Cat – Anticat Work

Task 1:

Total qubits: 4 main qubits + 4 ancillas

QCBM Circuit (Encoder):

Loss Function: MMD Loss + 1*(log10(P(n)^2) ;P(n) = Particle number distribution

KL Divergence: -sum[q(n)*log(p(n)/q(n))] + 1*(log10(P(n)^2) ;p(n) = obtained distribution

; q(n) = original distribution

Original Cat Distribution: All possible 3-particle number states

Anticat Distribution: 1-particle number states

Hybrid VQC + QCBM Circuit:

Full Target Distribution is 11110000. Now for local loss function i.e.,

Target Distribution1: All 1's at top half of circuit (first 4 qubits)

Target Distribution2: All 0's at bottom half of circuit (bottom 4 qubits)

Loss Function: MMD Loss

KL Divergence: - sum[q1(n)*log(p1(n)/q1(n))] - sum[q2(n)*log(p2(n)/q2(n))]

Top Half of Circuit: Particle Number Distribution of Original Cat + VQC (RZ+IsingXY+IsingZZ) (3 folds)

Bottom Half of Circuit: Anticat Distribution

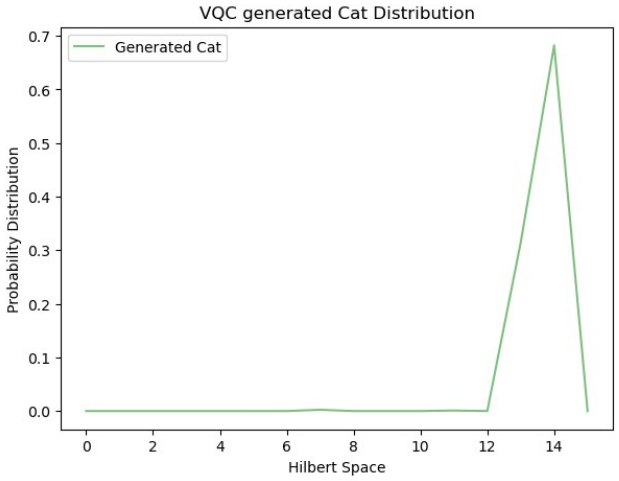
+ dagger (QCBM) Circuit.

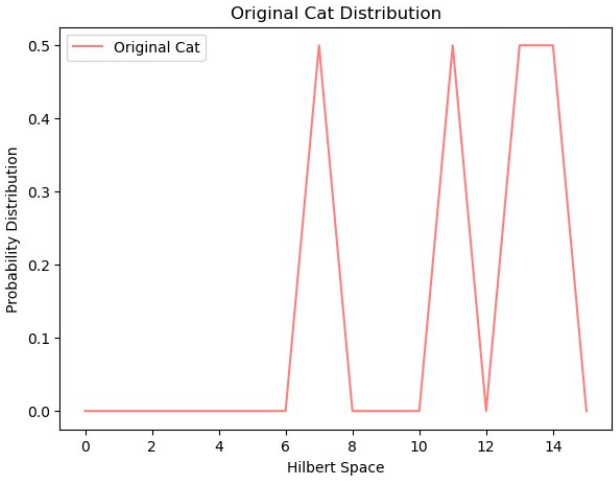
Result: The Hybrid circuit converges to 11110000, with KL Divergence = 1e-2.

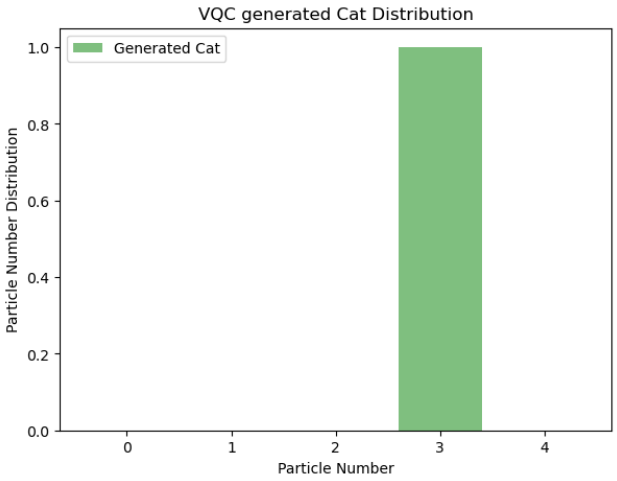
Observation:

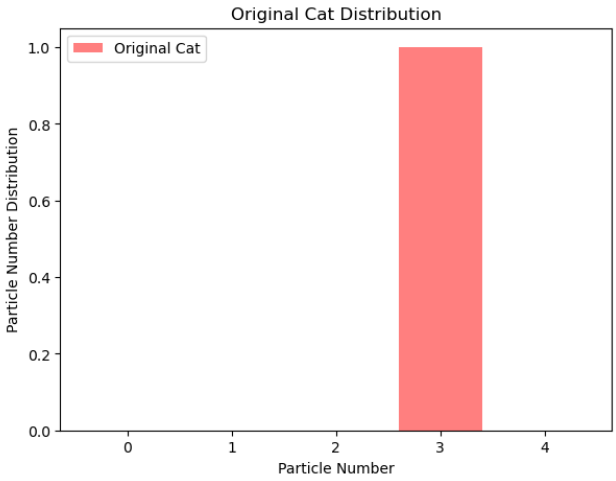
1) The trained VQC corresponds to 1111 Distribution.

2) Particle Number Distribution of Original Cat + trained VQC = Generated Cat which has same particle number distribution as Original Cat, but is not exactly the same distribution.









Task 2:

Total qubits: 4 main qubits + 4 ancillas

QCBM Circuit (Encoder):

Loss Function: MMD Loss ;P(n) = Particle number distribution

KL Divergence: -sum[q(n)*log(p(n)/q(n))] ;p(n) = obtained distribution

; q(n) = original distribution

Original Cat Distribution: Gaussian Distribution

Anticat Distribution: anticat of gaussian

Hybrid VQC + QCBM Circuit:

Full Target Distribution is 10101010 (Better convergence than 11110000). Now for local loss function i.e.,

Target Distribution1: All 1's at odd qubits

Target Distribution2: All 0's at even qubits

Loss Function: MMD Loss

KL Divergence: - sum[q1(n)*log(p1(n)/q1(n))] - sum[q2(n)*log(p2(n)/q2(n))]

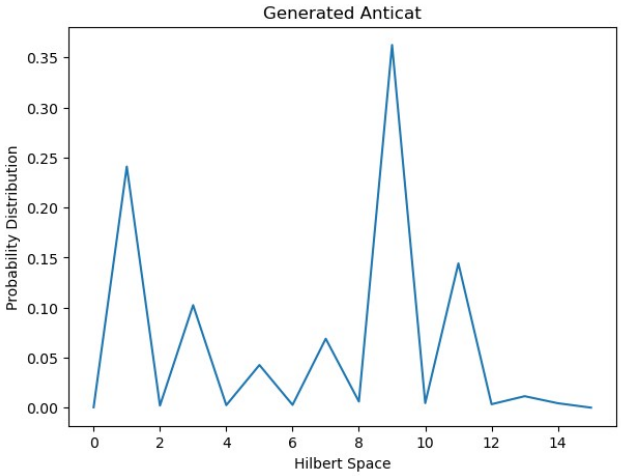
Top Half of Circuit: Original cat distribution

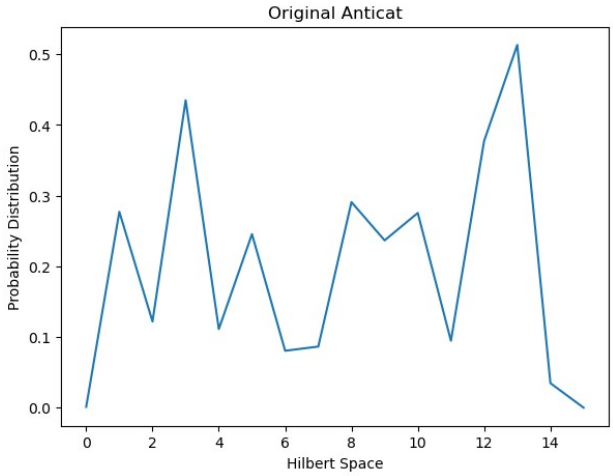
Bottom Half of Circuit: Particle Number Distribution of AntiCat + VQC (RZ+IsingXY+IsingZZ) (3 folds) + dagger (QCBM) Circuit.

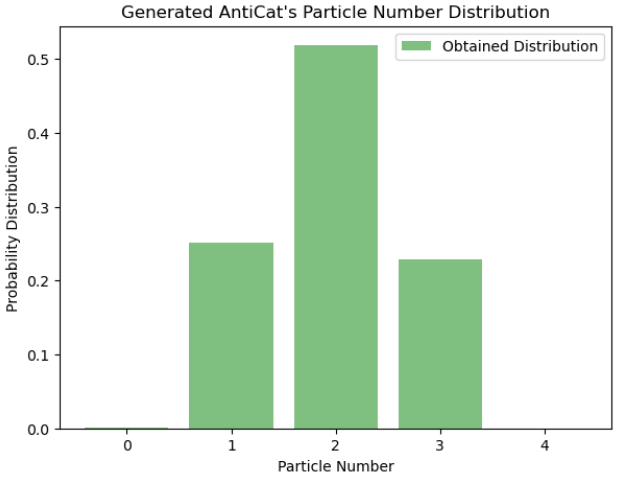
Result: The Hybrid circuit converges to 10101010, with KL Divergence = 0.809.

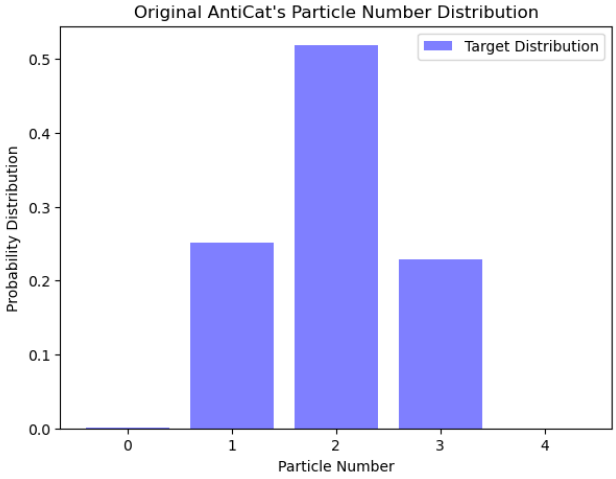
Observation:

1) Particle Number Distribution of AntiCat + trained VQC = Generated Anticat which has same particle number distribution as Original Anticat, but is not exactly the same distribution.


Generated Anticat
Probability Distribution
Hilbert Space


Original Anticat
Probability Distribution
Hilbert Space


Generated AntiCat's Particle Number Distribution
Obtained Distribution
Probability Distribution
Particle Number


Original AntiCat's Particle Number Distribution
Target Distribution
Probability Distribution
Particle Number