Boston University Metropolitan College

Course Title: Computational Mathematics for Machine Learning

Course Number: BU MET CS 550 (Summer II, 2024)
Course Format: On-Line

Instructor Name: Eugene Pinsky epinsky@bu.edu

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1010 Commonwealth Avenue, Room 327, Boston, MA 02215

Course Times: Tue & Thursdays 6:00-7:30 p.m.
Office Hours: TBA

Teaching Assistants (Facilitators): TBA

Course Objectives: mathematics is fundamental to data science and machine learning. This course reviews essential mathematical concepts and procedures which are fundamental. These concepts are illustrated by Python and/or R code and by many visualizations.

Teaching Approach and Goals: This course discusses mathematical concepts and computational methods for data science using simple self-contained examples, intuition, and visualization. These examples will help develop intuitive explanations behind mathematical concepts. Extensive visualizations will be used to illustrate core mathematical concepts. The emphasis is on mathematics and computational algorithms at the heart of many algorithms for data analysis and machine learning. This course will advance students' mathematical skills that can be used effectively in data analytics and machine learning.

Books (Required):

Mathematics for Machine Learning by Marc Deisenroth, Cambridge University Press, 2020

Prerequisites: basic knowledge of Python or R

Courseware: Blackboard, Course Notes

Additional materials will be added to "From Your Professor" section under group discussion section.

Class Policies

Weekly programming assignments submitted through blackboard on-line. Late homework is accepted with 50% penalty. Final projects are submitted through blackboard on-line. Students will present their projects on the last day of class. Both quizzes and final are closed-book.

This is an on-line class. All lectures are recorded.

Academic Conduct Code – "Cheating and plagiarism will not be tolerated in any Metropolitan College course. They will result in no credit for the assignment or examination and may lead to disciplinary actions. Please take the time to review the Student Academic Conduct Code:

Academic conduct code as specified below:

> http://www.bu.edu/met/metropolitan_college_people/student/resources/conduct/code.html.

Grading Criteria:

Final 30%, Project 20%, Homework 35%, Quizzes 15%

Homework: This is a “computational” class and students must have practice. Most homework assignments will consist of both programming problems and pencil-and-paper problems. Programming can be done either in Python or in R.

Quizzes/Final: There are six 30 minute quizzes. The final is 2 hours. All quizzes and the final exam will be done in the blackboard.

Project: The project is open ended and the topics can be chosen by students (subject to instructor’s approval). In the project, students have to illustrate the usage of Python or R to implement computational algorithms to real problems in data analysis. Students will present their projects on the last day of the course.

Course Overview:

Week 1: Numeric Python and Pandas review, arrays, vectorizations, time-series with Pandas, plotting with Matplotlib. Review of computational calculus, derivatives and integration. Gradient descent

Week 2. Analytic geometry: vectors, norms, distances, lengths. Inner products. Orthonormal basis. Rotation and orthogonal projections.

Week 3. Linear algebra: scalars, vectors, matrices, tensors. Matrix multiplication and inversion. Norms and Scalar Gramm matrices. Matrix decomposition.

Week 4: Eigenvalues and eigenvectors. Eigenvector computation. Singular vector decomposition. Dimensionality reduction via principal component analysis.

Week 5: Mathematical tools (approximation, convex optimization, quadratic programming, integration), gradient-based optimization, Newton-Raphson method. Lagrange multipliers.

Week 6. Random variables. Discrete and continuous probability distributions. Maximum likelihood estimation. Expectation, variance and covariance. Histograms and empirical distributions. Correlations and covariance matrices, Bayes rule