Taming the Complexity Monster or: How I learned to Stop Worrying and Love Hard Problems

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ABSTRACT

We live in interesting times - as individuals, as members of various communities and organisations, and as inhabitants of planet Earth, we face many challenges, ranging from climate change to resource limitations, from market risks and uncertainties to complex diseases. To some extent, these challenges arise from the complexity of the systems we are dealing with and of the problems that arise from understanding, modelling and controlling these systems. As computing scientists and IT professionals, we have much to contribute: solving complex problems by means of computer systems, software and algorithms is an important part of what our field is about.

In this talk, I will focus on one particular type of complexity that has been of central interest to the evolutionary computation community, to artificial intelligence and far beyond, namely computational complexity, and in particular, $\mathcal{NP}$-hardness. I will investigate the question to which extent $\mathcal{NP}$-hard problems are as formidable as is often thought, and present an overview of several directions of research that aim to characterise and improve the behaviour of cutting-edge algorithms for solving $\mathcal{NP}$-hard problems in a pragmatic, yet principled way. For prominent problems ranging from propositional satisfiability (SAT) to TSP and from AI planning to mixed integer programming (MIP), I will demonstrate how automated analysis and design techniques can be used to model and enhance the performance characteristics of cutting-edge solvers, sharing some surprising insights along the way.

CCS Concepts

•General and reference → Empirical studies; Design; Performance; •Theory of computation → Complexity classes; Design and analysis of algorithms; *Algorithm design techniques; Automated reasoning;* **•Computing methodologies → Machine learning; Search methodologies;**

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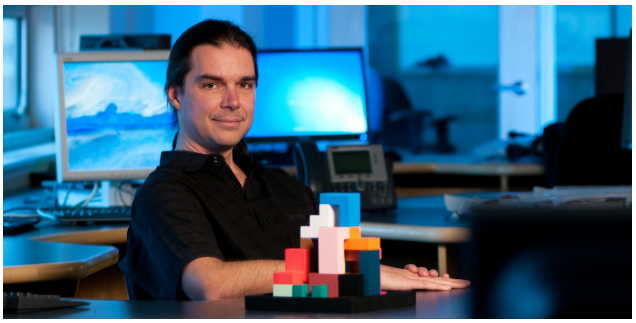
Keywords

computational complexity; NP-hardness; empirical algorithmics; scaling analysis; automated algorithm design; programming by optimisation (PbO)

Author Bio

Holger H. Hoos is a Professor of Computer Science at the University of British Columbia (Canada) and a Faculty Associate at the Peter Wall Institute for Advanced Studies. His main research interests span empirical algorithmics, artificial intelligence, bioinformatics and computer music. He is known for his work on the automated design of high-performance algorithms and on stochastic local search methods. Holger is a co-author of the book "Stochastic Local Search: Foundations and Applications", and his research has been published in numerous book chapters, journals, and at major conferences in artificial intelligence, operations research, molecular biology and computer music. Holger was elected a Fellow of the Association for the Advancement of Artificial Intelligence (AAAI) in 2015 and won two prestigious IJCAI/JAIR best paper prizes in 2009 and 2010. He is a past president of the Canadian Artificial Intelligence Association / Association pour l'intelligence artificielle au Canada (CAIAC) and Associate Editor of the Journal of Artificial Intelligence Research (JAIR). His group has helped UBC to produce better exam timetables, Actenum Inc. to increase production efficiency in the oil and gas industry, and IBM to improve their CPLEX optimisation software, which is used by 50% of the world's largest companies and thousands of universities. For further information, visit Holger's webpage at www.cs.ubc.ca/∼hoos.



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