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INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY
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Technology, Social Impact

Classification using Quantum Machine Learning

ABSTRACT

The probabilistic nature of qubits and the entanglement between them gives quantum computing an edge over classical computing. Quantum mechanics concepts can be applied to the field of machine learning as well. Quantum machine learning can be used to perform classification problems. The current NISQ (Noisy Intermediate-Scale Quantum) era demands for quantum algorithms to use less qubits and be robust against errors, making variational classifiers ideal for tackling binary classification tasks in NISQ systems and this can be extended to multiclass classification.

METHOD

Binary classification of classical data can be done using a variational classifier (Fig 1). The process involves encoding the data into feature vectors, embedding it in the quantum circuit and then training the parameters of the ansatz based on the cost function specified. Encoding methods include angle encoding, amplitude encoding etc. Moreover, it is possible to learn the encoding using special encoding circuits (Quantum Metric Learning).

$$|\boldsymbol{x}\rangle = \sum_{i=1}^{N} f_i(\boldsymbol{x})|i\rangle \text{ where, } \sum_i |f_i|^2 = 1$$

Equation 1. Amplitude encoding

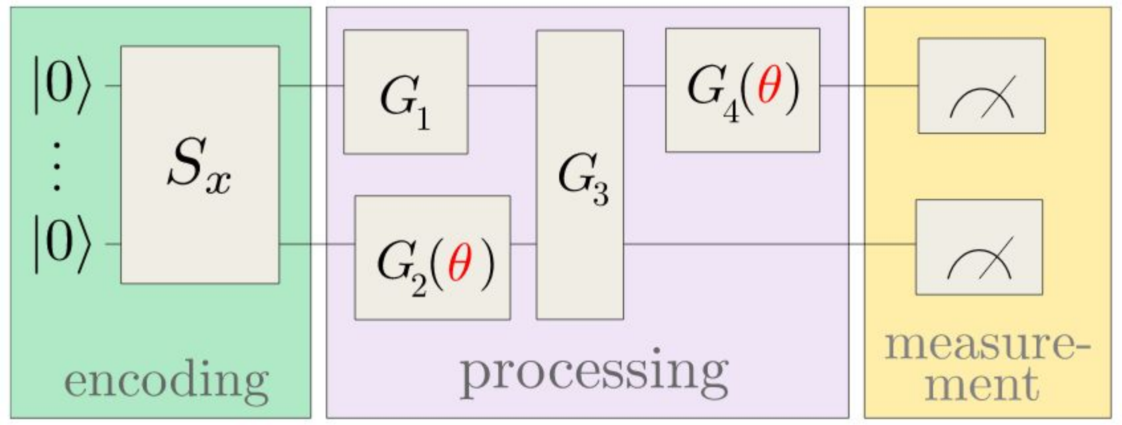

Fig 1. Schematic for a variational classifier

Once the classical data has been encoded and embedded into the quantum circuit, the data is trained using the classifier. The classifier constitutes quantum gates whose parameters are learnt after the cost is calculated based on measurements taken after each epoch. For the IRIS dataset, the data is encoded using amplitude encoding. We can also extend this to image classification problems on real world datasets like the MNIST dataset where the image pixels are encoded and embedded instead.

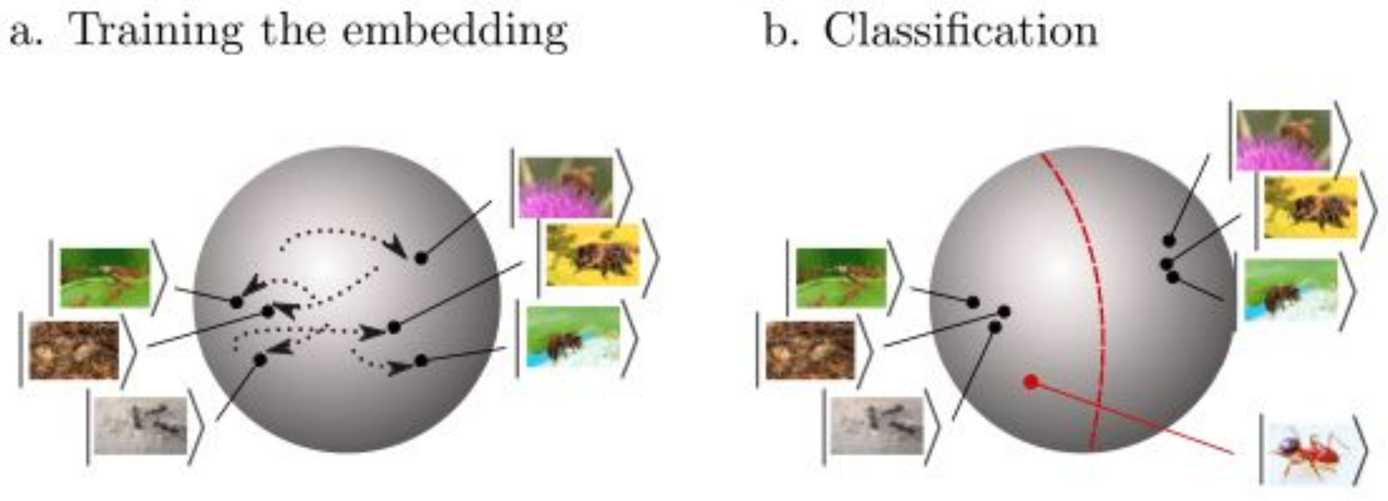

Fig 2. Quantum Metric Learning

RESULTS

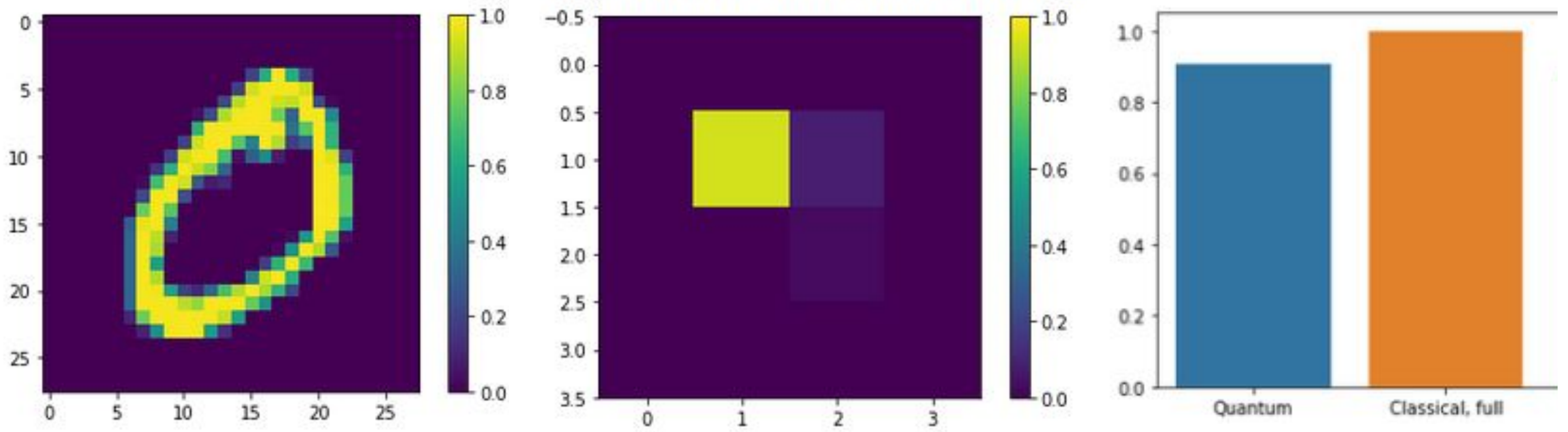

Fig 3. MNIST Classification (a) Dataset after converting pixel values to [0,1] range from [0,255] (b) Downsized image (c) Comparison between QNN and CNN

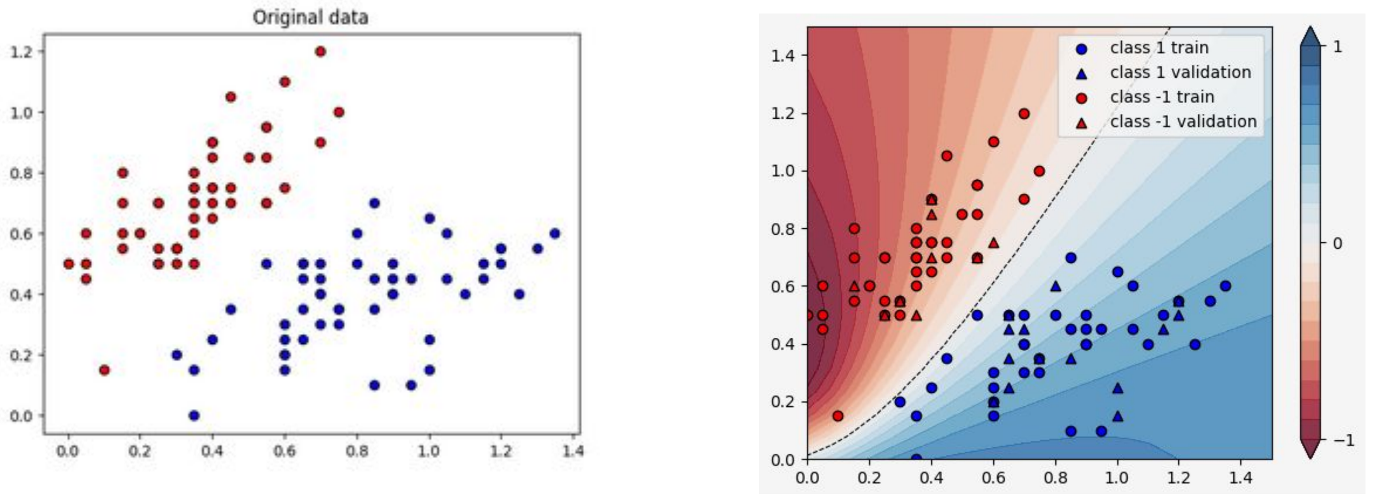

Fig 4. IRIS dataset classification (a) Original dataset (b) Datapoints and their measurements

References

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