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Quantum code challenge

Innovative Quantum Algorithms for Smart Cities

22-25 OCTOBER 2024

THE EVENT IS ENDORSED BY

QITALY

PSC MIMIT - FSC 2014-2020 Programma di supporto tecnologie emergenti nell'ambito del 5G Asse I Progetto "CDL – Casa delle Tecnologie Emergenti di Cagliari" CUP G27F22000040008

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WiData

W3 WINDTRE

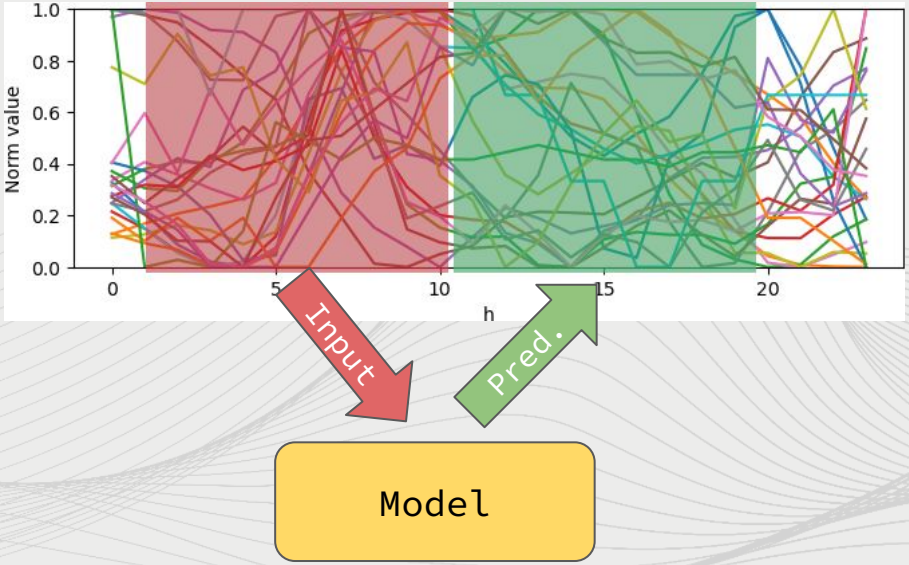
Motivation: Effects of Climate Change

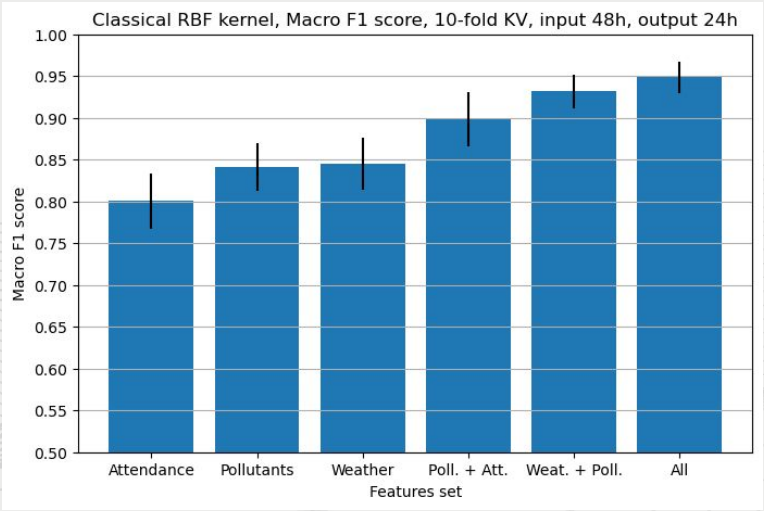
- "Climate change concerns the increase, in **intensity and frequency of extreme phenomena such as strong storms, floods, rising sea levels**,[...]" https://www.mase.gov.it/pagina/i-cambiamenti-climatici
- "Storms have become more intense and frequent in many geographic areas [...].**These storms are capable of destroying entire communities, causing enormous human and economic losses.**" https://unric.org/it/effetti-del-cambiamento-climatico
- "Other effects of climate change, **rising sea levels will increase the risk of flooding and erosion around coasts, with significant consequences for people, infrastructure, businesses and nature** in these areas.[...].

  Severe thunderstorms are expected to become more common and intense[...]" https://climate.ec.europa.eu

Task definition

- Predict if **rains** at least once within the **next N** hours based on sensor data from **previous M** hours
- Different set of features possible from all datasets
- Supervised binary classification task on sliding windows evaluated with **Macro F1 score**



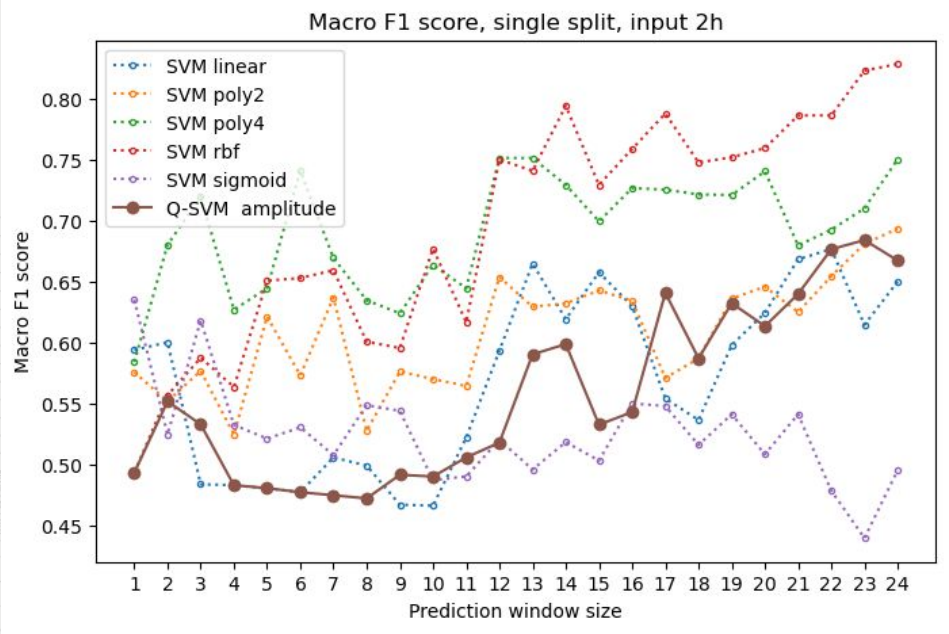


Data preprocessing

- **27** sets of features from “**Particulate Matter**”, “**UniqueAttendance_15**” and “**Weather**”
- Sampled **hourly** from the 1st of August at 0:00 to the 8th October at 21:00
- **Missing** data approximated with forward filling strategy
- Label **rain** if “**cod_weather**” in “**Weather**” is **2xx**, **3xx** or **5xx**
- ~**1300** Unbalanced data samples (**1/4** rain over all windows with **N=24**, **1/25** with **N=2**)
- **Variable** input and prediction windows sizes (M and N)

Results with Q-SVM

- **Quantum** SVM with **amplitude** and **angle** embedding quantum kernels
- **Simplified** task to allow simulation of quantum kernels
- Amplitude kernel **efficient** (logarithmic) and **comparable** with classical ones
- Angle kernel is **better** than classical ones on the same setting!



Model	Macro F-1 score
Q-SVM angle embedding	**0.76**
Q-SVM amplitude embedding	0.61
SVM linear kernel	0.53
SVM poly 2 kernel	0.56
SVM poly 4 kernel	0.70
SVM RBF kernel	0.73
SVM sigmoid kernel	0.52