Fully machine learning-driven control and characterisation of quantum devices

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Scaling semiconductor qubit devices requires precise control over high-dimensional device parameters, a challenge that increasingly benefits from machine learning techniques [1]. In this talk, I will present our demonstration of fully autonomous spin qubit tuning (Fig.1), where machine learning systematically maps operational regimes and extracts qubit properties across a broad parameter range. This approach enables real-time identification of Rabi frequencies spanning 50 to 150 MHz within a single charge transition [2].

Beyond tuning, machine learning is particularly useful for understanding and characterising device variability. I will show how physics-informed models reveal disorder potentials in quantum dot devices [3] and how these insights contribute to closing the gap between simulation and experiment [4]. Finally, I will discuss emerging directions in cross-platform device tuning [5,6], physics-aware quantum control, and digital twin frameworks.

References

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[4] B. van Straaten et al., QArray: A GPU-accelerated constant capacitance model simulator for large quantum dot arrays, SciPost Phys. Codebases 35 and 35-r1.3 (2024)

[5] B. Severin et al., Cross-architecture tuning of silicon and SiGe-based quantum devices using machine learning, Sci. Rep. 14, 17281 (2024)

[6] J. Hickie et al., Automated long-range compensation of an rf quantum dot sensor, Phys. Rev. Appl. 22, 064026 (2024)

Figures

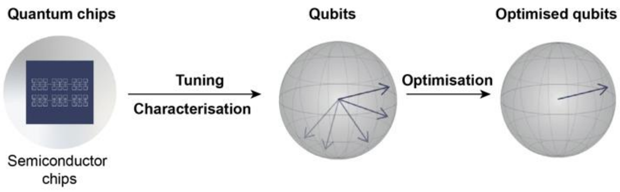

Figure 1: Semiconductor quantum devices require precise tuning and control protocols to function as qubits. Machine learning can automate and accelerate these processes, enabling high-throughput characterisation and optimisation of qubit metrics.