Demonstrating Hybrid Quantum-Classical Neural Network

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As quantum computing becomes more popular, the need for testing quantum implementations of classical algorithms increases as we need to see the limits of quantum algorithms. With the increasing use of machine learning and neural network algorithms in various fields of science and society, testing quantum neural networks is a natural idea. We have chosen to test the implementation of a hybrid quantum-classical convolutional neural network.

Here we use a dataset of chest X-ray images [1, 2] for classifying whether the patient has pneumonia or not. There are 4077 training images and 582 test images. Each image has the dimensions 640×640 and 3 colour channels(red, green, and blue).

The architecture of the hybrid quantum-classical[3, 4] convolutional neural network consists of 3 pairs of convolutional and pooling layers, a dropout layer to reduce overfitting, followed by 2 fully connected layers, the quantum layer[3, 5], and a final linear layer. The quantum layer was simulated with the aer simulator with the 'statevector' method [3, 6]. The training data was divided into batch sizes of 8 the training was done over 16 epochs with a learning rate of 0.0001 and a cross-entropy loss function. The training followed an increase in accuracy with the increase in epochs (Fig. 1).

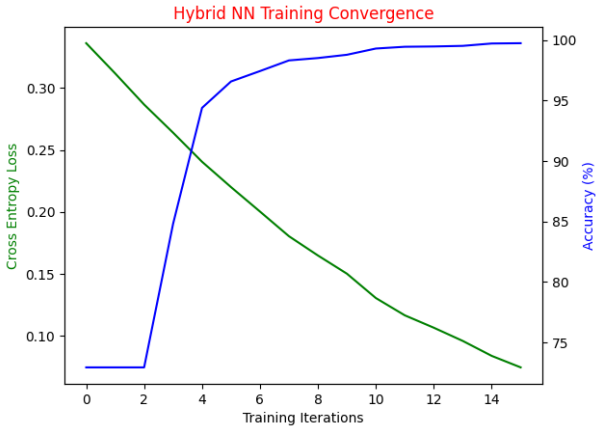

Figure 1: Training data of the hybrid quantum-classical neural network.

We have also trained a classical convolutional neural network with similar architecture, just replacing the quantum layer with a linear layer. The comparison is given in Table 1. This comparison shows that the hybrid model can produce similar accuracy to the classical model. We note that the quantum layer is pretty simple but can be replaced by more complex layers as more development is done in quantum computers. We also note that since we are using a quantum simulator, the time for training the hybrid model is more than it would have been had it been running on a quantum computer.

Table 1: Comparison of classical and hybrid quantum neural network

	Classical	Hybrid
Training Time(s)	4378.131	5848.856
Accuracy(%)	95.02	95.02

References

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