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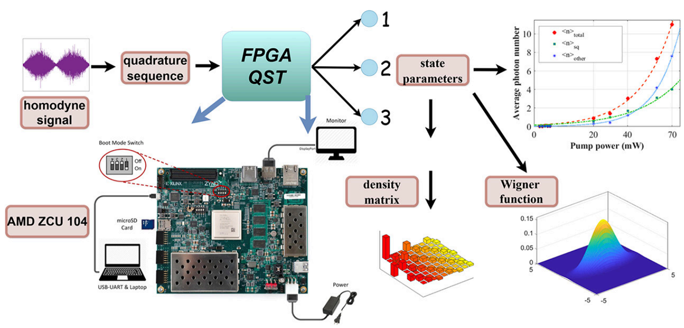
Analysis technique based on commercially available device enhances performance of quantum state tomography.



The performance of quantum computers and gravitational wave detectors both rely on understanding the quantum systems underlying them, but fully characterizing those systems is difficult due to the computational cost of the analytic algorithms. Wu et al. applied a commercial machine learning technique to enhance the performance of quantum state tomography (QST), a common technique used to characterize quantum systems.

The authors used a reconfigurable field-programmable gate array (FPGA) to achieve real-time, high-precision quantum state analysis on resource-constrained devices. Compared to machine learning QST based on computationally powerful graphics processing units, the FPGA-based approach reduces the system's average inference time by an order of magnitude, from 38 ms to 2.94 ms, while only experiencing an average fidelity reduction of about one percent.

"As quantum states have been used in true applications from quantum metrology and quantum information manipulation using continuous variables, FPGA-based ML-enhanced QST can be used as in-line diagnostic toolboxes," author Ray-Kuang Lee said.

To test the new method in a resource-limited environment, the team implemented the program on a FPGA edge device from Advanced Micro Devices (AMD), the ZCU 104 Evaluation Board with a Vitis AI Integrated Development Environment. This commercially available device provides software tools for deploying and running AI models on its hardware.

The authors said their results can apply to other quantum systems.

"In addition to application with Gaussian states, as illustrated in our study, this technology paves the way to dealing with more general quantum states, including non-Gaussian states and multi-partite quantum states at high throughput speeds," Lee said.

Source: "Machine learning enhanced quantum state tomography on a field-programmable gate array," by Hsun-Chung Wu, Hsien-Yi Hsieh, Zhi-Kai Xu, Hua Li Chen, Zi-Hao Shi, Po-Han Wang, Popo Yang, Ole Steuernagel, Te-Hwei Suen, Chien-Ming Wu, and Ray-Kuang Lee, *APL Quantum* (2025). The article can be accessed at https://doi.org/10.1063/5.0262942.

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