Quantum Biomimetics

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Quantum Biomimetics is a research field devoted to the design of quantum protocols emulating processes or properties of living systems. There are two main directions to which our work is oriented, each of them associated with different biological phenomena.

In the first group, the are the rules of natural selection governing the evolution of species, rules that we have employed as an inspiration source for developing an algorithm for Quantum Artificial Life [1, 2]. Here, the living units, or individuals, are encoded in qudits of d levels, which we use as physical registers for storing the genotype and the phenotype. While the genotype contains the genetic information that is transmitted generation after generation, the phenotype allows for the expression of the genotype into the environment, and is degraded during the lifetime of the individual. In our model, both genotype and phenotype are associated with the expectation values of observables.

After defining the physical registers the task is to find the combination of quantum dynamics that these undergo from which the processes of self-replication, mutation, finite-lifetime and interactions emerge for individuals displacing along a 2D world.

The second group of works orbit around the idea of intelligence. Our goal is to engineer quantum protocols able to learn complex functions in an autonomous and efficient way.

The mechanism we have designed consists on a sequential implementation of a time delayed dynamics that in each cycle increases the probability of finding the system in the quantum state encoding the solution [3]. The problem is defined via a multitask controlled unitary operation, in which each control state performs its own gate in the target subspace. Therefore, the solution is no other than the control state implementing the desired input-output transition in the target subspace. We have tested this algorithm in the frame of quantum networks, in which the transmission of excitations along the network is controlled by the internal state of the nodes.

In parallel, we have studied the possibility of simulating quantum systems with memory [4, 5]. Our motivation was to develop a set of techniques that can contribute to the emulation of intelligent and living systems by providing the protocols with a more autonomous character.

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