IMAGE SCANNING MICROSCOPY WITH A SPAD DETECTOR ARRAY

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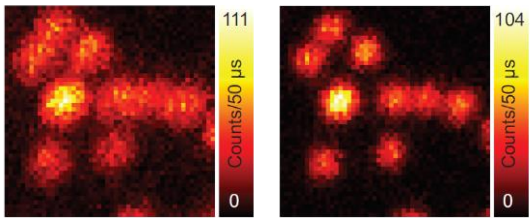
ABSTRACT:

In confocal microscopy, the selection of an optimal physical pinhole size is always a compromise between signal and lateral resolution. This problem can be overcome through modifications introduced on the detection plane. During the last years, several strategies (some purely optical) [1,2,3] have been proposed.
To be sure, the most straightforward approach is the substitution of the single detector with a small array of sensors [4]. Each element of the matrix is used to independently record a view of the sample for subsequent processing, resulting in a dataset of partial images. The final image can be reconstructed either by pixel reassignment, in which the pixel value of each partial image is reassigned to the appropriate coordinates, or by inverse filtering [5], adding 'a priori' information about the point spread function (PSF) of each detector element.
In this work, we used an innovative SPAD (single-photon avalanche diode) array of 25 detectors (arranged into a 5 by 5 matrix), specifically designed for microscopy. Thanks to our scanning microscopy control system (Carma), we are able to simultaneously acquire 25 partial images and to perform image processing to calculate the final reconstruction online. It is possible to obtain the standard confocal image (the same result that would be obtained with a single detector) simply by summing the partial images without processing. Hence, it is possible to investigate improvements in terms of resolution and signal-to-noise ratio of the proposed approach (which is completely backward compatible with traditional confocal imaging).
Experimental results, in agreement with theoretical simulations, showed an improvement in resolution from ~230nm to ~170nm (NIR range).
Further work will be devoted on improving the fill factor of the detector (e.g. using microlenses to convey photons to the active area of the pixels).



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