant spectral broadening and color flow images with mosaic patterns (typical of disturbed flow in stenosed and ulcerated vessels). The vessel wall's elastic modulus (391 kPa) was within the nominal range for human arteries. The vessel material's acoustic speed was 1801 m/s, and its attenuation coefficient was 1.58 dB/mm/MHz^n with a power coefficient of 0.97. These findings suggest that phantoms produced from our framework have potential to serve as ultrasound-compatible testbeds that can simulate complex flow dynamics similar to those observed in real vasculature. We will be using them to validate the feasibility of new flow imaging methods in cases with significant flow disturbance.



IUS1-PC2-4

Slow-time Golay Decoding for Doppler Detection of High-velocity Blood Flow

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Background, Motivation and Objective

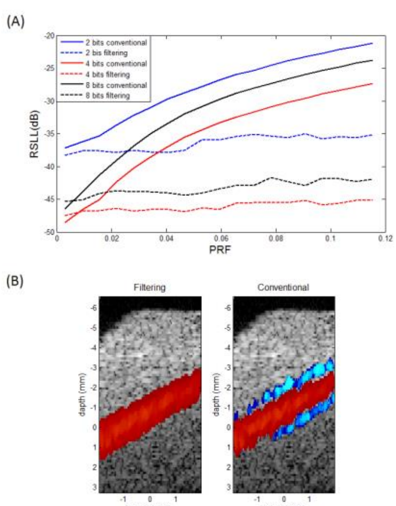
Conventionally, Golay excitation is decoded by two complementary transmit waveforms (i.e., A and B transmit) whose autocorrelation is summed for range side lobe cancellation. When the imaged object moves between the two transmit, however, Golay decoding degrades due to the occurrence of residual side lobe. Consequently, Doppler application of Golay code is generally limited to quasi-stationary tissue or low-velocity blood flow. In this study, it is proposed that a simple filtering can be utilized in the Golay-encoded Doppler system for high-velocity blood flow.

Statement of Contribution/Methods

In the proposed method, the blood flow is imaged by a sequence of alternating A and B transmit waveforms. The received echo is first processed by respective matched filter in the fast time and then stored in the memory for Doppler estimation. Since Golay excitation produces in-phase mainlobe component between A and B transmit, the corresponding Doppler spectrum is located around the DC region. On the contrary, the sidelobe component has its phase reversed every time the transmit waveform alters between A and B. Therefore, the Doppler frequency of sidelobe is at about half of the pulse-repetition-frequency (PRF). To extract the mainlobe without any sidelobe interference, low-pass filtering with cut-off frequency of PRF/4 can be performed in the slow time. The low-pass filter can be readily integrated with the existing clutter filter to provide a sidelobe-free detection with Doppler frequency up to PRF/4.

Results/Discussion

Color Doppler images of blood flow phantom were constructed to verify the proposed method. Compared to conventional method, the filtering method effectively suppresses range sidelobe level (RSLL) of Golay decoding. Fig(A) shows that, at a Doppler frequency of about PRF/10, the RSLL reduces by 10-15 dB for different bit lengths. Corresponding color Doppler images in Fig.(B) also illustrates that the conventional method suffers from severe sidelobe interference so that false blood flow appears. On the other hand, the filtering method can remove the artifacts to restore the correct flow information.



IUS1-PC2-5

High Sensitivity Blood Color Flow