Modern Planning Techniques

John Levine
AI Applications Institute
Division of Informatics
University of Edinburgh

Contents

• Introduction
• SAT Planning: Blackbox
• Heuristic Planning: FF
• Policy-Based Planning
• Optimisation of Plans
• Knowledge in Planning
Introduction

- What is Planning?
- Some Connections to NLP
- Modern Planning
- Assumptions for Planning
- Classification of Planners
What is Planning?

“The solution of a problem – any problem – consists in discovering how to transform an existing state of affairs into one that has not yet come into being.”

– Margaret Donaldson, “Children’s Minds”
Some Connections to NLP

- Language as part of rational behaviour
- Planning in the generation of language
- Allowing planning systems to communicate plans
Modern Planning

• Much progress in the last 6-8 years

• Planners which search are more efficient

• New knowledge-based techniques

• New approaches to learning in planning

• New approaches to optimisation

• The AIPS competitions and benchmarks
Assumptions for Planning

- No interfering agents in the world
- No interfering external events
- All actions are deterministic
- Planner has complete knowledge
- All world states are sets of facts
- No fuzziness or uncertainty
- Actions are quantum transitions
Classification of Planners

- Linear planners
- Parallel time-step planners
- Partial-order planners
- Search-based planners
- Knowledge-based planners
- Planners which learn
SAT Planning: Blackbox

- Kautz and Selman, 1998
- Blackbox = SATPlan + Graphplan
- Parallel time-step planner
- Creates a planning graph
- Converts to CNF for SAT solving
- Various SAT solvers
Blackbox: Performance

- MUCH better than SATPlan or Graphplan
- Extremely good at logistics problems
- Not so brilliant for other benchmarks
- Can encode domain-dependent knowledge
- Tends to run out of memory due to the size of the planning graph
Heuristic Planning: FF

- Hoffmann and Nebel, 2001
- Linear planner
- Son of HSP (Bonet and Geffner, 1998)
- FF uses enforced hill-climbing
- Heuristic from relaxed problem, \( \mathcal{P}' \)
- Solve \( \mathcal{P}' \) using graphplan
FF: Performance

• Fastest search-based planner at AIPS 2000

• Creates over-long plans

• Incomplete strategy $\rightarrow$ best-first search

• Very good at all competition domains

• Not good at all domains
Search-Based Planning: Summary

- MUCH better than it used to be
- Very active research area
- Restrictive assumptions
- Somewhat artificial benchmarks
- Loses out to knowledge-based planners
- “I don’t plan – I just do.”
Policy-Based Planning

- TLPlan (Baccus and Kabanza, 1998)
- SHOP (Nau et al., 1999)
- TALPlanner (Doherty and Kvarnström, 2000)

- All these are linear planners

- Plan using \(<state, goal> \rightarrow action\) rules:
  1. If you can grab a well-placed block, do it.
  2. Put any non-well-placed block on the table.

- Policy set = planning algorithm
Policy Sets: Performance

- Complete and very fast
- MUCH faster than search-based planners
- Creates non-optimal (over-long) plans
- Need to encode the policy sets by hand
- Learning policies:
  - Khardon (1999)
  - Martín and Geffner (2000)
Optimisation of Plans

• ANY plan? Or the best plan?

• Optimizing policy-generated plans:
  • Ambité and Knoblock (1998)
    – Uses hand-encoded rewrite rules
  • Westerberg and Levine (2001)
    – Genetic optimisation
    – Domain independent technique
    – Also works as a post-processor
O-Plan Optimal

• O-Plan (Currie and Tate, 1991) is an expansion-based HTN planner
  – choice of schema, $S_i$, for high-level action $A_k$
  – choice of resources, $R_i = \{r_0, r_1 \ldots r_n\}$ to use for $S_i$

• Partial-order planner

• O-Plan Optimal (Ruscio, Levine, Kingston, Kothari):
  – Simplified version of O-Plan
  – All choices encoded as a genotype
  – Final scheduled plan is the phenotype
  – Try to find the optimal plan
Knowledge in Planning

1. Decision theoretic planning

2. Deterministic policy rules

3. Probabilistic policy rules

4. Shortcuts, e.g. HTN schemas

5. Domain specific heuristics $h(s_i, g)$

6. Search control rules

All of these can be learnt...