Medical Image Classification with a Measurement-Free Quantum Classifier Head

ABSTRACT

This project builds a medical image classification system and then adds quantum computing based algorithms as a novel classifier head. The idea is to start with a normal deep learning model for medical images and replace the final prediction layer with a quantum circuit to see how quantum methods behave on real data. To avoid issues with private patient information, the project uses public medical datasets such as histopathology slides (for example benign vs malignant breast cancer patches), where images are small and typically used for binary classification tasks.

The base pipeline follows a standard medical image processing approach: images are pre-processed, passed through a convolutional neural network to get a compact feature vector, and then classified. On top of this backbone, two types of classifier heads are implemented: a regular fully connected layer with softmax and a small-qubit quantum classifier head. For the quantum part, feature vectors are encoded into quantum states, and a measurement-based variational quantum classifier (VQC) is used as a baseline. The main novelty is a **measurement-free quantum classification method**, which uses SWAP-test or fidelity-style quantum operations between test states and learned template states instead of relying on repeated noisy measurements on NISQ hardware.

The project compares three setups on the same medical dataset: purely classical CNN + softmax, CNN + VQC with standard measurements, and CNN + measurement-free quantum head, analysing accuracy, stability, and feasibility on simulators or small real quantum devices. Results show how far current small-scale quantum methods can go on realistic medical imaging tasks and whether measurement-free designs can reduce the impact of hardware noise. The pipeline is designed so that, if private dental X-ray data later becomes available, the same architecture can be reused with minimal changes to demonstrate the approach on radiology images as well.

TEAM MEMBERS:

Pranesh S (113222031096)
Srivaishnav S (113222031143)
Tarakeshwaran S (113222031159)

PROJECT GUIDE: Dr.S.Gunasundari , Professor

Guide’s Signature
(Dr.S.Gunasundari , Professor)
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