Ultrafast Second harmonic inversion for ultrasound contrast harmonic imaging

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Background, Motivation and Objective

To emphasize the detection of Ultrasound Contrast Agent (UCA) at second harmonic, several techniques are used. Among them, Pulse Inversion (PI) is implemented to cancel the fundamental frequency component, by adding two images obtained with two pulses of same frequencies and opposite phase amplitudes. This technique has been adapted here with a quadrature phasing to cancel the second harmonic component. This technique, called Second Harmonic Inversion (SHI), allows canceling the second harmonic on the steady tissue, but not in the flow, where UCA are present. This study aims to combine SHI with Coherent Plane Wave Compounding (CPWC). CPWC is based on averaging multiple frames obtained by applying slightly different transmit strategies. Each frame is beamformed from plane wave emissions with different steering angles. The resulting frames are coherently combined into radio frequency images. The goal of this combination is to merge the advantages of both techniques.

Statement of Contribution/Methods

An experimental phantom imitating the carotid artery was used to evaluate the performance of CPWC-SHI. The set-up is composed of a PVA vessel phantom connected to a flow pump and of an agar based tissue mimicking medium; UCA are injected into the flow. Acquisitions are performed using the Verasonics Vantage 256 system coupled with the L5-12 linear probe. The bandwidth of the probe used being 5-12MHz (at -6dB), the central frequency of the transmitted signals was set at 5.25 MHz to transmit signals on the low frequency part of the probe in order to generate a second harmonic component exploitable on its high frequency part. The medium was insonified using 11 plane waves with steering angles distributed between +/-10°. The performance of CPWC-SHI was compared to the ones of CPWC second harmonic obtained by filtering the fundamental and by using PI respectively.

Results/Discussion

The CPWC-SHI method reduces the second harmonic generated by nonlinear wave propagation. The method is simple to implement. In vitro measurements show improvements in Agent-to-tissue ratio (ATR), which corresponds to the power ratio between the flow (where UCA are present) and the tissue. Indeed the CPWC-SHI (Fig. 1d) improves the ATR up to 12 dB and 15 dB in comparison to the CPWC second harmonic obtained by filtering the fundamental (Fig. 1b) and the second harmonic obtained by CPWC-PI (Fig. 1c) respectively.

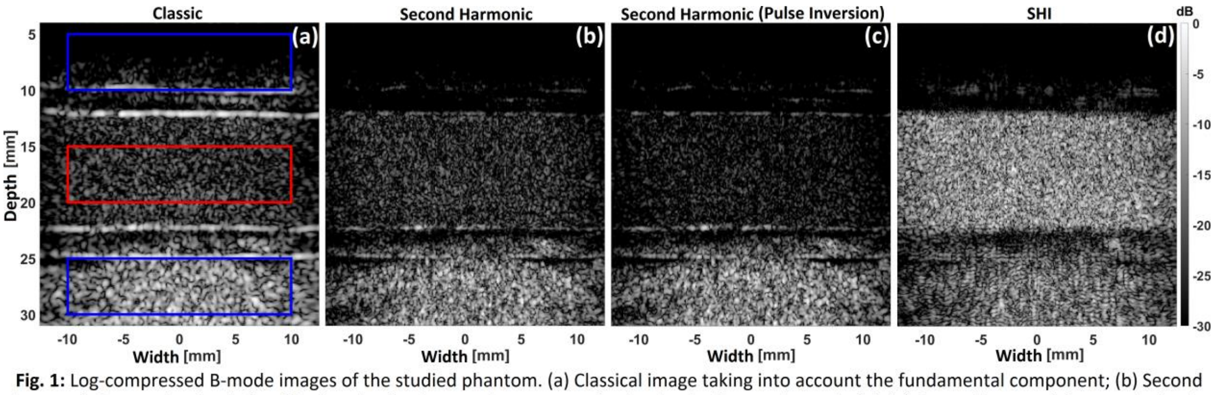

Fig. 1: Log-compressed B-mode images of the studied phantom. (a) Classical image taking into account the fundamental component; (b) Second harmonic image obtained after filtering the fundamental component in the classical image shown in (a); (c) Second harmonic image obtained using the Pulse Inversion technique and (d) Dynamic second harmonic image obtained using SHI. In (a) are shown the boxes used to calculate the different ATR.