QTx Documentation supplementary material

Tomás Ockier Poblet

Supplementary material for the README.md file of https://github.com/tomiock/QNNs. Used to display equation and other graphics.

I. COST FUNCTION:

Each circuit has a local cost function (Eq. 1) evaluated using the mean square error method:

$$C_l = \frac{1}{2m}\sum_{i=1}^{m}(\varphi_i - y_i)^2 \tag{1}$$

The global cost function is just the average of the local cost of all the circuit:

$$C_g = \frac{1}{M}\sum^{M}\frac{1}{2m}\sum_{i=1}^{m}(\varphi_i - y_i)^2 \tag{2}$$

With M being all the circuits and m all the measurement of a circuit.

II. OPTIMIZATION:

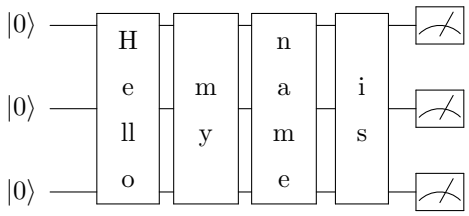
To optimize the circuit we update the parameters according to the gradient of the cost function until the function is at its minima. We use the parameter shift method for the evaluation of the gradient:

$$\frac{\partial}{\partial\theta_k}C_l(\boldsymbol{\theta}) = C_l(\boldsymbol{\theta} + \frac{\pi}{4}\Delta_k) - C_l(\boldsymbol{\theta} - \frac{\pi}{4}\Delta_k) \tag{3}$$

Where $C_l(\boldsymbol{\theta})$ is the local cost of a circuit with the parameters $\boldsymbol{\theta}$, and Δ_k is a vector representing unit-form perturbation of the parameter θ_k.

III. CIRCUITS:

Example of the circuit equivalent with the phrase "Hello my name is":



With each word of the sentence as a quantum gate.
The actual gates are Parameterized Pauli-X gates:

$$R_x(\theta) = e^{-i\theta X/2} = \cos\frac{\theta}{2}I - i\sin\frac{\theta}{2}X = \begin{bmatrix} \cos\frac{\theta}{2} & -i\sin\frac{\theta}{2} \\ -i\sin\frac{\theta}{2} & \cos\frac{\theta}{2} \end{bmatrix} \tag{4}$$

Each word has its gate with own parameter for example in this circuit the word "Hello" has the parameter θ_1):