Fast three-dimensional random access scanning using a MEMS-based spatial light modulator

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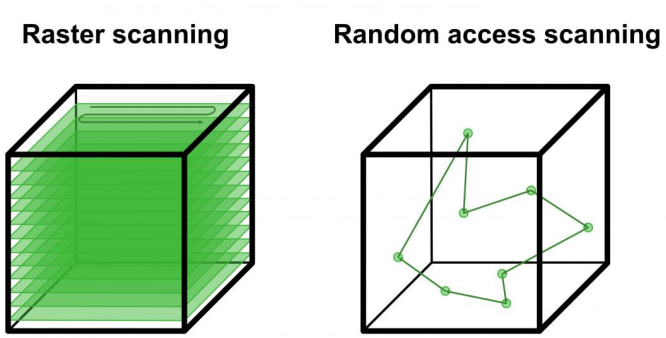
Abstract

For *in vivo* imaging of neuronal activity with single-cell resolution, laser scanning multiphoton microscopy is often the method of choice. Its speed, however, is primarily limited by the speed of the scanning mirrors and fundamentally limited by the fluorescence lifetime, which restricts the pixel dwell time to a minimum on the order of nanoseconds. Random-access scanning can speed up point scanning microscopy by sampling only pre-selected locations, for example neurons or spines. This requires a scanning mechanism with negligible inertia, which has previously been realized using acousto-optic deflectors [1].

Here we propose a method using a MEMS-based spatial light modulator for three-dimensional random-access scanning above 100 kHz update rate, substantially faster than commonly used acousto-optic deflector setups. The compact, modular setup allows the display of arbitrary linearly separable two-dimensional patterns for three-dimensional beam steering and wavefront shaping. This can be used to correct for aberrations introduced by the system as well as the sample.

We show the method's applicability to two-photon imaging of neuronal and synaptic activity in zebrafish larvae and organotypic slices.



References

1. Martí Duocastella *et al* 2021 *J. Phys. Photonics* **3** 012004