Optimization for machine learning

Pierre Hellier

Pierre Hellier
pierre.hellier@irisa.fr

- Current position: prof at Rennes university
- 14 years in academia, 12 years in industry, startup creation
- research interest: computer vision, machine learning.
- Applications: content creation, edition (postproduction), compression. Human motion modeling and realistic avatar animation.

Course objectives

- Formulate an ML problem as an optimization problem
- Understand the classes of optimization problems
- Know the right tool for a given problem
- Compute an analytic solution when possible
- Be able to implement an optimization method with in-house tools, and popular libraries

$\approx$ 30 hours of training, decomposed as:

- Courses: speak up, interactivity is key!
- During courses, exercises on paper
- Practical sessions with python notebooks: read and understand parts that are provided, add cells and add code (for instance, tensors shape, data information, etc)
- Download `https://people.irisa.fr/Pierre.Hellier/TP-UM6P.zip`

Outline

Sessions

- General introduction: rationale, motivations, ML as an optimization problem, convexity and gradients
- Constrained optimization
  - Formulation, lagrangien and KKT, linear programming
  - practical session linear programming
- Unconstrained optimization:
  - Formulation, optimality, OLS, descent algorithms, non-smooth optimization and proximal operator
  - Practical session linear regression, gradient descent, logistoc regression, Ista
- Deep-learning optimization
  - Differentiation on graph, backprop, neural networks, dimensionality reduction
  - practical session AD

References

- Statistical machine learning and convex optimization. Francis Bach - Aymeric Dieuleveut
- Apprentissage statistique : modélisation décisionnelle et apprentissage profond, Introduction à l'apprentissage supervisé. Nicolas Audebert
- Optimization for machine learning. Remy Flamary
- Optimization for Machine Learning. Suvrit SRA
- An introduction to optimization for machine learning. R. Le Riche, *et al.*
- Linear and Convex Optimization. Arkadi Nemirovski
- Convex Optimization. Boyd and Vandenberghe (`https://web.stanford.edu/~boyd/cvxbook/.`)
- Introduction to constrained optimization. Gilles Gasso.
- Dive into deep learning `https://d2l.ai/`
- Understanding deep learning `https://udlbook.github.io/udlbook/`