CptS 591 Reaction Paper

Parallel Algorithms and Heuristics for Efficient Computation of High-Order Line Graphs of Hypergraphs.[1]

High-order Line Graphs of Non-uniform Hypergraphs: Algorithms, Applications, and Experimental Analysis.[2]

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03/26/2022

Summary: The focus of the first article [1] describes a fast and efficient algorithm that can be used to compute High-Order Line Graphs of Hypergraphs. One of the steps in constructing the s-line graph of a hypergraph is the s-overlap computation, as highlighted in this article. The goal of most graph analyses and combinatorics is to understand node interactions. This study showed that using hypergraphs could help understand multi-dimensional interactions (interactions between more than just two entities), thus providing better meaningful data and network analytics insights. In large datasets, computing the s-line graph of the hypergraph can be highly challenging if each possible combination of pairs of hyperedges is considered. To this end, this article posits an algorithm that computes s-line and s-overlap graphs of hypergraphs faster.

The focus of the second article [2] describes a new scalable s-line graph computation framework used to study non-uniform hypergraphs. The major challenge of most hypergraph analyses described in this article is the problem of creating graph representations from the structure of the initial hypergraph using graph expansion methods--it appears that the size of the newly expanded graph increases exponentially. This article explains that an s-clique graph of a hypergraph can reduce the density of the graph projections while preserving and amplifying the essential features of the network. In order words, this article posits an algorithm that drastically reduces the memory footprint of higher-order graph expansions of hypergraphs.

Both papers [1-2] reference the hypergraph concepts taught in class. Both pieces studied the concepts of hypergraphs and their corresponding s-overlap and s-line graphs while studying the problems of s-overlap computations and applications. It is also important to highlight that both papers discussed the importance of hypergraph theory and its value in solving optimization problems such as scheduling and location problems. These papers also showed that a proper combination of algorithmic optimization and workload balancing technique could significantly improve the performance of an s-line graph computation, which is the most critical and compute-intensive part of the methods used in both articles.

Critique: Both publications have about eight listed authors. Looking at their field of study and research interests, I discovered that these authors appear to have a well-grounded and extensive background in networks analytics, data analytics, and spectral graph theory, among others. The citations in their report draw on excellent past research, which showed the author's strengths. One of which was how they were able to explain, in detail, the different computation techniques and theories applied throughout the study. The first paper [1] describes an algorithm that is the first of its kind—an algorithm that is more than 10x faster in computations than older algorithms. While the first paper [1] discussed the higher-order analogs of hypergraph methods in detail, it also investigated the efficient computation of s-overlaps for larger datasets, which is one of the strengths of this paper – expanding the scope of the literature.
Consequently, the second paper [2] describes an algorithm that is 5-31x faster than older heuristic-based algorithms for s-line graph computations. Another strength of both papers is the implication

the algorithms posited offer to researchers and the industry in terms of their usefulness (data analytics and network science community). Another strength of [1] is how the authors applied the algorithms to different datasets from different domains, which makes the proposed algorithm reliable and applicable. I do not believe any of the papers had unrealistic assumptions.

Further Work: There have been a couple of related works on hypergraphs and how the concept of hypergraphs can be used as a framework to model many applications in data and network analytics. Both papers highlighted a couple of past works and the use of tools from analysis to approach problems in graph theory which has become an active area of research. Proposed further work in line with research [1-2] will be research examining the atomic bipartite graph ideas in enabling wide-ranging triangle counting in hypergraphs. Also, studying the s-overlaps based measures for weighted hypergraphs and ordered hypergraphs would be interesting. An exciting application of the algorithm proposed in [2] would be to apply the algorithm to investigate cascading behaviors in networks; how will these two ideas interface?

References Cited

1. Xu T. Liu, Jesun Firoz, Andrew Lumsdaine, Cliff Joslyn, Sinan G. Aksoy, Brenda Praggastis, Assefaw H. Gebremedhin. *"Parallel Algorithms for Efficient Computation of High-Order Line Graphs of Hypergraphs,"* 2021 IEEE 28th International Conference on High-Performance Computing, Data, and Analytics (HiPC), 2021, pp. 312-321, DOI: 10.1109/HiPC53243.2021.00045.

2. Xu T. Liu, Jesun Firoz, Sinan G. Aksoy, Ilya Amburg, Andrew Lumsdaine, Cliff Joslyn, Brenda Praggastis, Assefaw H. Gebremedhin. *"High-order Line Graphs of Non-uniform Hypergraphs: Algorithms, Applications, and Experimental Analysis,"* 36th IEEE International Parallel & Distributed Processing Symposium (IPDPS), 2022. Lyon, France. https://arxiv.org/abs/2201.11326