QuantumNAS: Noise-Adaptive Search for Robust Quantum Circuits using GPUs

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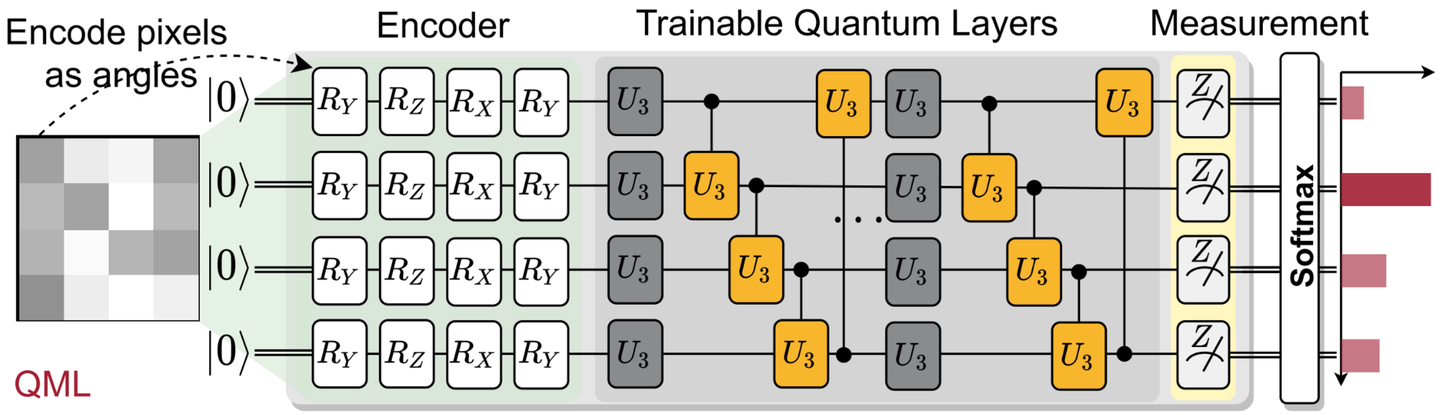
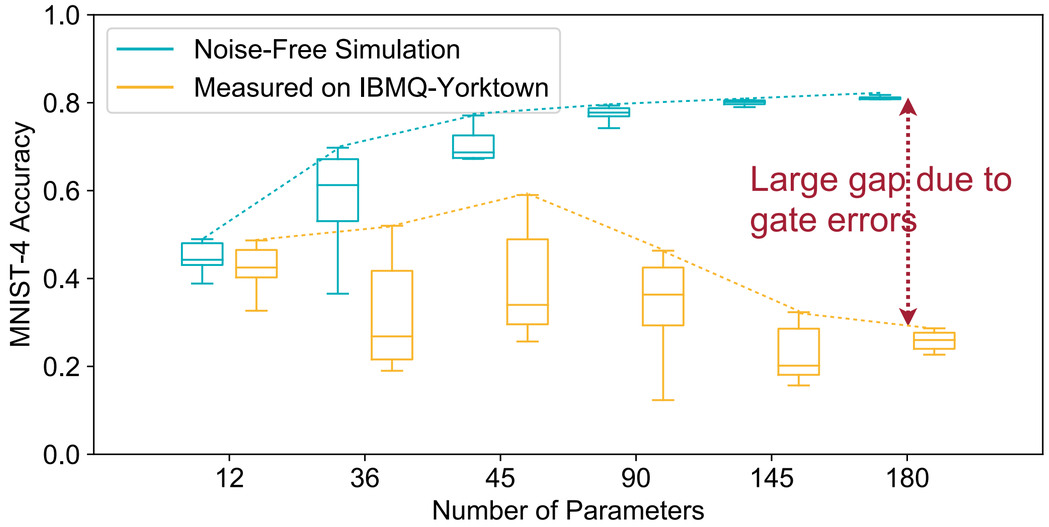
Background and Motivation

- Quantum computer bottleneck: **large quantum noise**
- Benchmark: Quantum Neural Networks (QNN) architecture

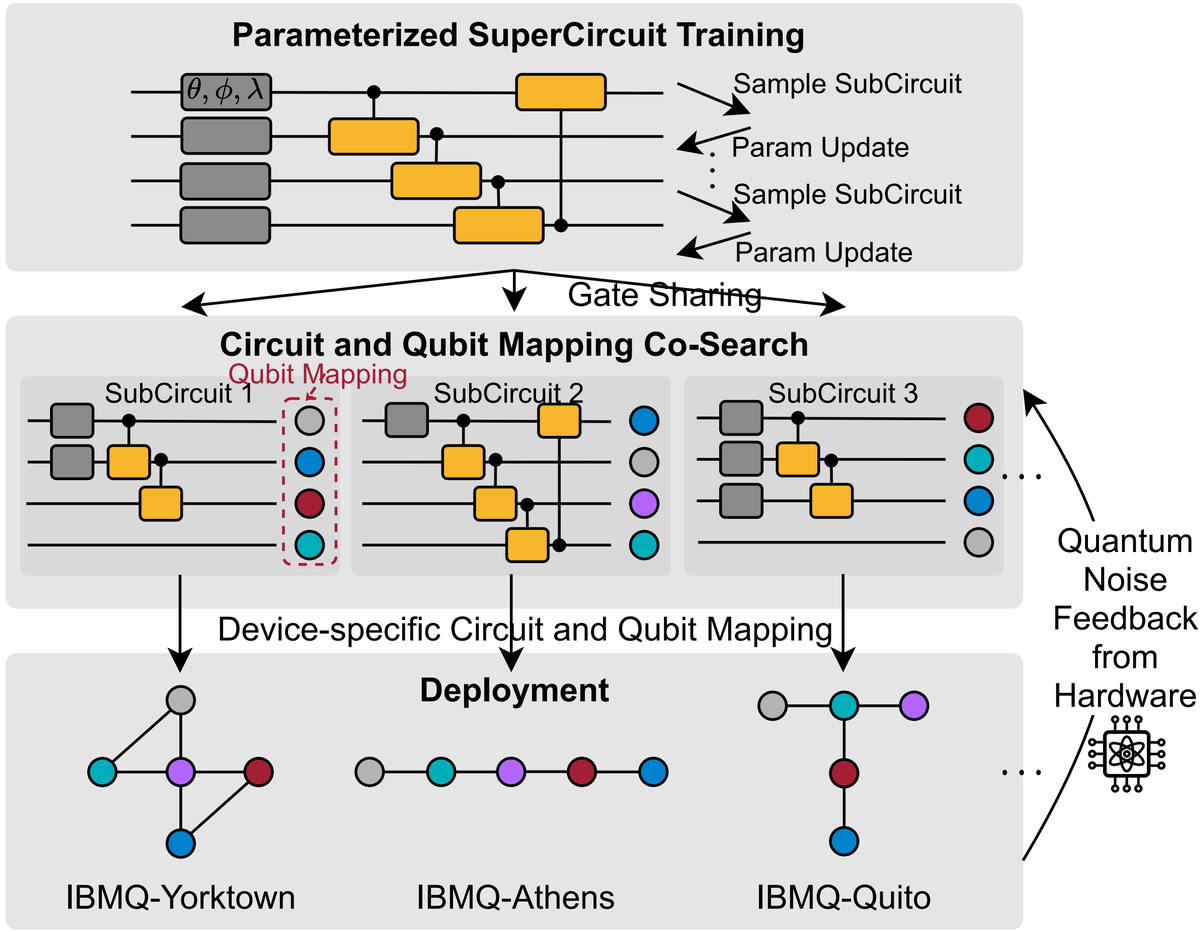




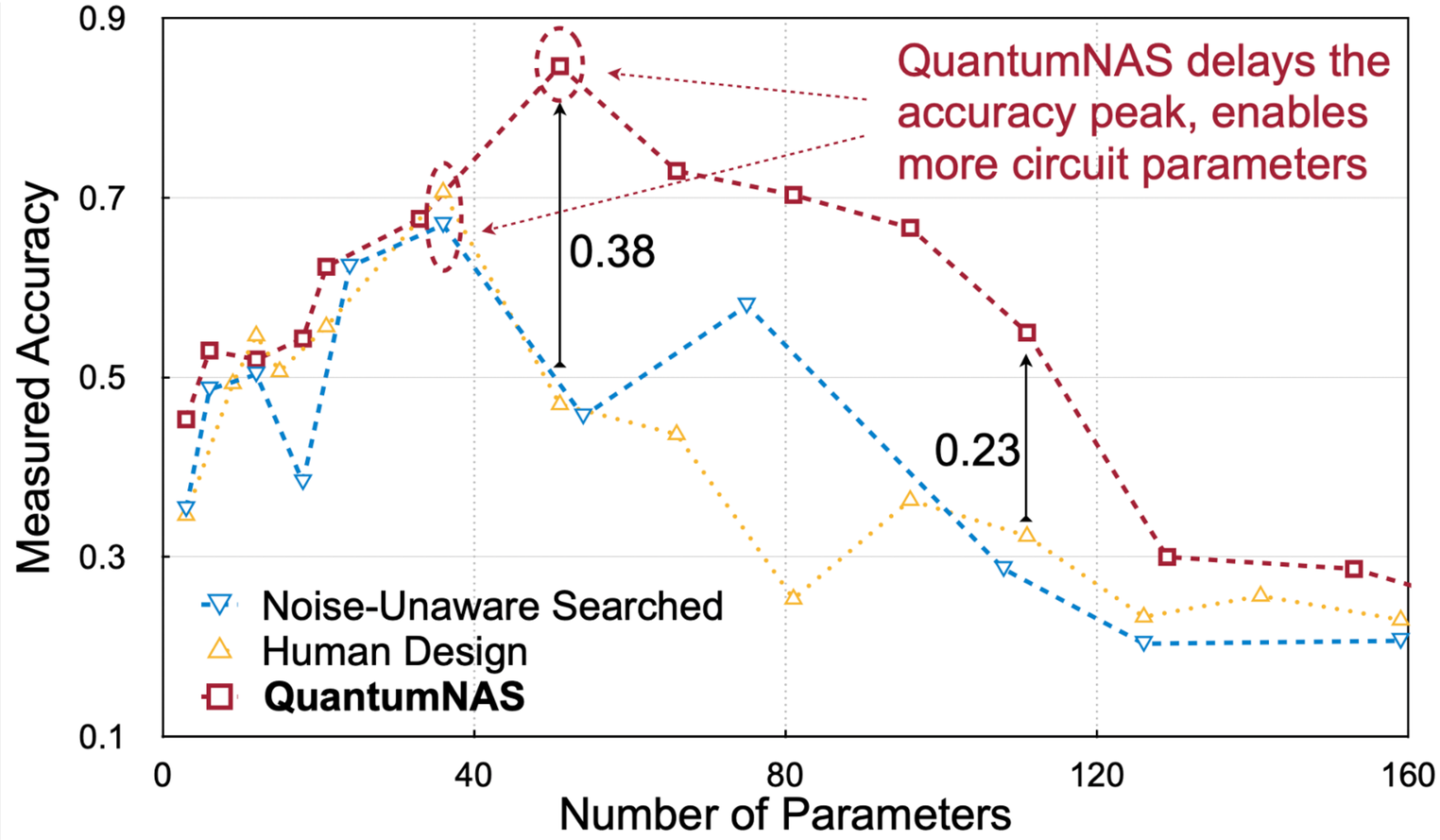
- A large **gap** between noise-free simulation and real deployment
- More parameters increase the noise-free accuracy but **degrade measured accuracy**
- Find **most noise-robust** circuit

QuantumNAS Framework

- Step 1: Given a circuit design space, a '**SuperCircuit**' is constructed as the largest possible circuit. The parameters of it are trained by **iteratively sampling and updating** a subset of parameters ('**SubCircuit**')
- Step 2: Perform an evolutionary **search with real hardware feedback** to find the most robust model architecture and its qubit mapping
- Step 3: Train the searched architecture from-scratch and **Prune** away small magnitude gates
- Step 4: D**eploy on real QC**



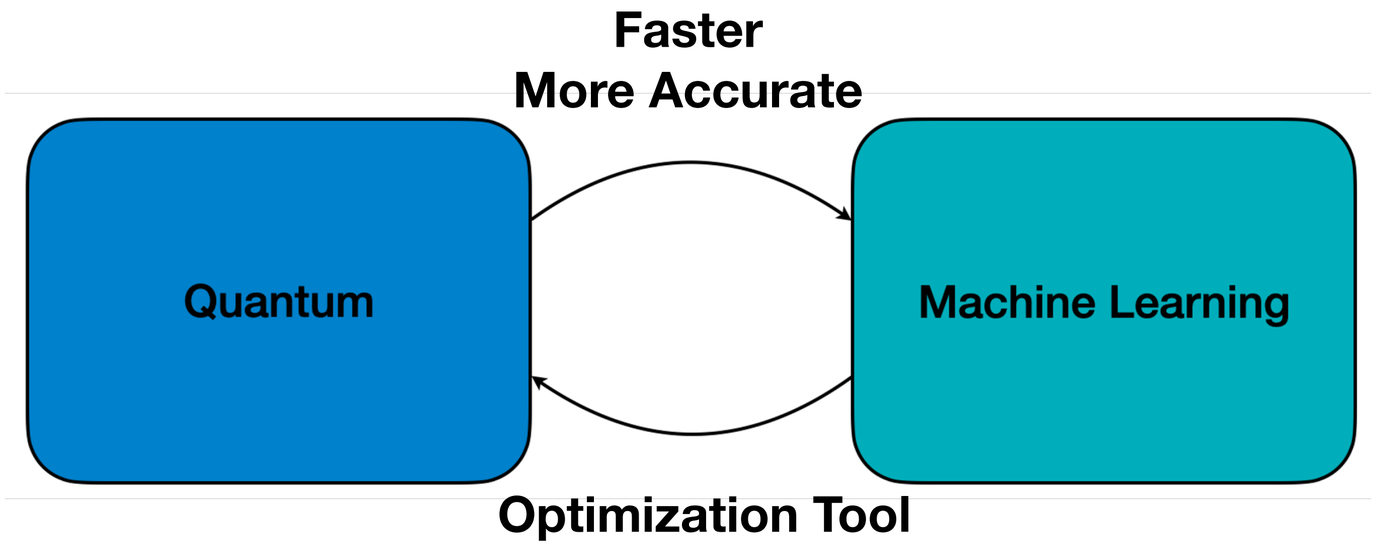
Results on Real Quantum Computer



- Up to **38% higher** accuracy than search without noise information and human design baselines

TorchQuantum – A library for fast Quantum+ML on GPUs

- Quantum ML and ML for Quantum
- Easy construction of parameterized quantum circuits such as Quantum Neural Networks in **PyTorch**
- Support batch mode inference and training on **GPU/CPU**, supports highly-parallelized training
- Support **easy deployment** on real quantum devices such as IBMQ
- Provide **tutorials, videos and example projects** of QML and using ML to optimize quantum computer system problems



Thank you for watching!

Torch Quantum

github.com/mit-han-lab/torchquantum

qmlsys.mit.edu