CS 6824: Papers and Projects

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February 17, 2014

Topics

- Undirected hypergraphs: each edge is a set of nodes.
- Directed hypergraphs
  1. Hyperarcs: the tail of each edge is a set of nodes, the head contains exactly one node.
  2. Hyperedges: both the tail and head of each edge is a set of (disjoint) nodes.
  3. Carefully distinguish for which type of hypergraph you are presenting algorithms.

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- Shortest paths
- Flow and cuts
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- Focus on algorithmic papers that we can implement during this semester.
- In the slides, paper titles link to online versions.

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- "Linear connectivity problems in directed hypergraphs" by Thakur and Tripathi
  - Everyone should read Section 2 for a general background and summary of known results on shortest paths in directed hypergraphs.
  - Use notation and terminology in this paper in all presentations, i.e., in your presentations, rewrite other algorithms using this paper's notation. Goal is to make all presentations as uniform as possible.

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- "Directed hypergraphs and applications," Gallo, Longo, Pallottino
  - Present algorithms in Sections 5 and 6 and the notation needed for them.
  - Weighting functions are complex and strange at first glance. Try to understand why they are needed.
- "Optimal Traversal of Directed Hypergraphs", Ausiello, Giaccio, Italiano, and Nanni
  - Present Theorem 3.1 and Corollary 3.2.
  - Check overlap of rest of Section 3 and Section 4 with other papers. Ignore Section 5.
  - Need good understanding of reductions in NP-completeness proofs.

k shortest paths

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- "Finding the K shortest hyperpaths using reoptimization", Nielsen, Andersen, Pretolani: consider presenting the extensions in this paper as well.

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- *I cannot find a paper that computes k shortest paths in general hypergraphs.* Try to find such a paper by Friday, February 28.

Flows and Cuts

- "A Note on Menger's Theorem for Hypergraphs", Borndörfer and Karbstein
  - On undirected hypergraphs
  - Read the two citations, at least the PhD thesis.
  - Need a good understanding of linear programming.
- "Flows on hypergraphs", Cambini, Gallo, and Scutellà
  - Hyperedges are hyperarcs.
  - Can omit Sections 4 and 5.
  - Section 6 is interesting. Try to present it.

Clustering in Undirected Hypergraphs

- "Multilevel hypergraph partitioning: applications in VLSI domain", Karypis, Aggarwal, Kumar, Shekhar
  - Algorithm is very wordy so you will need to condense it in your presentation.
- "Learning with hypergraphs: Clustering, classification, and embedding", D Zhou, J Huang, B Schölkopf
  - Sections 6 and 7 are optional.
  - Read "Normalized cuts and image segmentation", Shi and Malik for important background.
  - Need a good understanding of random walks and matrices.
  - Highlight connection to random walks.

Random Walks in Directed Hypergraphs

- "Random walks in directed hypergraphs and application to semi-supervised image segmentation", Ducournau and Bretto
- Need a good understanding of random walks and matrices.

Final Projects

- Research Projects
  - Software + analysis project.
  - We will define a project inspired by the papers you present.
  - I will discuss list of projects within the next few weeks.
  - You can propose a project to me.
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  - You can use Perl, C, C++, Java, Python, R ...
- Hypergraph Library (in Python)
  - You will need to find efficient data structures for hypergraphs.
  - You will implement basic algorithmic problems on hypergraphs based on your presentation.
    - Shortest Paths
    - Random Walks
    - Network Flows
    - Hypergraph Matching
  - This library will be immediately useful for current research projects.

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- The software has to run on Linux!

Hypergraph Library

- Class hierarchy of different types of hyperedges and hypergraphs.
- Define API for hyperedge.
- Define API for hypergraph.
- Methods for degree, neighbour, iterate over nodes, edges, neighbours.
- Methods for paths
  - defining path lengths of various types,
  - computing shortest paths
  - defining ILPs and using CPLEX when necessary
- Methods for random walks, compute stationary probability distribution
- either directly (when possible) or
- by very efficient simulation.
- Methods for clustering.

Hypergraph Data Input

- Methods for reading hypergraphs
  - Convert BioPAX, KEGG, SBML into internal hypergraph representations.
  - Anna Ritz will help.
- Methods for hypergraph output for visualization
  - Use GraphSpace.
  - Craig Estep and Anna Ritz will help