Boston University, College of Engineering  
Department of Electrical and Computer Engineering  

ENG EC503 (Ishwar) – Spring 2024

LEARNING FROM DATA

Instructor: Prof. Prakash Ishwar (e-mail: pi@bu.edu)  
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Lectures: Tue + Thr, 1:30-3:15 pm (EPC 208)  
Discussions: Wed 6:30-8:15 pm (PHO 205)  
Instructor’s office hours: Tue + Thr 6:00-7:30 pm (PHO 428)  
TA’s office hours: Mon + Fri (times + locations to be decided)

Description:  
This is an introductory graduate course in (classical) machine learning covering the basic principles and methods of four major non-sequential supervised and unsupervised learning problems namely, classification, regression, clustering, and dimensionality reduction. A variety of contemporary applications will be explored through homeworks and a project.

Prerequisites:  
Probability (EK381 or equivalent), Linear Algebra (EK102 or equivalent), Multivariate Calculus (MA225 or equivalent), Matlab (EK125 or equivalent).

Syllabus:

- **Key concepts, terms, and technical tools**: training, testing, cross-validation, performance-evaluation, under- and over-fitting, inner-product, norm, orthogonal projection, eigen-decomposition, SVD, empirical first- and second-order statistics, gradient, Hessian, optimization, convex set, convex function, subgradient, stochastic sub-gradient descent.
- **Nearest-Neighbor (NN) methods**: k-NN classification and regression, k-centers clustering and vector-quantization.
- **Linear methods**: Classification: artificial neuron, Fisher-LDA, logistic-loss, single-layer feed-forward artificial neural network (ANN), support-vector machine (SVM); Regression: ordinary least squares (OLS), ridge-regression, support-vector regression (SVR); Dimensionality-reduction: principal-component analysis (PCA).
- **Kernel-methods**: Representer-theorem, kernelization of learning and inference, kernel versions of kNN, SVM, ridge-regression, k-means, PCA.
- **Multilayer feed-forward ANNs**: architecture, universal-approximation, backpropagation algorithm;
- **Selected Topics (as time permits)**: decision trees and random forests, boosting, document classification with bag-of-words model, robust-regression, sparse-regression, spectral clustering, nonlinear dimensionality reduction methods, probabilistic framework for learning and inference.
Grading:

22% Homeworks

9 HWs consisting of Matlab and/or analytical exercises. Will take better of “all 9 HWs” and “best 8 of 9 HWs”. Due: 10:55pm of due date (upload report to Gradescope + code to Blackboard). Late submission penalty: 5 points per minute.

50% Exams


25% Project

Team project (3-4 members) involving algorithm development. Details to follow later in the semester. Presentation: Apr. 30 (1:30–3:15pm) in EPC 208 and May 1 (6:30–8:15pm) in PHO 205.

3% Class-participation

For attendance and constructive and proactive engagement during lectures, discussions, office hours, and on Piazza.

Outcomes: As an outcome of successfully completing this course, students will:

- understand basic theoretical principles and algorithmic methods of learning from data,
- be able to use computer-based machine learning tools,
- know how to analyze and extract information from real-world data,
- be able to select and optimize appropriate machine learning methods and tools for various real-world problems,
- be able to understand and communicate key ideas from articles and technology related to machine learning.

Web site: http://learn.bu.edu for registered students only. Will contain lecture slides, notes, links, discussion materials, and other useful information related to the course.

References: This course has no textbook. You will need to rely on lectures, discussions, office hours, and course materials that will be uploaded regularly to the course web site. Below is a list of reference books which you may consult should you like to explore further. Each book is on reserve in the Science and Engineering Library (max. 2 hour check-out period; also available electronically online).


Matlab: Each computer assignment will involve the use of Matlab to illustrate and compare the main methods discussed in the lectures and discussions. You could run Matlab on your own computer using BU’s site-wide licensing program. See:

http://www.bu.edu/tech/services/cccs/desktop/distribution/mathsci/matlab/

Alternatively, you could run Matlab remotely on BU machines. See:

https://www.bu.edu/engit/knowledge-base/citrix/citrix-how-to/

You may use your own computers to complete the homeworks and/or project. You may also use the workstations in PHO 305 (Tue, Thu 6:30-8:30pm + Fri 3-8:30pm) and PHO 307 (Mon 4:30-6:30pm + Wed 6:30-8:30pm). If you do not already have it, contact the lab administrator enghelp@bu.edu for an account and apply for card-access using Zaius: http://www.bu.edu/dbin/eng/zaius/
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**Audio-visual recordings during class:** Instructor consent is needed before recording during class due to copyrighted materials. Such recordings must not be posted on any public forum without instructor consent.

**Academic integrity, plagiarism:** Collaboration is essential for the course project, permitted on homeworks, but illegal in exams. In project reports, you may paraphrase relevant ideas from references, but not quote sentences verbatim from them. *Homework collaboration = only discussion.* If you allow your solution or code to be viewed by anyone or reversely you see someone’s solution or code then you have gone beyond collaboration. You may discuss problems, but you must create a solution by yourself. **If there is collaboration in a homework, all collaborators must be explicitly acknowledged and the nature and extent of collaboration must be clearly explained. Each collaborator must turn in their individual analysis/code and description of results.** All solutions (including code) will be automatically checked for plagiarism against solutions from all registered students, solutions from previous semesters, and also solutions available from online sources.

The student handbook defines academic misconduct as follows: “*Academic misconduct occurs when a student intentionally misrepresents their academic accomplishments or impedes other students’ chances of being judged fairly for their academic work. Knowingly allowing others to represent your work as theirs is as serious an offense as submitting another’s work as your own.*” Please see the student handbook for procedures that will follow should academic misconduct be discovered.

**Inclusion:** I consider the classroom to be a place of learning where all individuals are expected to contribute to provide a respectful, welcoming and inclusive environment for every member of the class irrespective of how they identify themselves.

**Disability accommodations:** If you are a student with a documented disability or believe you might have a disability that requires accommodations, requests for accommodations must be made in a timely fashion to Disability & Access Services, 25 Buick St, Suite 300, Boston, MA 02215; 617-353-3658 (Voice/TTY). Students seeking academic accommodations must submit appropriate medical documentation and comply with the established policies and procedures [http://www.bu.edu/disability/accommodations/](http://www.bu.edu/disability/accommodations/)

**BU health-safety guidelines and policies:** BU strongly recommends staying up-to-date with vaccines, wearing a high-quality mask in crowded indoor spaces, and testing if you are feeling unwell, to reduce the risk of disease transmission, especially for individuals who have a higher risk of severe illness. Students should be compliant with all BU health-safety policies. For BU health-safety guidelines and policies, please visit: [https://www.bu.edu/chiefhealthoffice/bu-covid-19-policies/](https://www.bu.edu/chiefhealthoffice/bu-covid-19-policies/)

**Illness/Medical issues:** These will be resolved by case-specific discussions with the instructor. Student must inform the instructor by email as soon as possible and be prepared to provide suitable documentation. This may also require contacting BU’s disability access services.