Quantum Supremacy

Student's name
Amsterdam University of Applied Science
Amsterdam, The Netherlands
student.email@hva.nl

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Summary

The promise of quantum computers is that certain computational tasks might be executed exponentially faster on a ...

1 Introduction

In the early 1980's, Richard Feynman proposed that a quantum computer would be an effective tool with which to solve problems in physics and chemistry, given that it is exponentially costly to simulate large quantum systems with classical computers (Feynman, 1982).

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This research paper is organized as follows. Section 2 offers .... Section 3 describes the .... Section 4 reports a .... Finally, in Section 5 we state ...

2 A suitable computational task

To demonstrate quantum supremacy, we compare our quantum processor against ...

For a given circuit, we collect the measured bitstrings $\{x_i\}$ and compute the *linear cross–entropy benchmarking fidelity*, which is the mean of the simulated probabilities of the bitstrings we measured:

$$\mathcal{F}_{\text{XEB}} = 2^n \left\langle \mathbf{Pr} \left\{ x_i \right\} \right\rangle_i - 1, \tag{1}$$

where n is the number of ...

3 Building a high–fidelity processor

We designed a quantum processor named "Sycamore", shown in Figure 1, which consists of a two–dimensional array of 54 transmon qubits, where each qubit is tunably coupled to four nearest neighbors, in a rectangular lattice.

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The qubit is encoded as the two lowest quantum eigenstates of the resonant circuit. Each transmon has two controls:

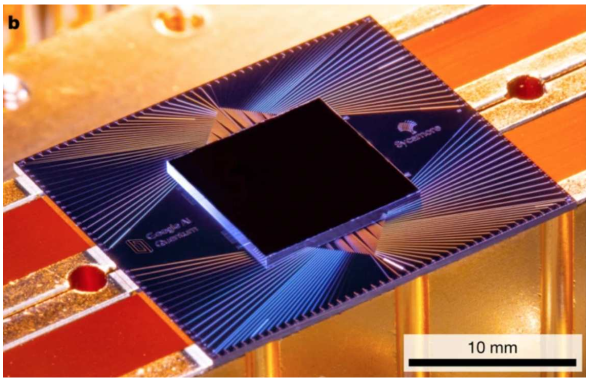

Figure 1: Photograph of the Sycamore chip.

Average error	Isolated	Simultaneous
Single–qubit (e_1)	0.15%	0.16%
Two–qubit (e_2)	0.36%	0.62%
Two–qubit, cycle (e_{2c})	0.65%	0.93%
Readout (e_r)	3.1%	3.8%

Table 1: Average (mean) values of Pauli errors (black, green, blue) and readout errors (orange), measured on qubits in isolation and when operating all qubits simultaneously.

- A microwave drive to excite the qubit, and
- A magnetic flux control to tune the frequency.

Each qubit is connected to a linear resonator ...
...

4 Experiments

For the full experiment, we generate quantum circuits using the two–qubit unitaries measured for each pair during simultaneous operation, rather than a standard gate for all pairs ...

Finally, we benchmark qubit readout using standard dispersive measurement (Wallraff et al., 2005). Measurement errors averaged over the $|0\rangle$ and $|1\rangle$ states are shown in Table 1. We have also measured the error when operating all qubits simultaneously, by randomly preparing each qubit in the $|0\rangle$ or $|1\rangle$ state and then measuring all qubits for the probability of the correct result. We find that simultaneous readout incurs only a modest increase in per–qubit measurement errors.

5 Conclusions

Quantum processors based on superconducting qubits can now perform computations in a Hilbert space of dimension $2^{53} \approx 9 \times 10^{15}$, beyond the reach of the fastest classical supercomputers available today. To our knowledge, this experiment marks ...

References

Feynman, R. P. (1982). Simulating physics with computers. *International Journal of Theoretical Physics*, *21*(6/7).

Wallraff, A., Schuster, D., Blais, A., Frunzio, L., Majer, J., Devoret, M., Girvin, S., & Schoelkopf, R. (2005). Approaching unit visibility for control of a superconducting qubit with dispersive readout. *Physical Review Letters*, *95*(6), 060501.