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Topographically Detailed Computational Model of the Somatosensory and Motor Thalamus

The thalamus is a relay center, forwarding information between the cerebral cortex and the periphery. Thalamic relay cells are capable of firing at two different regimes, the tonic- and burst-firing mode, and have been a major focus of experimental preparations and computational models. However, only recently have researchers gained insights into the network dynamics at different nuclei, each exhibiting highly specific connectivity patterns. The precise functional processing of these circuits is still an unsolved puzzle. To address this gap, we developed a large-scale model of the motor and somatosensory thalamus, with ~2.250 neurons, ~33.000 connections and incorporating recent data on projection targets and cell type-specific circuit architecture. Our objective was to reconcile the single-cell dynamics with circuit-level observations. The model was built using the NetPyNE tool and the NEURON simulator. It is composed of four first-order (FO) excitatory nuclei and a higher-order (HO) nucleus with separate motor and somatosensory projecting sectors. FO nuclei present topographical connectivity and HO nuclei are connected via a divergence rule. All nuclei send and receive projections from the inhibitory and interconnected reticular nucleus. The connectivity rules were based on data of axonal and dendritic footprints for each nuclei, and probability and weight of connections were tuned within biological constraints to match dynamics observed experimentally. We used single-compartment cell models based on Destexhe (1996) with adjusted parameters. Results show our model reproduces key features reported in literature, such as tonic and burst firing. We are currently integrating this model with existing models of motor cortex and somatosensory cortex. This will provide a framework to study the cortico-thalamo-cortical circuits of the sensorimotor pathway with an unprecedented level of detail, including physiological and pathological conditions, such as epilepsy and ALS.