Quantum Canary: Neural Network Based Autonomous Noise Drift Detection in NISQ Era Quantum Processors

Singh, Kanishka (School: Urbana High School)

Quantum computers use the principles of quantum mechanics — superposition, entanglement, and coherence — to solve problems that classical computers simply cannot. In the current era of Noisy Intermediate-Scale Quantum (NISQ), quantum bit (qubit) performance continues to degrade over time due to nearly imperceptible environmental interference (thermal fluctuations, electromagnetic interference, cosmic radiation, etc.) that disrupt the fidelity of these incredibly sensitive qubits between calibration cycles. Cloud-based quantum computing services offer daily snapshots of reliability/health, creating an unmonitored time between calibration cycles where any drift in environmental noise will undetectably affect the outcome of computations. Ultimately, the hundreds of computations run on these quantum computers in between calibration cycles may be off by a wide margin. Entities utilizing these systems for computation (including government bodies and pharmaceutical companies) are often unaware that their results may be flawed. This work introduces Quantum Canary, an autonomous system that leverages neural networks and canary circuits to provide real-time monitoring of quantum noise drift so that it can be detected before the platform's next calibration snapshot. The 3 canary circuits (Bell state fidelity, single qubit coherence, and gate error cancellation) feed features into a binary multi-layered perceptron (MLP) classifier. The MLP is trained using historical calibration data from IBM Quantum and validated against real IBM quantum processors. Quantum Canary had an AUC of 0.92 on testing data, a 21.2% increase over a traditional statistical method, and detected drift an average of 3 hours before IBM detected it.

Awards Won:
National Taiwan Science Education Center: Taiwan International Science Fair Special Award is a trip to participate in the Taiwan International Science Fair