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

Instructor: Xiaobai Sun
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(Subject Line starts with NA-2024)

Teaching Assistants:
Abdumalik Abdukayumov
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Classroom Location: LSRC D106

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Recitation Hour: TBA for each homework

Prerequisite: calculus, linear algebra, basic programming experience (in any program language)

Text books: at least one among the recommended (off or/and on line), choice based on personal background and research relevance

References: Suggested in lecture notes and assignments

Work load and evaluation:

* 15% warmup homework assignment (for add/drop decision)
* 25% homework-1
* 25% homework-2
* 25% final exam (take home)
* 10% attendance

Homework grading:

Each homework has two parts: theoretical analysis and computational experiments
Two persons per team; intra-team, inter-team communication or/and collaboration are encouraged

- individual points on analysis portion; team points on team experiment;
- reward on creative ideas and approaches;
- reward on post-grading correction within a week, up to 50% of the lost points
- penalty on delay, inadequate citation or/and acknowledgments; punishment on plagiarism

Exam grading:

- independent work, individual points, no post revision/correction

Homework tools:

+ LaTeX for text processing: drafting, editing, revising and viewing (in generated PDF);
+ MATLAB for data processing: algorithm prototypes, numerical experiments, result evaluation and rendering
Basic and integral topics & components

1. Basics of the basic
   - Convolutions (continuous & discrete)
     - Applications in statistic analysis, pattern matching or learning, compression
     - Convolution theorems (continuous & discrete)
     - Dual relationship between spatial analysis and spectral analysis
   - Data Fitting & Compression
     - Interpolation models and methods (extrapolation)
     - Sampling (predetermined, adaptive) and sample translation
     - Data fitting (exact, error-tolerant)
     - Compression (lossy, lossless), decompression (reconstruction)
   - Numerical calculus
     - Numerical integration: low dimension, high dimension
     - Numerical differentiation: discretized/discrete gradients
     - Numerical diffusion: regular & irregular (graph Laplace)

2. Numerical linear algebra
   - Compressive processing of large and structured matrices
     (relationship to compressive sensing)
   - Linear least squared optimization:
     Geometric projections and least-residual equations
   - Direct methods:
     - specially structured linear systems;
     - factored linear systems and factorization methods;
     - conjugate gradient method and its geometric properties
   - Iterative methods:
     - fixed point iterations: (stationary, non-stationary, adaptive)
     - conjugate gradient method and its spectral properties

Convergence analysis and stability analysis will be introduced.

3. Nonlinear system of equations & Optimization
   - Rootfings: polynomial equations, matrix eigenvalue problem
   - Non-linear equations arising in non-linear optimization
   - Local linearization, or linearization sequence
   - Graph spectra, near-neighbor graphs

4. Ordinary and partial differential equations
   - numerical solutions to ODEs and PDEs
   - data modeling with differential equations

We attempt to make connections to large data analysis in modern computation practice and applications, via class projects; and we encourage intellectual, mutually stimulative communication and collaborations with teammates and classmates.