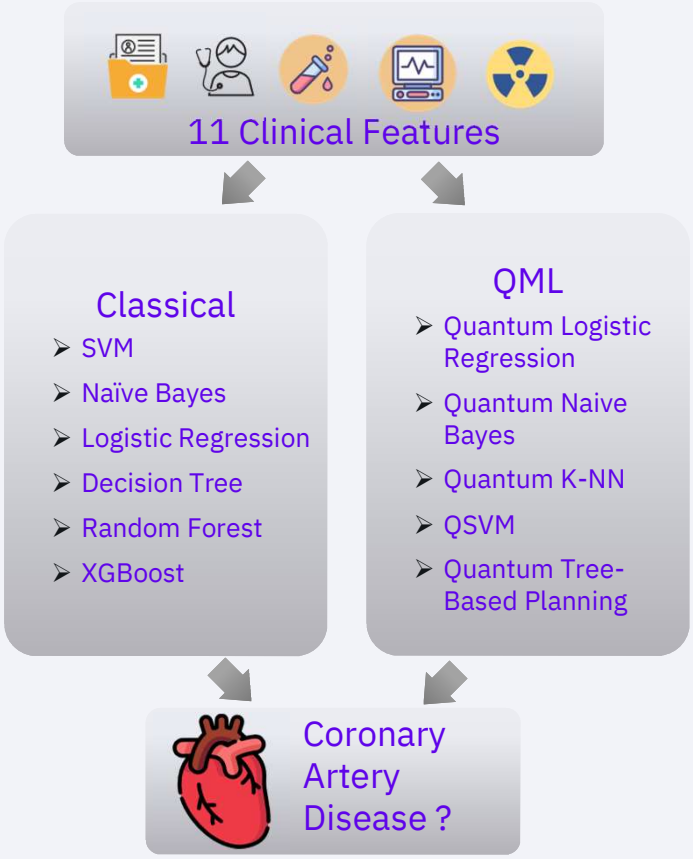
QML – A Cardiology Application

Qiskit

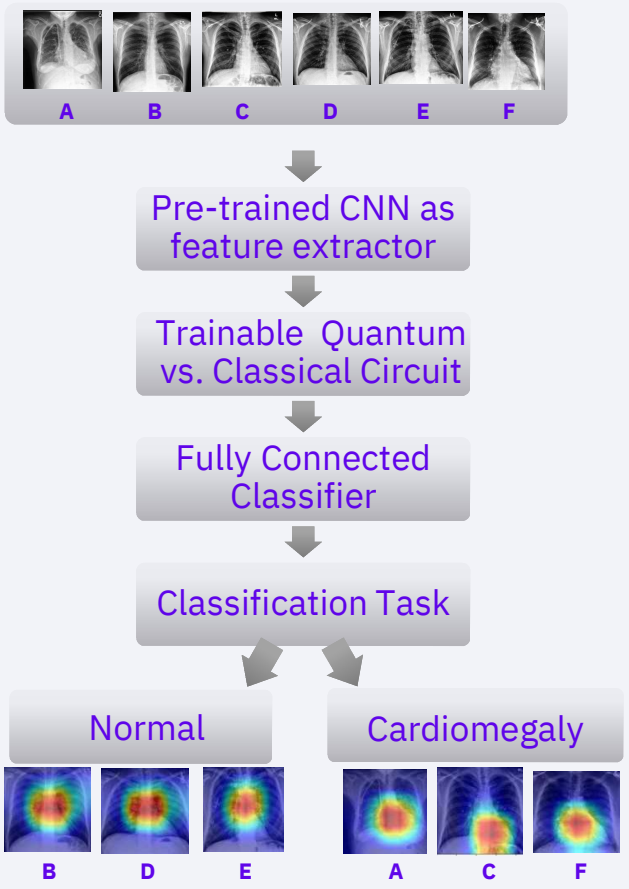
Two projects, one team:

- Mentees:
  - Alfaxad Eyembe
  - Hemavathi Santhanam
  - Soham Bopardikar
  - Tan Jun Liang
- Mentors:
  - Daniel Sierra-Sosa
  - Pierre Decoodt

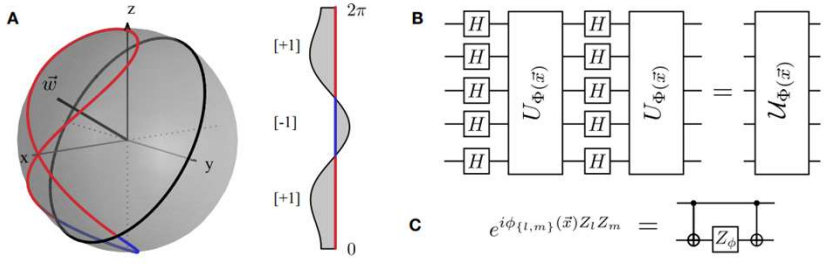
Tabular Data



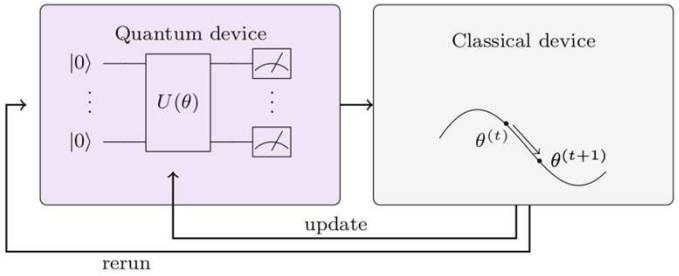
Imaging



Quantum Vector Support Machine and Variational Quantum Eigensolver



QSVM



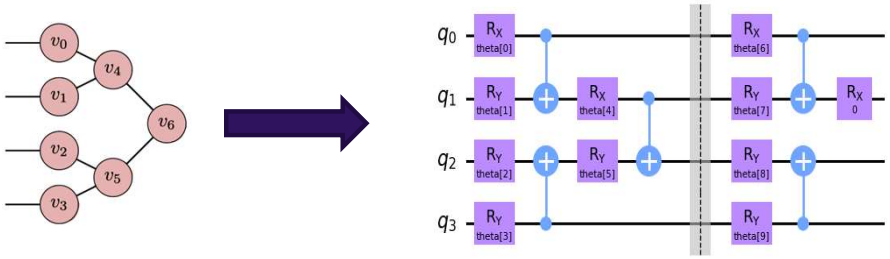
VQE Block Diagram

Results:

Technique	Accuracy	Precision_0	Precision_1	Recall_0	Recall_1	F1-Score_0	F1-Score_1
SVM	80.25%	82.30%	78.40%	77.50%	83.05%	79.83%	80.66%
Naive Bayes	78.99%	83.19%	75.20%	75.20%	83.19%	78.99%	78.99%
Logistic Regression	78.99%	81.42%	76.80%	76.03%	82.05%	78.63%	79.34%
Decision Tree	85.29%	84.07%	86.40%	84.82%	85.71%	84.44%	86.06%
Random Forest	88.24%	91.15%	85.60%	85.12%	91.45%	88.03%	88.43%
XGBoost	84.03%	87.61%	80.80%	80.49%	87.83%	83.90%	84.17%
QSVM	77.73%	75.00%	80.51%	79.65%	76.00%	77.25%	78.19%
VQC	73.95%	72.57%	75.20%	72.57%	75.20%	72.57%	75.20%

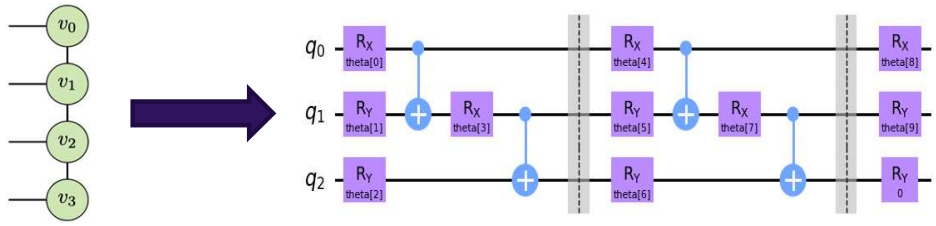
Tensor-Networks as Ansatz

Tree Tensor Networks(TTN)



Representation of the four qubit classical TTN on the left and Q-TTN on the right

Matrix Product State(MPS)



Representation of the three qubit classical MPS on the left and Q-MPS on the right

Q-TTN Circuit Result:

Dataset	Accuracy	Precision_0	Precision_1	Recall_0	Recall_1	F1-Score_0	F1-Score_1
Cleveland	63.9%	60.0%	81.8%	93.8%	31.0%	73.2%	45.0%
Hungarian	57.9%	0.0%	57.9%	0.0%	100.0%	0.0%	73.3%
Summary	66.0%	59.4%	82.4%	89.4%	44.8%	71.4%	58.0%

Q-MPS Circuit Result:

Dataset	Accuracy	Precision_0	Precision_1	Recall_0	Recall_1	F1-Score_0	F1-Score_1
Cleveland	75.4%	70.7%	85.0%	90.6%	58.6%	79.5%	69.4%
Hungarian	63.2%	66.7%	62.5%	25.0%	90.9%	36.4%	74.1%
Summary_IEEE	73.1%	68.7%	78.5%	79.6%	67.2%	73.8%	72.4%

Prominent Features of Tensor Networks:

- Compact representation of complex quantum states.
- Efficient simulation of long-range quantum systems
- Ability to accurately capture entanglement
- Better Time Complexity

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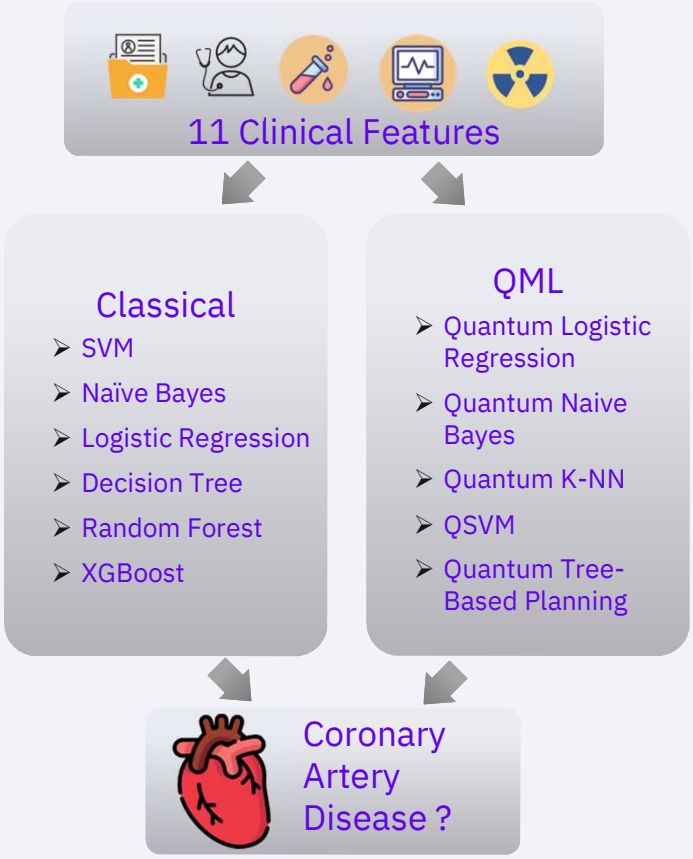

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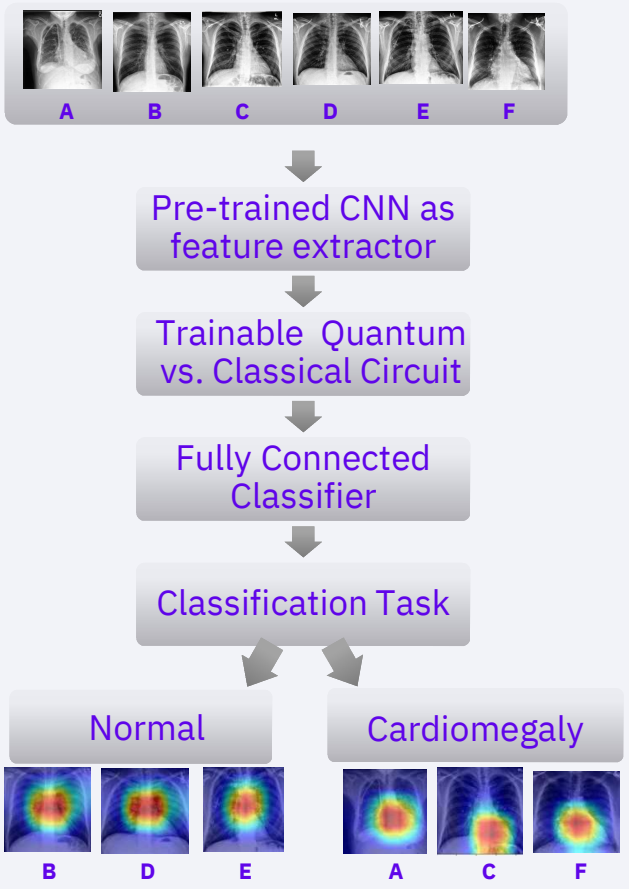

Classical Vs Classical-Quantum Hybrid Model (method)

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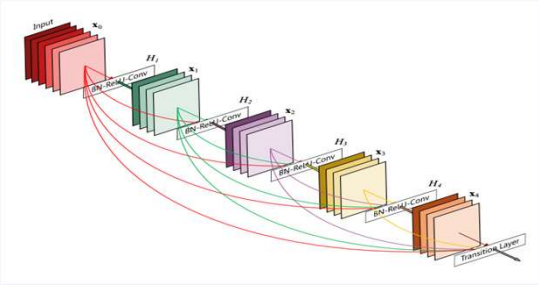
Densenet121



With pytorch

Pre-processing image

Pre-trained CNN as feature extractor

Train-able classical layer vs Quantum Circuit

Fully Connected Classifier

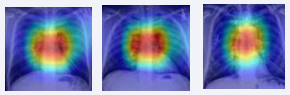
2 epochs with freezer

8 epochs without freezer

Classification Task

Normal

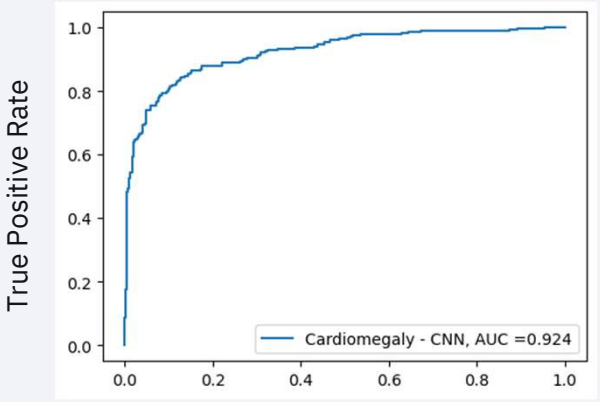
Cardiomegaly

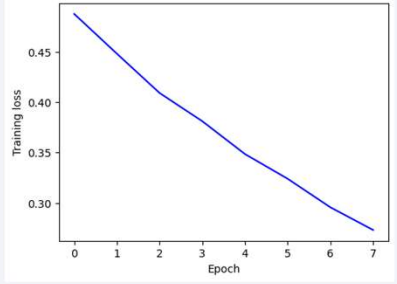


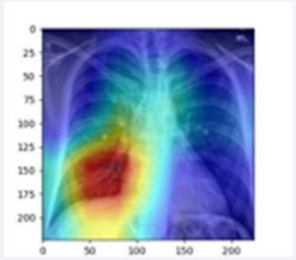
Classical Vs Classical-Quantum Hybrid Model (8 epochs)

Classical 512_512_2

	precision	recall	f1-score	support
0	0.8571	0.8476	0.8524	361
1	0.8525	0.8618	0.8571	369
accuracy			0.8548	730
macro avg	0.8548	0.8547	0.8548	730
weighted avg	0.8548	0.8548	0.8548	730







Hybrid 512_qnn_2

	precision	recall	f1-score	support
0	0.8811	0.8006	0.8389	361
1	0.8209	0.8943	0.8560	369
accuracy			0.8479	730
macro avg	0.8510	0.8474	0.8475	730
weighted avg	0.8507	0.8479	0.8476	730