Traineeship proposal

Analysis and comparison of parameter tuning for local search algorithms

Location : either University of Nantes (LINA) or University of Angers (LERIA), France

Salary : up to 3000 € for the whole period

Starting date : May 2010

Duration : at least 4 months

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Context

During the last decades, impressive improvements have been achieved to solve complex optimization problems, issued from real world applications, which involve more and more data and constraints. In order to tackle large scale instances and intricate problem structures, sophisticated solving techniques have been developed and combined to provide efficient solvers.

Among the different solving paradigms, local search has been widely used as an incomplete optimization technique for solving such problems. It is now integrated in solvers and combined with other techniques.

Local search mainly relies on the basic concept of neighbourhood. Starting from an initial configuration, a local search algorithm tries to reach the optimum by moving locally from a configuration to one of its neighbours, according to its evaluation. The performance of such an algorithm is strongly related to its ability to explore and exploit the search landscape. For instance, when faced to a very rugged landscape, one should be able to escape from many local optima while in presence of large plateaus, one should be able to widely explore the space.

In order to manage the balance between exploitation and exploration, various efficient heuristics have been proposed, usually relying on stochastic perturbations and restarts. Unfortunately, these heuristics are most of the time controlled by parameters whose setting has a great impact on the efficiency of the algorithm. Well known parameters are for instance the temperature cooling schedule in simulated annealing or the amount of random walk. Parameter tuning is nowadays a crucial issue and various tuning methods have been developed, including a dynamic management of parameters during the solving process.

Work plan

The purpose of this work is to study the influence of the parameters for simple local search algorithms and to define a methodology to compare the benefits of different tuning methods over a representative set of benchmarks.

The work will focus on the well known satisfiability problem (SAT) and on the seminal local search algorithm WalkSat. The SAT problem consists in finding an assignment that satisfies a Boolean expression. An instance of this problem is a Boolean formula written in conjunctive normal form (CNF), *i.e.* a conjunction of clauses. The proposed work can be decomposed into the following stages :

Step 1: collection of experimental data

Considering random SAT benchmarks, whose properties are well known, the purpose is to observe the behaviour of WalkSat *w.r.t.* its parameters values. Of course, it would be too computationally expensive to test all the combinations of parameters/problems and therefore sampling techniques will be necessary, based, for instance, on previous works on parameters relevance or racing techniques.

Step 2 : characterization of benchmarks

SAT benchmarks can be characterized according to various criteria (number of variables, number of clauses, size of the clauses…). Such criteria are used for instance in modern solvers (such as Satzilla) to predict computation time. Therefore this second stage will consist in analyzing problems instances and to study their distribution *w.r.t.* these criteria, in order to propose a notion of representative test set. Higher level criteria could also be proposed.

Step 3 : validation of tuning methods

This stage will be dedicated to the experimental validation of tuning methods (*i.e.* precise approximation of optimal parameters values) against empirical on random settings. Of course, this validation would be related to the famous NoFreeLunch theorems that highlights the fact that the more efficient is an algorithm for a specific problem, the less efficient it is for other instances.

Finally, the general purpose of this work is a fair methodology for analyzing and comparing tuned and specialized solving algorithms.

Research and technical environment

Concerning the technical environment, we have a cluster composed of 200 cores with a power of 566 GFlops and 392 Go total RAM, which allows to perform extensive experimental studies.

The WalkSat algorithm is implemented in C and even if it would not be necessary to modified it, a good programming skill is required.

Research Teams

This intership is part of the Rubis project, which involves the computer science laboratories of Nantes (LINA) and Angers (LERIA). Rubis is funded by the Atlanstic Research Federation. Its goal is to develop a unified framework for local search algorithms and use this framework to study statistical properties on their behaviour.

The LERIA (Laboratory of computer science research of Angers) is composed of 19 permanent members and 16 PhD students or postdocs. Our research group on Metaheuristics and Optimization techniques aims both at studying methodological aspects of solving techniques and designing new efficient algorithms for classes of problems. The group also focus on real world applications through collaborations with industrial partners (telecommunication, transportation, manufacturing…). We have especially worked on metaheuristic algorithms for the SAT problem, see for instance :

Autonomous Operator Management for Evolutionary Algorithms, Jorge Maturana, Frédéric Lardeux, Frédéric Saubion, Journal of Heuristics (2010) to appear.

GASAT: A Genetic Local Search Algorithm for the Satisfiability Problem. Frédéric Lardeux, Frédéric Saubion, Jin-Kao Hao, Evolutionary Computation 14(2): 223-253 (2006)

In Nantes, the LINA (Laboratory of Computer Science of Nantes-Atlantique) has around 70 permanent researchers. The Constraint team works on hybrid methods for constraint solving, and more precisely on a probabilistic study of the behaviour of incomplete algorithms, and on an extension of these methods to continuous problems, for instance :

Charlotte Truchet, Jean-Marie Normand and Marc Christie *A tabu search method for interval constraints*, Proceedings of the 5th International Conference on Integration of AI and OR techniques in Constraint Programming for Combinatorial Optimization Problems (CP-AI-OR'08).

Charlotte Truchet, Damien Noguès et Narendra Jussien, *Un modèle markovien pour GSAT et WalkSAT, résultats préliminaire*s, Proceedings des Journées Francophones de Programmation par Contraintes 2008 (JFPC'08)