Class Time: 4:40–5:55pm, Tu. Th.
Class website on Canvas

Classroom Location: LSRC 106

Instructor: Xiaobai Sun
Email : `xiaobai[at]cs.duke.edu`
(Subject Line starts with `Graph-Matrix-2024`)
Office Hour : TBA

Teaching Assistant: Amir Farzam
Email: `a.farzam[at]duke.edu`
Teaching Assistant: Juntang Wang
Email: `jw853[at]duke.edu`
ChatGPT

Recitation Hour: TBA for each assignment

Prerequisite: calculus, linear algebra, and basic programming experience

Reference books: see the recommended
(individual choice based on personal background & interest)

References articles: in lecture notes, assignments and via individual search

Work load:

* 2 homework assignments: for enhancing analysis and experiment skills,
  each assignment has two portions – analysis and experiment.
* 1 project presentation: for cultivating inquiry, investigation capabilities

Evaluation:

Homework grading policies. **30**% + **30**%
- ◇ individual points on analysis portion; team points on collaboration experiment;
  two members per team; intra- & inter-team collaboration are encouraged.
- ◇ reward points for creative and ideas or approaches.
- ◇ rebound points for post-grading correction within a week, up to 50% of the lost points.
- ◇ penalty on delay, inadequate citation or acknowledgments; severe penalty on plagiarism.

Project presentation: **30**%
- ○ 1/2 weight by the peer reviewers/classmates;
- ○ 1/2 weight by the teaching panel

Participation: **10**% attendance and activities

Tools:
+ LaTex for text processing (drafting, editing, revising and viewing); submission in PDF files;
+ MATLAB one platform for data processing, rapid algorithm prototyping, numerical experiments, empirical test and evaluation
+ ChatGPT

Basic components

- ◇ Graph or networks representing and mining relational data
  - vertices/nodes, edges/links
    observed, inferred, synthetic, generative
  - relationship between graph data and feature-point data
  - functions on vertices and edges
  - connectivity patterns (local and global)
  - state-space, spectral space,
    and phase-space with dynamic data analysis
- ◇ Graph-matrix association & analysis
  - associated matrices: adjacency, incidence, Laplacian and others
  - graph representation, operations, and analysis via matrices
  - analysis of large and sparse real-world networks
- ◇ Graph characteristics and measures
  - combinatorial, topological, deterministic;
  - algebraic, geometric, spectral;
  - statistical, probabilistic

Selected themes

- ▷ Graph characterization & generative models: structures + randomness
  - Topologically determined (noiseless)
  - Probabilistic
    Erdós-Rényl (ER) models, Gilbert model,
    Small-world networks, Watts-Strogatz (WS) model
    Scale-free networks, Barabasi-Albert (BA) model
    Random geometric model
    Stochastic block model
  - [advanced] Dynamic models
- ▷ Pattern differentiation, detection & knowledge discovery
  - Community detection a.k.a. graph clustering
    broad applications, including unsupervised segmentation
  - Prediction/forecasting under uncertainty
    such for nonlinear time series analysis
- ▷ Graph embedding and non-linear dimension reduction
- ▷ Graph compression and decompression for on-line access and queries

Reference books

"Graph Theory", by Reinhard Diestel, Electronic Ed. 2000

"Introduction to Graph Theory", by Doug West,

"Modern Graph Theory", by B. Ballobás, 2013

"Networks", by Mark Newman, 2nd Ed. 2018

"A first course in Network Theory", by E. Estrada and P. Knight, 2015

"Network Science", by A-L, Barabási

'A first course in Network Science", by F. Menczer, S. Fortunato and C. A. Davis, 2020