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Towards an empirically based model of the prefrontal cortex using AdEx neurons and NEST

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We present the development of a biologically grounded spiking neuronal network model of the prefrontal cortex (PFC), implemented in the NEST simulator using the adaptive exponential integrate-and-fire (AdEx) neuron model. Based on the architecture proposed by Hass et al. (2016), our model replaces the simplified AdEx (simpAdEx) neurons used in their study with the full AdEx model, thereby expanding the dynamical repertoire of individual neurons while preserving the original network topology.

The network comprises 1,000 neurons distributed across two excitatory and eight inhibitory populations, spanning cortical layers 2/3 and 5. Implementation is carried out in PyNEST, with neuron and synapse models defined in NESTML. The model supports AMPA, NMDA, and GABAergic synapses, each described by double-exponential kinetics, and includes a 30\% synaptic transmission failure rate. Synaptic weights and delays are sampled from log-normal and normal distributions, respectively. Connectivity is defined by population-specific connection probabilities, and synapses follow the Tsodyks-Markram (2002) short-term plasticity dynamics.

The goal is to provide a robust, data-driven, and openly accessible model of PFC circuitry to the NEST community. Preliminary simulations show that the network produces realistic membrane potential traces and supports asynchronous-irregular firing states consistent with in vivo cortical activity. This model offers a flexible platform for exploring prefrontal cortical dynamics and serves as a foundation for investigating both physiological and pathological states in large-scale simulations.

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Preferred form of presentation

Talk (& optional poster)

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Models and applications

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Primary author: RIBEIRO PINHEIRO, Pedro (Universidade de São Paulo)

Co-author: Dr ROQUE, Antônio (Universidade de São Paulo)

Presenter: RIBEIRO PINHEIRO, Pedro (Universidade de São Paulo)

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