Implementing a Hybrid Quantum-Classical Neural Network by Utilizing a Variational Quantum Circuit for Detection of Dementia

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Magnetic resonance imaging (MRI) is a common technique to scan brains for strokes, tumors, and other abnormalities that cause forms of dementia. However, correctly diagnosing forms of dementia from MRI's is difficult, as nearly 1 in 3 patients with Alzheimer's were misdiagnosed in 2019, which is an issue neural networks can rectify. This proposed novel neural network architecture makes use of a fully-connected (FC) layer, which reduces the number of features to obtain an accuracy, by implementing a variational quantum circuit (VQC). The VQC created in this study utilizes a layer of Hadamard gates, Rotation-Y gates that are parameterized by tanh(intensity) * (p / 2) of a pixel, controlled-not (CNOT) gates, and measurement operators to obtain the expected values. This study found that the proposed hybrid quantum-classical convolutional neural network (QCCNN) provided a 97.5% and 95.1% training and validation accuracy, respectively, which was considerably higher than the classical neural network (CNN) training and validation accuracies of 89.2% and 89.2%. Additionally, the QCNN achieved a 96.5% testing accuracy compared to the CNN testing accuracy of 90.0%. Lastly, the QCNN took a fifth of the time to train (18.1 vs 90.2 minutes) and 23 MB less feature space, achieving a higher time and space efficiency. With hospitals like Massachusetts General Hospital beginning to adopt machine learning applications for biomedical image detection, this proposed architecture would approve accuracies and potentially save more lives. Furthermore, the proposed architecture is generally flexible, and can be used for transfer-learning tasks, saving time and resources.

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