Evaluation of lateral and axial resolution in photoacoustic tomography with linear US probe and pixel-based beamformers

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Photoacoustic (PA) imaging techniques use the ability of some materials (chromophores) to emit sound after being excited by a pulsed light [1]. These materials, after absorbing the laser energy, become acoustic sources whose signals can be recorded with a typical ultrasonic (US) acquisition system and conform molecular images [1]. This technique allows to differentiate the chromophores of tissues, for example oxyhemoglobin and deoxyhemoglobin, since each chromophore has a characteristic absorption spectrum, which makes it a promising medical imaging technique with molecular contrast, better resolution than pure ultrasound imaging and greater tissue penetration than optical techniques [1]. Classical ultrasonic linear phased arrays, often employed in ultrasound imaging systems, have been adapted for their use in photoacoustic imaging systems. However, the use of these receptors reduces the quality of the obtained PA images, since the laser-generated acoustic signals are travelling in all directions in the 3D-space, which makes it necessary to use more complex reconstruction algorithms that take advantage of the properties of the recorded ultrasonic signals, obtaining images with improved resolution and contrast.

The main objective of this work is to compare the resolution of a PA tomography system using a laser beam excitation, a linear ultrasound probe and using pixel-based beamformers: Delay And Sum (DAS) [2], Delay Multiply And Sum (DMAS) [3], Minimum-Variance (MV) [4] and MV-DMAS [5]. To achieve this, both experiments and simulations have been carried out with two point-like absorbers initially overlapped and are separated until we are able to identify them as two independent sources in the reconstructed image using pixel-based beamformers. We use the criterium of 6 dB in the amplitude difference between the peaks and the valley in the reconstructed image to determine whether they have been resolved or not. The experiments and the simulations showed a good agreement as shown in Figure 1. The obtained results ease a proper choice of the most suitable beamformer depending on the limitations of the linear probe tomography system.

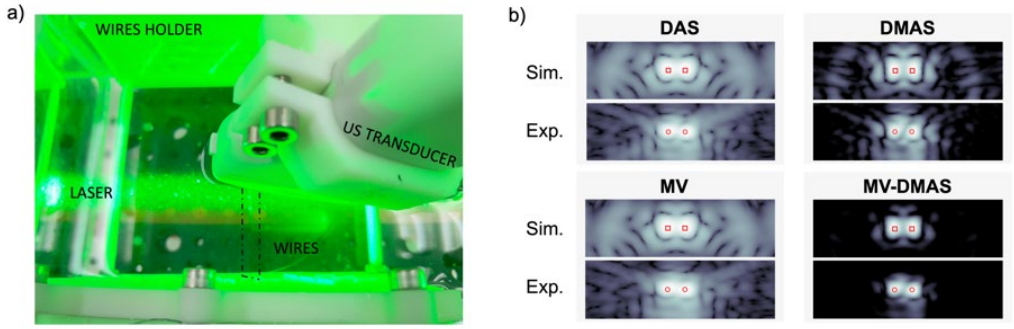


Figure 1. a) Experimental set-up. b) Beamformed simulated and experimental data from lateral resolution study, all reconstructions are shown with a dynamic range of 60 dB. The original sources have been marked in red.

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