Optimization

Academic Year: (2021 / 2022) **Review date: 27-05-2021**

Department assigned to the subject: Department of Signal and Communications Theory

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

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

Students attending this course will:
- 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.

Link to document

DESCRIPTION OF CONTENTS: PROGRAMME

Unit 1. Introduction
- Optimization problems and constraints
- On closed-form optimization: analytical versus algorithmic solutions
- Types of optimization problems
- Modelling and applied linear algebra

Unit 2. Convex Optimization
- Convex sets and convex functions
- Convex optimization problems
- Disciplined convex programming, CVX
- Quadratic optimization
- Lagrange duality and KKT conditions

Unit 3. Optimization Algorithms
- Local optimization algorithms
- Stochastic optimization
- Global optimization
- Integer programming and metaheuristics

Unit 4. Applications
- Optimization for machine learning
- Final project

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

- Assessment tasks of Units 1-2: 35%
- Assessment tasks of Unit 3: 35%
- Final project: 30%

Assessment tasks consist on the exercises and practical assignments delivered throughout the course. The course Optimization requires a final project. The purpose of this project is to relate the contents of the course to the student's research work and interests. Evaluation of the project will be based on a short report and on a final presentation.

Grading in the extraordinary evaluation period will be based on a single exam covering all the contents of the course (Units 1-4).

% end-of-term-examination:	0
% of continuous assessment (assigments, laboratory, practicals…):	100

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/