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A framework for studying the impact of structural plasticity on learning in firing-rate-based neuronal networks

Computational models are essential for understanding the connection between high-level cognitive processes and low-level mechanisms that involve synaptic changes. These synaptic processes and modifications constitute what is known as synaptic plasticity. In the last decades, computational models mostly focused on modeling plasticity mechanisms that involve strengthening or weakening of existing synapses and their role in cognitive processes such as memory and learning. Together with these changes in synaptic strength, there is another type of plasticity called structural plasticity, which includes the stabilization, creation, or erasure of synapses. Growing evidence suggests that this form of plasticity plays a critical role in learning and memory consolidation. In this regard, we develop a phenomenological computational model that includes these effects of structural plasticity in a firing-rate-based neural network [1]. Through a training-test protocol, we study how many patterns can be stored by the network. We also developed a theoretical framework capable of giving an estimation of the memory capacity of our network as the number of training patterns and other model parameters vary.
In summary, our work sheds light on the impact of structural plasticity on the memory capacity of a neural network. In the future, such a framework can be used to study the impact of anomalies in structural plasticity that are believed to correlate with developmental disorders such as autism and schizophrenia on the learning capability and the memory capacity of a neuronal network.

[1] Tiddia G, Sergi L and Golosio B (2023) A theoretical framework for learning through structural plasticity. arXiv:2307.11735 [q-bio.NC].

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