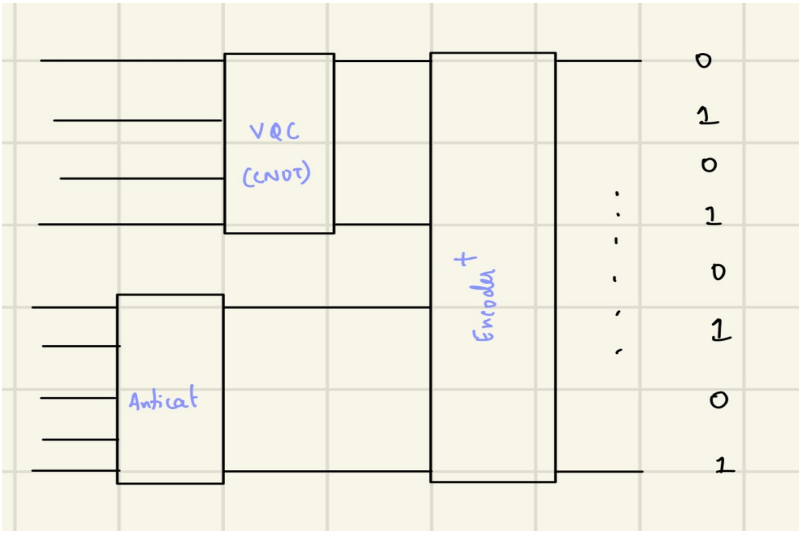
Cat Anticat Work

23/03/2025

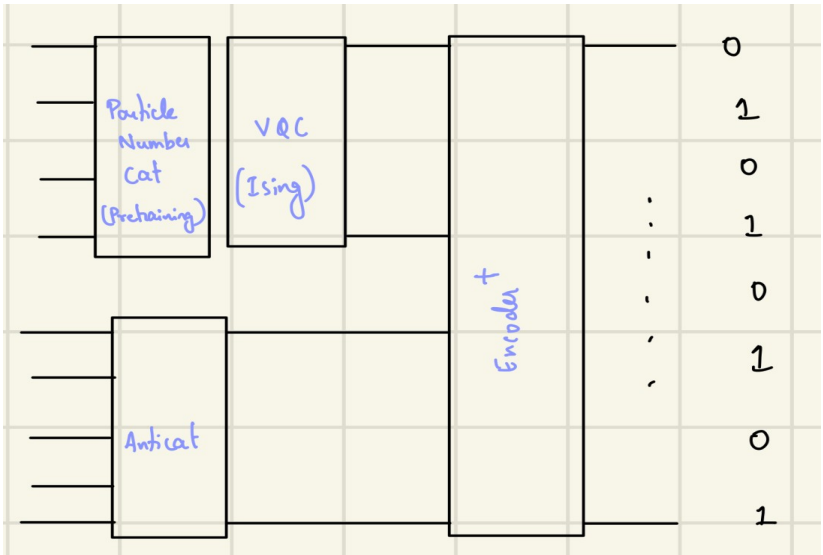
Task 1: Verifying the learning ability of VQC

Case 1: Fully Entangled VQC



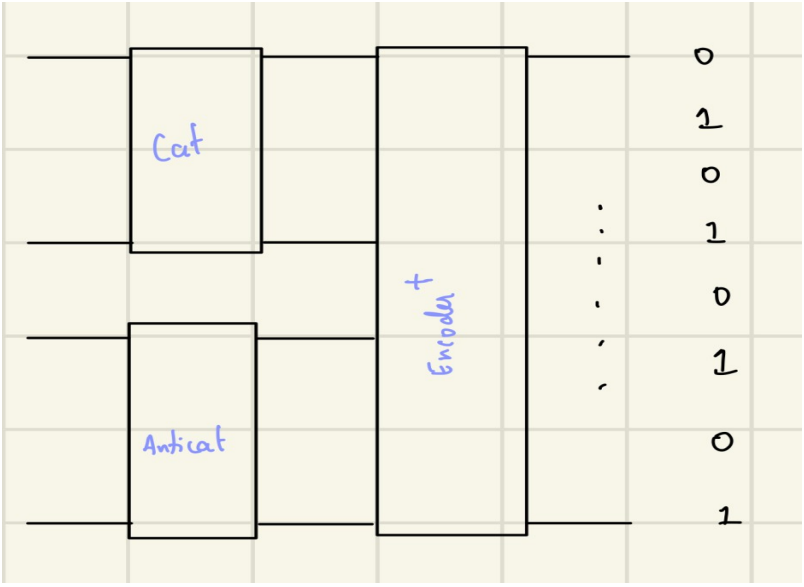
Result: Trained VQC learns the subset of Original Cat Distribution.

Case 2: Ising Entangled VQC



Result:
a) Trained VQC always converges to ‘0000’ state, irrespective of number of folds (gate repetitions)
b) Trained VQC + Particle number pretrained of Cat, gives the subset of Original Cat Distribution.

Task 2: Cat – Anticat Distribution to Half particle number state



Case 1: Cat Distribution = 3-Particle Number Distribution

Result: The convergence of the model is KL div = 1e-3

Case 2: Cat Distribution = 4 qubit Gaussian Distribution

Result: The convergence of the model is KL div = 0.78

Case 3: Cat Distribution = 4 qubit ReLU + Sigmoid

Result: The convergence of the model is KL div = 0.89

Observations: There is a loss of information between Cat and Obtained Anticat distribution. This can be seen here for case 2 and case 3. This loss is most probably is the cause of hybrid decoder, being unable to converge to half-particle number state.

NOTE: The Convergence of our hybrid decoder for different Cat Distributions to half-particle number state is given below:

1. For 3-Particle Cat Distribution is KL div = 1e-3
2. For 4 qubit Gaussian Distribution is KL div = 0.719
3. For 4 qubit ReLU + Sigmoid Distribution is KL div = 0.921

These KL divergences are close to the ones obtained in Task 2.

Task 3: Convergence of Hybrid Decoder to different half–particle number states

Cat Distribution: 4 qubit Gaussian Distribution

Case 1: Ising VQC + Ising Encoder

Desired Half Particle State	KL Divergence
01010101	0.719
10010101	0.732
11110000	0.793
11101000	0.771
11100100	0.757
10110100	0.744
10101010	0.719
00001111	0.765
Superposition of all half-particle states	0.900

Case 2: Fully Entangled VQC + Ising Encoder

Desired Half Particle State	KL Divergence
01010101	0.429
10010101	0.429
11110000	1.004
11101000	0.429
11100100	0.428
10110100	0.428
10101010	0.429
00001111	0.478
Superposition of all half-particle states	0.495