University of Illinois at Urbana-Champaign
Department of Industrial and Enterprise Systems Engineering
IE 533 Big Graphs and Social Networks

Spring 2022

Instructor: Dr. Rakesh Nagi
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Office hrs.: Tu, Th: 2:00-3:00 p.m. (and by appointment)
https://illinois.zoom.us/j/87387510393?pwd=YmFXbnhXSU5FdkJENkVuSThvNDM1QT09

Class Schedule: When course is online, please see reorded lecture ahead of time.
Discussion Tu, Th: 12:30-1:50 p.m.,
https://illinois.zoom.us/j/89536176124?pwd=NGN2Ky82YkVwV0ZTdjZVclhHSk96QT09
1131 Siebel Center for Comp Sci (CRN# 73530)

Catalog Description

This course will cover the fundamentals of graph theory and network optimization. It will focus on algorithmic challenges associated with big graphs and intertwine the GPU-CUDA (or Hadoop or another High-Performance Computing Framework) for solving example problems like shortest paths, link analysis, graph association and inexact graph matching. Applications in social network analysis will include study of network types, random graph models, exact and approximate computation of centrality measures, finding high value individuals, community detection, diffusion processes and cascading models, and influence maximization.

Course Overview

This graduate mixed professional/research level course is a comprehensive coverage of concepts network optimization problems and algorithms, high performance computing approaches to dealing with large graphs, network science, and social networks. The course has algorithmic leaning for most topics. Network optimization (about 5 weeks) covers the fundamental problems in algorithms for small graphs as a foundation to build on. The course will shift examples of big graph problems motivated by real-world situations. This aspect should be equally appealing to students interested in making research advances. Specific topics will be link analysis, graph association and graph matching. This will lead to the motivation of high performance and accelerated computing methods. Parallel graph algorithms using CUDA on graphics processing units (GPUs) will be covered (4.5 weeks). Network Science and Social Network structures, centrality measures, diffusion and influence maximization and community detection will be the emphasis (4 weeks). Students will engage in a group project; research students are encouraged to publish their work.

Prerequisites

- Notions of graphs, networks, relational data
- Basic course in discrete mathematics/structures, e.g. MATH 213 or CS 173.
- Basic optimization (linear and mixed-integer linear programming), e.g., IE 411
- Analysis of Data, e.g., IE 300
- Familiarity with C/C++ is expected (and preferably NVIDIA CUDA)

Course Optional References

[M1] Ravindra K. Ahuja, Thomas L. Magnanti, James B. Orlin, Network Flows: Theory, Algorithms, and Applications, Prentice Hall, 1993, ISBN: 013617549X.

[M2] Barabási, A-L. (2016). Network Science. Cambridge University Press.
http://networksciencebook.com
[Ref] Easley, D. & Kleinberg, J. (2010). Networks, Crowds, and Markets: Reasoning About a Highly Connected World. New York: Cambridge University Press.
http://www.cs.cornell.edu/home/kleinber/networks-book/
[Ref] Jackson, M. (2008). Social and Economic Networks, Princeton University Press.
http://press.princeton.edu/titles/8767.html
Handouts for supplementary material.

Course Web Page: Canvas; Lecture videos should be viewed ahead of the discussion session.

Course Topics

I. Graph Theory and Network Optimization (5 weeks)
   1. Introduction to Network Flows
   2. Paths, Trees, and Cycles
   3. Algorithm Design and Analysis
   4. Shortest Paths
   5. Maximum Flows
   6. Minimum Cost Flows
   7. Minimum Spanning Trees

II. Big Graph Algorithms using CUDA Programming (4.5 weeks)
   8. Link Analysis
   9. Graph Association
   10. Graph Matching
   11. Introduction to Accelerated Computing and CUDA
   12. Parallel Algorithms and Graph Data Structures
   13. CUDA: Fundamental Graph Algorithms (Triangle and Truss Counting)
   14. CUDA: Single Source Shortest Path; Linear Assignment Problem

III. Social Networks (4 week)
   15. Network Science and Network Types
   16. Working with iGraph
   17. Centrality Measures and Computing Approximate Centrality
   18. Diffusion models and Influence maximization
   19. Community detection

Required Work and Grading Policy

1. Homeworks/Programming Assignments	- (bi-)weekly assignments	30%
2. Exam	- one mid-term	20%
3. Project (Group of 3)	- end of term	50%

(+/- Grading scheme will be in effect; I will grade on a curve; expect average = B)

Computer Usage and Academic Honesty

Students are expected to use computer programs in completing some homework assignments. Plagiarism will constitute grounds of University Sanctions including immediate failure in course for reason of academic dishonesty (see http://studentcode.illinois.edu/article1_part4_1-401.html).