Quantum Neural Network for Index Detection in MATLAB

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Abstract

In this paper, quantum neural network (QNN) is utilized to detect the index of transmit antenna in index modulation. Ansatz circuit in PQC layer, fully connected layer, and output softmax layer is applied in MATLAB to determine one active transmitter of two existing transmitters using maximum likelihood detector. The QNN is expected to have less complexity than the classical neural network (CNN).

Ⅰ. Introduction

Neural network is known as a solution for the high speed demand of communication in 6G. It offers several flexible solution for the optimal solution of wireless communication [1]. Quantum neural network is the type of NN that offers higher speed of computation since it can process more data bit in the same processing time [2].

Index modulation is one of the strong candidate in 6G communication that can have additional bits to the conventional M-ary bits [3]. In the previous work, the index detection in index modulation utilizing maximum likelihood has already studied using the classical neural network [4]. However, they did not utilize QNN for the the system. Moreover, another previous work of QNN in wireless communication use IBM Quantum Lab as the platform to simulate the system. In this paper, MATLAB is used as the application to simulate the index detection in index modulation referring to [5].

Ⅱ. System Models

In the communication system, one active of two transmit antenna is transmitting signal using M-QAM modulation with M =4. Assuming the direct path is blocked by some obstacles, the Rayleigh fading is applied in the channel. In Fig. 1, the network architecture consisted of several QNN layers is defined [5] with the details as follow:

- Input Layer
- PQC Layer
- Fully Connected Layer
- Softmax Layer

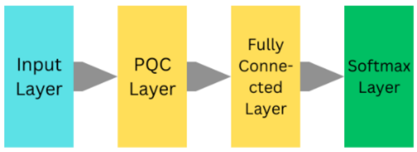

Figure 1. Network Architecture

Two qubits, which are initially in the |0⟩ state, make up the quantum circuit. Apply an RX gate with rotation angle θ_a 1 to the first qubit and an RX gate with rotation angle θ_b to the second qubit to build the quantum circuit., with the second qubit acting as the target and the first qubit acting as the control. By adding two programmable learnable parameters, A and B, to the rotation angles, these gates prepare the qubit states based on the coordinates of the input data.
These parameters scale the x- and y-coordinates of the XOR problem to 1 = Ax and 2 = By. They are the scaling factors for the rotation angles of each qubit. Next, a measurement is made on the second qubit within the <Z'> basis. The magnetization of the second qubit, which is the difference in counts of this qubit being in the |0> state and the |1> state, is the quantity of interest. Based on the qubit states, the measured quantity ⟨Z'⟩ has a predicted form of cos 1 $\cos\theta_a \cos\theta_b$ for this quantum circuit.

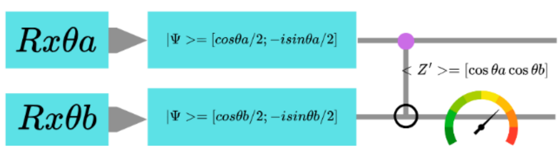

Figure 2. Quantum circuit.

III. Performance Analysis

From Fig.3, it can be seen that the accuracy of this model is around 90% with loss less than 0.5

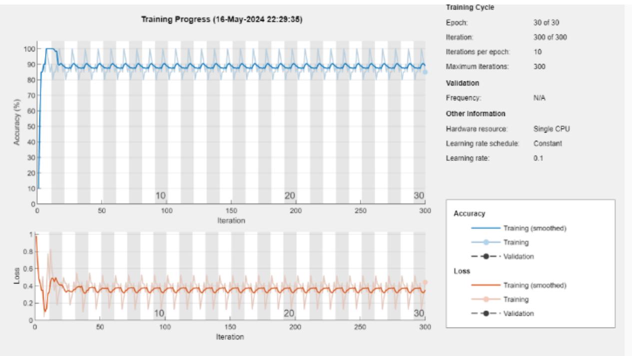

Figure 3. The training process and results.

IV. Conclusion

In this paper, the index detection of index modulation is detected using the quantum neural network. From the result, it seems that the accuracy is more than 90% with loss less than 0.5.

IV. Future Work

Since this is still an ongoing work, this study still needs a lot of improvement. For the future, this study can also added with reconfigurable intelligent surfaces

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