Using artificial intelligence for improving quantum channel discrimination

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1 Introduction

Using quantum computers for investigating fundamental problems in quantum mechanics and quantum information is one of the natural directions for developing new applications of quantum technologies. Machines obeying the rules of quantum mechanics provide an ideal playground for diving into the structure of quantum states, exploring the properties of quantum channels or testing the fundamental limits of quantum dynamics.

In this presentation, we describe a workflow used to develop a protocol for quantum channel discrimination enhanced by employing artificial intelligence. In particular, we use the approach based on reinforcement learning to improve the quality of the ansatz used to perform the quantum channel discrimination task.

2 Contribution

First, we introduce the building blocks used for the underlying variational quantum algorithm. We describe the variational procedure for quantum state diagonalization [1] combined with the standard methods exploiting channel-state isomorphism in quantum theory.

Next, we demonstrated how it can be adopted for the problem of channel discrimination or alternatively as a quantum device certification task [2]. We provide some estimations on the quality of the procedure on the ensemble of random quantum operations. We also demonstrate implementation of the procedure and give some overview of the quantum resource requirements.

Finally, we show how one can improve the proposed method by exploiting the learning capabilities of reinforcement learning agent. We demonstrate that by using the appropriate encoding method and the policy, it is possible to create a resource-aware version of the procedure, based on some assumption about the capabilities of quantum computers [3].

3 Discussion

The goal of this presentation is to provide some examples illustrating the possibility of using variational quantum computing and machine learning for solving tasks in quantum physics. In particular, we discuss the following issues:

- What are the obstacles for developing new applications of quantum computing in fundamental physics, and what tasks in quantum computing and quantum information theory can be targeted?
- How one can use artificial intelligence, including methods based on reinforcement learning or harnessing generative models, for improving the usage of quantum computers with limited capabilities?
- To what extent the proposed approach can be used in the case of the noisy quantum circuits?

References

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