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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: Alexey Frolov

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 02-10-2024**

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 Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

The thesis by Luis Ernesto Campos Espinoza provides a comprehensive analysis of the variational model of quantum computing, and its trainability limitations. The author identifies several challenges, including the abrupt trainability transitions limitation, training saturation limitation, and identity initialization strategy pitfalls.

The work is well-structured, and the author presents a clear argument for the importance of understanding these limitations. The use of specific examples, such as the quantum approximate optimization algorithm (QAOA) for unstructured search, MAX-CUT, and MAX-k-SAT, helps to illustrate the challenges faced by variational quantum circuits.

The thesis's findings have the potential to significantly impact the development of variational quantum algorithms. The author's proposal for a recipe for variational parameters that can be used to bypass the QAOA training process for unstructured search is particularly noteworthy.

Overall, this thesis provides a thorough and thought-provoking analysis of the variational model of quantum computing. Its findings will be of great interest to researchers in the field of quantum computing and will contribute significantly to the development of more efficient training strategies for variational quantum circuits.

Recommendations:

Here are some points that I consider should be discussed in more detail

1. In Chapter 1, in the trainability section, It would be good to discuss recent results that suggest the absence of barren plateaus implies classical stimulability.
2. In Chapter 2 are abrupt transitions observed when compiling other unitaries?
3. In Chapter 3, is there any likely explanation to why the saturation depth is p* = n?
4. In Chapter 4 it is mentioned that a similar analysis in a two-dimensional subspace failed to give good results, it would be interesting to expand on the possible reasons.

Minor technical comments:

1. There is a typo in page 28: “encounter” -> “encountered”

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*