Quantum Machine Learning for Heart Disease Detection: A Case Study

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Introduction

Introduction

- Quantum machine learning based binary classifier for heart disease prediction
- Classical machine learning based classifier
- Advancement of algorithm, availability of massive high dimensional data
- In health care performing prediction tasks such as decision support, forecasting, categorizing (e.g., cancer diagnosis), and recognizing anomalies (e.g., viral mutations)

Quantum Computing

- Adheres to the rules of quantum mechanics
- Capable of performing tasks that are thought to be difficult for conventional machines
- Computational speedup
- Achieved better accuracy in classification task (i.e. breast cancer detection) using qsvm

Related Work

Alotaibi et al. created a machine learning model that compares five alternative methods for predicting heart disease. This study compared the classification algorithms of decision trees, logistic regression, random forest, naive bayes, and SVM for accuracy.	Shah et al. investigated classifiers on quantum hardware using a modified SVC kernel configuration and concluded that conventional computers struggle to work on datasets with large dimensional spaces.

Objective

- Building quantum machine learning binary classifier and classical classifier
- Comparison between classifiers based on evaluation metric
- Effect in accuracy in set of feature selections
- Relevant work not found

Data Description

4500

Data Points with 16 different columns collected from kaggle

Quantum Computer

Matrix Product State (MPS) IBM Quantum Computer

100 qubits

Supported Gates: 'unitary', 't', 'tdg', 'id', 'cp', 'u1', 'u2', 'u3', 'u', 'cx', 'cz', 'x', 'y', 'z', 'h', 's', 'sdg', 'sx', 'swap', 'p', 'ccx', 'delay' ,and 'r

Methodology

Classical Machine Learning:

Classical Support vector machine (SVM)

- SVM finds the best margin that separates the classes, reducing the risk of error in the data.
- The kernel function used in an SVM has a significant influence on its performance.
- Used a 2 degree polynomial kernel.

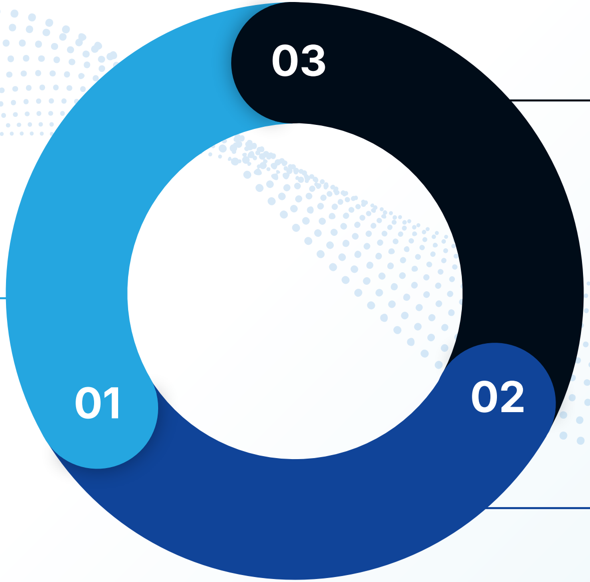
Quantum Machine Learning:

Quantum Support Vector Classifier (QSVC)

- QSVM is an efficient binary classifier with complexity logarithmic in vector size and training example number
- Used the Harrow-Hassidim-Lloyd (HHL) quantum algorithm with an exponential speedup where FT, U, $H^{\dagger}$, and R denote Fourier transform, rotation gate, Hadamard gate conjugate and transpose, and controlled rotation gate, respectively

Set of features

Age, BMI, current smoker
Predicted : Ten years of Coronary heart disease



Age, Prevalent stroke, current smoker

Predicted : Ten years of Coronary heart disease

Cigs per Day, Prevalent hypertension, heart rate
Predicted : Ten years of Coronary heart disease

Learning Algorithms

Classical (SVM)

- Finds the best margin that separates the classes, reducing the risk of error
- Kernel choice of polynomial degree 2.0

Quantum (QSVM)

- Quantum Support Vector Classifier with MPS simulator, using a one-dimensional array of tensors that classify classical data.
- Quantum kernel of degree 3

Experiment & Result Analysis

Features	SVM	QSVM
Age, current smoker,BMI	86%	44%
Age, current smoker, Prevalent stroke	88%	88%
Cigs Per day, Prevalent hypertension,	76%	52%

Discussion

- → Classifiers performance varied with feature selection
- → Produces similar result in some set of features
- → QML has lengthy training and execution durations (in simulators) and can only handle small data samples

Thanks!

Any questions?

Backup

QC:
https://www.overleaf.com/read/dcqknhbktshk#c4b7ef

References:
https://www.mdpi.com/2306-5729/7/3/28

Paper:
https://www.overleaf.com/read/mbbtfvstswsg#c30ea4