Robust probabilistic inference engines for autonomous agents

Stefano Ermon
Stanford University
Problem Solving in AI

What to compute?

How to compute?

Problem instance → Model Generator (Encoder) → General Reasoning Engine → Solution

Domain-specific instances → General modeling language and algorithms

Problem solving in AI:

Separate modeling from algorithms
Problem Solving in AI

What to compute?

How to compute?

Problem instance → Model Generator (Encoder) → General Reasoning Engine → Solution

Domain-specific instances

General modeling language and algorithms

Safety and reliability require:

1. precise models
2. accurate reasoning techniques
Challenges in reasoning about complex systems

- Preferences and Utilities
- Optimization
  - Combinatorial Optimization
  - Stochastic Optimization
- Decision-making
  - Probabilistic Reasoning
- Statistics
- High-dimensional Spaces
- Lack of information/Uncertainty
Challenges in reasoning about complex systems

Theorem provers, logical reasoning, SAT solvers, soundness, certificates of optimality, ...

Preferences and Utilities

Optimization

Stochastic Optimization

Decision-making

Probabilistic Reasoning

Program synthesis

High-dimensional Spaces

Lack of information/Uncertainty
Proposal and recent results

Proposal: use *combinatorial reasoning/optimization* techniques (logic, verification, synthesis) for *probabilistic reasoning* tasks (machine learning)

- Algorithms that can provide **certificates/proofs of accuracy**
- Handle **extreme (unsafe) events**
- Can support deterministic + probabilistic dependencies

• Some recent results:
  - Satisfiability Modulo Theory solvers for statistical hypothesis testing (Zhao et al., AAAI-2016)
  - Integer Linear Programming for sampling (Kim et al., AAAI-2016)
  - Integer Linear Programming and SAT for decision making under uncertainty (Xue et al., NIPS-2016)
  - Variational methods with guarantees (Achim et al., AISTATS-2016)
Thanks!