

Técnicas de optimización

TOPICS

Topic 1: Introduction to classical optimization techniques

- Optimization problems in the real-world
- Optimization algorithms
- Application of optimization methods to Machine Learning

Topic 2: Mathematical programming methods

- Linear programming
- Integer programming
- Binary programming
- Python software for mathematical programming
- Solving real-world problems with mathematical programming

Topic 3: Dynamic programming

- Deterministic and probabilistic dynamic programming approaches
- Steps in the solution of optimization problems using dynamic programming
- Implementation of dynamic programming approaches in Python
- Solving real-world problems with dynamic programming

Topic 4: Markov chains and Markov processes

- Modeling problems under uncertainty using Markov chains
- Markov chain states, transition probabilities and Markov chain characterizations
- Markov processes
- Methods of iterations of policies
- Modeling problems with dynamic programming using Python

Topic 5: Optimization methods for machine learning

- Optimization problems in supervised and unsupervised learning
- Convex machine learning problems
- Gradient descent methods for deep learning
- Optimization for machine learning problems using Python

Topic 6: Hybrid optimization approaches and application of optimization algorithms

- Combination of different optimization approaches
- Applications in Engineering
- Applications in Bioinformatics and Medicine
- Applications in Economy and Finance

The course will comprise lectures and practical classes, the latter will consist in solving exercises using the Python-based Jupyter notebook framework. In the laboratories, students will work in teams and individually to find appropriate solutions to practical problems using optimization algorithms. As part of the evaluation, students will use available Python software (e.g., numpy, pyomo, pulp, mdptoolbox, tensorflow, etc), to solve practical problems and present them as projects.

The course will have a virtual space in Egela where links to useful software, bibliography, and problem repositories will be available. The slides of the course lecture will be also available from the virtual class in Egela. Students could use the forum in the virtual space to discuss the problems.

Students are also advised to create and use github accounts for the completion of the individual and team projects.

BIBLIOGRAFÍA BÁSICA

E. Castillo, A. J. Conejo, P. Pedregal, R. García, and N. Alguacil, 2002. Building and Solving Mathematical Programming Models in Engineering and Science, Pure and Applied Mathematics Series, Wiley, New York.

R. L. Rardin. Optimization in operations research. Upper Saddle River, NJ: Prentice Hall; 1998.
W. Winston. 1991. Operations Research. Applications and Algorithms. PWS-Kent Publishing Company

A. Lew and H. Mauch. Dynamic programming: A computational tool. Vol. 38. Springer, 2006.

N. C. Jones and P. A. Pevzner. An introduction to bioinformatics algorithms. MIT 2004.

Henk C. Tijms. A First Course in Stochastic Models. Wiley, 2003.

K. P. Bennett and E. Parrado-Hernández. The interplay of optimization and machine learning research.

BIBLIOGRAFÍA DE PROFUNDIZACIÓN

S. Boyd and L. Vandenberghe, 2004. Convex optimization. Cambridge university press.

L. Bottou and O. Bousquet, 2008. The tradeoffs of large scale learning. In Advances in neural information processing systems (pp. 161-168).

L. Bottou, 2010. Large-scale machine learning with stochastic gradient descent. In Proceedings of COMPSTAT2010 (pp. 177-186). Physica-Verlag HD.

REVISTAS

Operation Research Journal
Journal of Machine Learning Research

DIRECCIONES DE INTERNET DE INTERÉS

Convex optimization
https://web.stanford.edu/~boyd/cvxbook/bv_cvxbook.pdf

An overview of gradient descent optimization algorithms
<http://ruder.io/optimizing-gradient-descent/index.html>

Optimization in Python cookbook: bowl, plate and valley functions
<https://medium.com/@alexrachnog/optimization-cookbook-1-262aa5555b61>

Jupyter notebooks

<http://jupyter.org/>

Optimization with PuLP

<https://pythonhosted.org/PuLP/>

Optimization with Pyomo

<http://www.pyomo.org/>