

Quantum Volume Circuit with Noise and QGAN Training

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Methodology

Quantum Volume Circuit with Noise:

- ▶ **Setup:** 4 qubits, depth 3, noise strength 0.3.
- ▶ **Transformation:** Apply Haar transformation.
- ▶ **Unitary Application:** Haar-random unitaries and interleaved two-qubit gates (CNOT, CY, CZ).
- ▶ **Measurement:** Pauli observables (X, Y, Z).

QGAN Training:

- ▶ **Real Data Circuit:** Hadamard gate and rotation gates.
- ▶ **Generator Circuit:** Sequence of RX, RY, RZ gates and a CNOT gate.
- ▶ **Discriminator Circuit:** Similar structure with a different arrangement.
- ▶ **Training:** Adam optimizer, learning rate 0.01, 100 steps for both discriminator and generator.

Results: Quantum Volume Circuit

- ▶ **Data Distribution Visualization:** Histograms for each qubit.
- ▶ **Synthetic Data Generation:** Noisy measurements from the quantum circuit.

Results: QGAN Training

Training Metrics:

- ▶ Prob(real classified as real): 0.9133
- ▶ Prob(fake classified as real): 0.9729
- ▶ Discriminator cost: 0.0596

Bloch Vectors:

- ▶ Real Bloch vector: $[-0.2169, 0.4505, -0.8660]$
- ▶ Generator Bloch vector: $[0.0593, 0.0501, -0.9952]$
- ▶ Absolute differences: $[0.3205, 0.1513, 0.0801]$
- ▶ Average absolute difference: 0.1839

Results: Classifier Performance

- ▶ **Accuracy on Generated Data:** 0.42
- ▶ **Classification Report:**

Class	Precision	Recall	F1-Score
0	0.29	0.24	0.26
1	0.50	0.57	0.53
Accuracy		0.42	
Macro avg	0.39	0.40	0.39
Weighted avg	0.41	0.42	0.41