A WEAKLY-SUPERVISED AUTOMATED WORKFLOW FOR THE ANALYSIS OF LARGE-SCALE 4D DATA SETS OF NEURONS IMAGED IN VIVO

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In vivo two-photon imaging has established structural alterations of dendrites and spines as a key mechanism of neuronal plasticity [1]. Longitudinal experimental paradigms provide prime access to correlate behavioral readouts with changes in dendritic structure. Reliable quantitative analysis of large 4D datasets obtained from in vivo imaging remains a challenge, although several software solutions have been developed. Here, we present a weakly-supervised and automated approach to analyze dynamic changes of dendrites and spines considering the complete dendritic tree of prefrontal cortical neurons in vivo.

We acquired high-resolution two-photon image stacks containing the morphology of entire neurons at weekly intervals before and after a perturbation in the somatosensory system to address the question if the perturbation, assessed with a behavioral assay, causes dendritic plasticity of cortical neurons. The automated computing and analysis workflow consists of several steps: preprocessing, registration, tracing of structures, and quantitative analysis of dendritic tree geometry. To improve the tracing fidelity and to measure efficiency of structural changes on the level of the entire neuron, individual dendrites and spines, a novel Bayesian incremental learning and 3D tracing algorithm has been developed. It computes large-scale 3D datasets in a weighted global to local optimization manner. Blood vessels and neighboring cells can be identified without influencing the tracing of target neurons. Furthermore, exact 3D tracing and vectorization support accurate 4D correspondence. Our preliminary results document successful automated registration and tracing neuronal spines and dendrites on high-resolution 4D image stacks.

Based on the image analysis results, reliable and meaningful quantitative information on neuronal networks and their dynamic changes over time can be extracted by providing a better understanding of neuronal structural plasticity in the prefrontal cortex in relation to sensory perturbation.

Reference: