# Overestimation of the spatial resolution of advanced algorithms using the PSF method on PAT systems

## Background, Motivation and Objective

The Point Spread Function (PSF) is the standard approach to determine the resolution of photoacoustic tomography (PAT) systems, as it provides good results with a single measurement. Recently, adaptive and nonlinear reconstruction algorithms exploiting the spatio-temporal coherence between the received signals have been developed for its use with conventional linear ultrasound imaging probes, showing remarkable improvements. However, these algorithms may lead to an overestimation of the resolution when using the PSF method. The aim of this work is to characterize and compare the spatial resolution of a PAT system using two methods (PSF and Rayleigh criterion).

## Statement of Contribution/Methods

Photoacoustic images using an array-based PAT system have been reconstructed using traditional, adaptive and nonlinear algorithms, i.e, Delay-Multiply-And-Sum, Minimum-Variance, MV-DMAS and Coherence Factor. Their spatial resolutions have been determined, first measuring the Full-Width-at-Half-Maximum of one point source using the PSF and, then, applying the Rayleigh criterion to images of two nearby points, considering a 6 dB peak-to-valley difference of their profiles.

## Results/Discussion

The evaluated lateral and axial resolutions manifest a good agreement between experiments and simulations (see table). Advanced algorithms show discrepancies between the two methods, particularly for the lateral resolution, while for the conventional Delay-and-Sum (DAS) resolutions remain similar. Figure (a) shows that DAS images of two points are resolved if the separation is above the lateral resolution (green profile) and are not when the separation is below (red). The PSF method overestimates the lateral resolution value (0.09 mm) for MV-DMAS, since two sources are not distinguished at a larger separation (d = 0.17 mm), while they are at the separation indicated by the Rayleigh criterion (d = 0.23 mm). The reason for these differences is attributed to the sidelobe interaction between sources. Hence, this feature is not captured when the resolution is characterized by a single source (PSF method). Moreover, since sidelobes are related to the limited numerical aperture of the linear array, their interaction is more relevant for the lateral resolution compared to the axial resolution, resulting in much bigger differences between methods for the former.

| | | PSF | | Rayleigh | |
|---|---|---|---|---|---|
| | | Sim | Exp | Sim | Exp |
| $R_L$ (mm) | DAS | **0.25** | 0.25 | **0.26** | 0.25 |
| | MV | 0.16 | 0.17 | 0.32 | 0.32 |
| | DMAS | 0.14 | 0.14 | 0.19 | 0.15 |
| | MV-DMAS | **0.09** | 0.09 | **0.20** | 0.17 |
| | CF | 0.12 | 0.12 | 0.22 | 0.16 |
| $R_A$ (mm) | DAS | 0.19 | 0.19 | 0.19 | 0.22 |
| | MV | 0.18 | 0.19 | 0.19 | 0.21 |
| | DMAS | 0.17 | 0.17 | 0.19 | 0.21 |
| | MV-DMAS | 0.12 | 0.12 | 0.17 | 0.18 |
| | CF | 0.17 | 0.17 | 0.19 | 0.21 |

