QCBM Documentation

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1 Model Description

Training Data: Gaussian Distribution
Pre-training: Particle number distribution
Number of qubits: 4
Loss Function: MMD Loss
Kernel: Gaussian RBF kernel
Accuracy: KL Divergence
Learning rate: 1.0
Optimizer: optax.adam

2 Observations

2.1 Pre-Training

QCBM Circuit = RZ + IsingXY gates

S.No	Initialized State	Model
1	[‘0000’, ‘0001’, ‘0011’, ‘0111’, ‘1111’]	Converges
2	[‘0000’, ‘randomly chosen’ × 3, ‘1111’]	Doesn’t Converge
3	[‘0000’, ‘superposition’, ‘1111’]	Converges

Table 1: Model convergence based on different initial states

2.2 Superposition Pre - Training

S.No	**qcbm circuit**	**Layers**	**min KL Div**	**Model**
1	RZ + Ising XY	$\geq 2layers$	10^{-1}	Converges
2	RX + RZ + CNOT	$\geq 3layers$	10^{-4}	Converges
3	RY + RZ + CNOT	$\geq 3layers$	10^{-3}	Converges
3	RZ + IsingZZ	$\geq 1layers$	10^{0}	Converges

Table 2: Model convergence based on different qcbm circuits

2.3 No Pre - Training

S.No	**qcbm circuit**	**Layers**	**min KL Div**	**Model**
1	RZ + Ising XY	-	10^{38}	Doesn't Converge
2	RX + RZ + CNOT	$\geq 3layers$	10^{-4}	Converges
3	RY + RZ + CNOT	$\geq 3layers$	10^{-3}	Converges
3	RZ + IsingZZ	-	10^{38}	Doesn't Converge

Table 3: Model convergence based on different qcbm circuits

3 Conclusion

Pre-training the QCBM circuit with the superposition of all the states with amplitudes corresponding to the particle number distribution of the target Gaussian distribution doesn't help the model when using the maximally entangling circuit i.e., with CNOT gates. Whereas using IsingXY or IsingZZ entangling operation instead requires pre-training for the model to converge.

The other conclusion is that the QCBM circuit with RZ and IsingZZ operations in the presence of pre-training leads to very minimal to no learning.