

## Optimization and linear programming

### Introducing

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#### Description

- Introduction to constrained optimization: definitions and generalities, existence of solutions, convexity and uniqueness
- Optimality conditions: first and second order conditions in unconstrained differentiable optimization, Karush-Kuhn-Tucker (KKT) conditions in constrained differentiable optimization, Lagrangian notion
- Algorithms for unconstrained optimization: gradient algorithm (fixed step, optimal step), Newton's algorithm, linear and nonlinear least squares problems
- Introduction to linear constrained optimization: modeling formalisms, characterization of the search space, geometric interpretation, graphical resolution, link with KKT conditions, simplex algorithm, method of dictionaries, complexity, duality of a PL problem, strong and weak duality theorems, complementary deviations theorems, Farkas lemma, alternatives theorem.

Detailed course handout provided.

Keywords : differentiable optimization, first and second order optimality conditions, gradient algorithms, Newton, least squares problems, linear programming and simplex algorithm.

#### Objectives

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At the end of this module, the student will have understood and be able to explain (main concepts):

- The notions of local extremum and convexity
- Characterization of a local extremum by optimality conditions: first and second order conditions in unconstrained differentiable optimization, Karush-Kuhn-Tucker (KKT) conditions in constrained differentiable optimization
- The first algorithms for unconstrained optimization: gradient algorithm (fixed step, optimal step), Newton's algorithm, linear and nonlinear least squares problems
- Optimization under linear constraints (Linear Programming/PL): modeling in PL, characterization of the search space, geometric interpretation, solution principle, simplex algorithm, dictionary methods, complexity, duality.

The student will be able to:

Choose and implement a relevant and numerically efficient optimization method for an unconstrained differentiable optimization problem or for a linear programming problem.

#### Necessary prerequisites

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Differential calculus: know how to calculate a gradient and a hessian. Link with differential.

Linear algebra: know how to diagonalize a matrix, calculate the eigenvalues, notion of semi-definite positivity.

#### Évaluation

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L'évaluation des acquis d'apprentissage est réalisée en continu tout le long du semestre. En fonction des enseignements, elle peut prendre différentes formes : examen écrit, oral, compte-rendu, rapport écrit, évaluation par les pairs...

## Practical info

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### Location(s)

 Toulouse