Neural-, Genetic-, and Quantum Information Processing: Towards an Integrative Connectionist Theory and Systems

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Abstract. The paper reviews the main principles of information processing at neuronal-, genetic-, and quantum information levels. Each of these levels has already inspired the creation of efficient computational models, such as: artificial neural networks for learning; evolutionary computation for optimization; gene and protein interaction networks; quantum computation for fast parallel processing. The paper extends these paradigms to integrative connectionist models and systems, so that they integrate in their structure and algorithms principles from different hierarchical levels of information processing in their dynamic interaction. Examples given include: evolving spiking neural networks, applied to adaptive multimodal audio-visual information processing; integrative computational neurogenetic models applied to modeling brain functions; quantum evolutionary algorithms for exponentially faster optimization; quantum neural networks for building exponentially larger associative memories. The new models are significantly faster in feature selection and learning and solve efficiently NP complete biological and engineering problems for adaptive, incremental learning in a large dimensional space. They can also help to better understand complex information processes in Nature and in the brain, especially how information processes at different information levels interact, and to extend our understanding on the fundamental concept of *Information,* leading to a new Integrative Connectionist Information Theory. Open questions, challenges and directions for further research are presented.

Keywords: Integrative Information Theory; Artificial neural networks; Evovling spiking neural networks; Multimodal audio-visual information processing; Gene interaction networks; Computational neurogenetic modeling; Quantum computation; Evolutionary algorithms; Quantum neural networks; Associative memories; Feature selection.

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Biodata:

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