Paper title

A supervised hybrid quantum machine learning solution to the emergency escape routing problem.

My understanding

In the paper's context, escape routing is finding the most optimal path from the start to the exit point in a dynamically changing environment due to natural disasters like an earthquake. Classical algorithms like Dijkstra and A* work are well suited to modeling solutions to this problem of escape routing in static environments. However, in a continually changing environment, finding an optimal solution becomes difficult. To solve this problem, the paper proposes a novel hybrid supervised learning approach.

The circuit architecture consists of a PHN(Physical Hardware Noise) with FiLM(Feature-wise linear modulation) model. This model is comprised of a classical FiLM neural network and a quantum neural network. The inputs to this model are Earthquake coordinates start/end points and information about the immediate neighbors of the nodes. The inputs are fed to both the classical and quantum networks and processed. Post-processing, the outputs are combined linearly to produce an outcome. The outcome is then passed on to a fully connected layer and reduced to five values. The outputs of this architecture are five numbers that act as a logit layer(raw output) to the node classifier. Finally, the neighboring node corresponding to the highest number is chosen as the next node.

In all, this model finds the corresponding next node for an optimal path solution.

Below, I've shown the state vector after each operation:

these are states of qubit after each operation

$$|\psi\rangle = U_{\mathrm{BEL}}^{\mathrm{main}}(\theta)\left[\prod_{c=1}^{2}\prod_{t=3}^{7} CX_{c,t}\right]|\psi\rangle_{\mathrm{FiLM}} \otimes |\psi\rangle_{\mathrm{main}}$$

data reuploading circuit

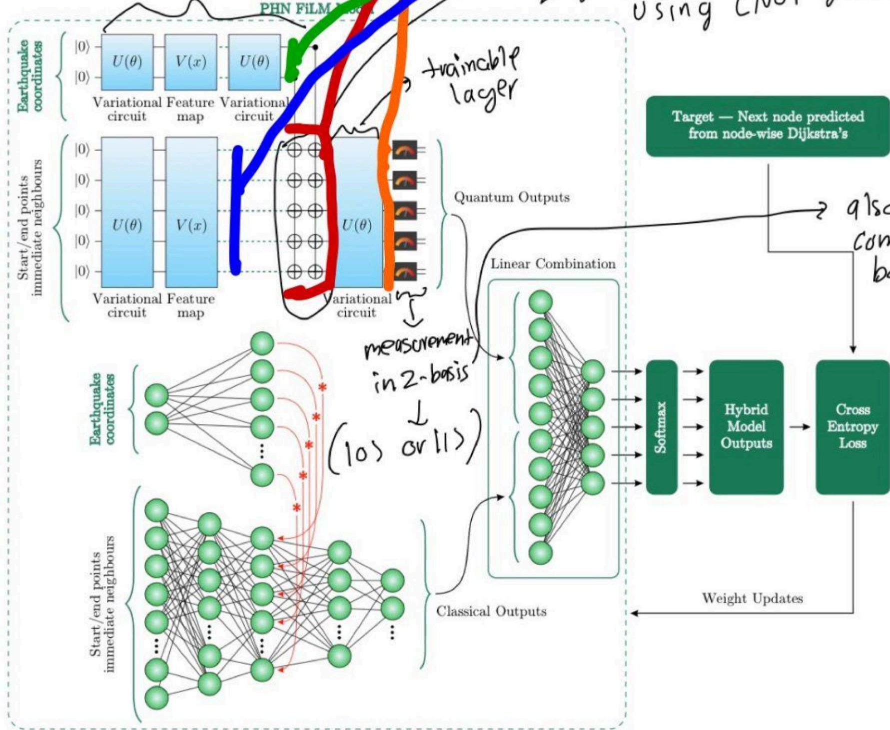
entangling upper 2-qubits with lower 5 using CNOT gates

6

trainable layer

also c/s computational basis states

measurement in Z-basis ($|0\rangle$ or $|1\rangle$)



$$|\psi\rangle_{\mathrm{main}} = S_{\mathrm{QDIL}}(\mathbf{x},\theta)\,|0\rangle^{\otimes n_{\mathrm{qubits}}}, \quad (1)$$

$$S_{\mathrm{QDIL}} = \left(\prod_{l=1}^{n_{\mathrm{subvec}}} U_{\mathrm{BEL}}(\theta_l)V(\mathbf{x}_l)\right)U_{\mathrm{BEL}}(\theta_0) \quad (2)$$

$$U_{\mathrm{BEL}}(\theta_l) = \prod_{t=1}^{n_{\text{sub-layers}}}\prod_{q=1}^{n_{\mathrm{qubits}}} CX_{q,q+1}e^{-\frac{i}{2}\theta_l^{t,q}\sigma_X^{(q)}},$$

$$|\psi\rangle_{\mathrm{FiLM}} = S_{\mathrm{FiLM}}(x_{\mathrm{epi}}, y_{\mathrm{epi}}, \theta)\,|0\rangle^{\otimes n_{\mathrm{qubits}}},$$

where $S_{\mathrm{FiLM}}(x_{\mathrm{epi}}, y_{\mathrm{epi}}, \theta)$ is given by:

$$\left(\prod_{l=1}^{d} U_{\mathrm{BEL}}(\theta_l)e^{-\frac{i}{2}(\sigma_Z^{(1)}x_{\mathrm{epi}}+\sigma_Z^{(2)}y_{\mathrm{epi}})}\right)U_{\mathrm{BEL}}(\theta_0)$$