Quantum ML for Credit Card Fraud Detection (CCFD)

2025 Quantum Machine Learning REU Program

Sophia Wilhelm[1], Tanay Patel[2], Glen Uehara[2], Andreas Spanias[2]
[1]Grainger College of Eng, UIUC, [2]SenSIP Center, School of ECEE, ASU

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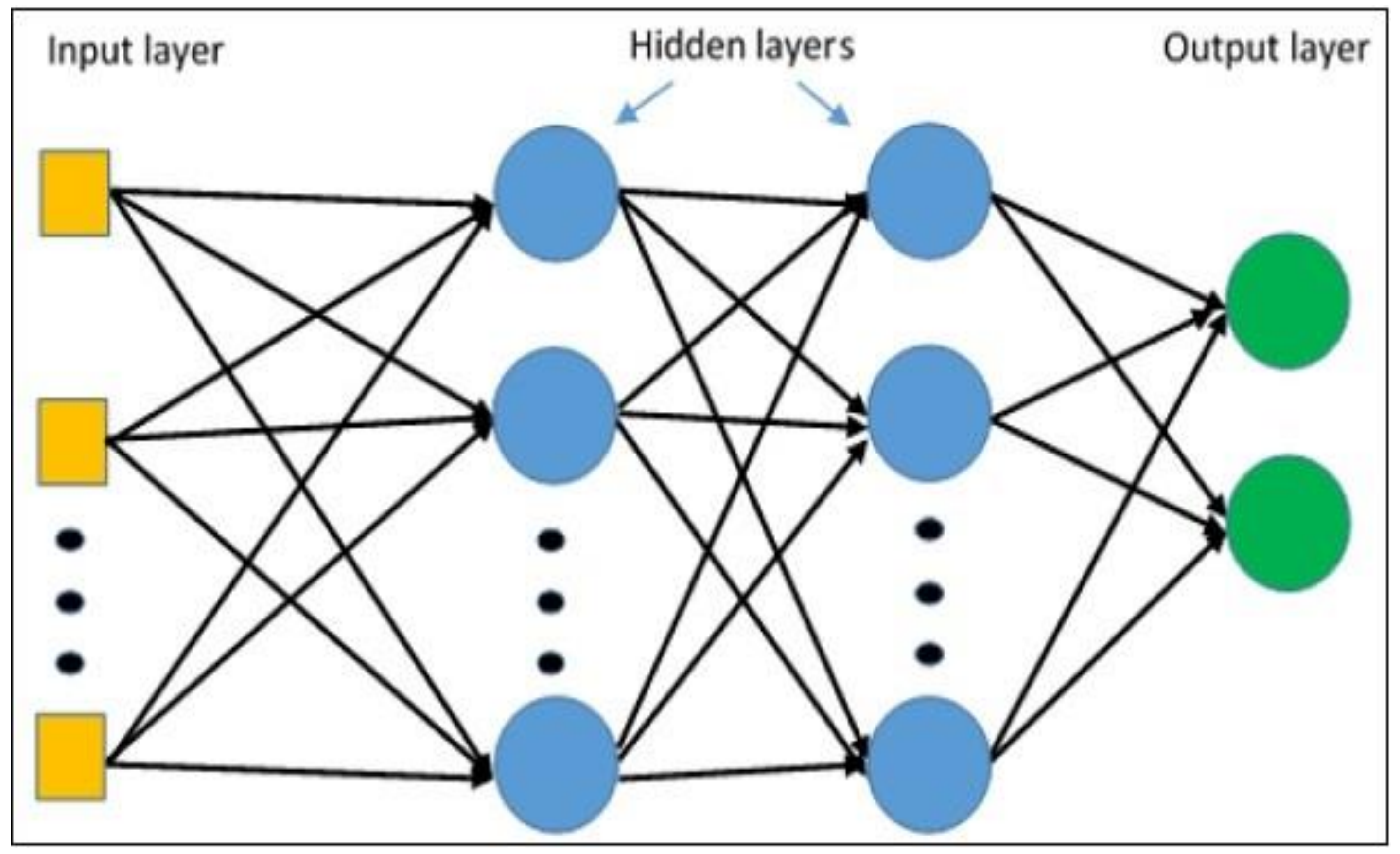
RESEARCH BACKGROUND/DESCRIPTION

- CCFD causes substantial annual financial loss
- Dataset challenges:
  - Missing values
  - Class imbalance
  - Large number of features
- Classical machine learning has had success; quantum ML can build on it

RESEARCH OBJECTIVES/PLAN

- Quantum feature extraction
- Hybrid quantum-classical model
- Goal: uncover unique quantum correlations that increase detection accuracy

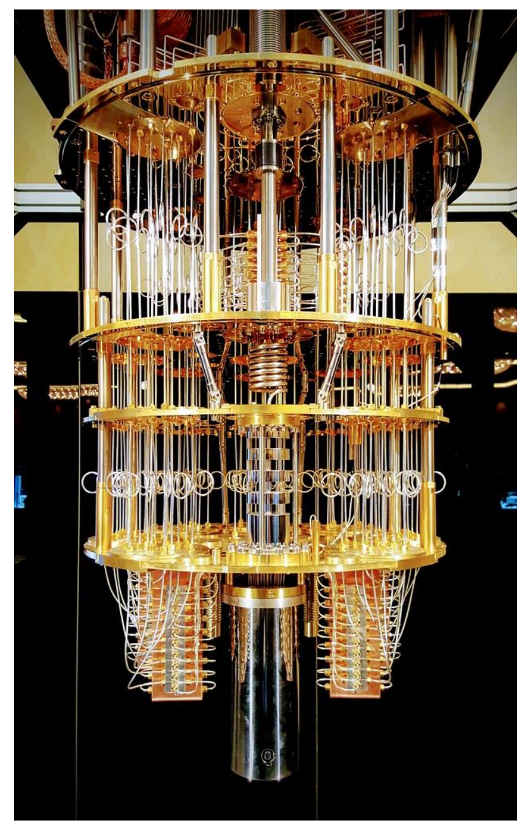


Neural Network architecture

METHODS

Quantum Embedding

- RY Angle Encoding
- Random ansatz (seeded)
- Observables: Z

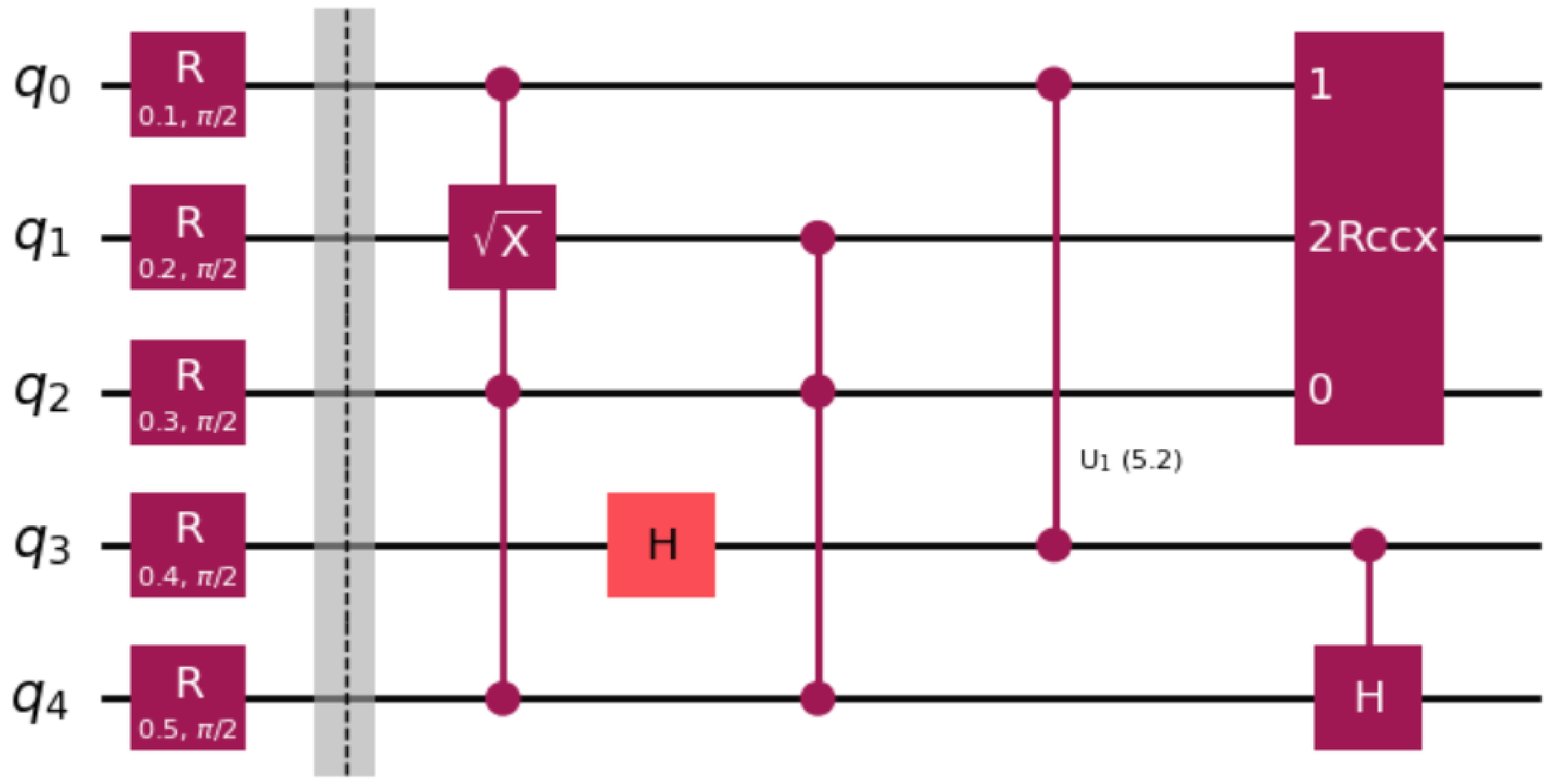


Classical Architecture

- Classical models:
  - XGBoost
  - Neural Network (NN)

Data (IEEE CIS)

- Preliminary results: first week of data
  - 26792 genuine, 804 fraud transactions
- 5 features chosen by classical analysis



Quantum embedding

REFERENCES

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[2] A. Tudisco et al., "Evaluating the computational advantages of the variational quantum circuit model in financial fraud detection," IEEE Access, vol. 12, pp. 102918–102940, 2024
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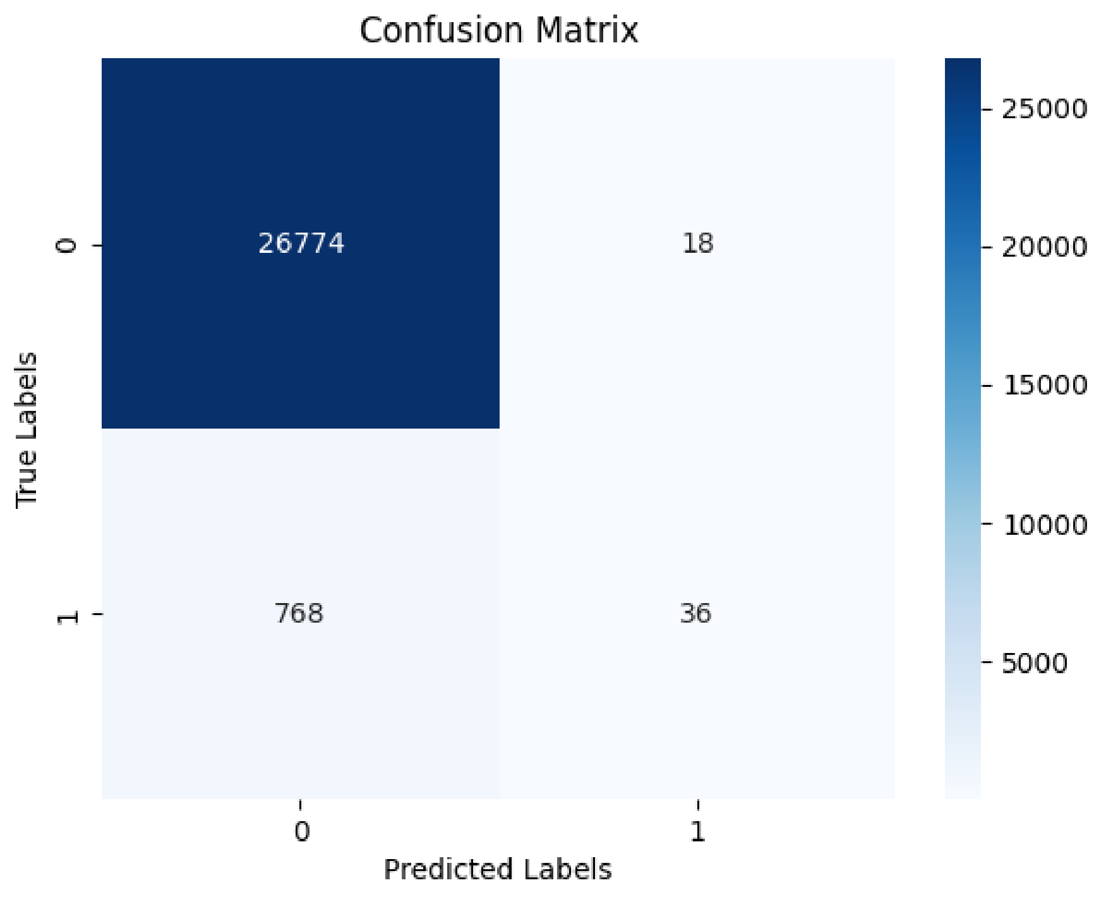
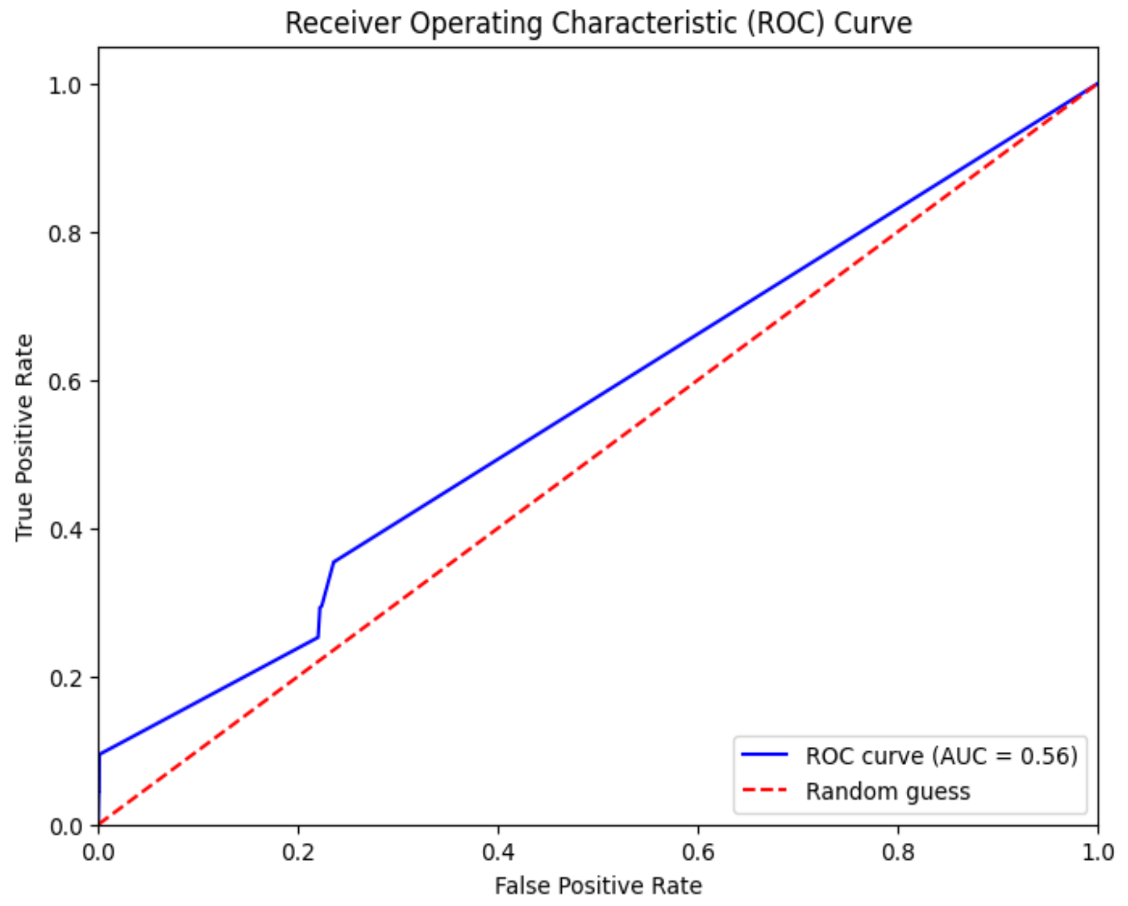
PRELIMINARY RESULTS

- Confusion matrix (left)
  - Successfully ID'd 36/804 fraud cases
- ROC curve (right)
  - AUC = 0.56





CONCLUSIONS

- Classical models give good accuracy
- Quantum models have potential
  - Worked on finding quantum correlation

NEXT STEPS

- Increase quantity of data
  - Number of features (qubits)
  - Time frame
- Improve random ansatz
  - Iterate to find most promising seed
- Swap XGB for NN
  - Start with MLP
  - Prune NN to reduce complexity

Ira A. Fulton Schools of Engineering
ARIZONA STATE UNIVERSITY

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