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CLUTTER ARTIFACT REDUCTION IN PHOTOACOUSTIC IMAGING

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Background, Motivation and Objective. Photoacoustic (PA) imaging is a technique used to obtain functional information at molecular levels of biological tissue and presents simultaneous high contrast and high spatial resolution. On PA imaging, the energy deposited on tissue by pulsed light causes a thermoelastic expansion and an initial pressure rise, creating ultrasound waves. These waves can be detected by an ultrasound (US) probe to generate PA images. Epi-PA (epi- prefix, “above”, “upon”) imaging is performed by illuminating the tissue from the same side where the US-probe is positioned to record the pressure waves. This geometry allows the acquisition of US and PA images simultaneously but, due to the high light absorption by melanin present on human skin, the PA waves generated at skin surface propagates to the tissue and are backscattered by structures presented on image plane, creating the clutter artifact that deteriorates the contrast, signal-to-noise ratio (SNR) and significantly limits imaging depth. In this study, methods to minimize the clutter artifact in Epi-PA images from a tissue-mimicking phantom containing a light absorber layer at its surface were investigated.

Methods. For PA signal generation, a Nd:YAG laser (Brio Quantel) was used delivering pulsed light at 532 nm wavelength with 5 ns pulse duration and 20 Hz repetition rate. The signal was recorded with a linear US probe (L14-5/38 Ultrasonix). The phantom was manufactured using the copolymer styrene-ethylene/butylene-styrene (SEBS) in mineral oil. The phantom had a cylindrical shape with 25 mm height and 75 mm diameter. A semi-spherical inclusion with higher light absorption coefficient was add to the bottom of the phantom to obtain optical contrast in the PA image. In addition, a high light absorber layer with 5 mm thickness containing India ink was positioned on the top of the phantom, to simulate the human skin. In order to remove the clutter artifact in the PA image, besides acquiring just conventional PA images, a PA image was acquired after mechanically displacing the region containing the phantom inclusion. A displacement of 50 µm was applied using a cylindrical piston attached to a micrometer. Reduction of clutter artifact was than obtained by subtracting the two PA images: the conventional and the post-displacement one.

Results. The conventional and post-clutter reduction PA images are shown on figure 1.a and 1.b, respectively. It is possible to see the reduction of background signal in the resulting image, with almost total elimination of the clutter artifact.

Discussion and Conclusions. The results demonstrates that the method used works well and presents high potential. One limitation to this method is that the original PA signal just remain in the displacement region of the image, once the signal is the same where there were no shift and the signal goes to zero after subtracting the two images.

Figure 1

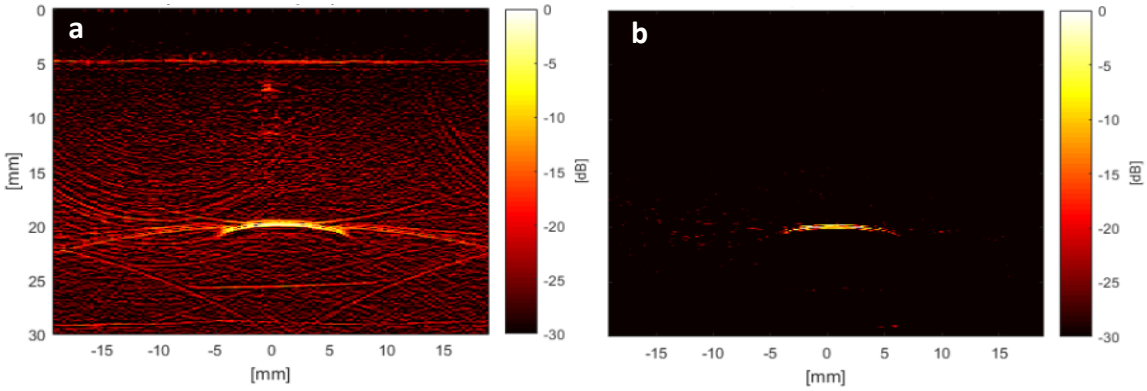

Figure 1 – Conventional PA image (a) and post-clutter reduction PA image (b).

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Keywords. Photoacoustic imaging; clutter; artifact; ultrasound; Laser.