Mitacs Globalink 2023 - Research Project Plan

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Project ID: 29870
Project Title: LP based Approximation Algorithms
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Project Goals:	QAOA is a recent quantum algorithm used for optimization. It uses parameterized Hamiltonians for the cost function and mixing, which are applied repeatedly in stages. The quality of the solution depends on the number of stages. In the original paper by Farhi et al., the approach was illustrated on MAX-CUT, and numerical results were given for a particular class of graphs. Later the analysis was extended to general graphs for a single stage (Wang et al. 2017). Since then, numerous studies have been conducted on using QAOA for MAX CUT. The project is to identify instances of MAXCUT (or similar problems) where QAOA has utility. This means QAOA is demonstrably better at producing (the same or better quality solutions) within a limited budget on instances too large for a classical computer to handle. The quality of the solution would be measured as compared to the classical approximation ratio of Goemans and Williamson.
Student activities and timeline:	Broadly speaking, the student will perform three activities, Reading, coding, and reporting. The details are below. The estimated timeline for the activities are Background Reading - 2 weeks Programming - 9 weeks Report and Presentation 1 week Background Reading: The student will read the foundational papers in the area and discuss them with the PI. Some of the papers are listed below. Edward Farhi, Jeffrey Goldstone, and Sam Gutmann. A Quantum Approximate Optimization Algorithm. arXiv:1411.4028 [quant-ph], November 2014. Wang, Zhihui, et al. "Quantum approximate optimization algorithm for MaxCut: A fermionic view." Physical Review A 97.2 (2018): 022304. Karloff, Howard. "How good is the Goemans-Williamson MAX CUT algorithm?." Proceedings of the twenty-eighth annual ACM symposium on Theory of Computing. 1996. Programming: In collaboration with the PI, the student identifies instances and notions of utility to be used to evaluate QAOA. The student will write a program using Qiskit to perform an empirical evaluation.

	Report and Presentation: The report will contain the problem description, the methodology, related work, and the original findings. The code repository (on GitHub or a similar platform) will be submitted as part of the final report to the PI. A 50 min presentation summarizing the discovery during the internship will be made to the group by the student.
Deliverables:	The student will deliver a weekly progress report. At the end of the project, the student will submit a 12-page (single-spaced with usual margins) professional essay. The student will also give a 50-minute presentation to the group at the end of the internship.
Interaction:	The PI leads a team of PDF, graduate and undergraduate students. The student will attend the weekly meeting of the group. Separate weekly hourly sessions will happen to monitor progress, determine research direction and for collaborative activities. The PI is available to meet as and when needed for technical discussions.

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