ID de Contribution: **17** Type: **Talk (Long)**

Quantum physics for machine learning

mercredi 10 juillet 2024 14:00 (45 minutes)

Quantum computing aims to leverage the principles of quantum mechanics, such as superposition, to encode and process information in ways that classical computers cannot, potentially handling exponentially larger amounts of information. However, harnessing this computational advantage requires quantum algorithms capable of encoding data into superpositions and providing answers with minimal queries to the quantum device. Currently, only a limited number of algorithms are known to offer exponential [1,2] , or quadratic [3] speedups over classical algorithms. This is where machine learning plays a pivotal role. By treating the quantum system as a learning machine, we can develop algorithms that exploit quantum coherences [4] .

In our team, we focus on quantum machine learning using superconducting circuits with Josephson junctions [5] . We analyze the capacity of quantum systems to increase exponentially the number of neurons compared to a classical circuit, compare different sources of nonlinearity and study the contribution of quantum coherences to learning. Utilizing the framework of physical neural networks [6] , we show that our physical system can be trained through automatic differentiation. Our approach allows us to optimize various physical parameters, including drive amplitudes, phases, detunings, and dissipation rates, and demonstrate high performance across diverse tasks that test the nonlinearity and memory capabilities of the neural network.

References

1. Shor, P. W. Polynomial-Time Algorithms for Prime Factorization and Discrete Logarithms on a Quantum Computer. SIAM J. Comput. 26, 1484–1509.
2. Harrow, A. W., Hassidim, A. & Lloyd, S. Quantum Algorithm for Linear Systems of Equations. Phys. Rev. Lett. 103, 150502 (2009).
3. Grover, L. K. A fast quantum mechanical algorithm for database search. in Proceedings of the twenty-eighth annual ACM symposium on Theory of computing - STOC '96 212–219 (ACM Press, Philadelphia, Pennsylvania, United States, 1996).
4. Marković, D., Mizrahi, A., Querlioz, D. & Grollier, J. Physics for neuromorphic computing. Nat. Rev. Phys. 2, 499–510 (2020).
5. Dudas, J. et al. Quantum reservoir computing implementation on coherently coupled quantum oscillators. Npj Quantum Inf. 9, 64 (2023).
6. Wright, L. G. et al. Deep physical neural networks trained with backpropagation. Nature 601, 549–555 (2022).

Orateur: Dr MARKOVIC, Danijela (CNRS Thales)

Classification de Session: Physics for Machine Learning

Classification de thématique: Invited talks