IEG313 : Quantum Computing Course project

Indian Institute of
Information Technology
Kottayam

Quantum Medical Image Diagnostics using QML

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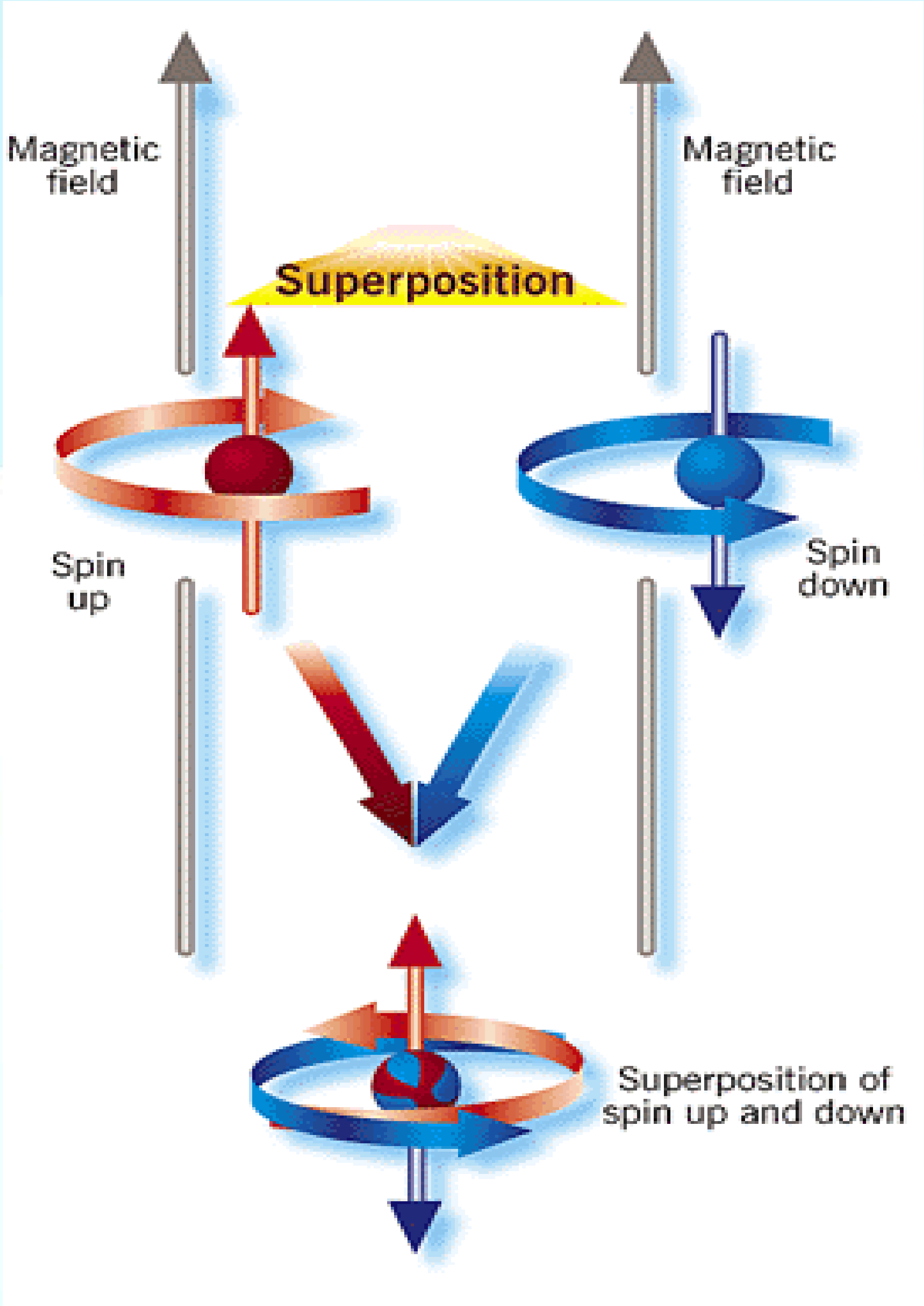
Problem Statement

Our mission is to delve into the unique convergence of quantum computing and image analysis.

Specifically, we aim to implement a model classifying face image data set to predict disorders (i.e.,Parkinson’s, Autism, etc), And to unravel the mysteries of QCNN architecture and its application in classifying images.

Conditions for Quantum Computation



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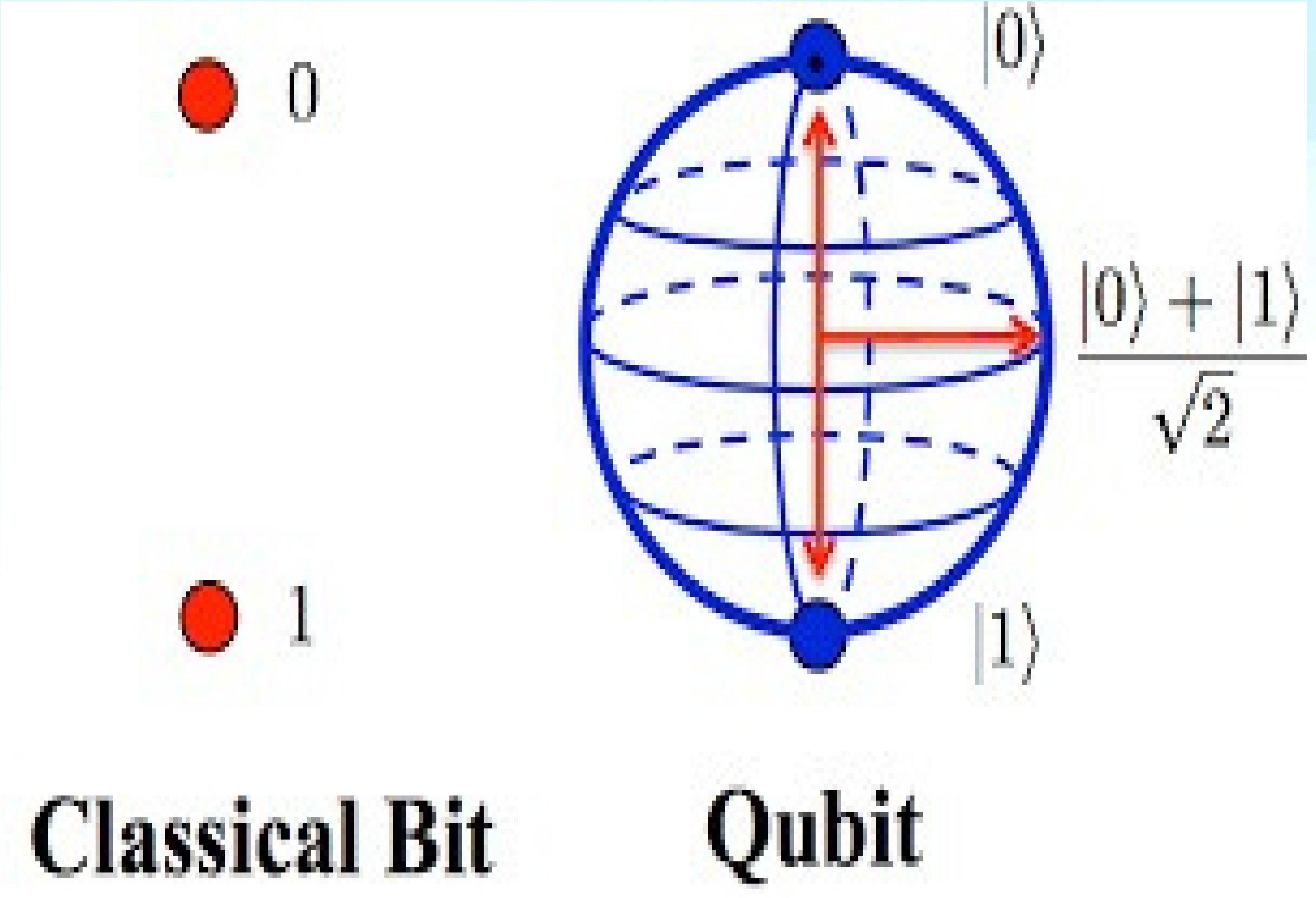
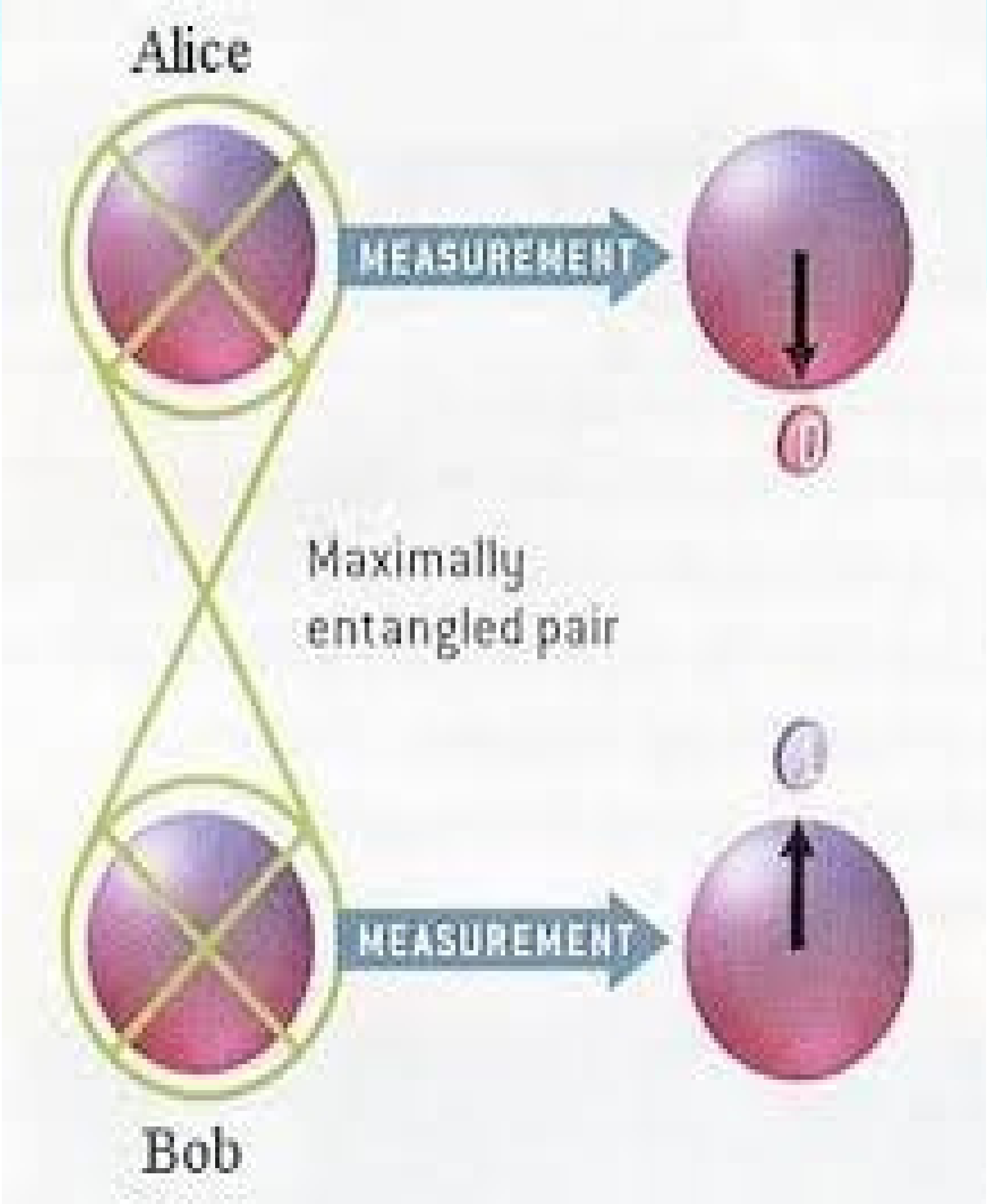
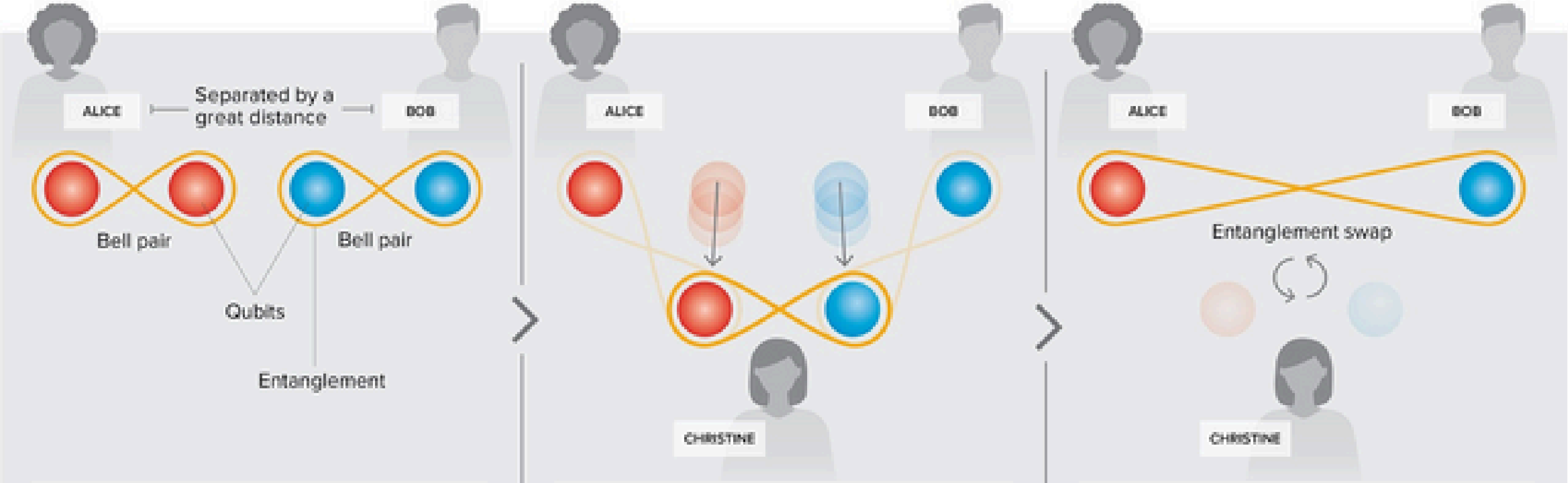




QUANTUM ENTANGLEMENT SWAPPING

Argonne NATIONAL LABORATORY

Building a quantum information network will rely on entangling qubits across great distances



Alice and Bob each have a pair of qubits in a **Bell state**, the simplest and maximally entangled state.

Each gives a qubit to Christine, who performs a **Bell projection**, cleaning up the noise and entangling her newly acquired qubits.

An **entanglement swap** occurs, linking Alice and Bob's qubits.

U.S. DEPARTMENT OF ENERGY

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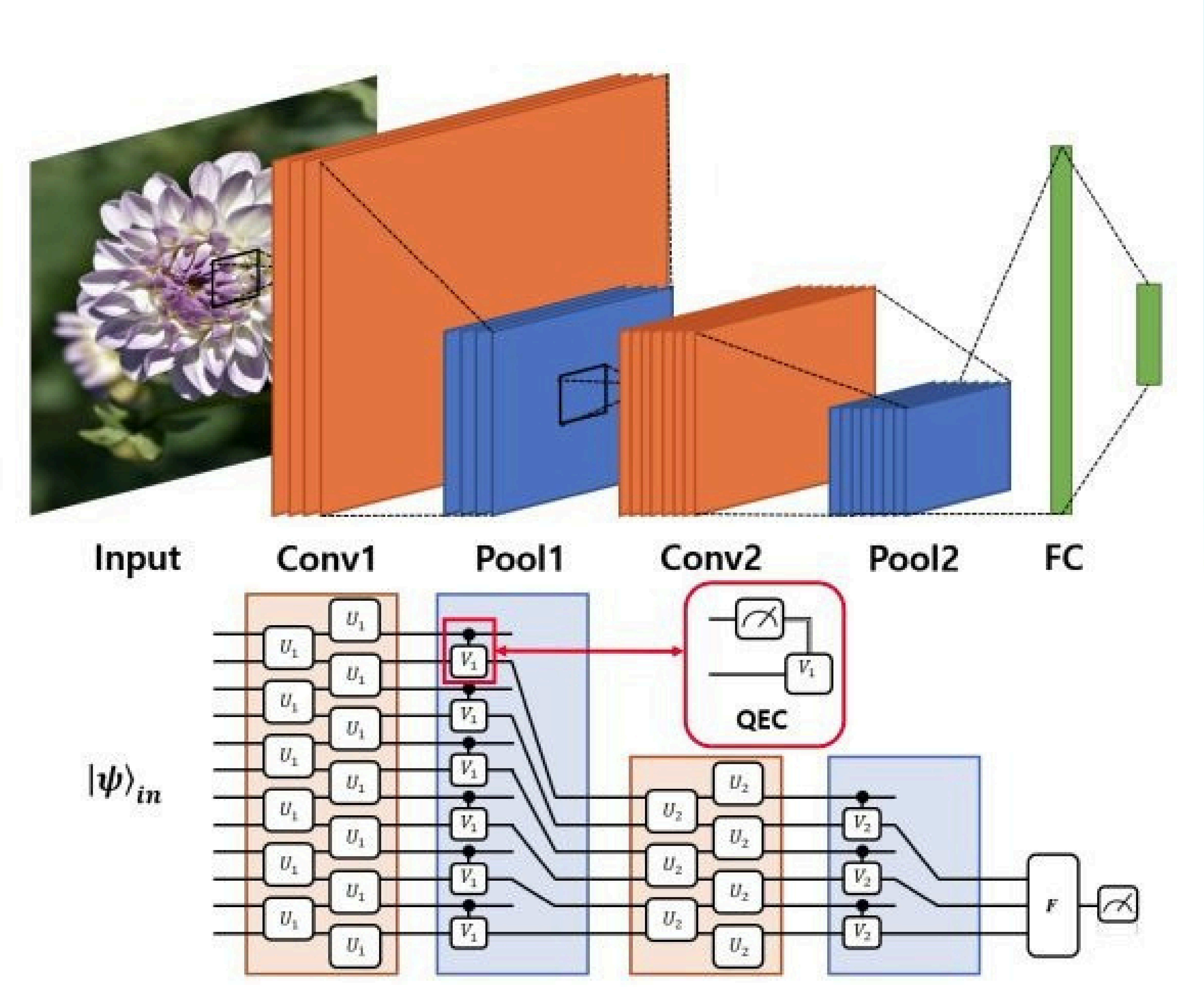
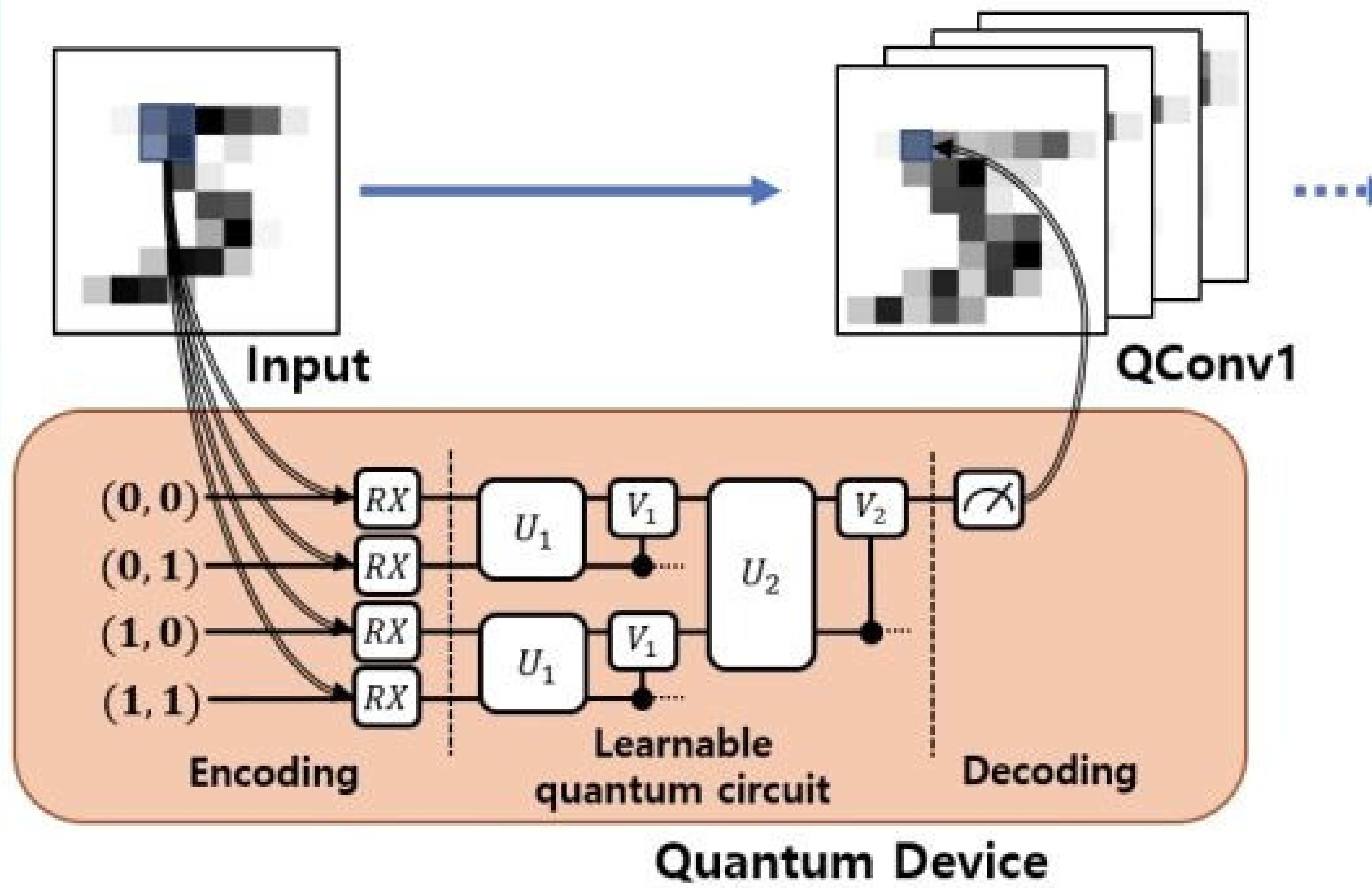
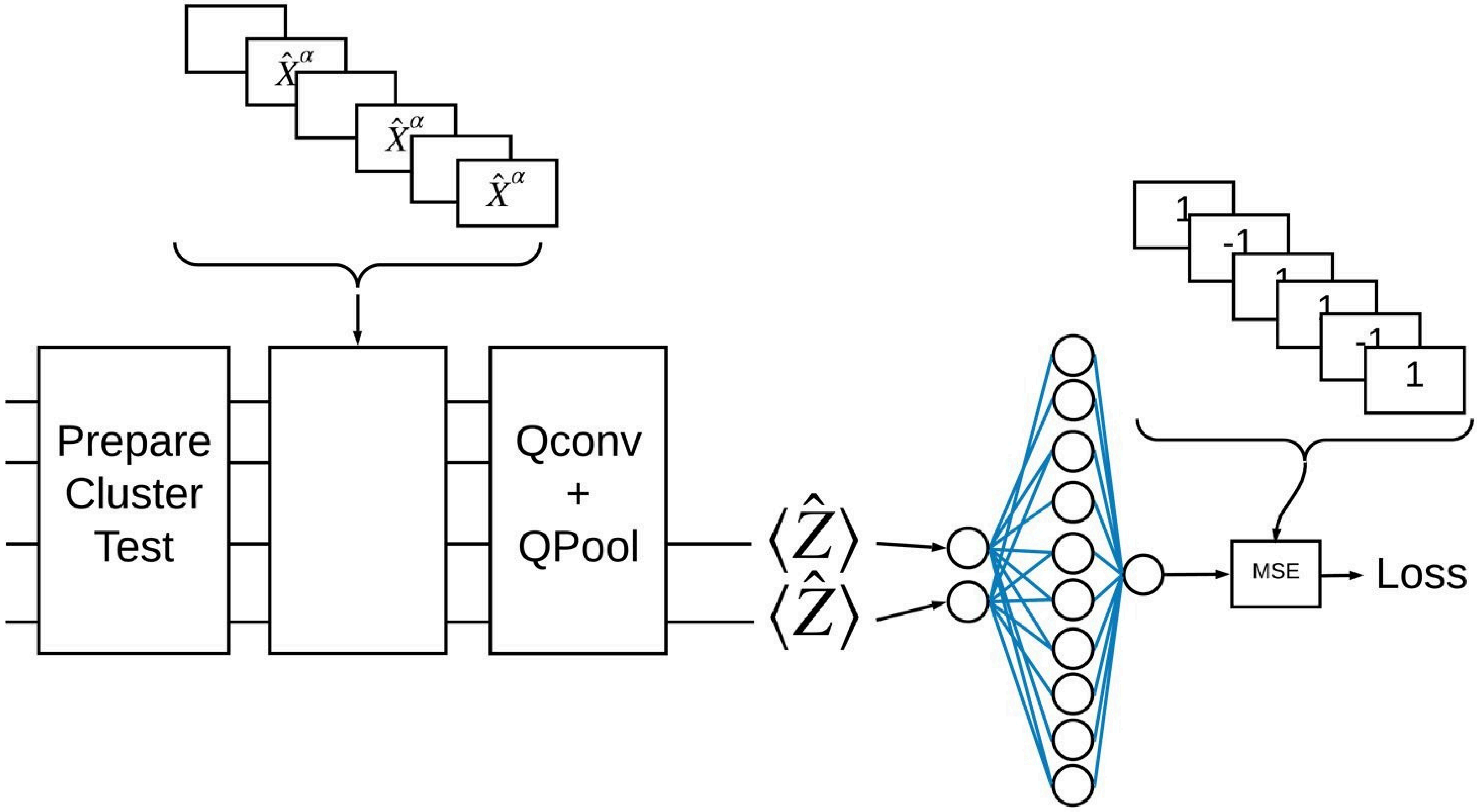
QCNN Architecture

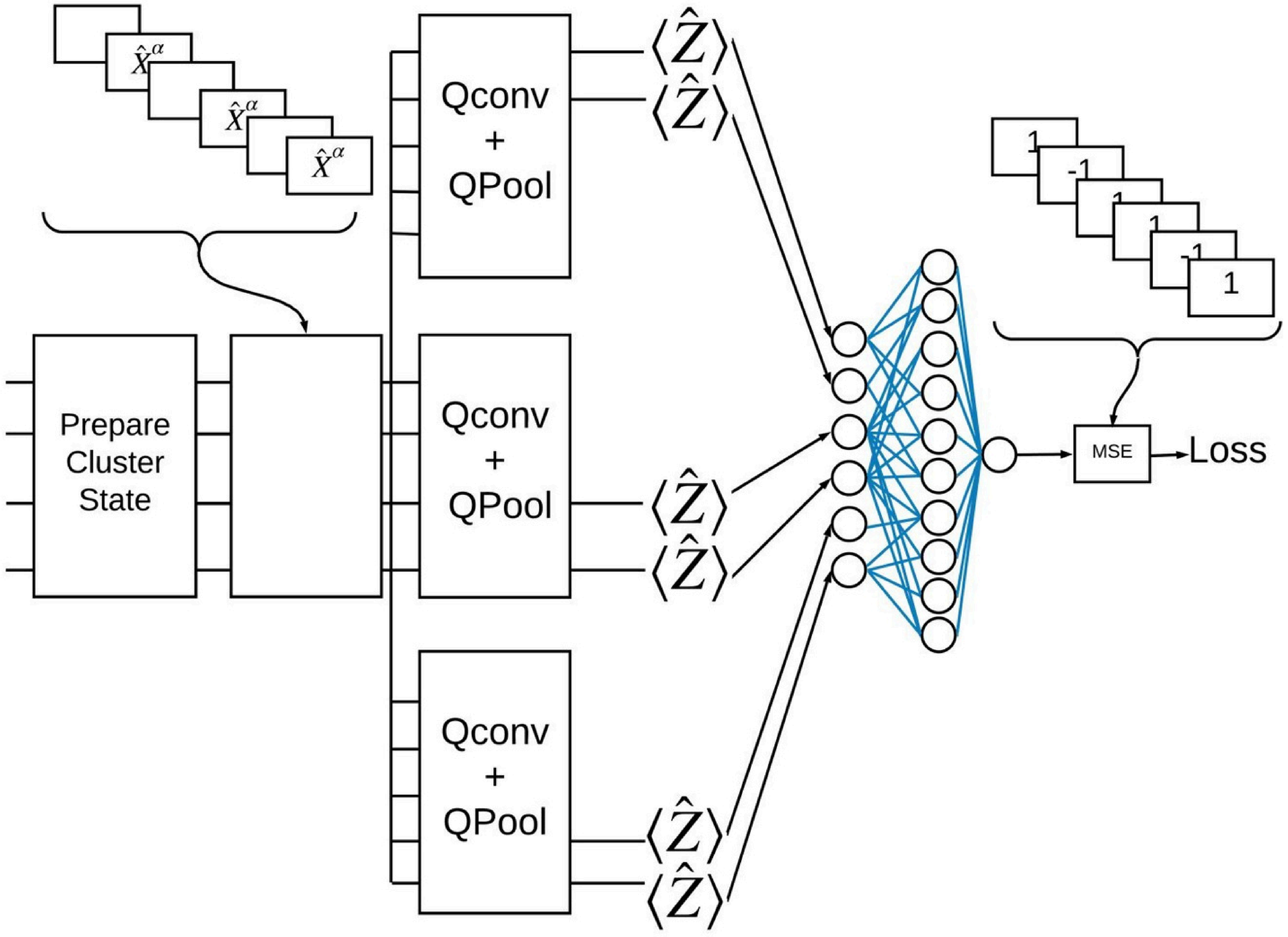




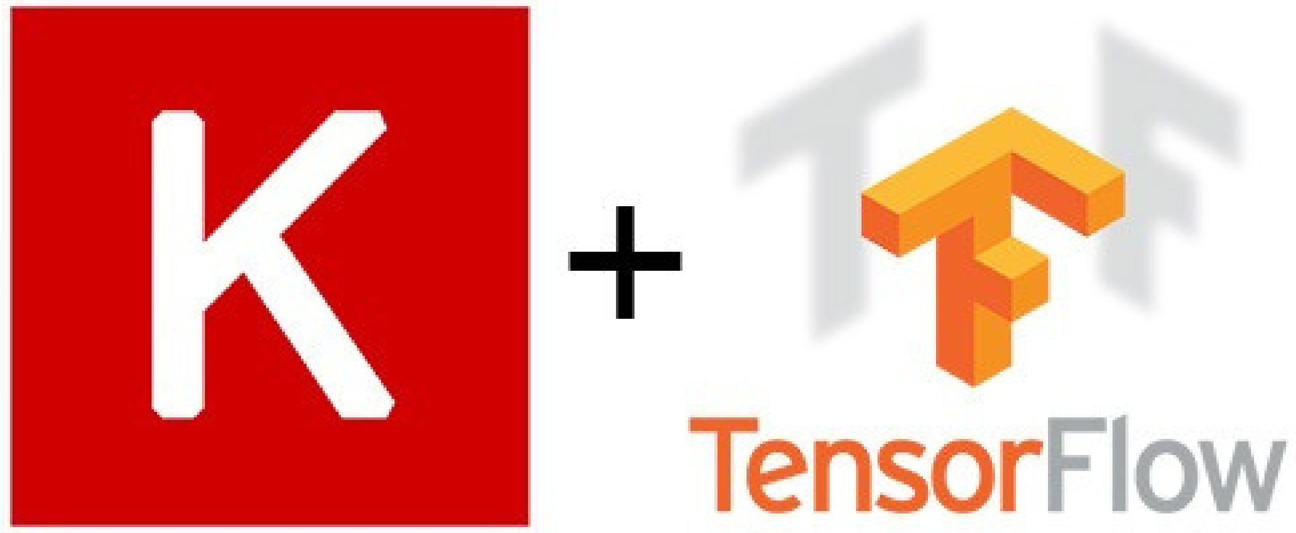
Understanding CNN with Quantum circuits, Image credits : Pennylane

Overview


$\hat{X}^{\alpha}$
$\hat{X}^{\alpha}$
$\hat{X}^{\alpha}$
Prepare Cluster Test
Qconv + QPool
$\langle \hat{Z} \rangle$
$\langle \hat{Z} \rangle$
1
-1
1
1
-1
1
MSE
Loss


$\hat{X}^{\alpha}$
$\hat{X}^{\alpha}$
$\hat{X}^{\alpha}$
Prepare Cluster State
Qconv + QPool
Qconv + QPool
Qconv + QPool
$\langle \hat{Z} \rangle$
$\langle \hat{Z} \rangle$
$\langle \hat{Z} \rangle$
$\langle \hat{Z} \rangle$
$\langle \hat{Z} \rangle$
$\langle \hat{Z} \rangle$
1
-1
1
1
-1
1
MSE
Loss

Libraries used for code



scikit
learn

Preparation of Dataset’s

Medical image dataset of Autism

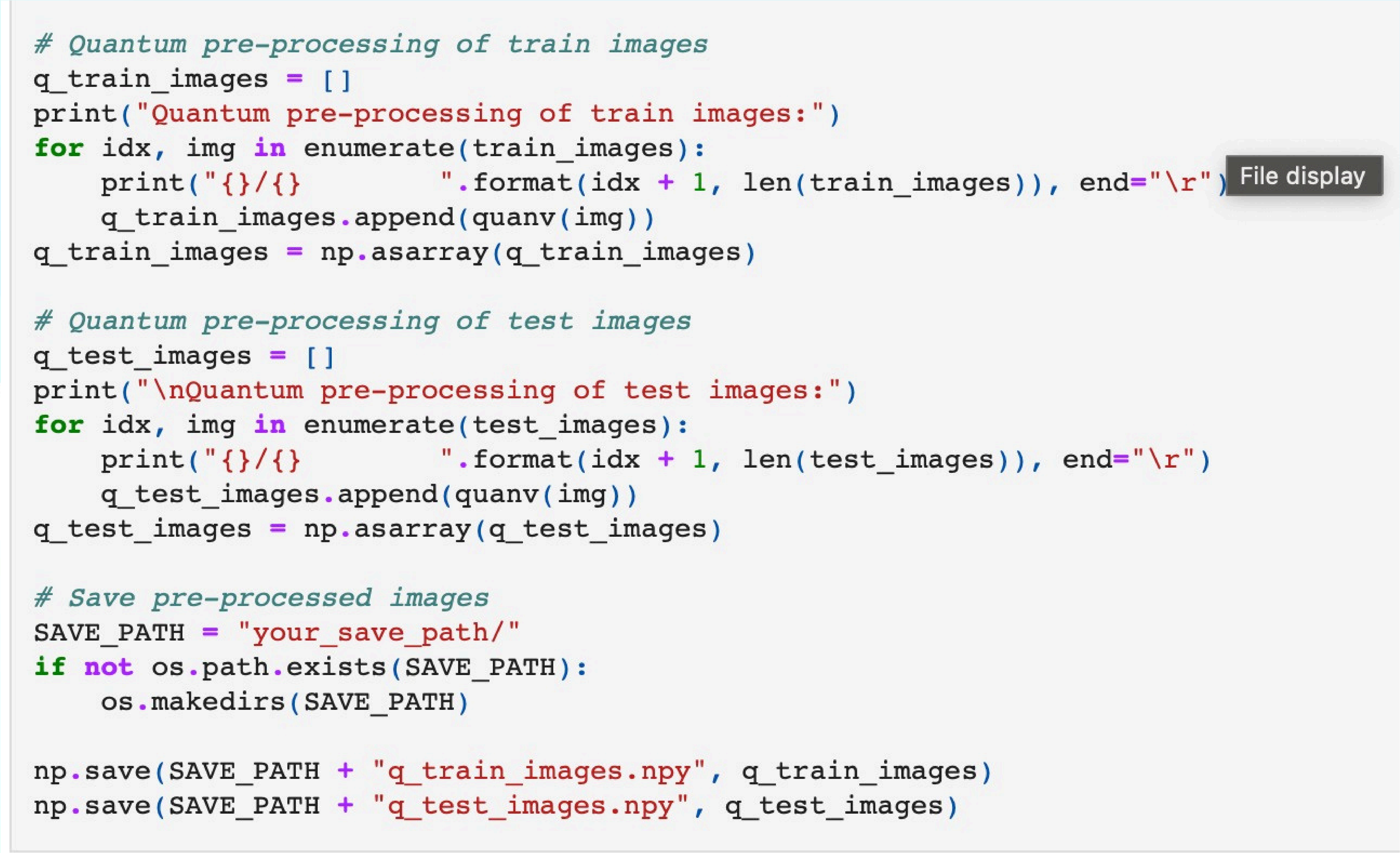
We have collected medical image dataset which represents patient with and without Autism.

Dataset from Kaggle

Design and Implementation

- Quantum circuit as a convolution kernel
- Quantum pre-processing of the dataset
- Hybrid quantum-classical model

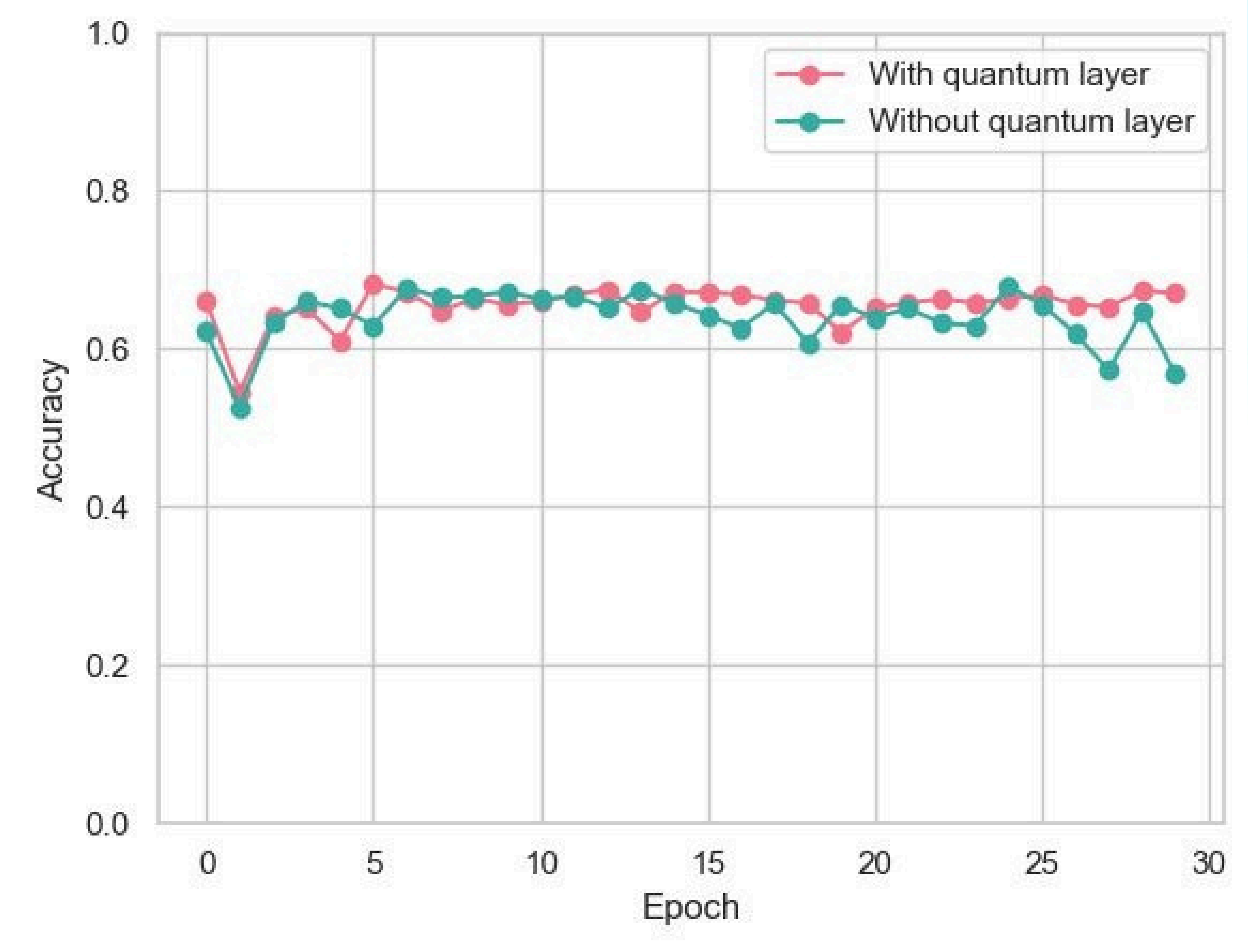
Training the dataset

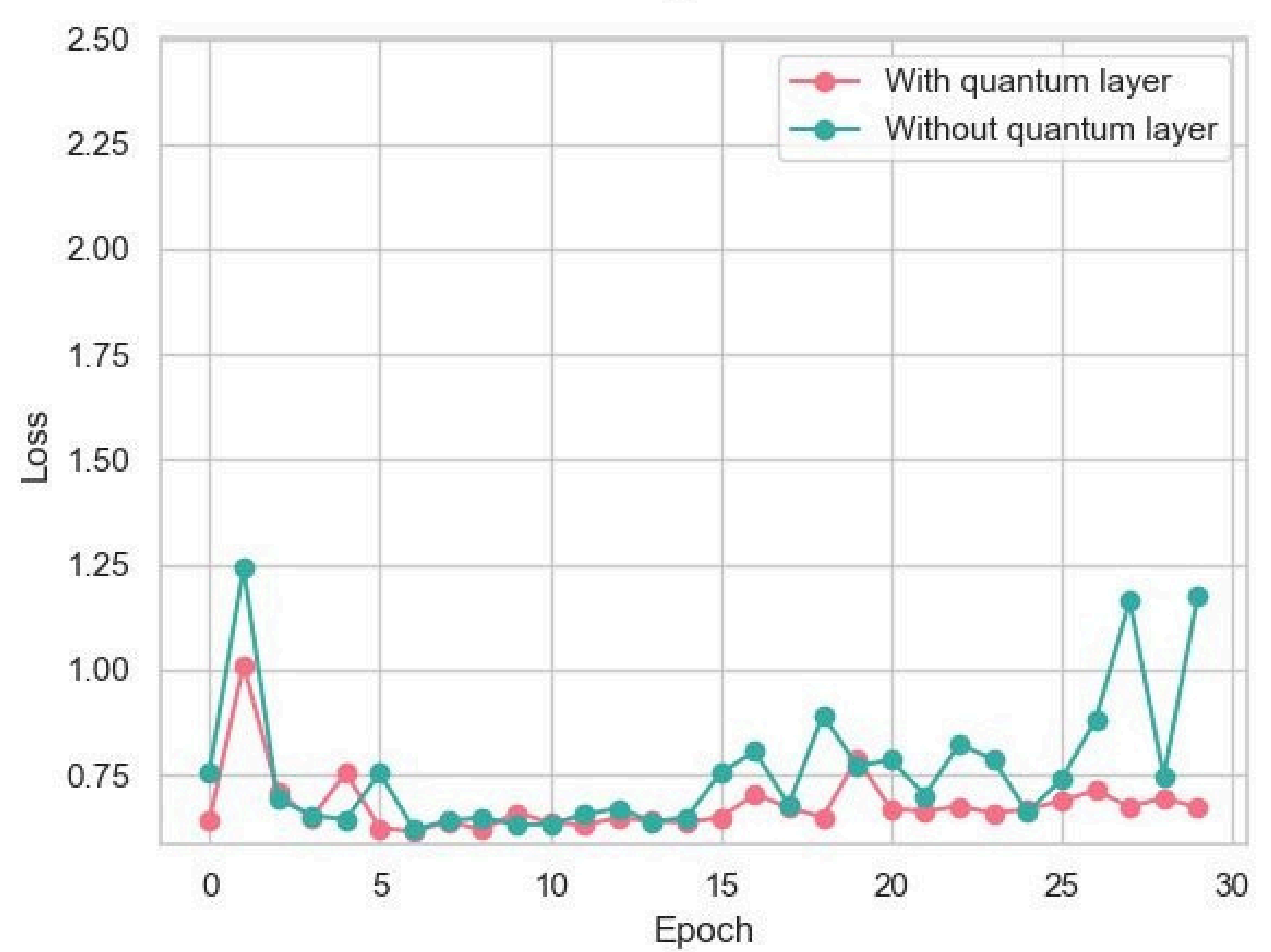


```
# Quantum pre-processing of train images
q_train_images = []
print("Quantum pre-processing of train images:")
for idx, img in enumerate(train_images):
    print("{}/{}        ".format(idx + 1, len(train_images)), end="\r")
    q_train_images.append(quanv(img))
q_train_images = np.asarray(q_train_images)

# Quantum pre-processing of test images
q_test_images = []
print("\nQuantum pre-processing of test images:")
for idx, img in enumerate(test_images):
    print("{}/{}        ".format(idx + 1, len(test_images)), end="\r")
    q_test_images.append(quanv(img))
q_test_images = np.asarray(q_test_images)

# Save pre-processed images
SAVE_PATH = "your_save_path/"
if not os.path.exists(SAVE_PATH):
    os.makedirs(SAVE_PATH)

np.save(SAVE_PATH + "q_train_images.npy", q_train_images)
np.save(SAVE_PATH + "q_test_images.npy", q_test_images)
```

- 80% datasets were used for training and rest were used for testing.

Result and Observation





References

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learning from unlabeled data. Proceedings of the 24th International Con- ference on Machine Learning*, 759–766 (2007).

- [4] Ville Bergholm, Josh Izaac, Maria Schuld, Christian Gogolin, Carsten Blank, Keri McK- iernan, an
Killoran. PennyLane: Automatic differentiation of hybrid quantum- classical computations. arXiv:1811.04968 (2018).

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