QBAS22 SCORE ON RIGETTI

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Introduction to DDQCL

Data Driven Quantum Circuit Learner (DDQCL) is the hybrid quantum-classical approach that is used to assist the characterization of the quantum devices and to train shallow circuits for generative tasks.

Our tasks

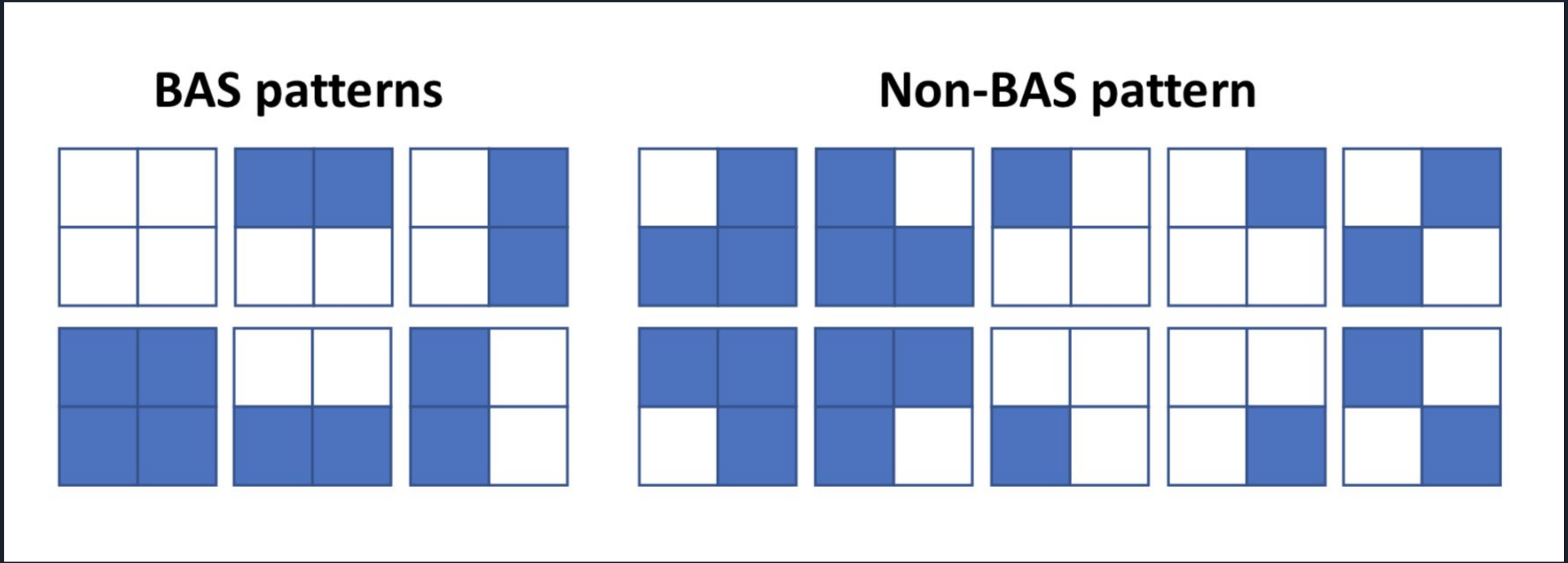
In our case of generative ML task we were given an input dataset and we output measurements.

We have a two step process:

1) DDQCL is used to encode BAS22 (shown on next slide) in the wave function of the quantum state

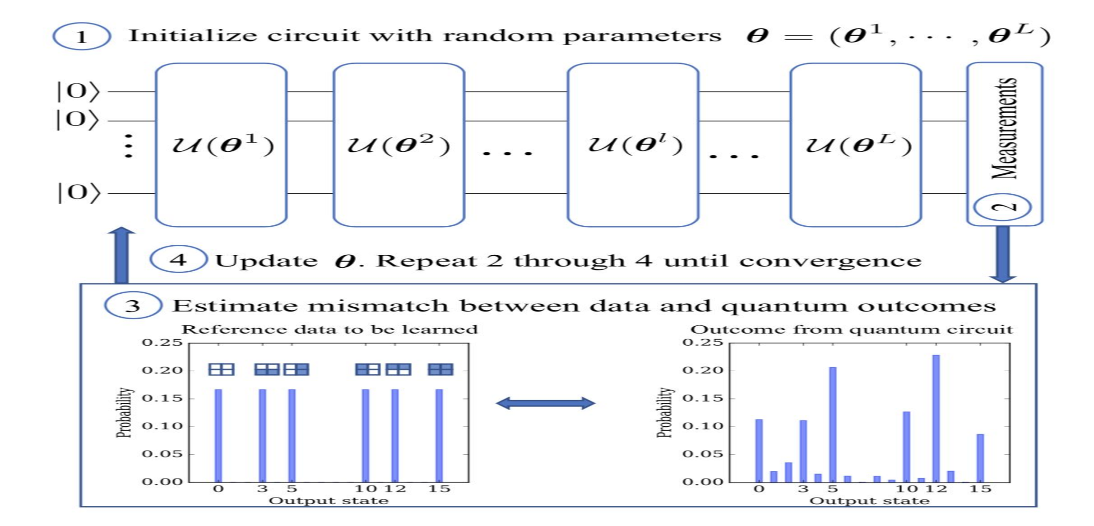
2) The best circuits, i.e. those with lowest cost function, are compared using the qBAS22 (explained later) score

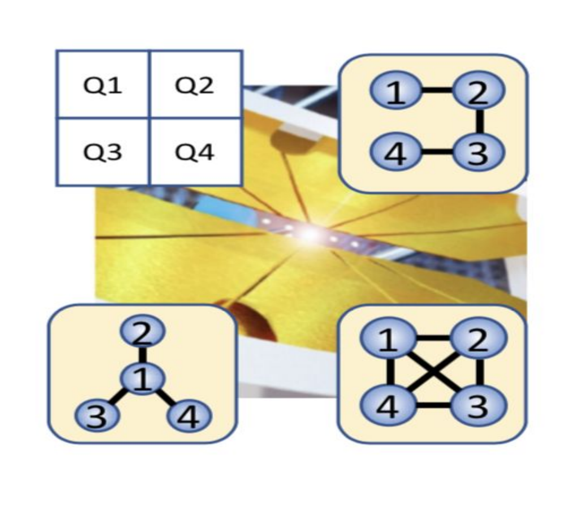
BAS22



QBAS SCORE

qBAS22 score for some of the possible choices of entangling layer topology (line, star, all-connected and different entangling gates YY, ZZ, CPHASE), and different number of layers.





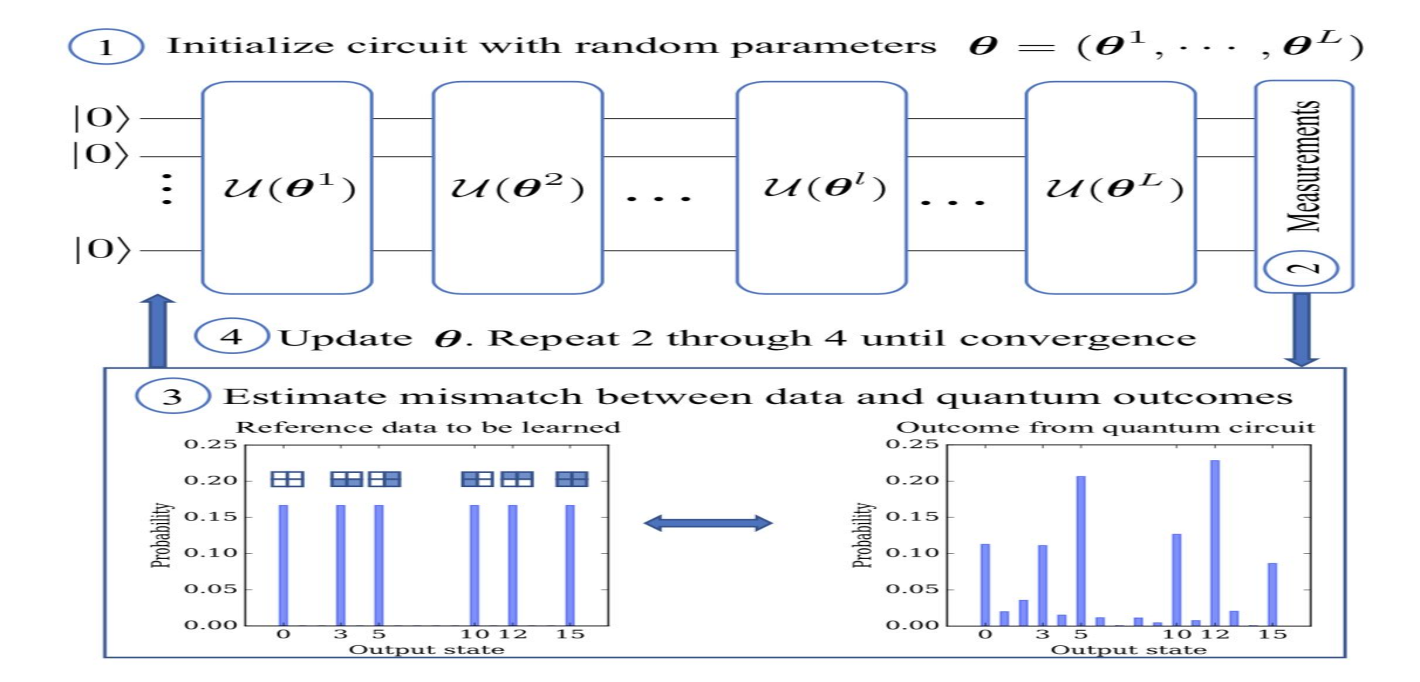
Procedure (High-level)

-Provided with a dataset D, the goal is to obtain a good approximation to the target probability distribution for BAS22.

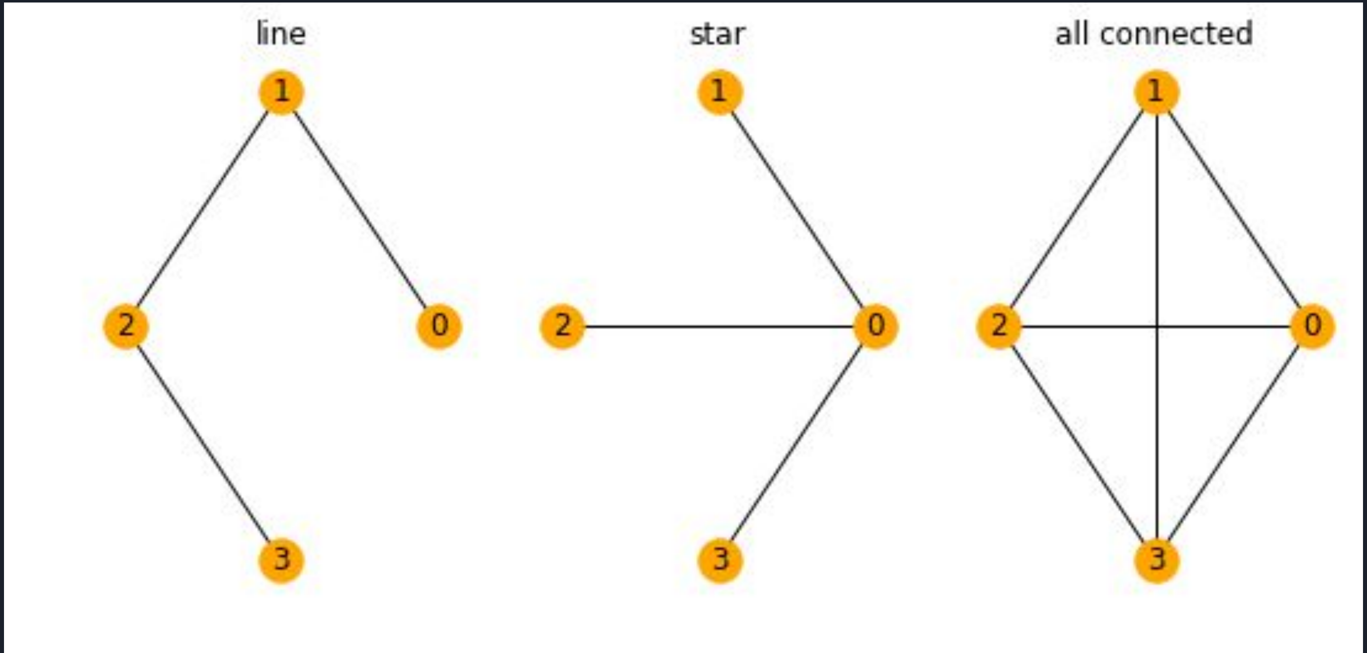
-The quantum circuit model is parametrized unitary gates angles, gate depths, and gate topology.

-Following the approach of generative modeling, we minimize with Kullback-Leibler function, and classically update parameters with Particle Swarm Optimization

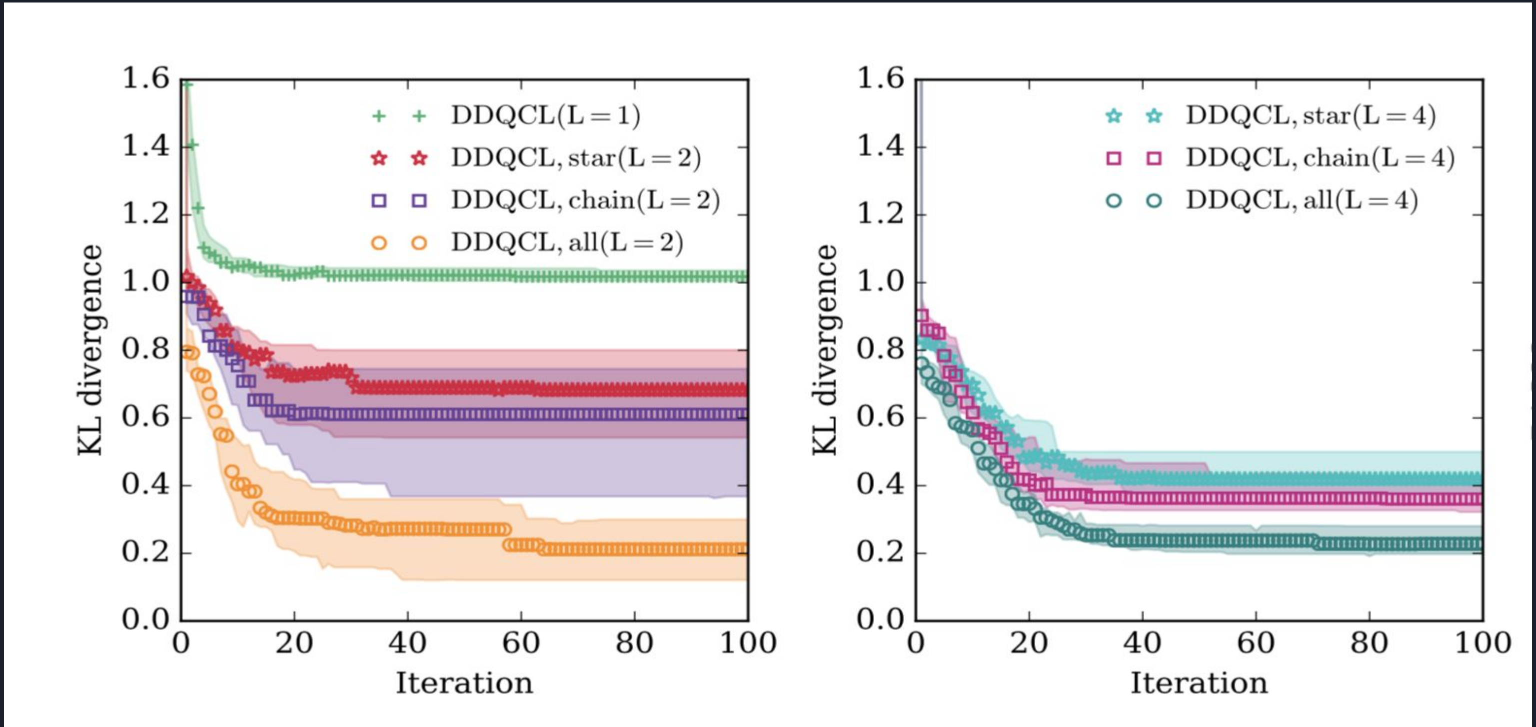
Circuit Layout



Topology



KL Divergence (In paper)

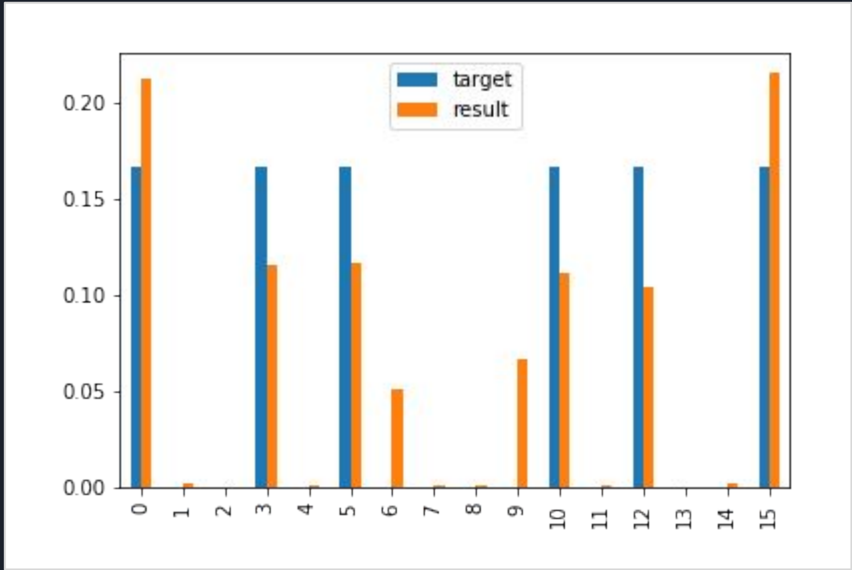


Results

Topology	Cost function	Inst	Entangling	Layers	Gate Volume
All connected	0.18	H	YY	2	159
All connected	0.28	H	YY	3	166
Star	0.81	H	YY	2	94
Chain	0.81	H	YY	2	46

Best performance

All connected topology, 2 layers, 0.18 cost



Analysis

-We’ve replicated the experiment, but with smaller trials.

-We’ve also noticed that all-to-all topology outperforms all other topologies even with just 10 iterations of PSO vs 100 iterations for any other topology

-We’ve also noticed that YY entangling gates perform the best versus ZZ and CPHASE entangling gates even though ZZ and CPHASE have less gate volume and depth than YY

-We’ve also noticed that, even though other topologies have less gate volume and depth than all-to-all connected topology, all-to-all was still most optimal

QBAS22

Next we compared qBAS scores for all-to-all topology with 2 layers (YY gates), star topology with 4 layers (YY gates), and all-to-all topology with 3 layers

-Those very different approximate solutions to the same problem can be compared at the level of qBAS22 score.

-Quantum simulations allow us to obtain the theoretical amplitudes for each of the states in the computational basis.

FORMULA

Precision = # of measurements belonging to BAS22 / total # of measurements

Recall = # of different BAS22 in N(read) measurements / total # of BAS22 patterns

QBAS F1 score = (2 * Precision * Recall) / (Precision + Recall)

***Goal is to score high (F1 ~ 1.0)

OUR RESULTS

As in the case of the simulation estimation of the qBAS score, we sample 500 times from the distribution. From each of the samplings, we compute a qBAS22 score.

All-connected, 2-layers:

Precision: 0.636, Recall: 1.0, qBAS F1: 0.7775061124694376

Star, 2-layers: