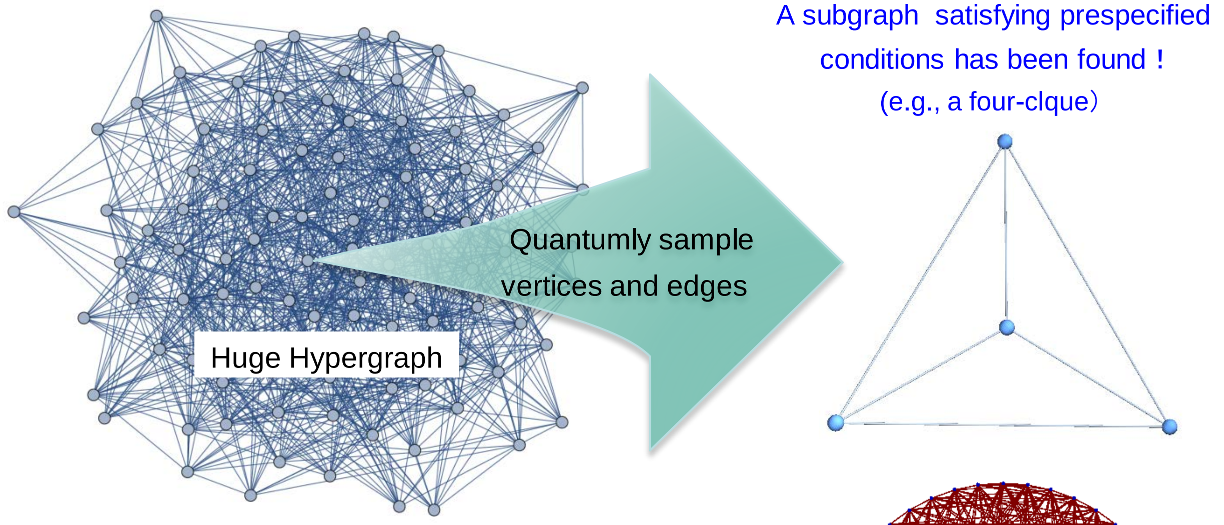
09 Quantum Search over Huge Network for Hidden Structures

～High-Speed Search over Hypergraphs via Quantum Walk～

Abstract

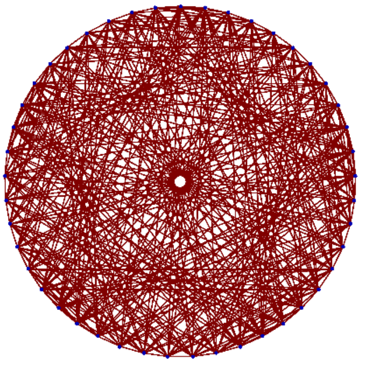
The goal of this research is to devise fast algorithms that search a huge input hypergraph for a substructure (i.e., sub-hypergraph) satisfying prespecified conditions, if it exists. Such algorithms are expected to discover new laws or principles that have been hidden in massive data, such as web access logs and sensor data. Presented here is a novel search algorithm that takes advantages of state-of-the-art techniques regarding quantum walk. This quantum algorithm runs much faster than any possible classical (i.e., non-quantum) algorithms, and also than the celebrated quantum search algorithm invented by Grover. The proposed algorithm is thus much more likely to find a specific substructure hidden in so huge a input hypergraph that classical algorithms fail or require unallowably long time to deal with.

Our algorithm can very quickly find a sub-hypergraph satisfying prespecified conditions with high probability (e.g., at least 99 %) by quantumly sampling vertices and edges in a huge input hypergraph.



Key Technique: Quantumly Sampling, namely, a sampling technique based on quantum walk, which achieves both high speed and high success probability

- Encode subsets (i.e., samples) of vertices and edges in the input hypergraph as nodes of a certain regular graph, called Johnson graph.
- "Quantum walk" over the Johnson graph J to almost randomly sample a node in the graph J.
- Decode the node, obtain a sample, and check if it contains a desired substructure.



Johnson Graph J(10, 2)

【Reference】

[1] F. Le Gall and H. Nishimura, S. Tani, "Quantum algorithms for finding constant-sized sub-hypergraphs," *Theoretical Computer Science* Vol. 609, Part 3, pp. 569 – 582, 2016.

[2] F. Le Gall and H. Nishimura, S. Tani, "Quantum algorithms for finding constant-sized sub-hypergraphs," in *Proc. 20th International Computing and Combinatorics Conference* (*COCOON '14*), 2014.

【Contact】

Seiichiro Tani Computing Theory Research Group, Media Information Laboratory

E-mail : tani.seiichiro(at)lab.ntt.co.jp