Automated Mechanism Design

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Mechanisms design has traditionally been a manual endeavor. In 2002, Conitzer and Sandholm introduced the automated mechanism design (AMD) approach, where the mechanism is computationally created for the specific problem instance at hand. This has several advantages: 1) it can yield better mechanisms than the ones known to date, 2) it applies beyond the problem classes studied manually to date, 3) it can circumvent seminal economic impossibility results that hold for classes of problems but not all instances, and 4) it shifts the burden of design from man to machine. In this talk I will overview our results on AMD to date. I will cover problem representations and the computational complexity of different variants of the design problem. Initial applications include revenue-maximizing combinatorial auctions and (combinatorial) public goods problems. Algorithms for AMD will be discussed. To reduce the computational complexity of designing optimal combinatorial auctions, I introduce an incentive compatible, individually rational subfamily called Virtual Valuations Combinatorial Auctions. The auction mechanism's revenue can be boosted (started, for example, from the VCG) by hill-climbing in this subspace. I will also present computational complexity and communication complexity results that motivate multi-stage and non-truth-promoting mechanisms. Finally, I present our first steps toward automatically designing multi-stage mechanisms.

Our work on automated mechanism design is covered in the following papers, and the talk presents selected results from them:

Early overview

o Sandholm, T. 2003. Automated mechanism design: A New Application Area for Search Algorithms. In Proceedings of the *International Conference on Principles and Practice of Constraint Programming (CP)*. Paper corresponding to an invited talk. (The review part is about joint research with Vincent Conitzer.)

Research on the general problem

o Conitzer, V. and Sandholm, T. 2004. Self-Interested Automated Mechanism Design and Implications for Optimal Combinatorial Auctions. In Proceedings of the *ACM Conference on Electronic Commerce (ACM-EC), pp. 132-141*.

o Conitzer, V. and Sandholm, T. 2004. An Algorithm for Automatically Designing Deterministic Mechanisms without Payments. In Proceedings of the *International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, pp. 128-135, New York, July 19-23. Early version appeared in Proceedings of the *IJCAI-03 Workshop on Distributed Constraint Reasoning*, Acapulco, Mexico.

- Conitzer, V. and Sandholm, T. 2003. Applications of automated mechanism design. In Proceedings of the *UAI Bayesian Modeling Applications Workshop*, Acapulco, Mexico. Extended version.
- Conitzer, V. and Sandholm, T. 2003. Automated mechanism design with a structured outcome space. Draft.
- Conitzer, V. and Sandholm, T. 2002. Complexity of Mechanism Design. In Proceedings of the *18th Conference on Uncertainty in Artificial Intelligence (UAI)*, August 1-4, Edmonton, Canada.
- Conitzer, V. and Sandholm, T. 2003. Automated Mechanism Design: Complexity Results Stemming from the Single-Agent Setting. In Proceedings of the *International Conference on Electronic Commerce (ICEC)*, Pittsburgh, September 30 – October 3.

Specialized techniques for combinatorial auctions, auctions, and other selling mechanisms

- Likhodedov, A. and Sandholm, T. 2005. Approximating Revenue-Maximizing Combinatorial Auctions. In Proceedings of the *National Conference on Artificial Intelligence (AAAI)*, Pittsburgh, PA.
- Likhodedov, A. and Sandholm, T. 2004. Methods for Boosting Revenue in Combinatorial Auctions. In Proceedings of the *National Conference on Artificial Intelligence (AAAI)*, pp. 232-237, San Jose, California.
- Sandholm, T. and Gilpin, A. 2003. Sequences of Take-It-or-Leave-It Offers: Near-Optimal Auctions without Full Valuation Revelation. In Proceedings of the *AAMAS workshop on Agent-Mediated Electronic Commerce (AMEC V)*, Melbourne, Australia.
- Likhodedov, A. and Sandholm, T. 2004. Mechanism for Optimally Trading Off Revenue and Efficiency in Multi-unit Auctions. Short paper in proceedings of the *ACM Conference on Electronic Commerce*. Extended version. (Early version in Proceedings of the *AAMAS workshop on Agent-Mediated Electronic Commerce (AMEC V)*, Melbourne, Australia, 2003.)