

QAMP Fall 2022 – Check Point 2 – Description

The main target of this Project is to diagnose neurodegenerative disease. So, we focused on the second Checkpoint in diagnosing Autism. Autism Spectrum Disorder (ASD) affects approximately 1% of the population, causes social impairment, and is associated with lifelong disability. The lack of effective means of diagnosing ASD was attributed to the breadth and complexity of ASD symptoms and an incomplete understanding of brain functional connectivity.

Functional MRI (fMRI) can indirectly measure neuronal activity using magnetic differences between oxygenated and deoxygenated blood. In addition, functional connectivity can be captured when a patient is performing a specific task or when a patient is in a resting or task-negative state (resting-state fMRI).

fMRI data are 4D image data composed of time series of 3D voxels. In recent years, machine learning and deep learning techniques have been widely used in fMRI datasets for ASD diagnosis. The advantage of machine learning is that feature extraction from fMRI data combined with known knowledge can increase diagnostic accuracy. However, machine learning is too subjective in extracting data features, limiting the accuracy of diagnosis on new data due to overfitting. It becomes complex to train machine learning models when the dataset has a greater number of features. The fewer features, the better the performance of the model.

Deep learning can automatically and objectively extract features from data through convolutional neural networks. This feature has made convolutional neural networks successful in image vision. Therefore, using deep learning in ASD diagnosis is the current trend. However, deep learning techniques still have limitations. When the training data size is large, deep learning exceeds machine learning. Deep learning will have a lower or similar effect when the training data size is insufficient than machine learning.

This situation is fatal in ASD diagnosis because fMRI data of ASD are not easy to obtain, and the data heterogeneity of ASD patients is high. Therefore, the method based on deep learning still faces a bottleneck in diagnosing ASD (the accuracy rate does not exceed 70%). Our team proposes to use a quantum machine learning-based approach to increase the accuracy of diagnosis in ASD. Recent studies have shown that quantum machine learning has advantages in CT medical image classification. It implies that quantum states may potentially express data characteristics.

We used the Autism Brain Imaging Data Exchange (ABIDE) dataset to train the model, which supplies publicly available fMRI datasets for ASD (1112 datasets, of which 539 were from ASD individuals and 573 from typical controls). In addition, we use a general image preprocessing pipeline to integrate raw 4D fMRI images into 3D images for training.

We propose three quantum machine learning strategies for comparison, which are 3D Quantum Convolutional Neural Network (3D QCNN), 3D Quantum Transfer Learning (3D QTL), and 3D Quantum Neural Network (3D QNN). 3D QCNN and 3D QTL combine convolutional neural network and quantum state, while 3D QNN combines quantum image representation and quantum state. We will implement these QML methods to compare and verify their effects.