

Lecture slides for
Automated Planning: Theory and Practice

Review for the Midterm Exam

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The Chapters We've Covered

- Chapter 1: Introduction
- Chapter 2: Representations for Classical Planning
- Chapter 3: Complexity of Classical Planning
- Chapter 4: State-Space Planning
- Chapter 5: Plan-Space Planning
- Chapter 6: Planning-Graph Techniques
- Chapter 7: Propositional Satisfiability Techniques
- Chapter 16: Planning based on MDPs
- Chapter 17: Planning based on Model Checking
- Chapter 9: Heuristics in Planning

Chapter 1: Introduction and Overview

- 1.1: First Intuitions on Planning
- 1.2: Forms of planning
- 1.3: Domain-Independent Planning
- 1.4: Conceptual Model for Planning
- 1.5: Restricted Model
- 1.6: Extended Models
- 1.7: A Running Example: Dock-Worker Robots

**No questions
on Chapter 1**

2: Representations for Classical Planning

- 2.1: Introduction
- 2.2: Set-Theoretic Representation
 - ◆ 2.2.1: Planning Domains, Problems, and Solutions
 - ◆ 2.2.2: State Reachability
 - ◆ 2.2.3: Stating a Planning Problem
 - ◆ 2.2.4: Properties of the Set-theoretic Representation
- 2.3: Classical Representation
 - ◆ 2.3.1: States
 - ◆ 2.3.2: Operators and Actions
 - ◆ 2.3.3: Plans, Problems, & Solutions

- ◆ 2.3.4: Semantics of Classical Representations
 - 2.4: Extending the Classical Rep.
 - ◆ 2.4.1: Simple Syntactical Extensions
 - ◆ 2.4.2: Conditional Planning Operators
 - ◆ 2.4.3: Quantified Formulas
 - ◆ 2.4.4: Disjunctive Goals
 - ◆ 2.4.5: Axiomatic Inference
 - ◆ 2.4.6: Function Symbols
 - ◆ 2.4.7: Attached Procedures
 - ◆ 2.4.8: Extended Goals
 - 2.5: State-Variable Representation
 - ◆ 2.5.1: State Variables
 - ◆ 2.5.2: Operators and Actions
 - ◆ 2.5.3: Domains and Problems
 - ◆ 2.5.4: Properties
 - 2.6: Comparisons
- Didn't cover these, so no questions on them**

Chapter 3: Complexity of Classical Planning

- 3.1: Introduction
- 3.2: Preliminaries
- 3.3: Decidability and Undecidability Results
- 3.4: Complexity Results
 - ◆ 3.4.1: Binary Counters
 - ◆ 3.4.2: Unrestricted Classical Planning
 - ◆ 3.4.3: Other results
- 3.5: Limitations

**No questions
on this chapter**

Chapter 4: State-Space Planning

- 4.1: Introduction
- 4.2: Forward Search
 - ◆ 4.2.1: Formal Properties
 - ◆ 4.2.2: Deterministic Implementations
- 4.3: Backward Search

- 4.4: The STRIPS Algorithm
- 4.5: Domain-Specific State-Space Planning
 - ◆ 4.5.1: The Container-Stacking Domain
 - ◆ 4.5.2: Planning Algorithm

**No questions
on these**

Chapter 5: Plan-Space Planning

- 5.1: Introduction
- 5.2: The Search Space of Partial Plans
- 5.3: Solution Plans
- 5.4: Algorithms for Plan Space Planning
 - ◆ 5.4.1: The PSP Procedure
 - ◆ ~~5.4.2: The PoP Procedure~~
- ~~5.5: Extensions~~
- 5.6: Plan Space Versus State Space Planning

Didn't cover these, so no questions on them

Chapter 6: Planning-Graph Techniques

- 6.1: Introduction
- 6.2: Planning Graphs
 - ◆ 6.2.1: Reachability Trees
 - ◆ 6.2.2: Reachability with Planning Graphs
 - ◆ 6.2.3: Independent Actions and Layered Plans
 - ◆ 6.2.4: Mutual Exclusion Relations
- 6.3: The Graphplan Planner
 - ◆ 6.3.1: Expanding the Planning Graph
 - ◆ 6.3.2: Searching the Planning Graph
 - ◆ 6.3.3: Analysis of Graphplan
- ~~● 6.4: Extensions and Improvements of Graphplan~~
 - ~~◆ 6.4.1: Extending the Language~~
 - ~~◆ 6.4.2: Improving the Planner~~
 - ~~◆ 6.4.3: Extending the Independence Relation~~

use my lecture notes

**Didn't cover this,
so no questions on it**

7: Propositional Satisfiability Techniques

- 7.1: Introduction
- 7.2: Planning problems as Satisfiability problems
 - ◆ 7.2.1: States as propositional formulas
 - ◆ 7.2.2: State transitions as propositional formulas
 - ◆ 7.2.3: Planning problems as propositional formulas
- 7.3: Planning by Satisfiability
 - ◆ 7.3.1: Davis-Putnam
 - ◆ 7.3.2: Stochastic Procedures

No questions on the satisfiability algorithms

- ~~● 7.4: Different Encodings
 - ◆ 7.4.1: Action Representation
 - ◆ 7.4.2: Frame axioms~~

Didn't cover this, so no questions on it

Chapter 16: Planning Based on MDPs

- 16.1: Introduction
- 16.2: Planning in Fully Observable Domains
 - ◆ 16.2.1: Domains, Plans, and Planning Problems
 - ◆ 16.2.2: Planning Algorithms

- ~~● 16.3: Planning under Partial Observability
 - ~~◆ 16.3.1: Domains, Plans, and Planning Problems~~
 - ~~◆ 16.3.2: Planning Algorithms~~~~
- ~~● 16.4: Reachability and Extended Goals~~

Didn't cover these, so no questions on them

17: Planning based on Model Checking

- 17.1: Introduction
- 17.2: Planning for Reachability Goals
 - ◆ 17.2.1: Domains, Plans, and Planning Problems
 - ◆ 17.2.2: Planning Algorithms
- 17.3: Planning for Extended Goals
 - ◆ 17.3.1: Domains, Plans, and Planning Problems
 - ◆ 17.3.2: Planning Algorithms
 - ◆ 17.3.3: Beyond Temporal Logics
- 17.4: Planning under Partial Observability
 - ◆ 17.4.1: Domains, Plans, and Planning Problems
 - ◆ 17.4.2: Planning Algorithms
- 17.5: Planning as Model Checking vs. MDPs

Didn't cover these, so no questions on them

Chapter 9: Heuristics in Planning

- 9.1: Introduction
- 9.2: Design Principle for Heuristics: Relaxation
- 9.3: Heuristics for State-Space Planning
 - ◆ 9.3.1: State Reachability Relaxation
 - ◆ 9.3.2: Heuristically Guided Backward Search
 - ◆ 9.3.3: Admissible State-Space Heuristics
 - ~~◆ 9.3.4: Graphplan as a Heuristic Search Planner~~ **No questions on this**
- 9.4: Heuristics for Plan-Space Planning
 - ◆ 9.4.1: Flaw-Selection Heuristics
 - ~~◆ 9.4.2: Resolver-Selection Heuristics~~ **Didn't cover this, so no questions on it**

The Exam

- Open book, open notes (closed neighbor)
- My exams are usually quite hard, **but**
 - ◆ I grade on a curve
 - ◆ Recall from the syllabus that during the final exam, you can choose how to weight each exam
- Statistics from some previous times I taught the course:

	2003	2004	2005	2007	2008
Midterm exam average:	72	60	75	72.5	75
Average final grade:	3.4	3.6	3.6	3.1	3.7

Miscellaneous

- If you have questions, please post them to the discussion forum rather than emailing me
 - ◆ Others might like to see the answers too!
- Sample exams: go to the “schedule and lecture notes” page, click on “private materials”
 - ◆ Send me email if you’ve forgotten the name/password
 - ◆ Midterm and final exams for three semesters
 - » The ones from 2007 and 2008 include answers
 - » No answers for the 2005 ones
 - Also, I covered the chapters in a different order that time