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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Luis Ernesto Campos Espinoza

PhD Program: Computational and Data Science and Engineering

Title of Thesis: On the trainability of variational quantum circuits as algorithmic models

Supervisor: Professor Jacob Daniel Biamonte

Name of the Reviewer: Professor Ivan Oseledets

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 19-10-2024**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the

Reviewer's Report

The thesis is devoted to variational quantum circuits and their applicability and efficiency as models (approximation) to certain algorithms. The thesis is based on 3 publications in top venues with Ernesto as the first author, which confirms its wide applicability in the community. Actually, he has more papers (not as a first author), but for some reasons they are not included in the thesis. One paper is cited, according to the Google Scholar, 100 times, and the paper with Ernesto as a first author is cited 61 times. This is a tremendous achievement for a PhD student.

The thesis consists of introduction, theoretical background part and 3 main chapters. The second chapter, named 'Abrupt trainability transitions' that is related to a layerwise trainability conjecture, that the circuit can be trained piecewise (which is actually quite unnatural due to a well-known fact that greedy algorithms in optimization are not optimal). However, layer wise training can clearly reduce the computational complexity. The chapter shows empirically that such training is not working well for certain gates and shows that the conjecture is false.

In Chapter 3

The layer wise training saturation is shown in QAOA (training an extra layer does not allow for overlap improvement). Necessary conditions for the saturation are derived.

Finally, in Chapter 4

Depth scaling of unstructured search via QAOA is studied. An upper bound for the depth (as a measure of complexity) is shown for the QAOA sequence that prepares a state that approaches a perfect overlap with the target is computed. It is larger that Grover algorithm, but asymptotically close.

Comments: Text still contains some misprints, i.e. 'anzatze' on page 38. However, in general the text is very well written.

General comment: It is not highlighted what those results mean in terms of practical quantum computing, especially in the era of mid-size NISQ devices. Can we expect some practical benefits? Because some of the results are negative, while other provide upper bounds. In would be nice to have a bigger picture.

Overall, I think it is a very high-level work.

Provisional Recommendation

I recommend that the candidate should defend the thesis by means of a formal thesis defense

I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report

The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense