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Computational neuroscience: simulation technology and study of the low-level correlates of high-level cognitive processes

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A deeper understanding of brain functions can be achieved by adopting several approaches, and computational models play a crucial role in shedding light on neuronal dynamics. Among the available techniques, spiking neural networks is one of the most relevant. Moreover, recent computing technologies are paving the way for large-scale simulations by using cutting-edge supercomputer clusters.
In this talk, we present an overview of the computing technologies currently available, with a particular focus on CPU and GPU-based spiking neural network simulators. We discuss how such simulators can efficiently exploit the hardware spanning from workstations to HPC clusters and how they can benefit from the development of exascale computing infrastructures.
One of the most interesting features of computational neuroscience is the possibility of exploring the link between low-level neuronal mechanisms and brain functioning. The second part of the presentation focuses on the studies we conducted on the synaptic correlates of high-level cognitive processes, whose aim is to evaluate the impact of low-level synaptic mechanisms in the behavior of highly connected networks of neurons involved in cognitive processes such as working memory and learning [1,2].

[1] Tiddia G, Golosio B, Fanti V and Paolucci PS (2022) Simulations of working memory spiking networks driven by short-term plasticity. Frontiers in Integrative Neuroscience 16:972055.
[2] Tiddia G, Sergi L and Golosio B (2023) A theoretical framework for learning through structural plasticity. arXiv:2307.11735 [q-bio.NC].

Primary author: Dr TIDDIA, Gianmarco (Istituto Nazionale di Fisica Nucleare, Sezione di Cagliari)

Co-authors: GOLOSIO, Bruno (Istituto Nazionale di Fisica Nucleare); SERGI, Luca (Istituto Nazionale di Fisica Nucleare); PAOLUCCI, Pier Stanislao (Istituto Nazionale di Fisica Nucleare); FANTI, Viviana (Istituto Nazionale di Fisica Nucleare)

Presenter: Dr TIDDIA, Gianmarco (Istituto Nazionale di Fisica Nucleare, Sezione di Cagliari)

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