Introduction to the Special Issue on Local Search Techniques in Constraint Satisfaction

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Constraint satisfaction plays an important role in theoretical and applied computer science. Constraint satisfaction problems (CSPs) are of particular interest to the constraint programming research community and for many real world applications. Along with pure systematic techniques for solving CSPs, stochastic local search (SLS) and hybrid techniques have proved to be very effective on some classes of problems. One central goal of research in SLS for constraint satisfaction is the design and implementation of efficient algorithms for use in stand-alone solvers or in conjunction with systematic techniques. As a result, there is a need to develop high-level SLS strategies that will lead to further progress towards the maturation of efficient and robust solvers for constraint satisfaction.

Just some of the hot topics related to the field of SLS for CSP are modeling, global constraints handling, learning techniques, and hybrid stochastic-systematic search methods. On the more theoretical front, current interests include the mathematical properties of the search space and the probabilistic analysis of algorithm behavior.

The design and analysis of SLS algorithms for constraint satisfaction involves a wide range of issues related to algorithms, programming, statistics, probability and empirical analysis. The design of SLS techniques for CSP is also a typical system engineering process, as it involves modeling, design, analysis and implementation activities. Moreover, empirical analysis is crucial for the assessment of performance results and it has to comply with the scientific approach.

This special issue of Constraints offers a representative selection of the current state-of-the-art in local search techniques for constraint satisfaction. The selected papers cover a broad spectrum of issues in the field, from applications to modeling.

The contribution by Ågren et al. describes the use of second-order logic, extended with counting, for modeling constraints. The authors show how this approach can simplify the design of local search by automatically providing data structures and functions for penalty evaluations. This work is an example of the research trend focused on developing software engineering tools and methodologies for the design and implementation of local search algorithms.

The paper by Chiarandini and Stützle provides an example of the design process of an effective and efficient stochastic local search solver for a hard constrained combinatorial optimization problem. Chiarandini and Stützle describe the development process of an SLS technique to tackle the Graph Set T-Colouring problem, which has real-world applications such as frequency assignment problems. In addition to its specific contribution to the problem, the work demonstrates that the design of an effective SLS solver has to rely on accurate empirical analysis.

Another application of SLS is discussed in the paper by Cotta et al., in which the authors design a hybrid solver for attacking the Golomb Rulers problem. The contribution of this paper consists primarily in showing how to effectively combine algorithmic components originated from different solvers. This process of hybridization is extremely relevant nowadays. The work raises issues that go beyond the implementation of single algorithms, such as the definition of a sound methodology for assessing the contribution of the single components to the whole solver and the selection of the best combination of components.

The stream concerning the study of expressive modeling languages and suitable SLS solvers is another relevant trend in this research field. The paper by Liu and Truszczyński addresses local search methods for tackling problems in which constraints are defined as Boolean combinations of pseudo-Boolean constraints. The authors describe a local search algorithm designed for tackling such formulations, including the adaptation of some high performance SAT heuristics.

The contribution by Grégoire et al. concludes the selection of papers. Their work shows the use of a hybrid approach for finding minimally unsatisfiable subformulas (MUSes) of SAT instances. The technique presented is based on the concept of critical clauses and incorporates a local search core that enables the algorithm to efficiently find MUSes. This paper shows that, notwithstanding decades of research and theoretical results, SAT is still providing AI researchers with challenging problems that can often be faced only by integrating techniques of different natures.

The five papers composing this issue have been selected from 15 submissions. Our reviewers thoroughly evaluated the papers and we are very grateful to them for this effort. Their comments and suggestions were extremely helpful in selecting the contributions and, we believe, valuable for the authors themselves. We would like to thank all the authors who showed their interest in this special issue, and Peter Van Beek for giving us the opportunity to serve as editors.