جـــامـــعـــة مـحـمـد بـــن زايـــد
للـــذكـــاء الاصـــطـــنـــاعـــي
MOHAMED BIN ZAYED UNIVERSITY
OF ARTIFICIAL INTELLIGENCE

Core Courses Syllabi

MTH702 - Optimization

Title	Optimization
Code	MTH702
Loading	4 Credit-hours
Prerequisites	Linear Algebra, Matrix Analysis, Probability and Statistics
Catalog Description	This course provides a graduate-level introduction to the principles and methods of optimization, with thorough grounding in the mathematical formulation of the optimization problems. The course covers fundamentals of convex functions and sets, 1st order and 2nd order optimization methods, problems with equality and/or inequality constraints, and other advanced problems.
Goal	This course aims to inculcate a deeper understanding of the optimization methods, so the students are capable of researching, developing, and implementing these methods for solving various problems, including the ones frequently encountered in Machine Learning.
Content	The course covers: basic gradient methods, acceleration techniques, stochastic optimization, dual methods, non-convex optimization and convex approximation, higher-order and interior point methods, a few special topics.
Recommended Textbooks	1. Convex Optimization. S. Boyd and L. Vandenberghe. Cambridge University Press, Cambridge, 2003. 2. Nonlinear Programming (3rd edition). D. Bertsekas, Athena Scientific
Recommended References & Supplemental Material	1. Numerical Optimization. J. Nocedal and S. J. Wright, Springer Series in Operations Research, Springer-Verlag, New York, 2006 (2nd edition). 2. Introductory Lectures on Convex Optimization: A Basic Course. Y. Nesterov. Kluwer, 2004.

	Overview of Optimization: Course information, Motivation
1	**Basic gradient methods** **Lecture** • Convexity • Gradient method (non-smooth and smooth) **Lab** • Implementation of the algorithms discussed in lecture • Assessment Items • Assignment 1 handed out
2	**Basic gradient methods** **Lecture** • Gradient method (strongly convex) • Some applications of gradient methods • Conditional gradient (Frank-Wolfe algorithm) **Lab** • Implementation of the algorithms discussed in lecture
3	**Krylov methods and acceleration** **Lecture** • Discovering acceleration with Chebyshev polynomials • Krylov subspaces, eigenvalues, and conjugate gradient **Lab** • Implementation of the algorithms discussed in lecture **Assessment Items** • Assignment 1 due at the end of the week • Assignment 2 handed out
4	**Krylov methods and acceleration** **Lecture** • Nesterov's accelerated gradient descent • Lower bounds, robustness vs acceleration **Lab** • Implementation of the algorithms discussed in lecture

	Overview of Optimization: Course information, Motivation
5	**Stochastic optimization** **Lecture** • Introduction to stochastic optimization • Learning, regularization, and generalization • Coordinate Descent **Lab** • Implementation of the algorithms discussed in lecture **Assessment Items** • Assignment 2 due at the end of the week • Assignment 3 handed out
6	**Dual methods** **Lecture** • Duality theory • Dual decomposition, method of multipliers **Lab** • Implementation of the algorithms discussed in lecture
7	**Dual methods** **Lecture** • Stochastic Dual Coordinate Ascent • Backpropagation and adjoints **Lab** • Implementation of the algorithms discussed in lecture
8	**Non-convex problems** **Lecture** • Introduction to Non-convex problems • Saddle points **Lab** • Implementation of the algorithms discussed in lecture **Assessment Items** • Assignment 3 due at the end of the week • Assignment 4 handed out

	Overview of Optimization: Course information, Motivation
9	**Non-convex problems** **Lecture** • Alternating minimization and expectation maximization • Derivative-free optimization, policy gradient, controls **Lab** • Implementation of the algorithms discussed in lecture
10	**Non-convex problems** **Lecture** • Non-convex constraints I • Non-convex constraints 2 **Lab** • Implementation of the algorithms discussed in lecture
11	**Higher-order and interior point methods** **Lecture** • Introduction to higher order optimization • Introduction to interior point methods **Lab** • Implementation of the algorithms discussed in lecture **Assessment Items** • Assignment 4 due at the end of the week • Assignment 5 handed out
12	**Higher-order and interior point methods** **Lecture** • Matrix differentials • Newton's method **Lab** • Implementation of the algorithms discussed in lecture

	Overview of Optimization: Course information, Motivation
13	**Higher-order and interior point methods** **Lecture** • Enter interior point methods • Primal-dual interior point methods **Lab** • Implementation of the algorithms discussed in lecture
14	**Higher-order and interior point methods** **Lecture** • Ellipsoid method • Submodular functions **Lab** • Implementation of the algorithms discussed in lecture **Assessment Items** • Assignment 5 due at the end of the week • Assignment 6 handed out
15	**Lecture** • Lovasz extension • Polynomial programs **Lab** • Implementation of the algorithms discussed in lecture **Assessment Items** • Assignment 6 due the following week