MATH3332: Data Analytic Tools
Course Outline - Fall 2023-2024

Course outline:

Instructor:
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Teaching Assistant: Li Jiayi
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Meeting time and Venue:
Lectures:
Date/Time: MoWe 9:00am—10:20am
Venue: Rm 2504 (lift 25-26)
Tutorial:
Date/Time: Tu 06:00PM—06:50PM
Venue: Rm 4504 (Lift 27-28)

Course Description:
This course will introduce to the students some mathematical analysis tools that are useful for data analysis. The topics include basic calculus on functionals (norm, inner product, linear operators, differentiation, functional expansion, etc), and basic convex analysis (convexity, gradient descent). All are demonstrated by case studies in data analysis and machine learning.

Intended Learning Outcomes
On successful completion of the course, students are expected to be able to:
1. Grasp the basic mathematical tools such as calculus on functions and basic convex analysis.
2. Use mathematical tools such as vectors, norms and convex functions to model the problems arising in machine learning.
3. Grasp basic algorithms on optimization problems and use it in machine learning
4. Grasp some basic machine learning algorithms such as K-means and SVM and use it in machine learning problems.

Assessment Scheme:
30% Homework (every two weeks), 20% Quizzes (every three weeks), and 50% Final Exam.

References:
1. Lecture notes.
2. Convex Optimization, S. Boyd, L. Vandenberghe, Cambridge University Press, 2003. (Free Online)
3. Wikipedia on related topics.

Tentative Course Schedule:

04 Sep: Introduction
06 Sep: vector space
11 Sep: normed vector space, Banach spaces.
13 Sep: Case study: k-means clustering, k-medians clustering.
18 Sep: Limit and convergence on vector spaces
20 Sep: Finite dimensional vector spaces, Inner products on vector space
25 Sep: Cauchy-Schwartz inequality, Hilbert spaces
27 Sep: Case study: Kernel trick, Kernel k-means clustering.
02 Oct. Holiday (The day following the Chinese Mid-Autumn Festival)
04 Oct: Linear functions on Hilbert spaces
09 Oct: Riesz representation theorem
11 Oct: Case Study: Linear regression and classifier
16 Oct: Case study: Support vector machine (SVM), and kernel SVM.

18 Oct: Hyperplanes; Projection onto hyperplanes; Affine functions
23 Oct. Holiday Chung Yeung Festival
25 Oct: Differentiability of functions on vector spaces, Gradient.
30 Oct: Case study: Solvability of unconstrained optimization problem.
01 Nov: Case study: Convexity, Gradient descent,
06 Nov: Linear transformations/linear operators
08 Nov: Linear transformations/linear operators
13 Nov: Linear approximation/differentiation of transformation
15 Nov: Linear approximation/differentiation of transformation
20 Nov: Linear approximation/differentiation of transformation
22 Nov: Case study: Neural network training.
27 Nov: Case study: Neural network training.
29 Nov: Matrix differentiation