

Quantum Computing at Mphasis

March 8, 2021





CASE STUDIES



QUANTUM COMPUTING EXPERIMENTS

Problem	Description	Quantum Achievement	Algorithms
Distributional Supply Network Optimization	<ul style="list-style-type: none"> Facility location problem Select best among potential sites to equip with services, while minimizing costs. 	<ul style="list-style-type: none"> Around 400% improvement in Prediction time 	Classical Simulated Annealer, Simulated Annealer, Hybrid Solver
Portfolio Optimization and Asset Allocation	<ul style="list-style-type: none"> Maximizing portfolio return while minimizing risks 	<ul style="list-style-type: none"> 76.65 % Reduced Time taken in optimization 2.29 % Better result for same no. of annealing steps 5.6 % Increased Portfolio Return 	Simulated Annealing, Hybrid Solver
Damaged Shipment Classification	<ul style="list-style-type: none"> Predicting damaged/not damaged shipment images using computer vision 	<ul style="list-style-type: none"> 12.34% improvement in test accuracy 325 % improvement in training time 3.44 % improvement in test time 	Image transformation + Transfer learning + quantum circuit layers + DNN (Hybrid QML model)
News Headlines Sentence Clustering	<ul style="list-style-type: none"> Clustering of similar news headlines together to analyze the trends of news 	<ul style="list-style-type: none"> 98.75% improvement in Training time 80% improvement in Testing time 8% improvement in coherence score 	QUBO HSS solver, QPU solver, K-means clustering
Covid 19 News Sentiment Analysis	<ul style="list-style-type: none"> Categorizing the sentiment of the new headlines into Positive, Negative and Neutral 	<ul style="list-style-type: none"> 4% improvement in accuracy 94% improvement in Training time 98.57% improvement in Testing time 	Qboost HSS solver, BERT, Qboost (Pure)



QUANTUM COMPUTING EXPERIMENTS

Problem	Description	Quantum Achievement	Algorithms
Resource Allocation Optimization	<ul style="list-style-type: none"> Problem is to select a set of trajectories that complete all repairs of machine while minimize the congestion across all resources. 	<ul style="list-style-type: none"> The time takes to get results from classical system is 40x more than the time taken to get the quantum results 	Classical Simulated Annealer, Simulated Annealer, Quantum Solver
Freight Route optimization	<ul style="list-style-type: none"> identify the optimal route to transfer packages through available destination routes, with minimum operational cost, maximum capacity utilization of legs 	<ul style="list-style-type: none"> The time takes to get results from classical system is 25x more than the time taken to get the quantum results 	Classical Simulated Annealer, Simulated Annealer, Quantum Solver
Capacitated Vehicle Routing Optimization	<ul style="list-style-type: none"> Obtain optimal route and number of trucks to minimize the cost function 	<ul style="list-style-type: none"> 68.74 % Reduced Time taken in optimization 	Genetic algorithm, Hybrid Solver
Time Series Forecasting	<ul style="list-style-type: none"> Time Series Demand Forecasting problem Predict the future 36 months of demands for the provided SKUs 	<ul style="list-style-type: none"> 2% Improved prediction percentage error achieved on 6 month future forecast. 	Timeseries decomposition + Quantum circuit + Deep learning (Hybrid QML framework)



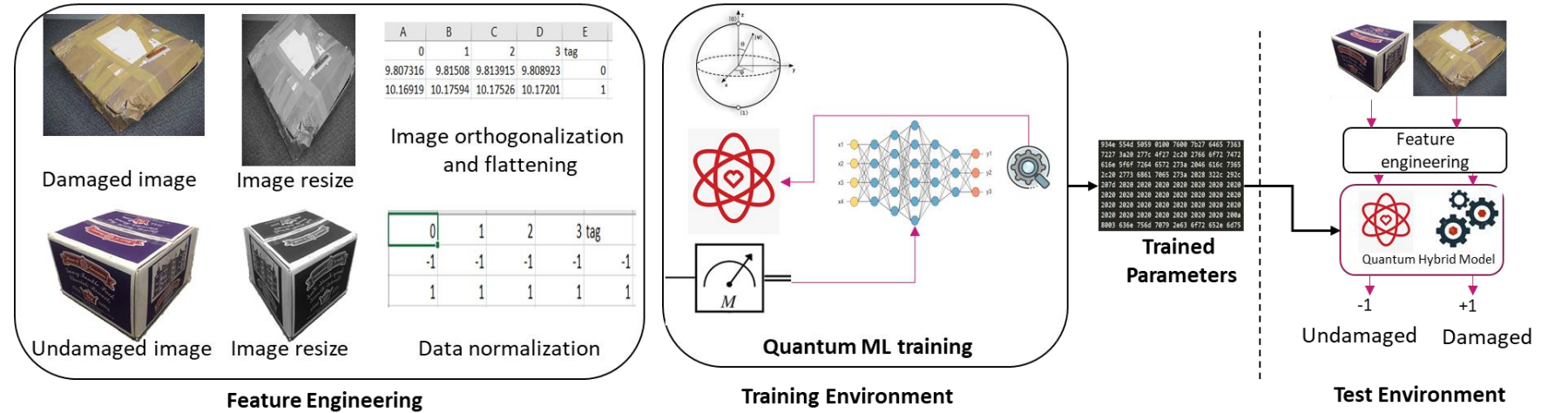
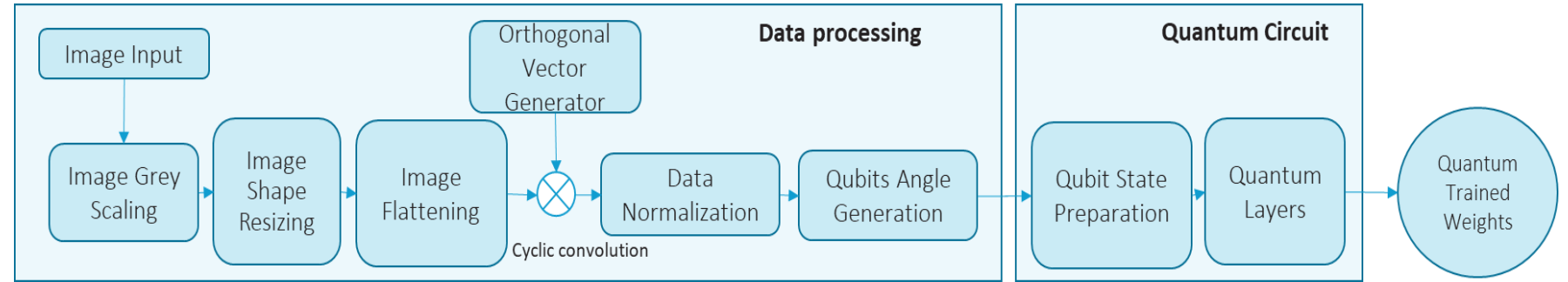


Damaged Shipment Classification– Feature Decomposition



Classify shipment boxes into either damaged or not damaged categories

- Image preprocessing
- EON: Image orthogonalization through convolution
- Quantum variational classifier
- Quantum ML pipeline



	Accuracy(%)
With EON	100
Without EON	41

- Training sample: 132
- Validation of model: 23
- Prediction on new images: 10





Damage Shipment Classification: Classical ML Vs Quantum ML

	Google Auto ML	EON powered QML
Training time (Sec)	8820	875
Training accuracy (%)	94.7	100
Validation accuracy (%)	82.6	100
Prediction accuracy (%)	9 out of 10	All 10



Damaged Shipment Classification – QCNN



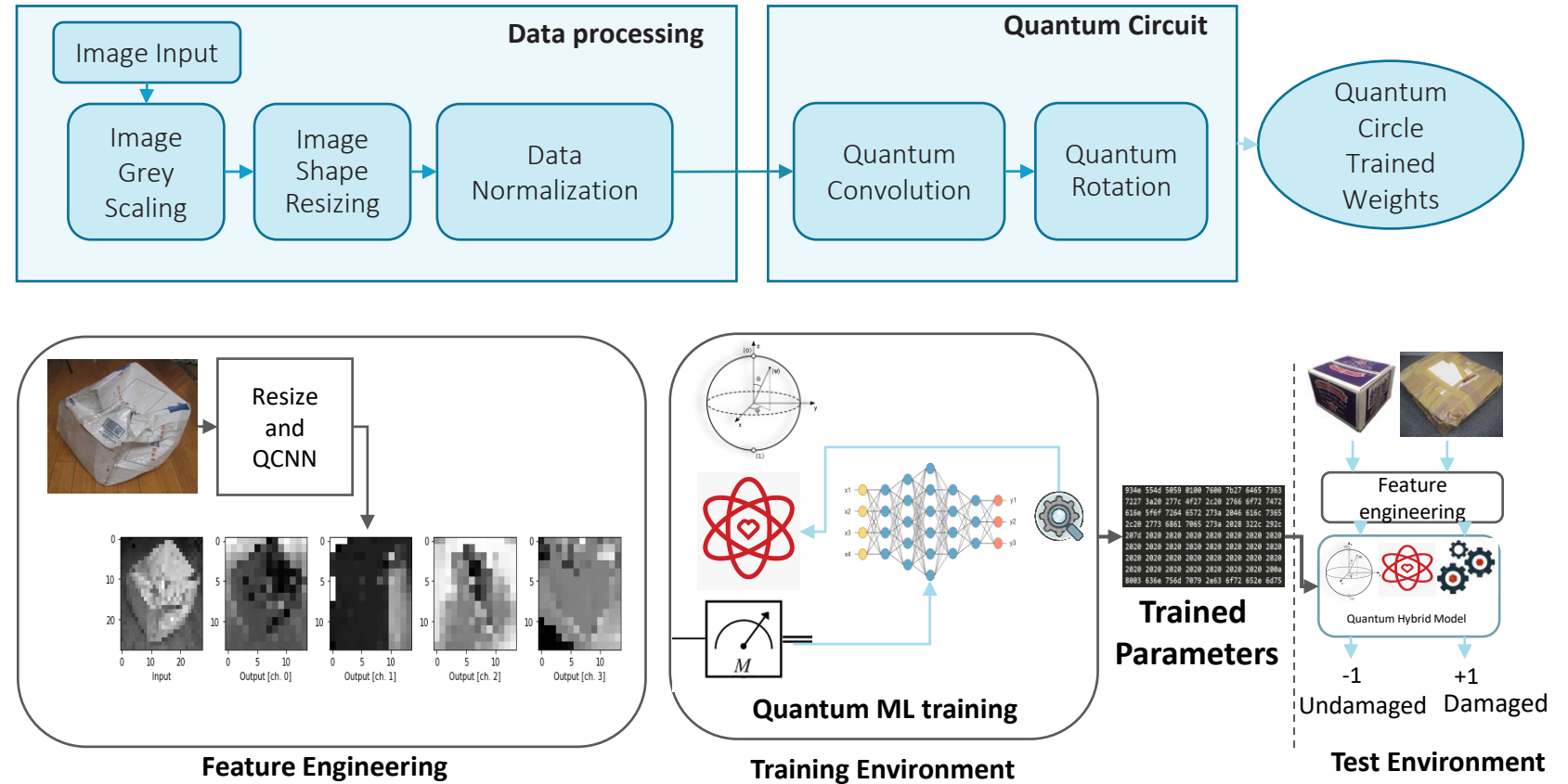
Classify shipment boxes into either damaged or not damaged categories



- Image preprocessing
- EON: Feature transformation, Resizing
- Quantum CNN
- Integrated DL-QML pipeline



	Accuracy(%)
With EON	81.25
Without EON	50



- Training sample: 132
- Validation of model: 23
- Prediction on new images: 10



Image Classification – Traditional CNN Vs. QCNN

	CNN	EON powered QML
Training accuracy (%)	73.89	99.36
Test accuracy (%)	50.00	81.25
Prediction accuracy (%)	5 out of 10	7 out of 10



Time Series Demand Forecasting



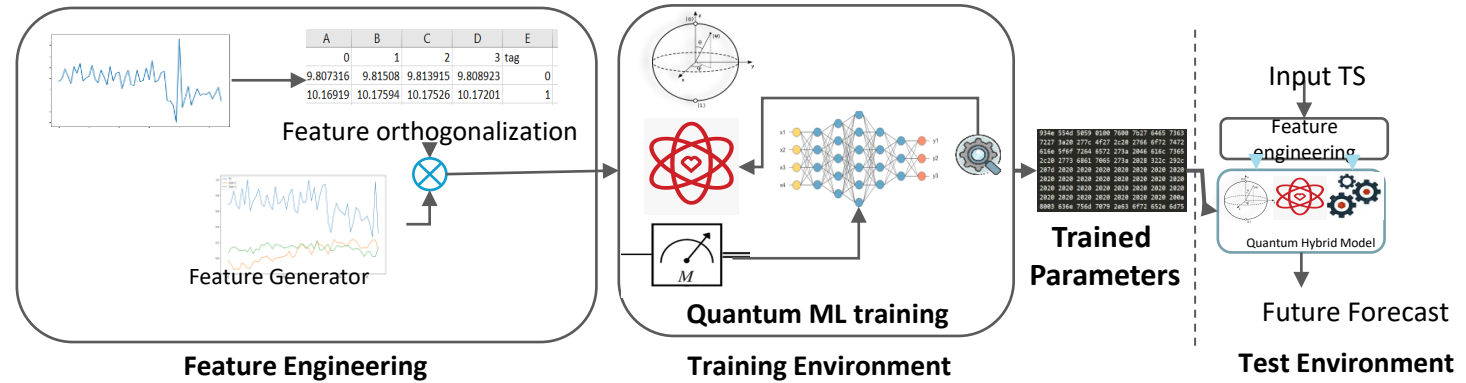
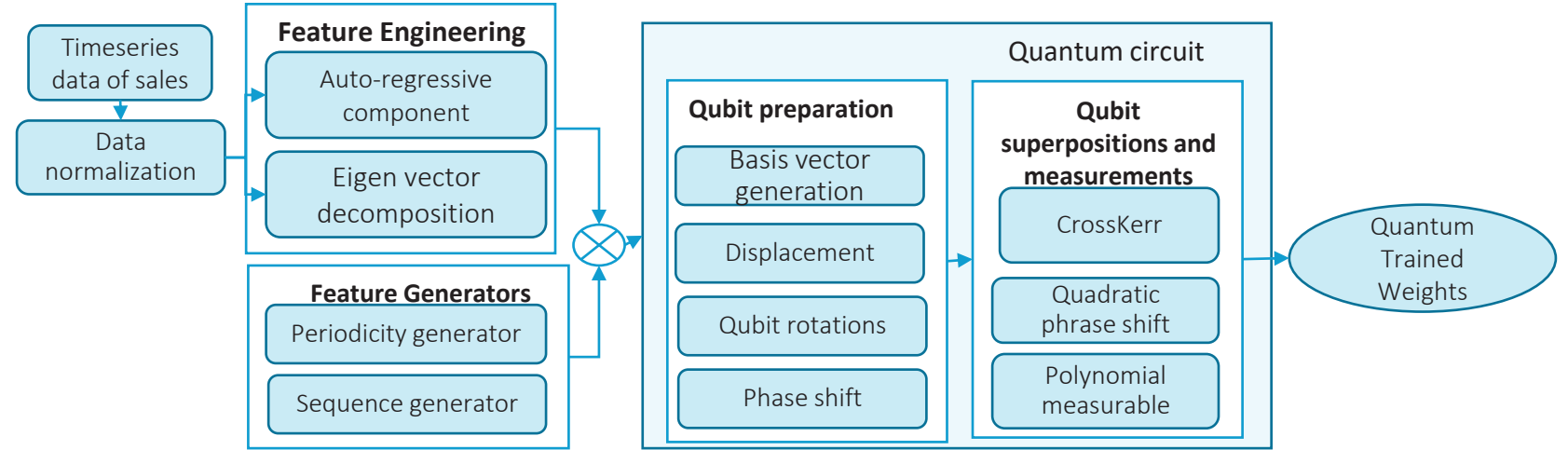
Forecast future demand using historic global demand data



- Time Series Forecasting
- EON: Vector decomposition and learning, Wave fit for seasonality
- Quantum function fit
- Quantum ML pipeline



	% of Wins over ML
With EON	62
Without EON	36



- Number of SKUs for forecasting: 10
- Size of timeseries: 53 months of sales for each SKU
- Train: 47 months data
- Forecast: Next 6 months
- Number of traditional trained: 42



Traditional Time Series Vs. Quantum function fit

- Number of SKUs for forecasting: 10
- Size of timeseries: 53 months of sales for each SKU
- Train: 47 months data
- Forecast: Next 6 months
- Number of traditional models used in past: 42

Models on which EON powered QML won (Out of 42)		
ID	# models	% of win
SKU1	24	57.14%
SKU2	39	92.86%
SKU3	22	52.38%
SKU4	23	54.76%
SKU5	42	100.00%
SKU6	30	71.43%
SKU7	28	66.67%
SKU8	30	71.43%
SKU9	19	45.24%
SKU10	30	71.43%



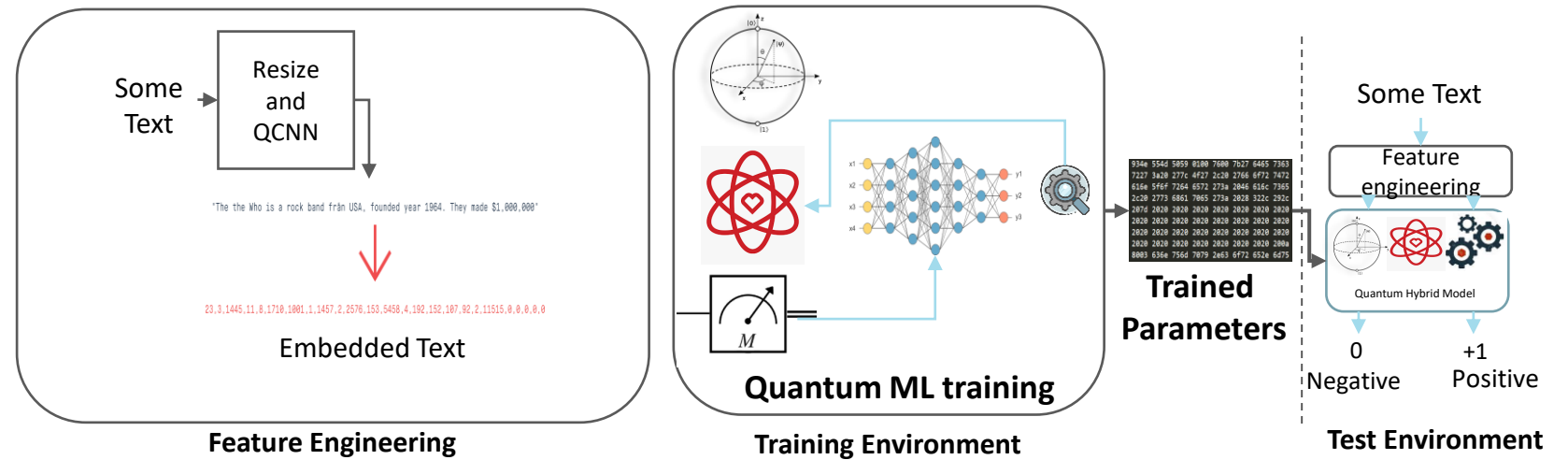
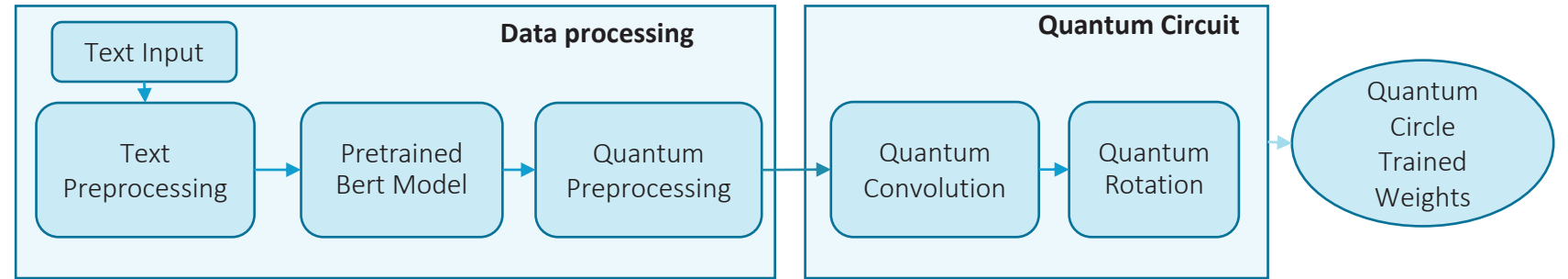
Sentiment Analysis - QCNN



Classify text input into either positive or negative sentiment



- Text preprocessing
- EON: Embedding and Autoencoder
- Quantum CNN
- Quantum ML pipeline



	Accuracy(%)
With EON	84
Without EON	67

- Dataset: COVID 19 News Headlines
- Training set size: 1216
- Validation set size: 304



Sentiment Analysis: Traditional ML Vs. Quantum Sentiment

	Traditional	EON powered QML
Training accuracy (%)	96	97
Validation accuracy (%)	82	84



Anomaly Detection



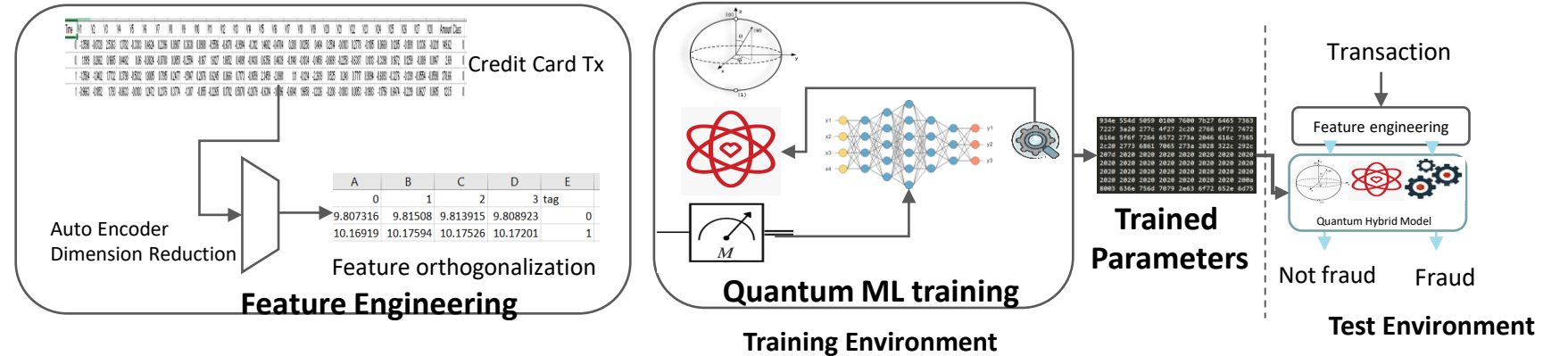
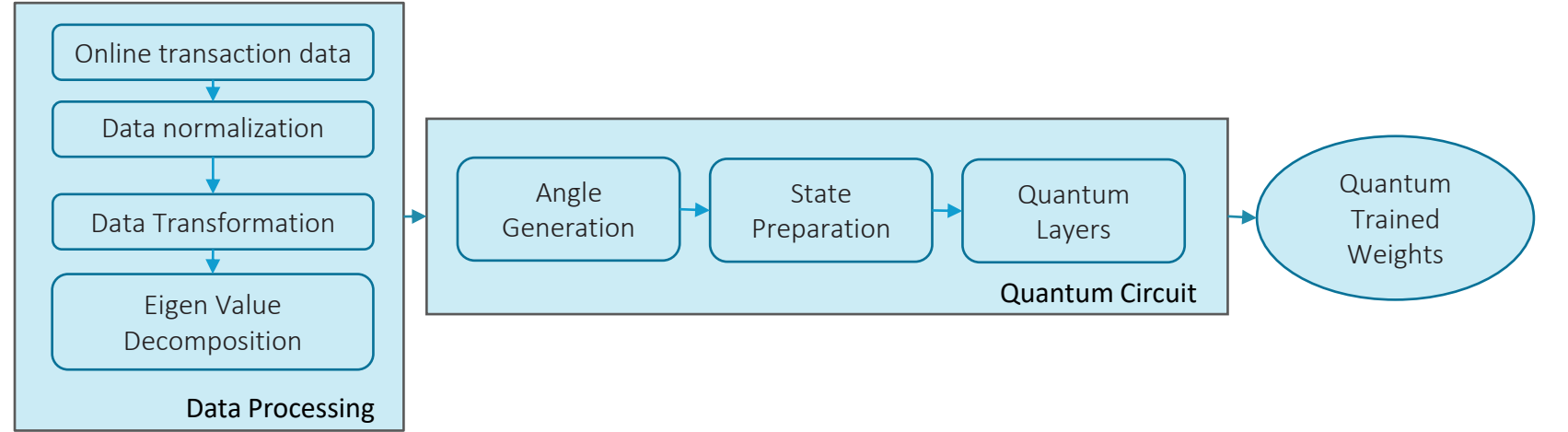
Classify shipment boxes into either damaged or not damaged categories



- Preparing Quantum data using Mphasis EON
- Quantum circuit design
- Quantum ML training
- Variational Classifier



- We were able to detect 3 out of 10 fraudulent transactions
- Need some more work



Data set Details

- Data set source: Kaggle
- Total transactions: 284807
- Fraudulent Transactions: 492
- Dataset is not balanced



Anomaly Detection (Contd.)

- Total transactions: 284807
- Fraudulent Transactions: 492
- Dataset is not balanced

	Quantum Circuit
Training accuracy (%)	88.4
Validation accuracy (%)	88.2
Prediction accuracy (%)	12.60



Conclusion

- Results of Quantum Machine Learning are encouraging
 - Data of different nature are handled for Quantum algorithms: Image, Text, Timeseries data
 - The results of image classification and Time series forecasting are promising and match the existing framework/techniques
 - Very good model accuracy and reduced training time compared to classical counter parts
- Currently, there is a limitation on the number of qubits available, which may result in
 - Increased training time
 - Information loss due to data transformation, especially while handling large set of attributes



THANK YOU

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