Lecture slides for
Automated Planning: Theory and Practice

Review for the Final Exam

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5:12 PM   April 30, 2012

What 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 10: Control Rules in Planning*
- Chapter 11: Hierarchical Task Network Planning*
- Chapter 14: Temporal Planning*

* These weren't on the midterm

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

No questions on these topics unless they were covered in other chapters:
  - 2.3.4: Semantics of Classical Reps
- 2.4: Extending the Classical Rep.
  - 2.4.1: Simple Syntactical Extensions
  - 2.4.2: Conditional Planning Operators
  - 2.4.3: Quantified Expressions
  - 2.4.4: Disjunctive Preconditions
  - 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

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

You don't need to know the details of the complexity tables, but you should know the basic concepts, e.g.:

- What does it mean to allow or disallow function symbols, negative effects, etc.?

- What's the difference between giving the operators in the input or in advance?

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~~ **No questions on this topic**
- 4.5: Domain-Specific State-Space Planning
  - ◆ 4.5.1: The Container-Stacking Domain
  - ◆ 4.5.2: Planning Algorithm

Chapter 5: Plan-Space Planning

No questions on these topics

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

  **use my lecture notes
  rather than the book**

- 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

  **No questions
  on these topics**

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 these topics

- 7.4: Different Encodings
  - 7.4.1: Action Representation
  - 7.4.2: Frame axioms

  No questions on these topics

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

No questions on these topics

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

No questions on these topics

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

Instead of this, I presented *FastForward*'s heuristic. Use my lecture notes instead of the text.

- 9.4: Heuristics for Plan-Space Planning
  - ◆ 9.4.1: Flaw-Selection Heuristics
  - ◆ ~~9.4.2: Resolver-Selection Heuristics~~

No questions on this topic

Chapter 10: Control Rules in Planning

● Intro to Part III: Heuristics and Control Strategies

● 10.1: Introduction

● 10.2: Simple Temporal Logic **Use the notation in my lecture notes rather than the book**

● 10.3: Progression

● 10.4: Planning Procedure

● 10.5: Extensions

● ~~10.6: Extended Goals~~ **No questions on this topic**

Chapter 11: HTN Planning

- 11.1: Introduction
- 11.2: STN Planning
  - 11.2.1: Tasks and Methods
  - 11.2.2: Problems and Solutions
- 11.3: Total-Order STN Planning
- 11.4: Partial-Order STN Planning
- ~~11.5: HTN Planning~~   **No questions on this topic**
- 11.6: Comparisons
  - ~~11.6.1: HTN Planning Versus STN Planning~~   **No questions on this topic**
  - 11.6.2: HTN Methods Versus Control Rules
- 11.7: Extensions
  - 11.7.1: Extensions from Chapter 2
  - ~~11.7.2: Additional Extensions~~
- ~~11.8: Extended Goals~~   **No questions on these topics**

Chapter 14: Temporal Planning

- 14.1: Introduction
- 14.2: Planning with Temporal Operators
  - ◆ 14.2.1: Temporal Expressions and Temporal Databases
  - ◆ 14.2.2: Temporal Planning Operators
  - ◆ 14.2.3: Domain axioms
  - ◆ 14.2.4: Temporal Planning Domains, Problems and Plans
  - ◆ 14.2.5: Concurrent Actions with Interfering Effects
  - ◆ 14.2.6: A Temporal Planning Procedure

No questions on these topics

- 14.3: Planning with Chronicles
  - ◆ 14.3.1: State Variables, Timelines and Chronicles
  - ◆ 14.3.2: Chronicles as Planning Operators
  - ◆ 14.3.3: Chronicle Planning Procedures
  - ◆ 14.3.4: Constraint Management in CP
  - ◆ 14.3.5: Search Control in CP

No questions on these topics

The Exam

- Tuesday, May 15, 1:30–3:30 according to Testudo:
  - http://www.testudo.umd.edu/soc/exam201201.html

- Closed book, but you may bring two pages of notes
  - You can write on both sides

- No electronic devices
  - Numeric calculations will be simple enough that you won't need a calculator

Studying for the Exam

- On the password-protected page, I've posted copies of old exams
  - both with and without answers
- Send me email if you've forgotten the name/password

- For each exam, look first at the version that has no answers, and try to write your own answers
  - Then look at the version that has answers, and compare those answers to yours

Miscellaneous

- If you have questions about what we've covered, please post them to Piazza rather than sending email

  - You'll get an answer faster

  - Others might like to see the answers