Assignment 4 ACML
Quantum Computing

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1 Introduction

We start with the circuit from the given notebook and we change a set of variables. In particular we focus on the following:

- The number of repetitions in the feature map
- The type of the feature map
- The type of entanglement in the feature map and variational circuit
- The type of variational circuit
- The optimizer

All the changes are with respect the initial circuit.
The initial model has an accuracy of 92.5% on the test set.

2 Experiment 1 - Number of repetitions in the feature map

In case we change the repetitions parameter of ZZFeatureMap and set it to 2, we notice that the test data were 100.0% classified.

Model	Accuracy (%)	Loss
Initial	92.5	0.1473
2 repetitions	100	0.0091

Table 1: Accuracy and loss values for experiment 1

3 Experiment 2 - ZFeatureMap

We changed the featureMap from ZZFeatureMap to ZFeatureMap and run the circuit with full entanglement.

Model	Accuracy (%)	Loss
Initial	92.5	0.1473
ZFeatureMap - full entanglement	72.5	0.2677

Table 2: Accuracy and loss values for experiment 2

From the table we can see that having a more complex feature map, ZZFeatureMap, gives a higher accuracy.

4 Experiment 3 - Linear entanglement

We set the entanglement in the feature map to linear. Then we did the same for the variational circuit. Since we have only 2 qbits, there is no difference between the linear entanglement and the full entanglement, therefore we are still obtaining an accuracy of 92.5%.

Model	Accuracy (%)	Loss
Initial	92.5	0.1473
ZZFeatureMap - linear	92.5	0.1473
Var. Circuit - linear	92.5	0.1473

Table 3: Accuracy and loss values for experiment 3

5 Experiment 4 - Change the variational circuit to PauliTwoDesign

We changed the variational circuit from RealAmplitudes to PauliTwoDesign. The main difference between the two is that the latter initialize the qbits with $\sqrt{H}$, uses a combination of RX, RY and RZ and CZ. RealAmplitudes uses only RY and $CNOT$.

In this case, we observe a lower accuracy (87.5%).

Model	Accuracy (%)	Loss
Initial	92.5	0.1473
PauliTwoDesign	87.5	0.2421

Table 4: Accuracy and loss values for experiment 4

However, this might be because the optimizer needs more iterations to find the optimal parameters.

6 Experiment 5 - Use ADAM optimizer

Initially we are using the COBYLA, which does not used derivatives. So, we can the ADAM optimizer, which is based on derivatives.

We use a learning rate of 0.05.

In this case, both optimizers find the same optimal point, however, ADAM is slower.

Model	Accuracy (%)	Loss
Initial	92.5	0.1473
ADAM	92.5	0.1473

Table 5: Accuracy and loss values for experiment 5

7 Conclusion

The dataset has noticeable effect on the accuracy of the model. From this experiments, we can notice that having more repetitions in the feature map can increase the quality of the model, at least in the simulation.