QML– A Cardiology Application

Qiskit

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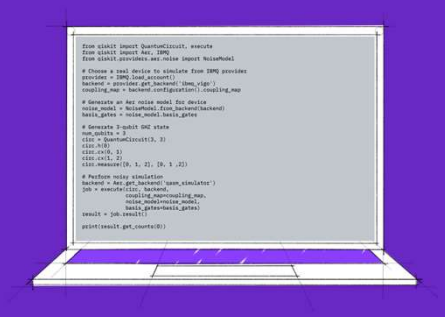
Description



Motivation:

Cardiology has been one of the branches of medicine where the most progress has been made in recent years. The high prevalence of cardiovascular pathologies has led to a constant development of new technologies for diagnosis and treatment.

Objective:

Explore the use of quantum computing to implement Quantum Machine Learning Techniques on ischemic heart disease datasets, taking into account the limitations imposed by the current NISQ devices such as the reduced number of qubits available and the coherence time.

Approach to the Proposed Problem

- **Tabular Data Assessment:** Classify coronary artery disease, comparing the results obtained from both classical and quantum machine learning techniques.
- **Image Assessment:** Classify cardiomegaly on chest X-ray images, using hybrid classical-quantum algorithms.

Tabular Data Source

This coronary artery disease dataset is curated by combining 5 popular coronary artery disease datasets already available independently but not combined before. In this dataset, 5 datasets are combined over 11 common features which makes it the largest coronary artery disease dataset available so far for research purposes. The five datasets used for its curation are:

- Cleveland
- Hungarian
- Switzerland
- Long Beach VA
- Statlog (Heart) Data Set

Target:

Diagnosis of heart disease (angiographic status):

- Value 0: < 50% diameter narrowing
- Value 1: > 50% diameter narrowing
  (in any major vessel)

Source: https://ieee-dataport.org/open-access/heart-disease-dataset-comprehensive

Processing Exploration

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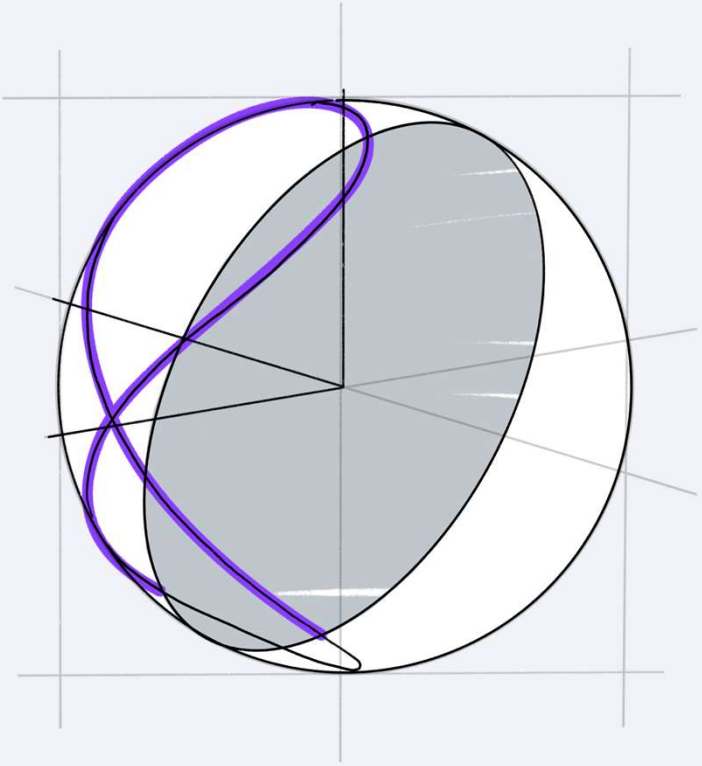
- Implement Data Encoding
- Implement Classic Techniques:
  - SVM
  - Naïve Bayes
  - Logistic Regression
  - Decision Tree
  - Random Forest
  - XGBoost
- Implement QML techniques:
  - Quantum Logistic Regression
  - Quantum Naive Bayes
  - Quantum K-NN
  - QSVM
  - Quantum Tree-Based Planning
- NISQ
  - Circuit optimization
  - Error correction
  - Better setup



X-Rays Data Source

The ChestXray-NIHCC data set comprises 112,120 frontal-view X-ray images with the text-mined fourteen disease image labels (where each image can have multi-labels), mined from the associated radiological reports using natural language processing.

Of them, we selected 30806 X-rays that were each the first occurrence for a unique patient (“Follow up = 0”)

Among them, 777 cases were labeled positive for Cardiomegaly.

A final balanced dataset of 1554 X-rays based on four classes, with a downsizing of the majority was extracted:

- Cardiomegaly alone: 461
- No Finding: 21403-> 461
- Any other findings, with cardiomegaly: 316
- Any other findings, no cardiomegaly: 8986 -> 316

Alternative: Balanced subset excluding anterior-posterior views : 1352 X-rays

Hybrid Classical-Quantum Transfer Learning

Platform:

- Classical: Keras, Pytorch, Tensorflow (?)
- Quantum: Qiskit

Pre-trained CNN model:

- DenseNet121
- ResNet34, ...

Quantum NN:

- number of qubits,
- feature map

Fully connected classical classifier, optimizer, and loss function

Target: Diagnosis of Cardiomegaly

Proposed Models:

- Model 1: Pre-trained CNN, ResNet18 with the last fully-connected layer replaced with a quantum circuit.
- Model 2: Quantum Neural Network sandwiched between Pytorch convolutional and fully-connected layers.
- ...