

Quantum artificial life created on the cloud

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A project by the UPV/EHU-University of the Basque Country has for the first time implemented a model of quantum artificial life on a quantum computer.

The Quantum Technologies for Information Science (QUTIS) research group, led by the Ikerbasque Professor Enrique Solano of the UPV/EHU's Department of Physical Chemistry, has developed a quantum biomimetic protocol that reproduces the characteristic process of Darwinian evolution adapted to the language of quantum algorithms and [quantum computing](#). The researchers anticipate a future in which machine learning, artificial intelligence and artificial life itself will be combined on a quantum scale.

One [artificial intelligence](#) scenario could see the emergence of models of simple organisms capable of experiencing the various phases of life in a controlled virtual environment. Quantum computers could enable an artificial life protocol that encodes quantum behaviours belonging to living systems, including self-replication, mutation, interaction between individuals, birth and death. The researchers executed such a model on an IBM ibmqx4 cloud quantum computer.

This is the first experimental realization on a quantum computer of a quantum artificial life algorithm following Darwin's laws of evolution. The algorithm follows a protocol that the researchers refer to as biomimetic, and which encodes quantum behaviours adapted to the same behaviours of living systems. Quantum biomimetics involves reproducing in quantum systems certain properties exclusive to living

beings. The researchers had previously managed to imitate life, natural selection, learning and memory by means of quantum systems. This research is aimed at designing a set of quantum algorithms based on the imitation of biological processes, which take place in complex organisms, and transfer them to a quantum scale.

Quantum artificial life with a promising future

In the scenario of artificial life that they designed, a set of models of simple organisms accomplished the most common phases of life in a controlled virtual environment, proving that microscopic quantum systems are able to encode quantum characteristics and biological behaviours that are normally associated with living systems and natural selection.

The models were considered as units of quantum life, each one of which is made up of two qubits that act as genotype and phenotype, respectively, where the genotype contains the information that describes the type of living unit, and this information is transmitted from generation to generation. By contrast, the phenotype, the characteristics displayed by individuals, are determined by genetic information as well as by the interaction of the individuals themselves with the environment.

To be able to regard the systems as organisms of artificial life, the researchers simulated birth and evolution, self-replication, and interaction between individuals and the environment, which gradually degrades the phenotype of the individual as it ages and ends in a state representing death. The protocol also considers interaction between individuals as well as mutations, which are implemented in random rotations of individual qubits.

This experimental test represents the consolidation of the theoretical framework of quantum artificial life in an evolutionary sense, but as the

model is scaled up to more complex systems, it will be possible to implement more accurate quantum emulations with growing complexity towards quantum supremacy, according to the authors.

In the same way, they expect these units of [artificial life](#) and their possible applications to have profound implications for the community of quantum simulation and quantum computing in a range of quantum platforms, whether trapped ions, photonic systems, neutral atoms or superconductor circuits.

Enrique Solano, director of the QUTIS group and leader of this project, says, "The bases have been established for addressing different levels of classical and quantum complexity. For example, one could consider the growth of populations of quantum individuals with gender criteria, their life aims both as individuals and as groups, automated behaviours without external controls, quantum robotics processes, intelligent quantum systems, until the threshold of quantum supremacy that could only be reached by a [quantum](#) computer can be overcome. What would emerge after that would be terribly risky questions, such as guessing the microscopic origin of [life](#) itself, the intelligent development of [individuals](#) and societies, or addressing the origin of awareness and animal and human creativity. This is only the start; we are at the beginning of the 21st century and we will have many fantasy dreams and questions that we will be able to respond to."

More information: U. Alvarez-Rodriguez et al. Quantum Artificial Life in an IBM Quantum Computer, *Scientific Reports* (2018). [DOI: 10.1038/s41598-018-33125-3](https://doi.org/10.1038/s41598-018-33125-3)

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