

Optimization

Academic Year: (2020 / 2021)

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Department assigned to the subject: Signal and Communications Theory Department

Coordinating teacher: VAZQUEZ VILAR, GONZALO

Type: Electives ECTS Credits : 6.0

Year : 1 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Students are expected to have a solid background in

- Linear Algebra

Prior knowledge on optimization is not required.

OBJECTIVES

- Develop a solid theoretical basis for solving convex optimization problems arising in industry and research.
- Learn manipulations to unveil the hidden convexity of optimization problems and relaxation techniques to treat non-convex optimization problems.
- Be able to characterize the solution of convex and non-convex optimization problems either analytically or algorithmically.
- Learn the usage of some of the more popular optimization toolboxes.

DESCRIPTION OF CONTENTS: PROGRAMME

Optimization theory is nowadays a well-developed area, both in the theoretical and practical aspects. This graduate course introduces the basic theory for solving optimization problems and illustrates its use with many recent applications in signal processing, communication systems and machine learning.

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Course contents

Unit 1. Introduction

- Optimization problems and constraints
- On closed-form optimization: analytical versus algorithmic solutions
- Types of optimization problems
- Applied linear algebra

Unit 2. Quadratic Optimization

- Problem formulation
- Matrix and vector derivatives
- Equality constraints
- Duality and Lagrange multipliers

Unit 3. Convex Optimization

- Convex sets and convex functions
- Convex and non-convex optimization problems
- Lagrange duality and KKT conditions
- Disciplined convex programming, CVX

Unit 4. Optimization Algorithms

- Local optimization algorithms
- Stochastic optimization
- Convex relaxation and approximate solutions

Unit 5. Applications

- Optimization for research

LEARNING ACTIVITIES AND METHODOLOGY

- Theoretical sessions: theoretical basis of optimization theory, illustrated with different applications and examples. Material for out-of-class work.
- Problem sessions: formulation and solution of exercises motivated by different problems from communications, signal processing and machine learning.
- Practical sessions: popular toolboxes for convex and non-convex optimization. The proposed projects will be solved in Matlab and/or Python programming environments.

ASSESSMENT SYSTEM

% end-of-term-examination/test:	0
% of continuous assessment (assignments, laboratory, practicals...):	100
- Midterm exam:	30%
- Labs:	30%
- Homework and classwork:	40%

A minimum grade of 4 is required in the midterm exam to pass the course.

BASIC BIBLIOGRAPHY

- S. Boyd and L. Vandenberghe Convex Optimization, Cambridge University Press, 2004

ADDITIONAL BIBLIOGRAPHY

- A. Zhang, Z. C. Lipton, M. Li and A. J. Smola Dive into Deep Learning, Online interactive book: <https://d2l.ai>, 2019
- S. Boyd and L. Vandenberghe Introduction to Applied Linear Algebra - Vectors, Matrices, and Least Squares, Cambridge University Press, 2018

BASIC ELECTRONIC RESOURCES

- S. Boyd and L. Vandenberghe . Convex Optimization: <https://web.stanford.edu/~boyd/cvxbook/>