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# Quantum code challenge

## Innovative Quantum Algorithms for Smart Cities

**22-25 OCTOBER 2024**

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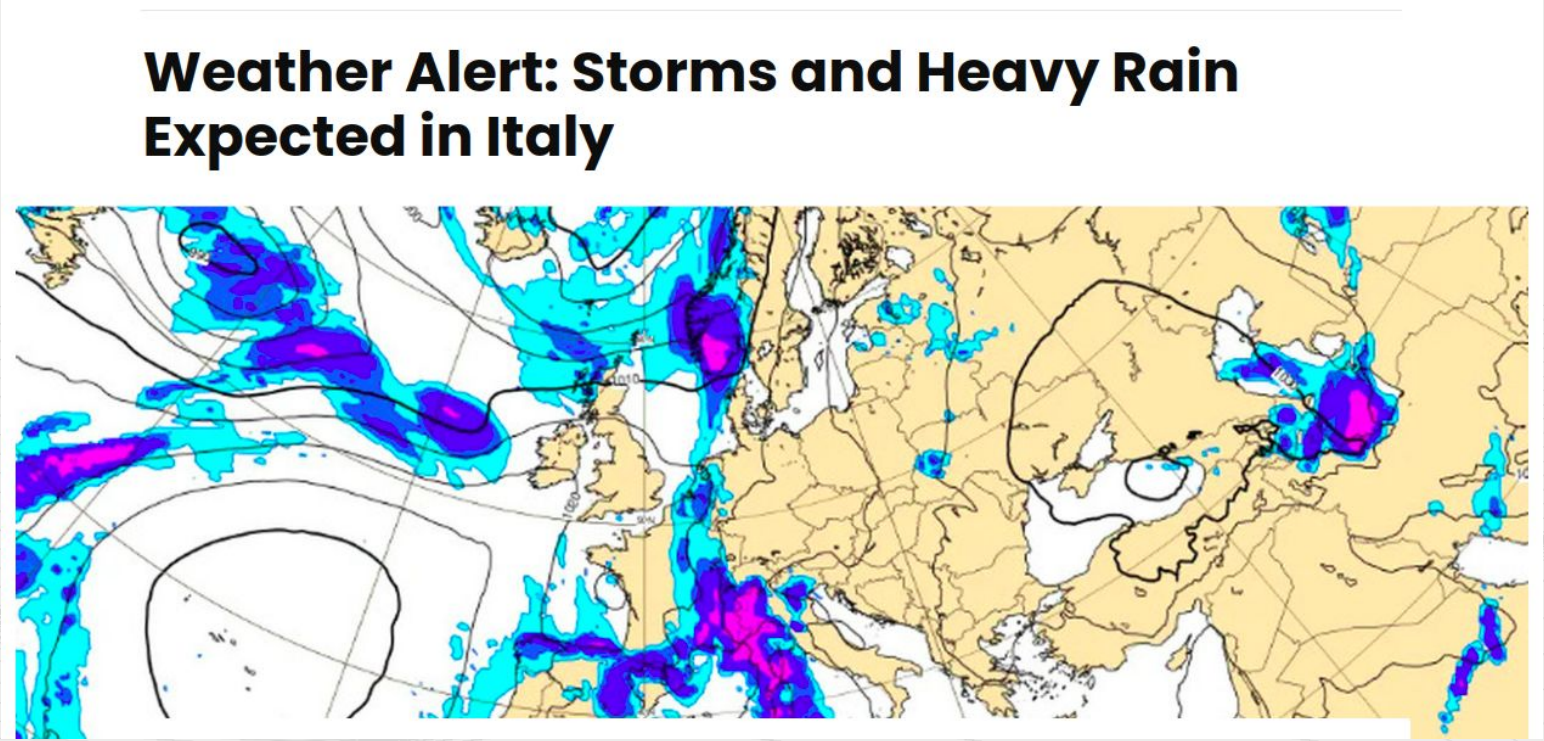
# Objective

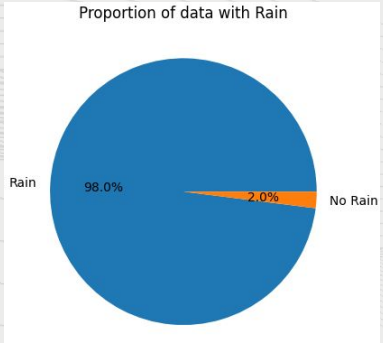
Predict rain events using quantum machine learning.



# Problem Statement

- Based on data like humidity, atmospheric pressure, temperature etc. Predict if it rains or not.
- Weather code: 5xx means rain. Data from 1st Aug - 9th Oct.
- Highly imbalanced dataset

| id | hum | pres | rain_1h | wind_speed | wind_deg | clouds_all | ts_get | max_temp | min_temp | ave_temp | cod_weather |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 42469 | 73 | 1016 | 0.00 | 1.54 | 170 | 0 | 2024-08-30 22:00:03 | 26.55 | 25.81 | 26.46 | 800 |
| 42861 | 54 | 1012 | 0.00 | 4.12 | 330 | 0 | 2024-09-16 09:00:02 | 22.66 | 21.81 | 22.23 | 800 |
| 42587 | 80 | 1011 | 1.97 | 3.60 | 190 | 40 | 2024-09-04 20:00:02 | 27.66 | 26.57 | 27.42 | 501 |
| 41974 | 79 | 1017 | 0.00 | 3.60 | 330 | 20 | 2024-08-10 06:00:02 | 24.90 | 22.81 | 23.80 | 801 |
| 41867 | 56 | 1011 | 0.00 | 0.45 | 126 | 100 | 2024-08-05 19:00:02 | 28.79 | 28.75 | 28.76 | 804 |
| 42243 | 37 | 1013 | 0.00 | 7.72 | 360 | 0 | 2024-08-21 11:00:03 | 31.81 | 30.97 | 30.99 | 800 |
| 43039 | 67 | 1014 | 0.00 | 4.12 | 350 | 0 | 2024-09-23 19:00:02 | 23.79 | 22.81 | 23.09 | 800 |
| 42715 | 61 | 1010 | 0.00 | 5.66 | 350 | 20 | 2024-09-10 04:00:02 | 23.23 | 22.64 | 22.91 | 801 |
| 42348 | 78 | 1015 | 0.00 | 2.06 | 170 | 0 | 2024-08-25 20:00:02 | 27.10 | 26.57 | 27.01 | 800 |
| 42845 | 42 | 1014 | 0.00 | 6.17 | 320 | 0 | 2024-09-15 16:00:02 | 23.21 | 22.81 | 23.21 | 800 |



# Models

- **Classical Support Vector Classifier**
- **Quantum Support Vector Classifier [1]**
- **QBoost [2] with Simulated Annealing**
- **QBoost with D-Wave’s Advantage_system4.1**

[1] Schuld, Maria, and Nathan Killoran. "Quantum machine learning in feature hilbert spaces." Physical review letters 122.4 (2019): 040504.
[2] Neven, H., Denchev, V. S., Rose, G., and Macready, W. G. Training a Binary Classifier with the Quantum Adiabatic Algorithm, 2008, arXiv:0811.0416v1

# Results

## Classical SVC

| Model | Recall | Precision | F1 Score | Accuracy |
|---|---|---|---|---|
| Random Oversampling | 1.00 | 0.45 | 0.63 | 0.98 |
| Class Weighted | 1.00 | 0.17 | 0.29 | 0.90 |
| SMOTE + Tomek | 0.90 | 0.29 | 0.44 | 0.95 |
| Baseline | 0.50 | 0.83 | 0.63 | 0.99 |

## QSVC

| Model | Recall | Precision | F1 Score | Accuracy |
|---|---|---|---|---|
| Class Weighted | 1.00 | 0.71 | 0.83 | 0.99 |
| Random Oversampling | 0.80 | 0.47 | 0.59 | 0.98 |
| SMOTE + Tomek | 0.80 | 0.42 | 0.55 | 0.97 |
| Baseline | 0.60 | 0.86 | 0.71 | 0.99 |

## QBoost (Simulated Annealing)

| Model | Recall | Precision | F1 Score | Accuracy |
|---|---|---|---|---|
| SMOTE + Tomek | 0.90 | 0.69 | 0.78 | 0.99 |
| Random Oversampling | 0.80 | 0.67 | 0.73 | 0.99 |
| Baseline | 0.60 | 0.60 | 0.60 | 0.98 |

## QBoost (Advantage_system4.1)

| Model | Recall | Precision | F1 Score | Accuracy |
|---|---|---|---|---|
| SMOTE + Tomek | 1.00 | 0.56 | 0.71 | 0.98 |
| Random Oversampling | 0.80 | 0.67 | 0.73 | 0.99 |
| Baseline | 0.60 | 0.60 | 0.60 | 0.98 |

# Summary

- Addressed the challenge of rain prediction using quantum ML techniques.
- Demonstrated progress in using quantum algorithms for smart city applications
- Further refinement is needed to fully realize the model.