Code and Data
for section 6.4.5 of "Using a Single Circuit to Compute the Gradients with Respect to All Parameters of a Quantum Neural Network"

Overview:

All the output data of the experiments in section 6.4.5 of the paper are in the "data" directory.

All the software code* of the Python programs for generating these data are located in the "code" directory.

Operating environment: Python 3.8.10 with Qiskit 0.21.2.

About the programs:

- *13_grad_conventional_sim_iris.py*:

  Training the quantum classifier for the Iris dataset using the conventional approach.

  Required input files:

  data/epoch_0_parameters.csv

  data/epoch_i_training_data.pickle (i=0, ... , total_training_epochs - 1)

  Output files:

  data/epoch_i_gradient_conv.csv (i=0, ... , total_training_epochs - 1)

  data/epoch_i_mapped_data_conv.pickle (i=0, ... , total_training_epochs - 1)

  data/epoch_i_parameters_conv.csv (i=1, ... , total_training_epochs)

  data/training_results_conv.csv

- *14_grad_improved_sim_iris.py*:

  Training the quantum classifier for the Iris dataset using the improved approach.

  Required input files:

  data/epoch_0_parameters.csv

  data/epoch_i_training_data.pickle (i=0, ... , total_training_epochs - 1)

  Output files:

  data/epoch_i_gradient_impr.csv (i=0, ... , total_training_epochs - 1)

  data/epoch_i_individual_shot_impr.pickle (i=0, ... , total_training_epochs - 1)

  data/epoch_i_mapped_data_impr.pickle (i=0, ... , total_training_epochs - 1)

  data/epoch_i_parameters_impr.csv (i=1, ... , total_training_epochs)

  data/training_results_impr.csv

- *15_accuracy.py*:

  Computing the classification accuracy in each epoch of training based on the

output files of *13_grad_conventional_sim_iris.py* and *14_grad_improved_sim_iris.py*.

Required input files:

data/epoch_0_parameters.csv

data/epoch_i_parameters_conv.csv (i=1, ... , total_training_epochs)

data/epoch_i_parameters_impr.csv (i=1, ... , total_training_epochs)

Output files:

data/accuracy.csv

About the data files:

- *accuracy.csv*:
  The classification accuracy in each epoch of training using the conventional and the improved approaches.
  Produced by *15_accuracy.py*.

- *epoch_i_gradient_conv/impr.csv* (i=0, ... , total_training_epochs - 1):
  The gradients with regard to the adjustable parameters of the VQC obtained in the *i*th epoch of the training using the conventional/improved approach.
  Produced by *13_grad_conventional_sim_iris.py*/*14_grad_improved_sim_iris.py*.

- *epoch_i_individual_shot_impr.pickle* (i=0, ... , total_training_epochs - 1):
  The numbers of individual shots obtained in the *i*th epoch of the training using the improved approach.
  Produced by *14_grad_improved_sim_iris.py*.

- *epoch_i_mapped_data_conv/impr.pickle* (i=0, ... , total_training_epochs - 1):
  The intermediate result obtained in the *i*th epoch of the training using the conventional/improved approach.
  Produced by *13_grad_conventional_sim_iris.py*/*14_grad_improved_sim_iris.py*.

- *epoch_0_parameters.csv*:
  The initial values of all adjustable parameters of the variational quantum circuit (VQC) used in this section.
  Randomly chosen.

- *epoch_i_parameters_conv/impr.csv* (i=1, ... , total_training_epochs):
  The values of the adjustable parameters of the VQC to be used in the *i*th epoch of the training using the conventional/improved approach.
  Produced by *13_grad_conventional_sim_iris.py*/*14_grad_improved_sim_iris.py* in the *(i-1)*th epoch of the training.

- *epoch_i_training_data.pickle* (i=0, ... , total_training_epochs - 1):

The input data used in the *i*th epoch of the training of the VQC.
Randomly chosen from the Iris dataset.

- *training_results_conv/impr.csv*:
Summary of the complete 50-epoch training results of the conventional/improved approach.
Produced by *13_grad_conventional_sim_iris.py*/*14_grad_improved_sim_iris.py*.