Optimisation via Adiabatic Quantum Computing

Vivek Katial

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Introduction

Main Research Question

- What instances characteristics of optimisation problems make them predisposed to being solved on a Quantum Computer?

Background

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- $$|\psi\rangle = \alpha\,|0\rangle + \beta\,|1\rangle \qquad \text{where } \alpha, \beta \in \mathbb{C}$$
- Also, $|\alpha|^2$ and $|\beta|^2$ correspond to the probability associated with measuring either $|0\rangle$ or $|1\rangle$,

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- This state corresponds to a 50% chance of being in $|0\rangle$ or $|1\rangle$ as $\alpha^2 = \beta^2 = 0.5$

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- To extend this framework to n qubits, we must represent that state by a 2^n vector. A shorthand notation has been developed where $|0\rangle^{\otimes 2}$ corresponds to the state $|00\rangle$

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- $|\psi(t)\rangle$ is our state vector, $H(t)$ is the time dependent Hamiltonian. A Hamiltonian of an n-qubit system $H(t)$ is given by $2^n \times 2^n$ matrix.

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- Loosely speaking, the adiabatic theorem tells us that if we vary from H_B to H_P *slowly enough* the system will remain in its ground state. This fact is a direct result of the Adiabatic Theorem.

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- Where $g(t)$ is the difference between the first two smallest eigenvalues of $H(t)$

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- The basic SAT formulation can be described as follows: Given a boolean formula (AND $\wedge$, OR $\vee$, NOT $\neg$) over n variables $(z_1, z_2, ..., z_n)$. Can one set z_i's in a manner such that the Boolean formula is true?
- A clause is an expression which the variables must satisfy. For example $z_1 \wedge z_2 \implies z_1 = z_2 = 1$

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- The 3-SAT problem in particular is a problem where each clause is comprised of 3 literals.

Mapping 3SAT to AQC

- How do we construct H_B and H_P so that we can solve our optimisation problem?

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- This ground state corresponds to a uniform superposition across all possible qubit assignments.

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- *Note:* We have applied a normalisation here.

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- Finally, complete measurement

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    2. Maximum Entropy of Entanglement

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- Ultimately, we can build a prediction model which maps instance features of different 3SAT instances to their inherent "Quantumness"

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- More ideas likely to come…

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3. Developed working environment, set up GitHub, scripts, organizational tools enabling an efficient working environment.

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3. Apply Instance Space Methodology from MATILDA to find decision boundaries for *Entanglement Entropy* and *Minimum Energy Gap*

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8. Extend research to look at other optimisation problems

About Me

- Vivek Katial (vkatial@student.unimelb.edu.au)
  - PhD Candidate (Optimisation on Quantum Computers)
- Check out the slides at https://tinyurl.com/vkatial-preconfirmation

References

References

1. Cook SA (1971) The complexity of theorem-proving procedures, In, *Proceedings of the third annual acm symposium on theory of computing*, ACM, 151–158.