Quantum Circuit Optimilization Using Reinforcement Learning

Liza Darwesh (500793232)
Amsterdam University of Applied Science
University Superviser Dick Heijnhuis
Research Company SURF BV
Superviser SURF Ariana Torres
Amsterdam, The Netherlands
liza.darwesh@hva.nl

***Abstract*—**

I. Introduction

Quantum computing is entering the Noisy Intermediate Scale Quantum (NISQ) era. There has always been said that these NISQ technology will be available in the near future [1]. The quantum computers from now a days may be able to perform tasks which surpass the capabilities of today's classical computers. Still there are a few limiting factors in today's quantum computers. Take for instance the noise in quantum gates that operate the logic of algorithms. This noise causes decoherence. Think of a spinning coin with information: either heads of tails. Eventually the coin will stop spinning and land on one of the sides. A quantum system that is in superposition, either one or zero, will experience a loss of this condition because of the decoherence. These input circuits consist of quantum gates and the noise causes limitations in the size of circuits that can be executed reliably. Which means information will be lost.

Another limiting factor is that input circuits must take into account the allowed connectivity of the qubits in the hardware. This architecture of connectivity is called topology. The topology shows what qubits can interact which each other directly. Which means that not every circuit can be executed due to connectivity constraints. A solution to this would be to optimize the circuits based on the qubit interactions that are possible. But then we also run into the issue that not every quantum device has the same topology and the issue of allocating logical qubits to physical qubits. This technique will be explained later in the paper. One way to optimize the circuits is through the use of reinforcement learning, where through a neural network the algorithm improves itself to yield better circuits.

This paper answers the main question: 'How can quantum circuit routing be optimized using reinforcement learning?'. This question will be answered by means of the following sub-questions:

- Why do circuits need to be optimized to perform on a quantum computer?
- How can the initial qubit placement procedure be performed?
- What are the actions taken to increase the fidelity of a circuit and decrease the circuit depth?

This research paper is organised as follows. Section **??** offers a description of basic knowledge about quantum computing phenomenon and techniques needed for understanding the main question. Section **??** describes the sub-problem initial qubit placement and how to solve it. Section **??** provides an overview of the experimental setup, which is how the reinforcement learning model is put together. Section V shows the results of what the reinforcement learning model delivered. Finally, in Section VI and VII states the discussion about the research that is performed and the final conclusion.

II.

A.

III.

IV.

V. Results

VI. Discussion

VII. Conclusions

References

[1] J. Preskill, "Quantum Computing in the NISQ era and beyond," *Quantum*, vol. 2, p. 79, Aug. 2018. [Online]. Available: https://doi.org/10.22331/q-2018-08-06-79