UNIVERSITY OF MASSACHUSETTS AMHERST

Resource-Bounded Reasoning Lab

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Research Areas

- anytime algorithms
- automated planning
- autonomous systems
- bounded rationality
- combinatorial optimization
- coordination
- cost-sensitive learning
- decentralized planning
- decision theory
- heuristic search
- metareasoning
- models of rational agency
- multi-agent systems
- probabilistic reasoning
- real-time decision-making
- reinforcement learning

The Resource-Bounded Reasoning Lab conducts research on the computational foundations of automated reasoning and action. We are particularly interested in the implications of uncertainty and limited computational resources on the design of autonomous agents. In most practical settings, it is not feasible to find the optimal action, making it necessarily to resort to some form of approximate reasoning. This raises a simple fundamental question: what does it mean for an agent to be "rational" when it does not have enough knowledge or computational power to derive the best course of action? Our overall approach to this problem is based on probabilistic reasoning and decision-theoretic principles, used both to develop planning algorithms and to monitor their execution and maximize the value of computation. The meta-level control components reason explicitly about the cost of decision-making and can optimize the amount of deliberation (or "thinking") an agent does before taking action. This research spans both theoretical issues and the development of effective algorithms and applications. We have recently developed new models for planning in situations involving multiple decision makers operating in either collaborative or adversarial domains. We are also working on decision-theoretic techniques to model and exploit bounded rationality and opponent models in decentralized settings.

CURRENT RESEARCH PROJECTS

Decision-Theoretic Foundations for Multi-Agent Systems

Developing new models (particularly decentralized MDPs) and algorithms for planning in situations that involve multiple decision makers, each having different partial information about the domain. In collaboration with the Multi-Agent Systems Lab (UMass). Sponsored by AFOSR and NSF.

Adaptive Optimization Techniques for Large Scale Stochastic Planning

Developing robust algorithms for planning under uncertainty in very large domains using approximate linear programming. Sponsored by AFOSR.

Foundations and Applications of Generalized Planning

Developing rich new plan representations that include branches and loops, and creating new ways to produce automatically algorithm-like plans that can apply to a large class of problem instances. In collaboration with Prof. Neil Immerman (UMass).

Resource-Bounded Reasoning Techniques for Autonomous Systems

Developing anytime planning algorithms that offer a tradeoff between computational resources and solution quality, and developing mixed human-robot control for semi-autonomous systems. In collaboration with INRIA and Univ. of Caen (France).

Online Planning for Decentralized POMDPs

Developing effective techniques for online coordination of multi-agent systems with limited communication. In collaboration with USTC (China).

RECENT PUBLICATIONS

D.S. Bernstein, C. Amato, E.A. Hansen, and S. Zilberstein. "Policy Iteration for Decentralized Control of Markov Decision Processes", *Journal of Artificial Intelligence Research*, 34:89-132, 2009.

C. Amato and S. Zilberstein, "Achieving Goals in Decentralized POMDPs", *Proc. of the 8th International Conference on Autonomous Agents and Multiagent Systems*, Budapest, Hungary, 2009.

A. Kumar and S. Zilberstein, "Constraint-Based Dynamic Programming for Decentralized POMDPs with Structured Interactions", *Proc. of the 8th International Conference on Autonomous Agents and Multiagent Systems*, Budapest, Hungary, 2009.

Sven Seuken and S. Zilberstein. "Formal Models and Algorithms for Decentralized Decision Making Under Uncertainty", *Autonomous Agents and Multi-Agent Systems*, 17(2):190-250, 2008.

C.V. Goldman and S. Zilberstein. "Communication-Based Decomposition Mechanisms for Decentralized MDPs", *Journal of Artificial Intelligence Research*, 32:169–202, 2008.

M. Petrik and S. Zilberstein. "Learning Heuristic Functions Through Approximate Linear Programming", *Proc. of the 18th Intl Conference on Automated Planning and Scheduling*, Sydney, Australia, 2008.

S. Srivastava, N. Immerman, and S. Zilberstein. "Learning Generalized Plans Using Abstract Counting", *Proc. of the 23rd Conference on Artificial Intelligence*, Chicago, 2008.

A. Carlin and S. Zilberstein. "Value-Based Observation Compression for DEC-POMDPs." *Proc. of the 7th International Conference on Autonomous Agents and Multiagent Systems*, Estoril, Portugal, 2008.

C.V. Goldman, M. Allen, and S. Zilberstein. "Learning to Communicate in a Decentralized Environment", *Autonomous Agents and Multi-Agent Systems*, 15(1):47-90, 2007.