Fully autonomous tuning of spin qubits

Natalia Ares

University of Oxford

The application of machine learning is rapidly transforming the tuning and characterization of quantum devices, enabling the exploration of complex, high-dimensional parameter spaces with high efficiency. These advanced algorithms not only identify optimal operational conditions but also exceed the capabilities of human experts in characterizing operational regimes. We demonstrate the first fully autonomous tuning of a spin qubit [1], a significant milestone toward the scalability of semiconductor quantum technologies. Our algorithm facilitates unprecedented mapping of qubit metrics across the full gate voltage parameter space, revealing qubits with Rabi frequencies ranging from 50 to 150 MHz within the same charge transition. I will conclude with a perspective on the future of machine learning in quantum device operation, highlighting our efforts on physics-aware machine learning [2], cross-architecture algorithms [3], and digital twinning [4] to further advance this field.

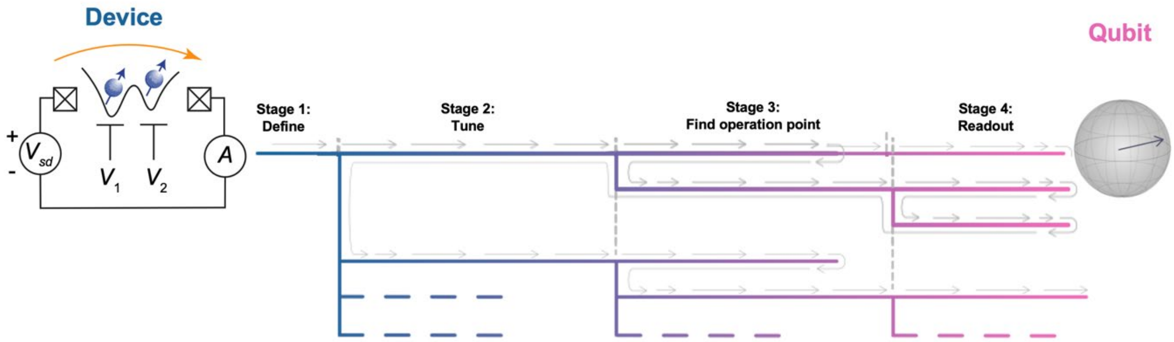

Figure 1, Schematic illustrating the structure of the fully autonomous tuning algorithm for a spin qubit. There are four stages that the algorithm needs to navigate to reach qubit operation. Each stage can either be successful (leading to one or more branches), or unsuccessful (leading to a backtracking to the closest stage that was successful). The search is therefore conducted in a tree structure. Some branches of the tree might be left unexplored (indicated by dashed lines).

[1] Schuff et al. Fully automous tuning of a spin qubit, arXiv:2402.03931

[2] Craig et al. Bridging the reality gap. Phys. Rev. X 14, 011001 (2024)

[3] Severin et al. Scientific Reports 14, 17281 (2024)

[4] Straaten et al. QArray: a GPU-accelerated constant capacitance model simulator, arXiv:2404.04994