Variational quantum algorithms and combinatorics

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Combinatorial optimization

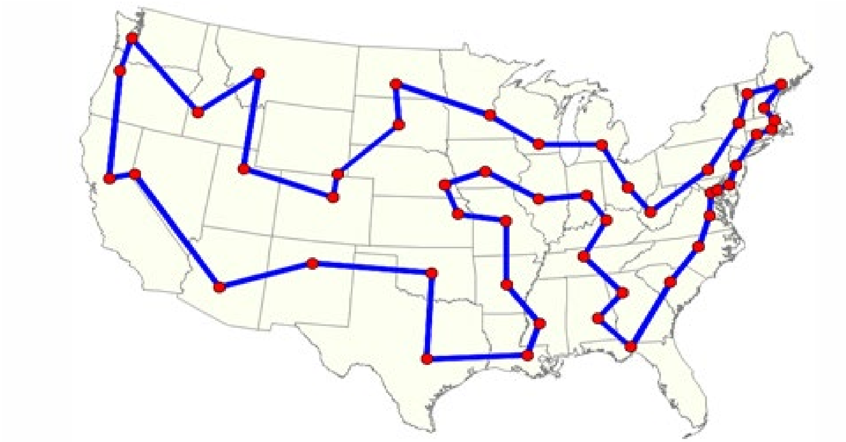
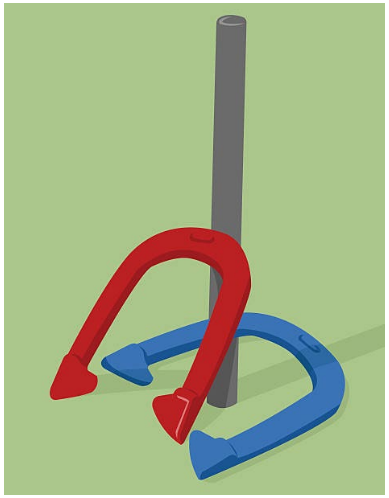


Image from https://physics.aps.org/articles/v10/s32



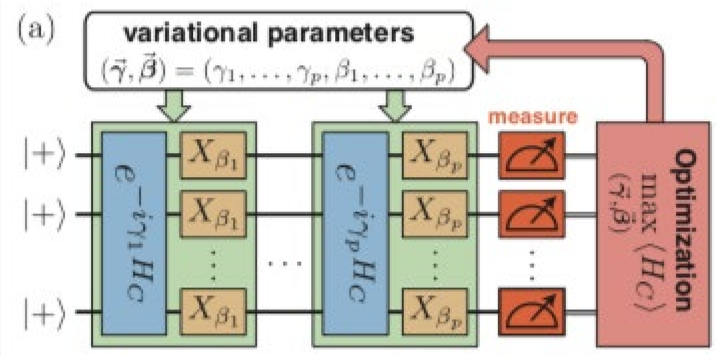


Image from https://medium.com/mit-6-s089-intro-to-quantum-computing/qaoa-bench-marking-7dfdd8a31e54

Pre-processing

- QAOA-in-QAOA [1]
- Divide and conquer [2]

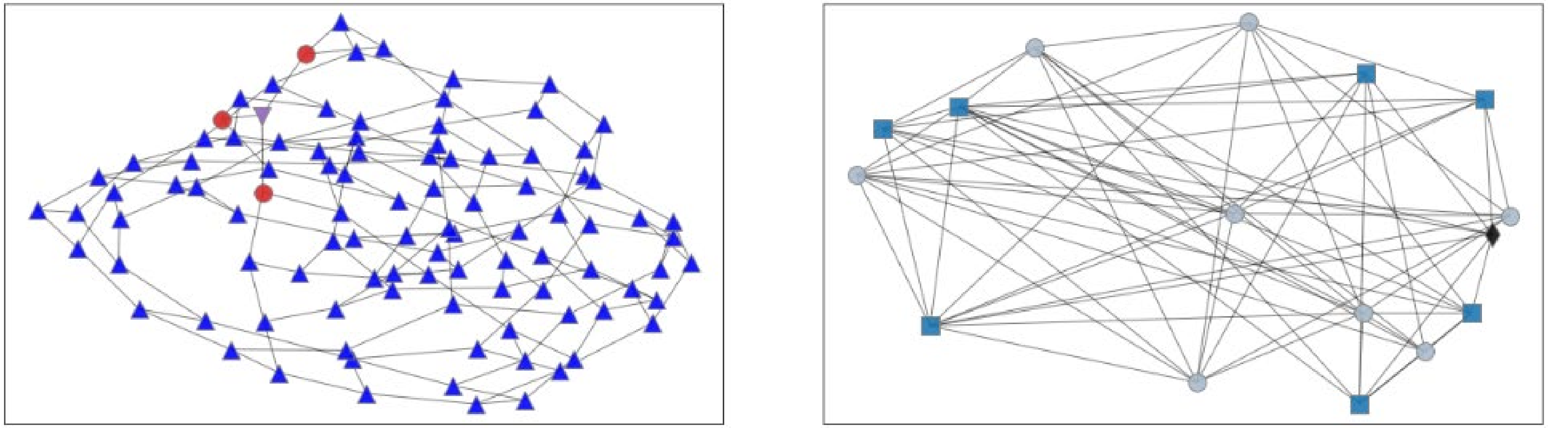


Image from [3]. Work with M. Ponce, P. Lotshaw, S. Powers, G. Siopsis, T. Humble, and J. Ostrowski

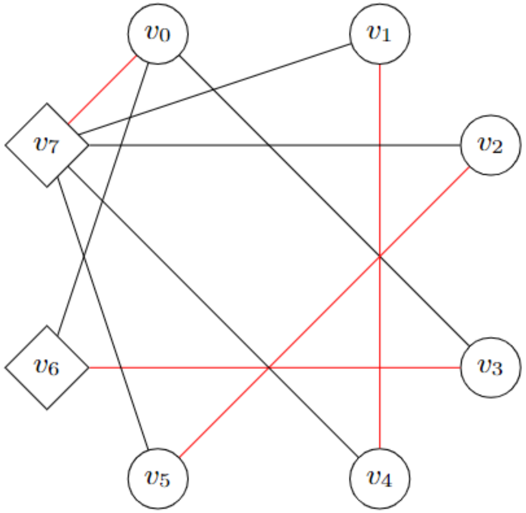
[1] Zhou, Zeqiao, et al. "QAOA-in-QAOA: solving large-scale MaxCut problems on small quantum machines." *Physical Review Applied* 19.2 (2023): 024027.
[2] Li, Junde, Mahabubul Alam, and Swaroop Ghosh. "Large-scale quantum approximate optimization via divide-and-conquer." *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems* (2022).
[3] Ponce, Moises, et al. "Graph decomposition techniques for solving combinatorial optimization problems with variational quantum algorithms." *arXiv preprint arXiv:2306.00494* (2023).

Pre- and post- processing

Approximation ratio			
QAOA	Decomp QAOA	Decomp Gurobi	H1-1 Results
0.75	0.96	0.96	0.99
0.77	0.97	0.98	
0.75	0.97	0.97	
0.76	0.96	0.98	
0.76	0.96	0.96	
0.76	0.95	0.94	
0.76	0.96	0.95	0.96
0.77	0.97	0.97	
0.76	0.98	0.96	0.93
0.77	0.96	0.96	
0.76	0.96	0.97	
0.76	0.97	0.95	0.95
0.75	0.93	0.94	
0.76	0.94	0.96	0.97
0.76	0.96	0.96	
0.74	0.97	0.95	
0.75	0.94	0.95	
0.76	0.96	0.95	0.96
0.77	0.97	0.97	0.97
0.76	0.95	0.95	0.98
0.75	0.95	0.96	0.98
0.76	0.95	0.96	
0.77	0.95	0.98	
0.76	0.94	0.97	
0.77	0.98	0.97	0.99

Triangle dropout for H_c

- Quantum dropout [7]
- Removing triangles (image from [8])
  - Over 90% of dataset (> 11000 graphs) had higher approximation ratio!



Joint with A. Wilkie, I. Gaidai, and J. Ostrowski

[7] Wang, Zhenduo, et al. "Quantum dropout: On and over the hardness of quantum approximate optimization algorithm." *Physical Review Research* 5.2 (2023): 023171.
[8] Wilkie, Anthony, et al. "QAOA with random and subgraph driver Hamiltonians." *arXiv preprint arXiv:2402.18412* (2024).

Future work

- Combinatorics inspired designs
- Making quantum computing accessible to non-physicists (QAO REU site)

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