Machine Learning with Applications (ROBT407)

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Spring Semester, 2021

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Course Description

ROBT 407 introduces the students to the state-of-the-art analytical tools and methods used for machine learning. Topics include (semi) supervised and unsupervised learning, neural networks, deep learning, support vector machines, the design of machine learning experiments, decision trees, linear discrimination and kernel-based learning methods. The course also contains integrated term projects. Python-based machine learning packages (e.g., scikitLearn, Pytorch, Numpy, Scipy, Pandas, Matplotlib) and online databases will be used extensively.

Required Materials

- Course materials available on Moodle.
- **Textbook:** *LEARNING FROM DATA*, Abu-Mostafa, Magdon-Ismail, Lin. Publication date and edition - 1st ed., March 27, 2012, ISBN Number - 1600490069
- **Textbook:** *Dive into Deep Learning : An interactive deep learning book with code, math, and discussions*, Alex J. Smola et al. Carnegie Mellon University, and Amazon, https://d2l.ai/

Prerequisites/Corequisites

Prerequisites: MATH 273 Linear Algebra with Applications, MATH 321 Probability, (must be completed with a grade of "C-" or better);

Course Objectives

Successful students:

1. Establish fundamental theoretical knowledge in statistical learning field
2. Acquire core knowledge and practical skills on basic techniques of machine learning, including linear/nonlinear methods
3. Be competent with theoretical analysis and formulation of statistical learning techniques for solving real-world data mining problems
4. Be familiar with the wide class of methods for supervised/unsupervised data analysis, classification, regression, including linear/logistic regression, kernel methods, neural networks, and other methods.

Course learning outcomes

At the completion of this course, students will know the following areas:

- Demonstrate an understanding of different types of learning algorithms used in engineering fields.
- Design and implement machine learning algorithms for feature extraction, classification, and clustering.
- Demonstrate hands-on experience with practical data mining using machine learning algorithms and implement those algorithms in different programming languages.
- Use advanced machine learning tools for data analysis.

Assessments

Activity	Tentative Dates	Weighting
Homework		15 %
Quizzes		15 %
Midterm Project		20 %
Midterm Exam		25 %
Final Project		25 %

Schedule

The schedule is tentative and subject to change. The learning goals below should be viewed as the key concepts you should grasp after each week, and also as a study guide before each exam, and at the end of the semester.

WEEK 1, 11/01 - 16/01:

- The Learning Problem
- Learning to answer Yes/No

WEEK 02, 18/01 - 23/01:

- The types of machine learning
- The feasibility of Learning

WEEK 03, 25/01 - 30/01: [Quiz-1]

- Training versus testing & the theory of generalization
- Noise and Error

WEEK 04, 01/02 - 06/02: [Homework-1]

- Linear Regression
- Logistic Regression

WEEK 05, 08/02 - 13/02:

- Linear Models for Classification
- Hazards of Overfitting

WEEK 06, 15/02 - 20/02: [Homework-2]

- Regularization
- Validation

WEEK 07, 22/02 - 27/02: [Midterm Project]

- Validation
- Introduction to Scikit-learn: machine learning in Python (part 1)

WEEK 08, 01/03 - 06/03: [Quiz-2]

- Introduction to the scikit-learn: machine learning in Python (part 2)
- Supervised learning and model selection with scikit-learn

WEEK 09, 08/03 - 13/03: [Midterm exam]

- Linear Support-Vector Machines
- Dual Support-Vector Machines

WEEK 10, 15/03 - 20/03:

- Kernel Support-Vector Machines
- Soft-Margin Support-Vector Machines

WEEK 11, 22/03 - 27/03: [Homework-3]

- Spring BREAK

WEEK 12, 29/03 - 03/04: [FINAL PROJECT]

[Quiz-3]Neural Networks Feed Forward Neural Networks with Pytorch

WEEK 13, 05/04 - 10/04:

- Deep Learning
- Convolutional Neural Networks
- Apply CNNs on MNIST and CIFAR datasets
- Modern Convolutional Neural Networks Architectures

WEEK 14, 12/04 - 17/04:

- Recurrent Neural Networks
- Long Short-Term Memory
- Gated Recurrent Units

Course expectations

- Students are expected to work independently on their homework assignments. However, discussion amongst students is encouraged, but when in doubt, direct your questions to the instructor
- Offering and accepting solutions from others are an act of plagiarism, which is a severe offense and all involved parties will be penalized according to the Nazarbayev University Policy.
- Homework and Lab assignments are due on the date specified in the course schedule, and they should be submitted via the University Moodle System. Handwritten homework should be scanned and converted to PDF for submission.
- For late submissions, there is a reduction of 10% of the total credit for each day it is late.
- Attendance is expected and will be taken each class and lab session. Students are not allowed to miss any class during the semester unless he/she is sick. Any further absences will result in point and grade deductions.
- Students are responsible for all missed work, regardless of the reason for the absence. It is also the absentee's responsibility to get all missing notes or materials.
- Absence during the midterm or final term exams will fail of the course. However, students will be able to re-take exams if an absence is due to a medical condition or treatment.

- Students are expected to regularly check Nazarbayev University email for updates and announcements about the course, and are also required to use Moodle as determined by the instructor.

Academic Integrity Statement

- Students may only get help on graded assignments from designated people, and are always welcome to get help on an assignment from the course instructor, teaching assistants. They may help at the computer,on paper, or any way they believe will be useful.
- Do not give direct help to, nor receive direct help from, your classmates on a graded assignment. Never show your work to your classmates or seek to see their work. Homework should be completed individually. In cases where inappropriate sharing occurs, all students involved are at fault, regardless of whether they are the source or recipient of shared work.
- If something has your name on it, you are claiming it as your own work and academic integrity rules apply. The assignments in this class are exercises designed to help you absorb and comprehend the covered topics. Doing the work is much more important than getting the right answer.
- The severity of sanctions imposed for an academic integrity violation will depend on the transgression and ascertain the intent of the student. Penalties for a first offense may range from failing the assignment to failing the course and referral to an academic review board. Students can find more information about the consequences of academic integrity violations from Student Affairs.

Grading

A	95-100
A-	90-94.9
B+	85-89.9
B	80-84.9
B-	75-79.9
C+	70-74.9
C	65-69.9
C-	60-64.9
D+	55-59.9
D	50-54.9
F	0-49.9