Lagrangian Relaxation in Cost Function Network Optimization

Location:	Institut National de la Recherche en Agronomie Laboratoire de Mathématiques et Informatique Appliquées de Toulouse 24, Chemin de Borde-Rouge, Auzeville-Tolosane (near Toulouse)
Intership level:	M1/M2 in Computer Science or Applied Mathematics
Intership duration:	4–6 months
Requested skills:	Algorithmics, Theory of linear and integer programming, C++
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Introduction. The Cost Function Network (CFN or, equivalently, Markov Random Field (MRF)) formalism for combinatorial optimization has arisen from various fields in Artificial Intelligence. Applications include computational protein design, protein folding, radio frequency assignment, satellite observation scheduling, computer vision and more. Several of these originate from the team at INRA.

The most successful solution techniques for CFNs are based on branch-and-bound search using dual bounds that approximate those produced by the linear relaxation of the instance. However, recent trends have been towards a mix of these techniques with exact solutions of the linear relaxation and even beyond, exploring, for example, higher levels of the Sherali-Adams hierarchy [Sontag, 2010].

Content of the internship. The goal of the internship is to adapt the algorithm used in Lagrangian Relaxation (e.g. Kelley and bundle methods [Lemaréchal, 2001]) to higher order structures —beyond trees— in order to obtain relaxations that are tighter than the linear relaxation. The student will then embed the method into the `toulbar2` CFN solver [Cooper et al., 2006], and use the information collected in the relaxation resolution to improve the solver. The tool will then be benchmarked on different widely studied problem from combinatorics, computer vision, etc.

References

M. Cooper, S. de Givry, M. Sanchez, T. Schiex, and M. Zytnicki. Virtual Arc Consistency for Weighted CSP. In *AAAI'08*, pages 253–258, 2006.

C. Lemaréchal. Lagrangian relaxation. In M. Jünger and D. Naddef, editors, *Computational combinatorial optimization: Papers from the Spring School held in Schloß Dagstuhl*, pages 112–156. Springer-Verlag, 2001.

D. Sontag. *Approximate Inference in Graphical Models using LP Relaxations.* PhD thesis, MIT, 2010.