Transfer Learning with Hybrid Neural Networks

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Introduction

Transfer Learning is a bio inspired artificial intelligence technique and comes from the idea of applying the knowledge gatherer from one task, to another different task that is usually related to it.

It usually involves two network architectures, one of them is fully trained, then the weights of this network are transferred to the other network, in order to speed the training process of the target network by either use those weights as a weight initialization or by keeping them just as they were given, and perform some optimizations over the final layers, when the task given is solved.

Youtube video

https://youtu.be/2Cuvaj-zbzU

Methodology

For this project we decided to reproduce the examples presented in *"Transfer learning in hybrid classical-quantum neural networks",* and then compare the results with classical implementations that would solve the same problem. We took the weigths of the pre trained network Resnet18 and added them to a hybrid network that used a dressed quantum variational circuit.

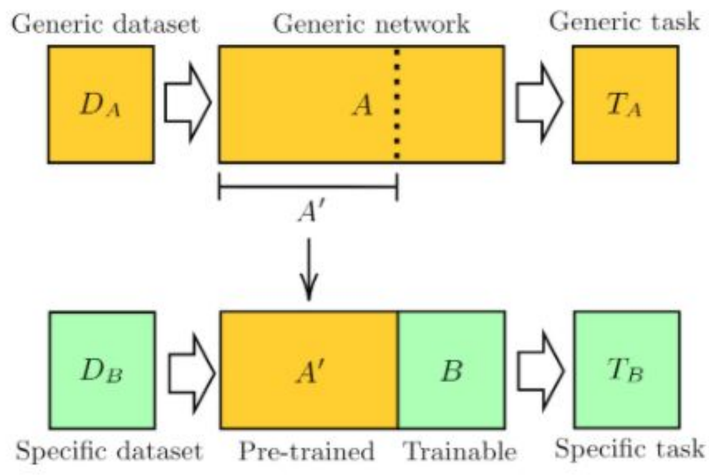

Figure 1.
Hybrid Neural Network

Datasets

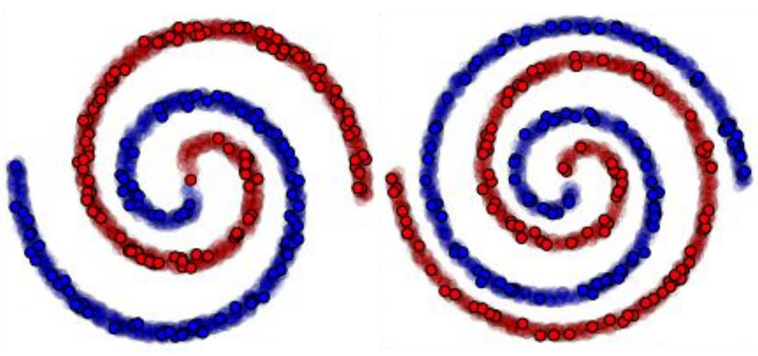

Figure 2.
Dataset example 1

Figure 3.
Dataset example 2

Figure 4.
Dataset example 3

Results

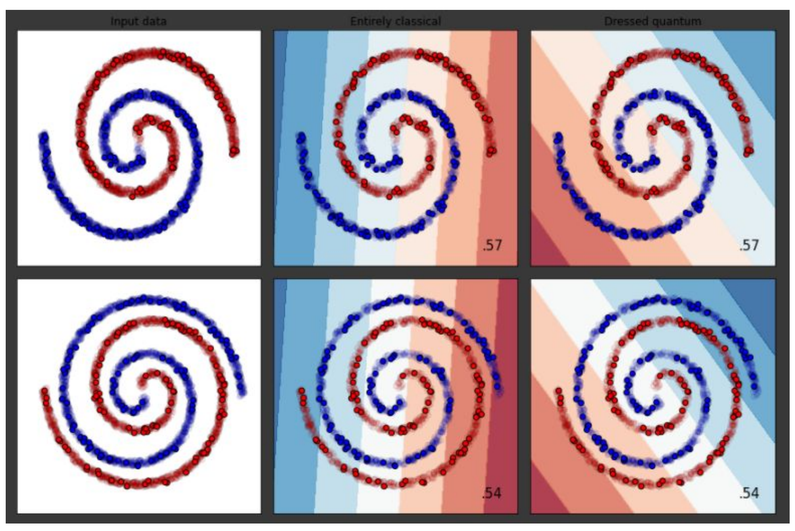

Figure 5.
Best results for Example 1

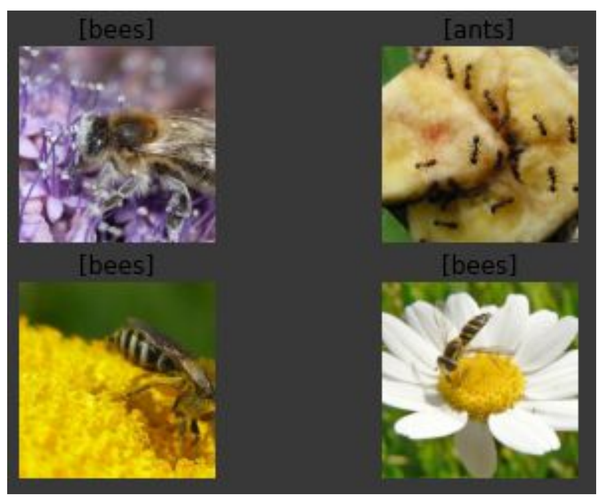

Figure 6.
Results for Example 2

Figure 7.
Results for Example 3

Discussion

Quantum Hybrid Networks might have a better performance in classification problems when the data has high nonlinear properties, when compared to a classical network.

Even though hybrid models took way more time in the training process than the classical ones when trained using transfer learning we think there is a lot of space for improvement, since this models runned over quantum simulators, that's why when the developments of quantum computers and noise correction reach better results we might be able to see the real potential of this kind of networks.

References

1. Andrea Mari, Thomas R. Bromley, Josh Izaac, Maria Schuld, and Nathan Killoran. Transfer learning in hybrid classical-quantum neural networks. arXiv:1912.08278 (2019).
2. Ville Bergholm, Josh Izaac, Maria Schuld, Christian Gogolin, M. Sohaib Alam, Shahnawaz Ahmed, Juan Miguel Arrazola, Carsten Blank, Alain Delgado, Soran Jahangiri, Keri McKiernan, Johannes Jakob Meyer, Zeyue Niu, Antal Száva, and Nathan Killoran. PennyLane: Automatic differentiation of hybrid quantum-classical computations. 2018. arXiv:1811.04968
3. Sasank Chilamkurthy, PyTorch transfer learning tutorial. https://pytorch.org/tutorials/beginner/transfer_learning_tutorial.html.