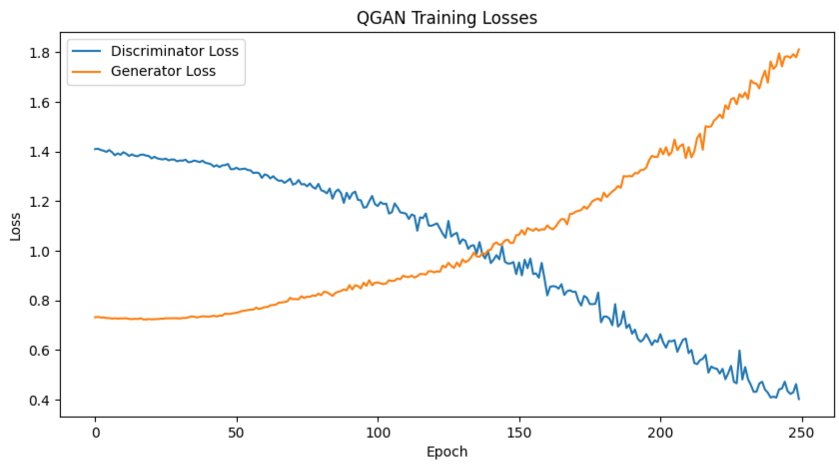
Final Report

Quantum Generative Adversarial Networks

This project used a hybrid Quantum Generative Adversarial Network (QGAN) where a parameterized quantum circuit was used as the generator and a classical neural network as the discriminator to learn a 2D Gaussian mixture distribution. The quantum generator used a 2-qubit hardware-efficient ansatz with RY/RZ rotations and CNOT entanglement using PennyLane, and the classical discriminator was a two-layer feedforward neural network constructed using PyTorch. The training is preceded by alternately updating the discriminator to classify real versus generated samples and training the quantum generator to deceive the discriminator according to the parameter-shift rule.



The training outputs, which are exhibited in the loss curves above, reflect the expected adversarial behavior where discriminator loss reduces as generator loss rises with time. Samples generated slowly converged towards the target distribution, although some mode collapse was reported for the latter epochs. This deployment was able to effectively prove that even a straightforward quantum circuit can learn hierarchical 2D distributions if paired with classical neural networks through an adversarial setting, pointing towards exciting futures for quantum machine learning in generative modeling. Although existing quantum hardware limitations limit circuit depth and the number of qubits, this proof-of-concept indicates the possibility of quantum benefits in generative modeling with improving hardware. Additional investigation into various ansatz architectures and noise reduction methods may improve performance.

1 References

- Zoufal, C., Lucchi, A., & Woerner, S. (2019). Quantum GANs. *arXiv preprint* arXiv:1904.00043.
- Dallaire-Demers, P. L., & Killoran, N. (2018). Quantum generative adversarial networks. *arXiv preprint* arXiv:1804.08641.
- PennyLane Docs: `https://docs.pennylane.ai`