Nature-Inspired methods for Combinatorial Machine Learning

Davide Anguita
Universita degli Studi di Genova
DIBE-Department of Biophysical and Electronic Engineering
Via Opera Pia, 11 a, 16145 Genova, Italy
Email: Anguita@dibe.unige.it

Abstract
Machine learning (ML), and especially Kernel Methods (KM), are one of the key emerging technologies for data processing, analysis and interpretation. Recent results are demonstrating both the theoretical strength of this approach and its effectiveness in solving real world problems. The main target of KM is the construction of a model of the phenomenon which has generated the data under analysis. This process is called "induction" and can be followed by a "deduction" process, which aims at extracting new knowledge from the model (and therefore from the phenomenon itself).
Most mathematical and statistical tools which are the basis for the ML algorithms make use of infinitesimal calculus and its application to statistical and probability theory. In other words, they rely mostly on sets of infinite cardinality among which a model is selected by an induction process (e.g. neural networks with real valued or continuous weights). On one hand, this approach simplifies the analysis of the methods but neglects the fact that no known practical computational method can deal with real numbers, if not relying on approximations.
Unfortunately, one of the main issues in the approach of using discrete and finite cardinality sets of models, from which selecting the optimal one, is the complexity explosion: a phenomenon which is well-known in several scientific fields (e.g. physics and mathematics) and has been the cause for much disillusionment. On the other hand, nature is able to approach and effectively solve very difficult problems in this context. The scope of this work is to identify and propose new research directions for Discrete Machine Learning methods, where the combinatorial explosion of the problem complexity can be attacked by nature-inspired techniques.