THE AUSTRALIAN NATIONAL UNIVERSITY
SCHOOL OF COMPUTING

COMP255/COMP4450/COMP6445 Advanced Computing R&D Methods – Semester 1, 2022
Assignment 1: Tutorial Topic Survey Paper
Tutorial Topic: Variational Quantum Algorithms

Logistics
Due: 11:59pm on Tuesday 22 March, 2022.
Submit as a single file via Wattle (http://wattle.anu.edu.au).
Value of the assignment: 15% of overall mark
Late penalty: 100%

The purpose of this assignment is to make sure every student has a fundamental understanding of the topic of their tutorial and has the same foundation for the next tutorials. For each tutorial you will receive a different survey paper which gives an overview to the state of the art on (a subset of) the topic of your tutorial. You can find the survey paper on Wattle, under Tutorial Material, folder "Assignment 1"

The assignment consists of two different parts. Part 1 are the general questions which are the same for every tutorial. Part 2 are paper specific questions. You should be able to answer all questions after carefully reading the survey paper. We assumed that it should take you about 7.5-10h to complete the assignment.

Full reference of the survey paper: Cerezo, M., Arrasmith, A., Babbush, R., Benjamin, S.C., Endo, S., Fujii, K., McClean, J.R., Mitarai, K., Yuan, X., Cincio, L. and Coles, P.J., 2021. Variational quantum algorithms. Nature Reviews Physics, 3(9), pp.625-644.
https://doi.org/10.1038/s42254-021-00348-9

Note: Short and precise answers are preferred. Answer in your own words. Please do not exceed around 250 words per question.

Part 1: General Questions (7.5 marks)

1. What is the branch in the survey paper you find most interesting and why? (1 mark)
2. Write a summary of the branch that you pick in your own words (2 marks)
3. What are the three papers you would read next if you were to do a research project on that branch. Please explain why you would pick these papers and give their full references. (1.5 marks)
4. Find and list at least 2 research groups who conduct state of the art research in this topic. Please justify your answer. (1 mark)
5. Name two open research problems in the field of this survey paper and explain why they are hard and interesting. (2 marks)

Part 2: Paper-specific Questions (7.5 marks)

6. Explain the difference between the Quantum Approximate Optimization Algorithm (QAOA) and the Variational Quantum Eigensolver (VQE). List at least two real-world problems that have been successfully applied and solved using the QAOA/VQE. (2 Marks)
7. Explain briefly researchers developing and investigating novel ansatz structures rather than using the traditional ansatz found in QAOA or VQE. (1 Mark)
8. Explain the effect of the barren plateau phenomena on gradient-based and gradient-free

optimisers. Describe at least two solutions for avoiding the barrent plateau phenomenon. (2 Marks)

9. Briefly explain in your own words any three applications of variational quantum algorithms. Do the applications you described have the potential for near-term quantum advantage? (1.5 Marks)

10. Based on your reading mention one open problem that you believe is worth addressing and explain why. (1 Mark)