Encoded Microscopy for Multi-Site Imaging

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One of the ultimate tasks in life sciences remains to reverse-engineer the mammalian brain. The biggest obstacles of this task are the large number and small size of cellular brain elements and the high complexity of their connections. Traditional ways of exploring the function of neuronal systems, e.g. with microelectrodes, are limited to small neuron populations and simple networks, and thus are not suited for this task.

To overcome these limitations when studying the living brain, innovative approaches increasingly rely on advanced optical techniques, employing specific molecules engineered to be activated and interrogated by photons. This requires appropriate techniques that extend beyond both spatial resolution to distinguish neuronal elements and temporal resolution to monitor neuronal signaling. In fact, to account for the inherent non-linear and non-stationary nature of brain signaling, multiple neuronal sites need to be activated and probed simultaneously.

Encoded microscopy is an elegant method to achieve simultaneous multi-site imaging. In this approach, multiple excitation beams are time- or frequency-encoded, emission signals are detected by a single sensor and decoded into multiple beam-associated channels with high spatio-temporal resolution. I will present advanced approaches of encoded microscopy suited to analyze structure, function and connectivity in different preparations. Emerging techniques of encoded high-throughput imaging systems to study large populations of neurons will be discussed.