



Internship offer at ONERA/IRIT (3IA ANITI, Toulouse, France)

Knowledge Compilation for Incomplete Combinatorial Optimization Techniques - Application to the aerospace field

In combinatorial optimization, the objective is to find an assignment to a set of decision variables that satisfies a set of constraints and that optimizes a given objective function. Such problems are often tackled by **incomplete search techniques** such as local search, tabu search, iterated local search, greedy-randomized adaptive search and on various kinds of metaheuristics. Incomplete search techniques do not offer the guarantee to find an optimal solution, but their main strength is their capacity to find good quality solutions even for large-size instances and even if the computation time is limited.

One common difficulty of incomplete techniques is the need to define **strategies to escape from local optima** and avoid revisiting the same solutions over and over. For instance, in tabu search, a *tabu list* is introduced to forbid considering some solutions or some local moves during a given time-period. This tabu list acts as a kind of memorization that helps the search process being less blind. However, it is usually exploited as a short-term memory, meaning that tabu configurations usually become non-tabu again later in the search process.

In this internship, we aim at exploring Knowledge Compilation (KC) techniques for boosting incomplete search algorithms thanks to long term and efficient memory data structures. The idea is to learn conflicting solutions (that violate some constraints or that are suboptimal) and to exploit them to (i) avoid reconsidering the same solutions and (ii) guide search.

Several directions shall be explored during the internship:

- **On-the-fly knowledge compilation:** Most of the time, KC techniques compile the static part of a problem *offline* and then answer *online* to various requests. Contrarily to this mainstream approach, the challenge is here to perform *on-the-fly knowledge compilation*, to be able to simultaneously search for an optimal solution and learn conflicts.
- **Conflict-based heuristics:** by forbidding some solutions, it might become impossible to make a sequence of local moves towards the highest quality solutions. On this point, one goal is to use the compiled conflict basis to guide the search : the basis can be requestedS to extract a non-conflicting assignment, which can serve to quickly move to a (currently) non-forbidden assignment. Other standard requests such as model counting could also be used, to make the search process move towards solutions which are far from the conflicting solutions.
- **Application to one standard optimization problem:** one key objective is to apply these techniques to problems related to the aerospace field. For this internship, we will consider a class of vehicle routing problems usable for synthesizing acquisition plans for Earth observation satellites. The study shall determine whether specific knowledge compilation techniques should be used to improve the efficiency of the approach.

This research will be conducted at ONERA and/or IRIT, within the stimulating environment of the Artificial and Natural Intelligence Toulouse Institute.

Contact

Helene Fargier, IRIT/CNRS, 3IA ANITI Senior Chair, fargier@irit.fr

Cedric Pralet, ONERA & 3IA ANITI, cpalet@onera.fr

Application profile

Master 2 research project or last-year engineering school internship. The ideal candidate will have a background in combinatorial optimization (e.g. SAT/CSP solvers) and Operations Research.

References

- Hélène Fargier, Pierre Marquis, Alexandre Niveau, Nicolas Schmidt: A Knowledge Compilation Map for Ordered Real-Valued Decision Diagrams. AAAI 2014: 1049-1055.
- Alberto Venturini, Gregory M. Provan: Incremental Algorithms for Approximate Compilation. AAAI 2008: 1495-1498.
- Tarik Hadzic, John N. Hooker, Barry O'Sullivan, Peter Tiedemann: Approximate Compilation of Constraints into Multivalued Decision Diagrams. CP 2008: 448-462.
- Gilles Audemard, Jean-Marie Lagniez, Laurent Simon: Just-In-Time Compilation of Knowledge Bases. IJCAI 2013: 447-453.
- Adnan Darwiche, Pierre Marquis: A Knowledge Compilation Map. J. Artif. Intell. Res. 17: 229-264 (2002).
- Gilles Audemard and Jean-Marie Lagniez and Bertrand Mazure and Lakhdar Sais : Integrating Conflict Driven Clause Learning to Local Search. Proceedings 6th International Workshop on Local Search Techniques in Constraint Satisfaction, 2009.
- Armin Biere, Marijn Heule, Hans van Maaren and Toby Walsh (Eds.) : Conflict Driven Clause Learning, Chapter 4, Handbook of Satisfiability. IOS Press, 2009.
- Michel Gendreau and Jean-Yves Potvin : Handbook of Metaheuristics. Springer Publishing Company, 2010.
- Andreas Schutt, Thibaut Feydy, Peter J. Stuckey and Mark G. Wallace : Solving RCPSP/max by lazy clause generation. Journal of Scheduling 16(3) : 273-289 (2013).