Quantum Insider Insights: Volume 6 – Correct Error Correction

At TQD access to our leading data platform - The Quantum Insider – allows us to provide deeper insights into the key recent quantum news.

Companies Make Sure, Steady Strides Toward Error Correction -- As More Challenges Await

Quantum computers are far from perfect. In the NISQ era, they might even be far from even good. But, on our way to fault-tolerant quantum computers, error correction approaches may make nearly good quantum computers much better and, eventually, make good quantum computers better than classical versions. Quantum scientists have a few ways to make them better. They can improve the hardware, making qubits more stable and less susceptible to interference. The other route to quantum advantage may be paved with better error correction. Several companies are making impressive strides there, including corporate leaders, such as Honeywell Quantum Solution (HQS) and Google AI. Meanwhile, recent research is showing just how important this error-correction will be.

Key points in our story on HQS's error correction and on Google's advance.

- In HQS's approach: In the paper, the researchers described how they created a single logical qubit (a series of entangled physical qubits) and applied multiple rounds of quantum error correction. This logical qubit is protected from two main types of errors that occur in a quantum computer: bit flips and phase flips.
- Just as there are several types of quantum computers, developers have devised several approaches to error-correction. Teams have looked at codes that only are capable of correcting a single type of error (bit or phase, but not both). Others have looked at quantum error detecting codes, which can detect both types of errors but not correct them. Further still, groups have demonstrated pieces of the quantum error correcting process.
- Google AI researchers report on the addition of logical qubits to reduce the logical qubit error rate. The team reports that repetition code logical errors can suppress errors when the number of qubits is increased from 5 to 21, with a total error suppression of more than 100×.
- Google's approach was facilitated by two recent advancements in gate calibration on the Sycamore architecture: a reset protocol, which removed population from excited states, including non-computational states, by sweeping the frequency of each measure qubit through that of its readout resonator and the implementation of a 26-ns controlled-*Z* (CZ) gate using a direct swap between the joint states.
- For deeper looks at the technology, HQS's error-correction paper is available on ArXiv, Google published their work in Nature.
- A research collaboration that included scientists from Lawrence Livermore National Laboratory found in a series of experiments that fluctuations in the electrical charge of multiple qubits can be highly correlated, as opposed to completely random and independent. Additionally, the team linked tiny error-causing perturbations in the qubits' charge state to the absorption of cosmic rays. Their work was published in Nature.

Observations

Why Error-Correction Matters

Quantum hardware companies continue to pursue aggressive roadmaps to develop devices that deliver real-world solutions. Meanwhile, funders are writing sizeable checks to these pre-IPO startups and investors are casting a wary eye on the funds that public companies are throwing at – to some – are very risky technologies. Like a ticking clock, companies will have to either achieve quantum advantage through hardware alone, or they will need robust error-correction to serve as a bridge to quantum advantage, or, perhaps a delay tactic to sooth rapidly rising expectations.

The Insider View

There are many variables in qubit performance and an ever-growing benchmarks that examine performance – from quantum number to quantum volume. Companies routinely use abstract and arbitrary statistics as quantum advantage goal posts – 1,000 qubits, 5,000 qubits, or 1 million qubits.

The truth is, at this point, it would be impossible to tell just how realistic most estimates are on achieving quantum advantage. It would be impossible to tell whether these benchmarks and statistics are even meaningful.

Error-correction, then, is an important brick in the path toward quantum advantage, at the very least. Companies that have robust error-correction programs with researchers who are publishing in scientific journals may have a life raft – or speed boat – to provide their customers real-world quantum solutions.

Google AI and Honeywell Quantum Solutions are examples of some of the companies that have achieved this position – good hardware projects buoyed by solid error-correction advances.

Insider Voices

"In the technical paper, we point to key improvements we need to make to reach the break-even point. We believe these improvements are feasible and are pushing to accomplish this next step."
-- Dr. Ciaran Ryan-Anderson, an advanced physicist and lead author of HQS's paper.

"The big, enterprise-level problems we want to solve with quantum computers require precision and we need error-corrected logical qubits to scale successfully."
-- Tony Uttley, president of Honeywell Quantum Solutions.

"For the most part, schemes designed to correct errors in quantum computers assume that the errors across qubits are uncorrelated — they're random. Correlated errors are very difficult to correct. Essentially, what this paper is showing is that if a high-energy cosmic ray hits the device somewhere, it has the potential to affect everything in the device at once. Unless you can prevent that from happening you can't perform error correction efficiently, and you'll never be able to build a working system without that."
-- Lawrence Livermore National Laboratory physicist Jonathan DuBois

Matt Swayne, Editor and Analyst

Matt Swayne is the editor of The Quantum Daily. He is a science and information officer at Penn State and has over 30 years journalistic experience. He has written extensively on the key quantum ethics issues, including numerous interviews with key industry thought leaders

Alex Challans, CEO

Alex Challans is the CEO of The Quantum Daily. He was previously an Investment Director of a London-based Private Equity fund, focussed on technology investments.