Course Syllabus

Syllabus

Lesson One: What is Network Science?

- What is (not) network science?
- The main premise of network science
- History and relation to graph theory, physics, sociology, and other disciplines.
- Examples of networks from different application domains

Lesson Two: Relevant Concepts From Graph Theory

- Undirected, directed, signed, weighted and spatial networks
- Paths, connected components, random walks, etc
- Directed Acyclic Graphs
- Bipartite graphs
- Max-flow/min-cut

Lesson Three: Degree Distribution and ER Graphs

- Degree distribution
- Friendship paradox
- ER graphs and their degree distribution
- Giant component size in ER graphs
- Assortative vs disassortative networks

Lesson Four: Random vs. Real Graphs and "Scale Free" Networks

- The degree distribution of real-world networks
- Power-law degree distributions
- Preferential attachment model
- How to detect a power-law and estimate the exponent
- Configuration model and degree-preserving randomization

Lesson Five: Network Paths, Clustering and The “Small World” Property

- Clustering and transitivity in networks
- Diameter and characteristic path length
- Small-world networks and the Watts-Strogatz model
- Network motifs

Lesson Six: Centrality and Network-core Metrics and Algorithms

- Link-based centrality metrics
- Path-based centrality metrics

- k-core decomposition
- Core-periphery structure
- Rich-club set of nodes

Lesson Seven: Community Detection and Hierarchical Modularity

- Hierarchical clustering in networks
- Modularity metric Algorithms for modularity maximization
- Limitations of modularity
- Hierarchical modularity

Lesson Eight: Advanced Topics in Community Detection

- Overlapping communities
- Dynamic communities
- Comparing community structures
- The role of nodes within and between communities Applications of community detection

Lesson Nine: Network Contagion and Epidemics

- Epidemics on networks
- Epidemic modeling (SI, SIS, SIR, etc) under homogeneous mixing
- Epidemic modeling under arbitrary degree distributions
- Basic reproductive number and superspreaders

Lesson Ten: Influence Phenomena On Networks

- The linear threshold model and the Independent cascades model
- Empirical studies in information and behavior spreading
- Seeding strategies on how to maximize influence
- Cascades and community structure

Lesson Eleven: Other Dynamic Processes Of/On Networks

- Percolation, random failures, and targeted attacks on networks
- Search on networks
- Synchronization on networks
- Coevolutionary networks

Lesson Twelve: Models of Static and Dynamic Networks

- Stochastic network models that generate power-law degree distributions
- Optimization-based network models
- Stochastic block models
- Hierarchical Random Graphs

Lesson Thirteen: Statistical Analysis of Network Data

- Network sampling methods
- Estimation of network metrics
- Association networks

- Network tomography

Lesson Fourteen: Machine Learning meets Network Science

- Node embeddings
- Graph neural networks
- Deep generative network models
- Limitations and applications of graph neural networks

Course Timeline (Summer 202)

Quiz (35% of the grade)

Lesson-1: Quiz
Due May 20 at 8:59pm

Lesson-2: Quiz
Due May 25 at 8:59pm

Lesson-3: Quiz
Due May 30 at 8:59pm

Lesson-4: Quiz
Due Jun 5 at 8:59pm

Lesson-5: Quiz
Due Jun 10 at 8:59pm

Lesson-6: Quiz
Due Jun 15 at 8:59pm

Lesson-7: Quiz
Due Jun 20 at 8:59pm

Lesson-8: Quiz
Due Jun 25 at 8:59pm

Lesson-9: Quiz
Due Jun 30 at 8:59pm

Lesson-10: Quiz
Due Jul 5 at 8:59pm

Lesson-11: Quiz
Due Jul 10 at 8:59pm

Lesson-12: Quiz
Due Jul 15 at 8:59pm

Lesson-13: Quiz
Due Jul 20 at 8:59pm

Lesson-14: Quiz
Due Jul 25 at 8:59pm

Project (65% of the grade)

Module One: Project
Due May 29 at 8:59pm

Module Two: Project
Due Jun 13 at 8:59pm

Module Three: Project
Due Jun 28 at 8:59pm

Module Four: Project
Due Jul 13 at 8:59pm

Module Five: Project
Due Jul 26 at 8:59pm