The Qibo Ecosystem: Integrating Advanced QML with Real-Time Hardware Control

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Abstract: We present the latest advancements to the Qibo ecosystem, a full-stack platform for quantum algorithm development, simulation, and hardware execution.

We present the latest advancements to the Qibo ecosystem, a full-stack platform for quantum algorithm development, simulation, and hardware execution. Recent developments focused on deeply integrating Quantum Machine Learning (QML) capabilities and real-time hardware control to accelerate research, prototyping, and deployment of quantum applications.

The dedicated Qiboml module introduces a flexible framework that simplifies the construction of complex, composite quantum-classical models and ensures interoperability with established classical ML libraries. This design minimizes the complexity involved in rapid prototyping and experimentation with varied model components, including different derivative rules, noise mitigation techniques, and automated on-the-fly chip re-calibration. The calibration process itself is managed through the Qibocal module.

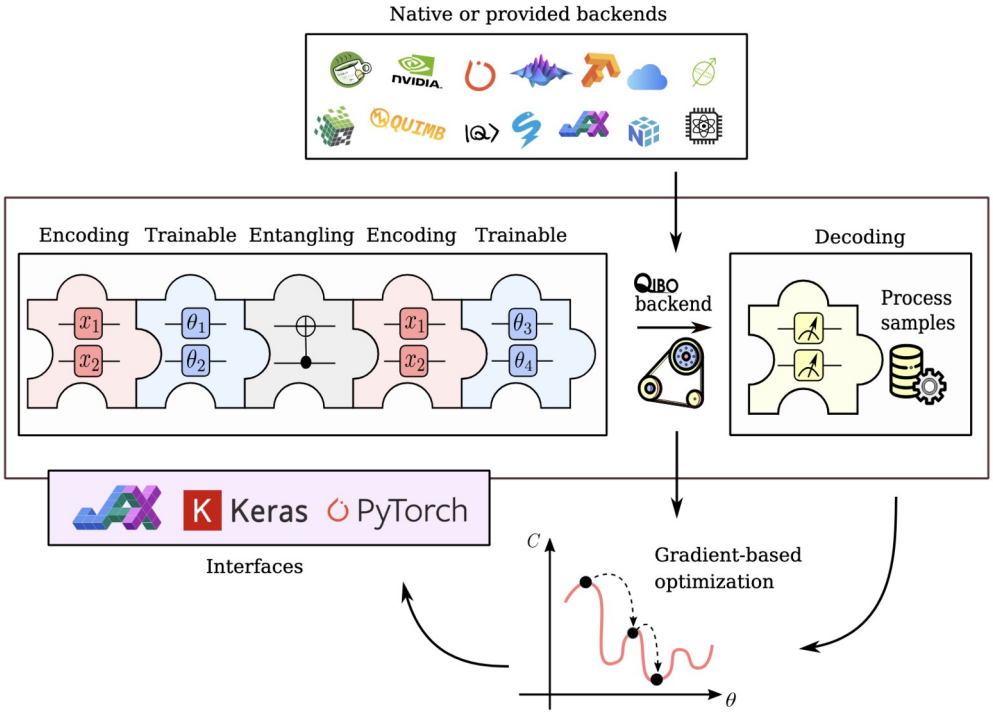

Fig. 1 Schematic representation of a quantum machine learning pipeline with Qiboml.

Its protocol library now extends calibration and stability management beyond single-qubit operations to include support for entangling-gate schemes. These include the operation of flux-tunable transmons, which require the precise handling of pulse distortions. These mechanisms are now formally exposed within Qibolab to ensure their reliable implementation across diverse experimental setups, aligning with the available literature.

Example References

[1] M. Robbiati, A. Papaluca, A. Pasquale, E. Pedicillo, R. M. S. Farias, A. Sopena, M. Robbiano, G. Alramahi, S. Bordoni, A. Candido, N. Laurora, J. S. Neto, Y. Paul Tan, M. Grossi, S. Carrazza, "Qiboml: towards the orchestration of quantum-classical machine learning," arXiv:2510.11773

[2] A. Pasquale, E. Pedicillo, J. Cereijo, S. Ramos-Calderer, A. Candido, G. Palazzo, R. Carobene, M. Gobbo, S. Efthymiou, Y. Paul Tan, I. Roth, M. Robbiati, J. Wilkens, A. Orgaz-Fuertes, D. Fuentes-Ruiz, A. Giachero, F. Brito, J. I. Latorre, S. Carrazza, "Qibocal: an open-source framework for calibration of self-hosted quantum devices," arXiv:2410.00101

[3] S. Efthymiou, A. Orgaz-Fuertes, R. Carobene, J. Cereijo, A. Pasquale, S. Ramos-Calderer, S. Bordoni, D. Fuentes-Ruiz, A. Candido, E. Pedicillo, M. Robbiati, Y. Paul Tan, J. Wilkens, I. Roth, J. I. Latorre, S. Carrazza, "Qibolab: an open-source hybrid quantum operating system," Quantum **8**, 1247 (2024).