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FACULTY OF DIGITAL MEDIA AND CREATIVE INDUSTRIES
HBO – Information and Communication Technologies

Quantum Supremacy

Quantum Capita Selecta

Student's name

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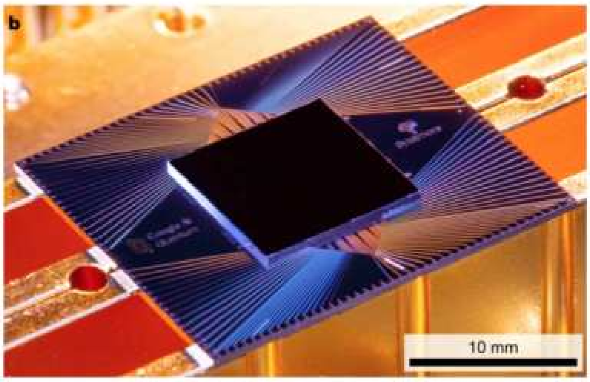

Figure 1: Photograph of the Sycamore chip.

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 ([1]).

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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:

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

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:

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 ([2]). 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

[1] R. P. Feynman, "Simulating physics with computers," *International Journal of Theoretical Physics*, vol. 21, no. 6/7, 1982.

[2] A. Wallraff, D. Schuster, A. Blais, L. Frunzio, J. Majer, M. Devoret, S. Girvin, and R. Schoelkopf, "Approaching unit visibility for control of a superconducting qubit with dispersive readout," *Physical Review Letters*, vol. 95, no. 6, p. 060501, 2005.