Comparative Analysis of Quantum-Classical Hybrid and Classical Machine Learning Models for Real-World Data

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The Dataset

- The model was trained and evaluated using a real-world classical dataset containing properties of a cooler, such as wind speed direction, flow rate, and others.
- The dataset initially comprised 15 features. Through correlation analysis, 5 features were selected for the final model: theta_avg_dc, outlet_area, flowrate, dch, and dcw.
- The target variable was T_delta_mean, which initially ranged from 0 to 10 in the dataset. This variable was normalized to 0 and 1 to create a binary classification problem.

The Quantum Classical hybrid approach (½)

- For this classification problem, we chose IBM's open-source framework Qiskit due to its well-documented API, extensive support community, and most importantly, its compatibility with real quantum hardware.
- The chosen model is a Variational Quantum classifier, a hybrid model with three essential components:
  1.Data encoding Feature map : Process classical data for effective use in quantum circuit.
  2. Ansatz (Variational component): This represents the parametrized quantum circuit used for classification.
  3. Classical Optimizer: This tunes the ansatz parameters to achieve optimal classification performance.

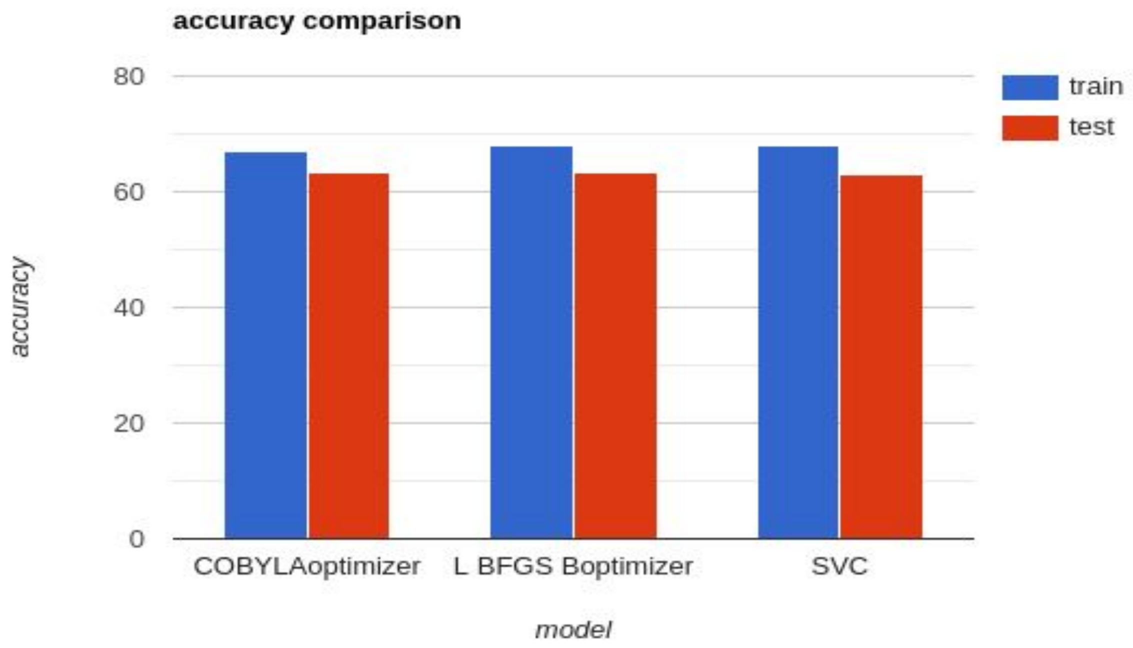
The Quantum Classical hybrid approach (2/2)

- Feature map: ZZFeatureMap, with feature dimension equal to number of features (in this case 5).
- Ansatz: EfficientSU2.
- Classical Optimizers: L_BFGS_B and COBYLA.

Accuracy Comparison b/w hybrid model VQC and classical model SVC (State vector classifier)

Models	Accuracy (in %)	Accuracy with data split (in %)
SVC	68	63
VQC with L_BFGS_B optimizer	68	63.4
VQC with COBYLA optimizer	67	63.4

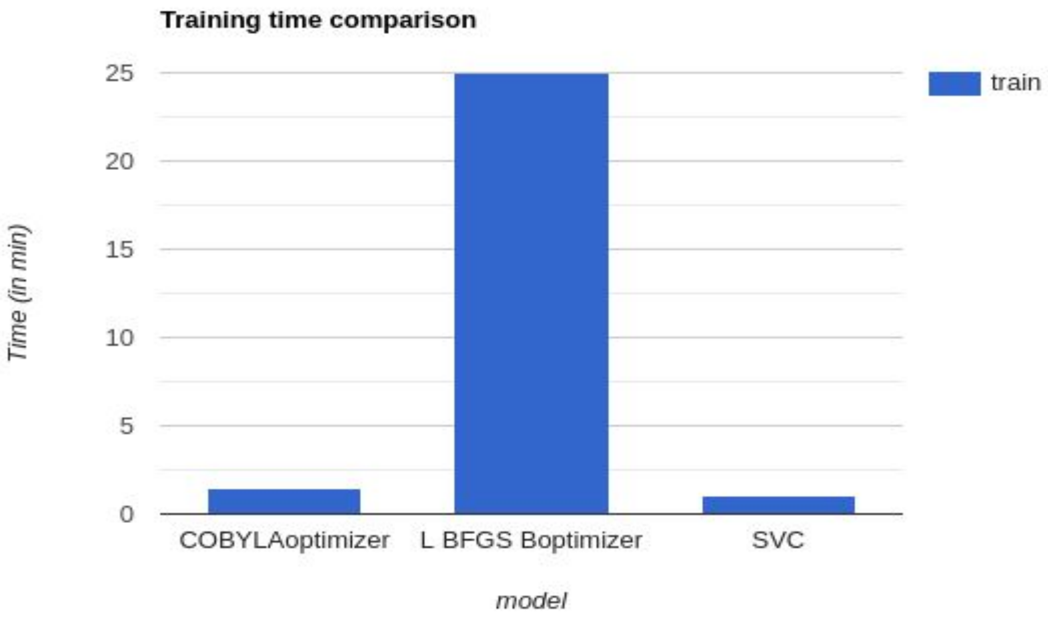
Accuracy Comparison graph



Time Comparison b/w hybrid model VQC and classical model SVC (State vector classifier)

Models	Training time (in min)
SVC	1
VQC with L_BFGS_B optimizer	25
VQC with COBYLA optimizer	1.5

Time Comparison graph



Results

- The quantum-classical hybrid model achieved comparable or even slightly superior accuracy compared to the classical model.
- The time difference between the classical and hybrid models was not significant enough to confer an advantage to the classical model (difference of 30 seconds). This suggests that the hybrid approach offers a promising alternative without compromising on computational efficiency.

Conclusion

- Even with the limitations of current quantum simulators, it is feasible to achieve performance comparable to classical models using quantum-hybrid models.
- Despite hardware limitations, hybrid models demonstrate the potential for real-world applications with the possibility of even exceeding conventional model performance.
- The rapid advancements in quantum technology warrant further exploration of the quantum-AI approach.