Fully autonomous tuning of a spin qubit

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Spanning over two decades, the study of qubits in semiconductors for quantum computing has yielded significant breakthroughs [1–3]. However, the development of large-scale semiconductor quantum circuits is still limited by challenges in efficiently tuning and operating these circuits. Identifying optimal operating conditions for these qubits is complex, involving the exploration of vast parameter spaces [4]. This presents a real 'needle in the haystack' problem, which, until now, has resisted complete automation due to device variability and fabrication imperfections [5]. In this study, we present the first fully autonomous tuning of a semiconductor qubit, from a grounded device to Rabi oscillations, a clear indication of successful qubit operation. We demonstrate this automation, achieved without human intervention, in a Ge/Si core/shell nanowire device. Our approach integrates deep learning, Bayesian optimization, and computer vision techniques. We expect this automation algorithm to apply to a wide range of semiconductor qubit devices, allowing for statistical studies of qubit quality metrics. As a demonstration of the potential of full automation, we characterise how the Rabi frequency and g-factor depend on barrier gate voltages for one of the qubits found by the algorithm. Twenty years after the initial demonstrations of spin qubit operation, this significant advancement is poised to finally catalyze the operation of large, previously unexplored quantum circuits.

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