Artificial Life in Quantum Technologies

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QUTIS Quantum Technologies for Information Science
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We have designed a quantum protocol for the realization of Artificial Life in an experimental quantum platform. Our framework allows to mimic a natural selection scenario where the living units, or individuals, are able to self-replicate, mutate, age, displacee, interact and finally die.Together with the development of the model, we have analyzed the feasibility of a possible experiment in a selection of the most controllable quantum platforms. We show that current technological resources could be enough to support the realization of our "Quantum Artificial Life".

Introduction to Quantum Information

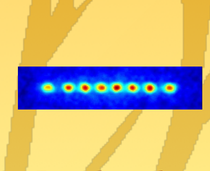
- **Information Register**
  Quantum bits

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$$

- **Computational Tasks**
  Schrödinger Equation

$$i\hbar\frac{d}{dt}|\psi(t)\rangle = H|\psi(t)\rangle$$

- **Physical Platforms**
  Trapped Ions
  Integrated Photonics
  Superconducting Circuits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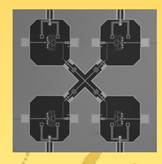
Oxford


Santa Barbara

Artificial Life Protocol

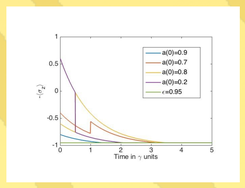
The living units are encoded in two different qubits, the genotype and phenotype. The information in each of them is employed to encode different processes of the natural selection model.

- **Self-Replication**
  Partial Quantum Cloning

$$\langle\sigma_z\rangle_{\rho_0} = \langle\sigma_z \otimes 1\rangle_{\rho_1} = \langle 1 \otimes \sigma_z\rangle_{\rho_1}$$

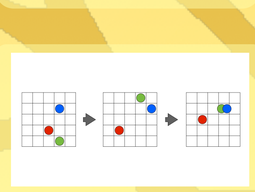
- **Lifetime**
  Dissipative Dynamics

$$\frac{d}{dt}\rho = \gamma(\sigma\rho\sigma^\dagger - \frac{1}{2}\{\sigma^\dagger\sigma, \rho\})$$

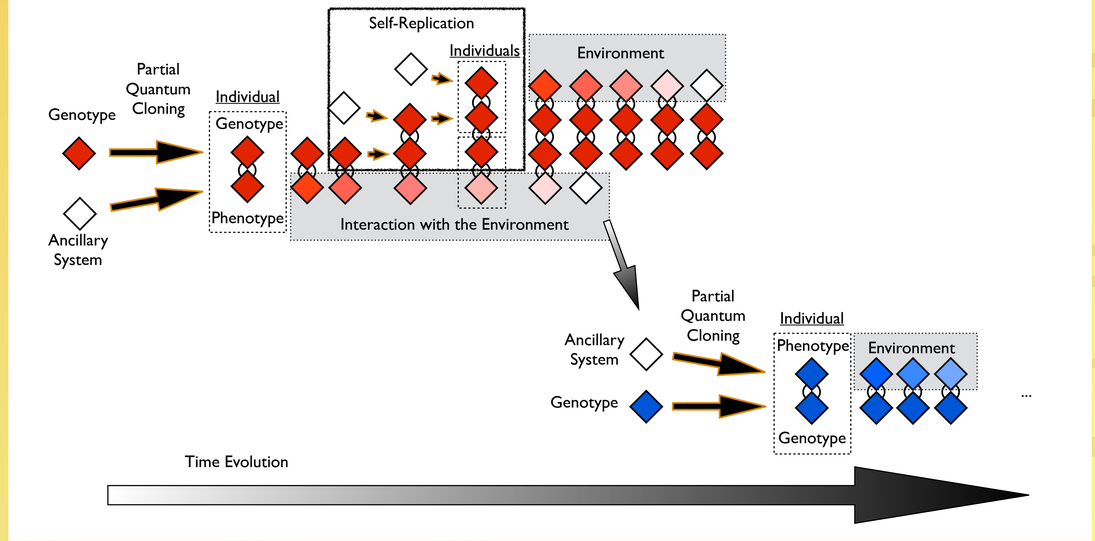


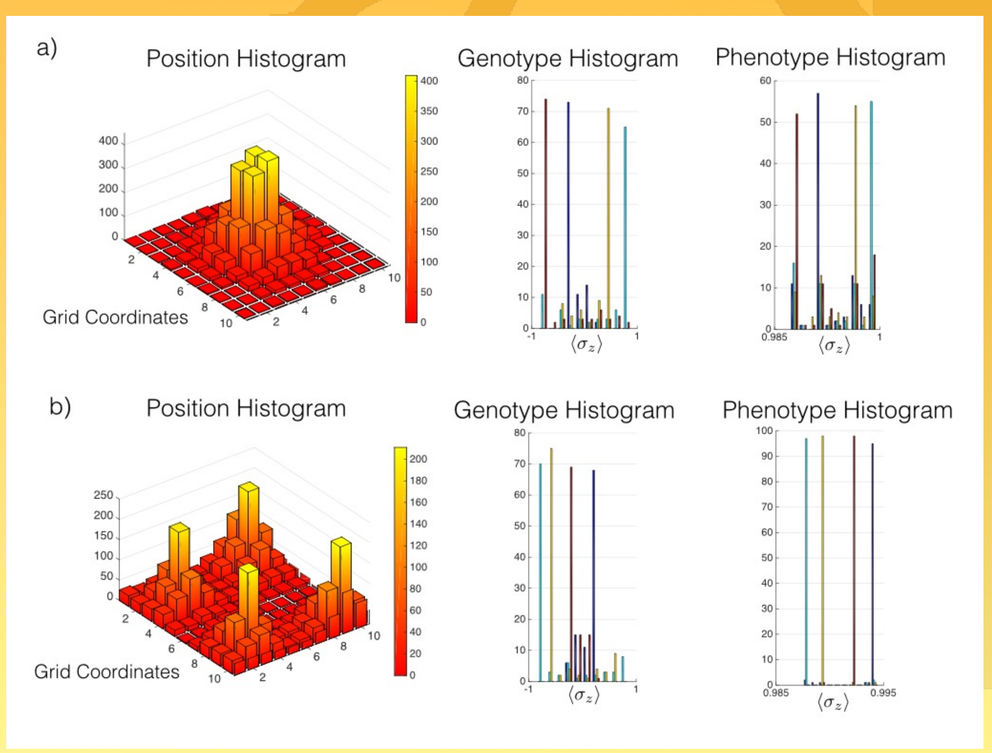
- **Mutations**
  Single Qubit Rotations

- **Interactions**
  4 Qubit Control Operations



- **Position**
  Random Classical Variable





Numerical Simulations

- **Position Histogram**
  Information Spreading and Location

- **Genotype Histogram**
  Self-Replication and Mutation Events

- **Phenotype Histogram**
  Lifetime and Interactions Events

[1] W. K. Wootters & W. H. Zurek, A single quantum cannot be cloned, Nature 299, 802 (1982) .
[2] U. Alvarez-Rodriguez, M. Sanz, L. Lamata & E. Solano, Biomimetic Cloning of Quantum Observables, Sci. Rep. 4, 4910 (2014).
[3] U. Alvarez-Rodriguez, M. Sanz, L. Lamata & E. Solano, Artificial Life in Quantum Technologies, Sci. Rep. 6, 20956 (2016).
[4] Quantum Life Spreads Entanglement Across Generations, MIT Technology Review

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