ALGORITHMS FOR OPTIMIZATION, INFERENCE AND LEARNING

By A. Braunstein

Subject fundamentals

Mandatory course for the Master in Physics of Complex Systems, 1st year, 2nd term. In this course some aspects of information theory are introduced, which are culturally close to statistical physics, whose study is developed, in parallel, in the course Statistical Physics and Biophysics. The course leads to the development of approximate algorithms for NP-complete problems which exhibit phase transitions in the computational complexity, a problem which is analog to the development of approximate methods for the study of statistical mechanics models exhibiting phase transitions.

Expected learning outcomes

The student must learn the fundamental concepts of complexity theory, the techniques for analyzing the computational complexity of an algorithm, and the main approximate algorithms for NP-complete problems. The student must also learn how to apply such algorithms to problems in statistical inference and combinatorial optimization.

Contents

Recursion and dynamic programming.
Introduction to graph theory.
Trees and data structures
Algorithms on trees.
Algorithmic complexity, polynomial reductions and NP-completeness.
Information theory and statistical inference: maximum entropy, maximum likelihood and Boltzmann learning.
Belief Propagation and inference on trees.
Inference of Trees: Chow-Liu theorem.
Hidden Markov models.

Texts, readings, handouts and other learning resources

Introduction to Algorithms", T.H. Cormen, C.E. Leiserson, R.L. Rivest, MIT Press, 2000.
"Elements of the theory of computation", R. Lewis and C. H. Papadimitriou. Prentice-Hall.
"Computer and Intractability. A Guide to NP-Completeness". M. R. Garey and D. S. Johnson. Publisher W. H. Freeman, 1979.
"Information Theory, Inference, and Learning Algorithms", D. J. C. MacKay, Cambridge University Press, 2003.
"Information, Physics and Computation", M. Mezard, A. Montanari, Oxford University Press, 2009.
"Biological Sequence Analysis", Durbin, Eddy, Krogh, Mitchison, Cambridge University Press, 1998

Assessment and grading criteria

The final exam can be chosen as either an oral exam on the contents of the course or, alternatively, an individual written project on a topic, closely related to the ones of the course, that has to be agreed upon with the lecturer.