Contribution ID: **6** Contribution code: **T-11** Type: **Talk**

Simplified neuronal model capturing brain-state specific apical-amplification, -isolation and -drive induced by calcium dynamics

Tuesday 18 June 2024 13:20 (20 minutes)

There is mounting experimental evidence that brain-state specific neural mechanisms supported by connectomic architectures serve to combine past and contextual knowledge with current, incoming flow of evidence (e.g. from sensory systems). Such mechanisms are distributed across multiple spatial and temporal scales and require dedicated support at the levels of individual neurons and synapses. A prominent feature in the neocortex is the structure of large, deep pyramidal neurons which show a peculiar separation between an apical dendritic compartment and a basal dentritic/peri-somatic compartment, with distinctive patterns of incoming connections and brain-state specific activation mechanisms, namely apical-amplification, -isolation and -drive associated to the wakefulness, deeper NREM sleep stages and REM sleep. The cognitive roles of apical mechanisms have been demonstrated in behaving animals. In contrast, classical models of learning spiking networks are based on single compartment neurons that miss the description of mechanisms combining apical and basal/somatic information. This work leverages the NEST multi-compartment modelling framework aiming to provide the NEST community with a simplified neuronal model (Ca-AdEx) that captures brain-state specific apical-amplification, -isolation and -drive through the integration of calcium dynamics in a distal compartment. The proposed neuronal model is essential for supporting brain-state specific features in NEST learning networks at minimal computational cost in the case of two-compartment Ca-AdEx usage. A machine learning algorithm, constrained by a set of fitness functions, selected the parameters defining neurons expressing the desired apical mechanisms. Furthermore, we identified a piece-wise linear transfer function (ThetaPlanes) to be used in large scale bio-inspired artificial intelligence systems.

Acknowledgements

This work has been co-funded by the European Next Generation EU grants CUP I53C22001400006 (FAIR PE0000013 PNRR Project) and CUP B51E22000150006 (EBRAINS-Italy IR00011 PNRR Project) and by the European Union Horizon 2020 Research and Innovation program under the FET Flagship Human Brain Project (grant agreement SGA3 n. 945539). This research has also been partially funded by the Helmholtz Association through the Helmholtz Portfolio Theme Supercomputing and Modeling for the Human Brain.
We acknowledge the usage of FENIX infrastructure computational resources under the ICEI project (grant agrement no. 800858) attributed to Chiara De Luca. Also, we acknowledge the support of the APE Parallel/Distributed Computing Laboratory of INFN, Sezione di Roma.

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Preferred form of presentation

Talk (& optional poster)

Keywords

spiking networks, apical mechanisms, brain-states, multi-compartment neuron model, evolutionary algorithm, learning, sleep, adaptive exponential integrate-and-fire neuron model

Topic area

Models and applications

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Primary author: PASTORELLI, Elena (INFN - Istituto Nazionale di Fisica Nucleare - sezione di Roma)

Co-authors: YEGENOGLU, Alper (SDL Neuroscience, JSC, Forschungszentrum Juelich); KOLODZIEJ, Nicole (Istituto Nazionale di Fisica Nucleare - sezione di Roma and Università di Roma Sapienza, Italy); WYBO, Willem (Forschungszentrum Jülich); Dr SIMULA, Francesco (Istituto Nazionale di Fisica Nucleare - sezione di Roma); DIAZ, Sandra (Forschungszentrum Jülich GmbH); STORM, Johan Frederik (University of Oslo); PAOLUCCI, Pier Stanislao (INFN - Istituto Nazionale di Fisica Nucleare - sezione di Roma)

Presenter: PASTORELLI, Elena (INFN - Istituto Nazionale di Fisica Nucleare - sezione di Roma)

Session Classification: Talks