UNIVERSIDADE DA CORUÑA USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA Universidade Vigo

Quantum Computing and Machine Learning (614551008)

Final Practice (2025-2026)

INSTRUCTIONS:

- **Deadline:** January 23, 2024, 23:59h.
- **Objectives**
  - In this practice you will apply the different Quantum Machine Learning (QML) models that we have seen in the subject to a dataset of your choice.
  - This practice will correspond to the "objective test" of the subject and will have a value of 40 % in the final grade.
- **Dataset**
  - You must choose a classification dataset to which to apply your QML models.
  - The main restriction is that **it cannot be a dataset that you have already used** for the subject in any of the practices or theory examples.
  - Another restriction is that **each practice group must base its work on a different dataset**, so it is necessary to inform the subject professor of the dataset we want to use and have them confirm that it has not been selected by another group.
  - **The same dataset must be used** for the different models developed in this practice.
  - You can find datasets available in Kaggle (`https://www.kaggle.com/`) or in the different frameworks used such as Keras (`https://keras.io/api/datasets/`) or Scikit-learn (`https://scikit-learn.org/stable/datasets.html`).
  - **The choice of complex datasets will be valued**, but keep in mind that large input dimensionality, or number of examples or classification categories, will affect training times of the subsequent experiments.
  - To keep the problem attainable, you might consider the use of **dimensionality reduction techniques**, dropping some instances to reduce its size, or simplifying the problem considering less categories.
  - Regardless, after the preprocessing step, it is recommended that the resulting dataset involve at least 100 training examples and at least 4 input features.

- **Tasks to be carried out**

  1. **Preprocessing**.
     - Preprocess the dataset to prepare it to feed to the different machine learning models as needed: flatten the images, convert integers to float values, normalize values, encode the labels using the one-hot encoding, etc.
     - If necessary, consider the application of dimensionality reduction techniques and justify its necessity.
     - Divide the data into training and test subsets, if the dataset is large enough you can consider using a validation dataset for hyperparameter tunning.
  2. **Develop a Quantum Neural Network (QNN)**.
     - Decide which feature map, ansatz and optimizer to use with the dataset.
     - Build a Variational Quantum Classifier (VQC) using the feature map, ansatz and optimizer chosen.
     - Try several alternatives and justify the decisions made.
  3. **Develop a Quantum Support Vector Machine (QSVM)**.
     - Decide hyperparameters: kernel function (i.e. quantum feature map), regularization parameter, multiclass strategy (one-vs-one, one-vs-rest)
     - Try several alternatives and justify the decisions made.
  4. **Conclusions**.
     - Discuss possible preprocessings that you might have applied to the original dataset.
     - Reach some final conclusions for the carried out experiments comparing the different models.
     - Elaborate on advantages and disadvantages of each method. For example, which model obtain the best results? Which model has the best training time performance? Which model does involve more complex hyperparameterization? Etc.

- **Submission**

  - **The practice must be carried out alone**
  - The exercises will be developed using Jupyter Notebooks.
  - **The notebook should include**:
    - The full name of the author on its first cell.
    - All the code developed.
    - The code shall be accompanied by cells with an explanatory report containing a description of the process followed, detailing the results obtained and justifying the decisions taken.
    - The notebook will be saved with the results of its execution included.
  - **Submission process**
    - The exercises will be submitted to professor (Eduardo Mosqueira Rey) by email (`mailto:eduardo.mosqueira@udc.es`) or by any other means agreed upon with him.
    - There is a strict deadline for each assignment. Past due submissions will be rejected.