Optimization

Academic Year: (2019 / 2020) **Review date: 27-04-2020**

Department assigned to the subject:

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 0. Introduction
1. Optimization and constraints
2. Convex versus non-convex optimization problems
3. On closed-form optimization: analytical versus algorithmic solutions
4. Types of optimization problems

Unit 1. Quadratic Optimization
1. Problem formulation
2. Matrix and vector derivatives
3. Equality constraints
4. Lagrange multipliers

Unit 2. Convex Optimization
1. Convex sets, functions and optimization problems
2. Lagrange duality and KKT conditions
3. Algorithms and optimization techniques
4. Lab: Disciplined convex programming: CVX

Unit 3. Non-Convex Optimization
1. Global optimization: local minima versus global minima
2. Local optimization algorithms
3. Convex relaxation and approximate solutions
4. Majorization-minimization principle
5. Lab: TensorFlow

Unit 4. Applications
1. Signal reconstruction and robust approximation
2. Optimization for machine learning
3. Low-rank optimization problems

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.
- Lab sessions: popular toolboxes for convex and non-convex optimization. The proposed projects will be solved in Matlab and/or Python programming environments.

ASSESSMENT SYSTEM

- Homework and quizzes:	10%
- Labs:	10%
- Exam:	40%
- Final project:	40%

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

% 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