Advanced Topics in AI: Planning

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Advanced Topics in AI: Planning

1. Introduction: What is "automated planning" about?
2. A proposal for course format.
3. Topics and resources.

What is "Automated Planning"?

- "*Planning is the art and practice of thinking before acting.*"
- The study of the complete or partial automation of all aspects of creating, modifying, managing, executing and monitoring plans of action.
- Creating "the Universal Puzzle Solver".

Think of Puzzles...
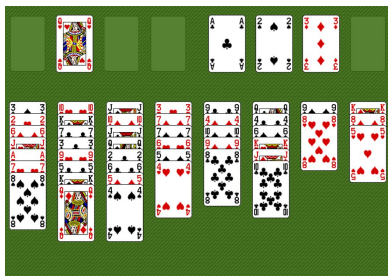
- 15-Puzzle
- Rubik's Cube
- Sokoban
- FreeCell

Real Puzzles: Airport Traffic Control
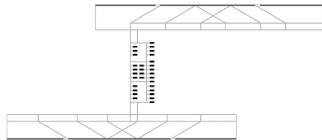

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Figure from Trüg, Hoffmann & Nebel.

- Route aircraft between runways and terminals.
- Aircraft must be kept safely separated!
  Safe distance depends on aircraft size and mode of travel (pushing or under own power).
- Minimize taxi and wait times.

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Real Puzzles: Manufacturing Automation

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- "Pick & Place" in circuit-board manufacturing.
- Plan component placement order & grouping, tray allocation, and movement path.
- Minimize (average) completion and reconfiguration time, subject to complex constraints (*e.g.* vibrations, acceleration, heat).

Real Puzzles: Genome Rearrangement
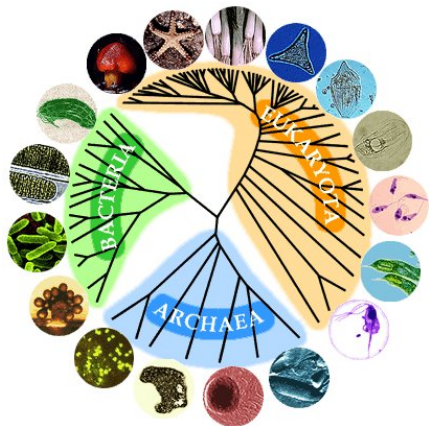
- The relationship between different organisms can be measured by the number of "evolution events" (rearrangements) that separate their genomes.
- Find shortest (or most likely) sequence of rearrangements between pairs of genomes.

The Planner: A Universal Puzzle Solver

- What do all puzzles have in common?
  - There are **rules** which define the legal "moves" of the game.
  - There is an **objective**: A goal state to reach, and a measure of solution cost.
- To a **domain-independent** automatic planner, formal **descriptions** of the rules and objective are given as **input** along with an instance of the problem to solve.
- The hardness of the domain-independent planning problem depends on the **expressivity** of the **input language**.

Proposed Course Organisation

- "Reading-Circle":
  - *N* topics studied by *X* students (starting points, references & resources provided).
  - Discussion / Q&A times instead of lectures.
  - Presentation to the rest of the group (examination).
- Questions:
  - Students / topic and topics / student?
  - Topics?
  - Objections to this idea?
- Alternatives:
  - Traditional lecturing course.
  - Implementation project.

Topics in Planning

1. Representation.
2. Search & Heuristics.
3. Planning with Time / Scheduling.
4. Planning in the Real World (tm).
5. The Planning Competition.
6. Additional topics.

1. Representation

An automated planner takes as input a description of the problem.
What different forms can this description take? Does it matter?
What can we do with it, besides solving the problem?

- STRIPS, ADL, PDDL, SAS, HTN – What does it all mean?
- Expressivity and computational complexity.
- Inference and analysis.

2. Search & Heuristics

Almost all automated planners rely on search, in form or another.
In what different ways can the search for a plan be organised?
How is the search guided towards a solution?

- State-space and plan-space search.
- Heuristics (admissible & inadmissible)
- Encodings into SAT, CSP and IP.

3. Planning with Time / Scheduling

What is the difference between planning and scheduling? How can the two be combined? Are there interesting problems that lie somewhere between them?

- Extending classical planning methods to deal with time.
- Temporal planning: Models, expressivity and complexity.
- Scheduling and scheduling-like planning methods.

4. Planning in the Real World

Where do we find applications of planning? What are the characteristics of application problems? Are current planners up to dealing with such problems? Are there issues other than solving the planning problem that are important when moving automated planning into "the real world"?

- Potential and fielded applications.
- Knowledge engineering and management.
- Plan execution, monitoring and management, user interaction and mixed-initiative planning.
- Remaining challenges.

5. The Planning Competition

The International Planning Competition (IPC) has been held five times in the last 10 years. What influence has it had on research in planning? How has the competition evolved, and in what direction should it evolve in the future?

- Evolution of "the state of the art".
- Impact: trends in the competition and in planning research.
- Benchmark domains and problems.

6. Additional Topics

- Planning under uncertainty
  - Probabilistic & non-deterministic problems.
  - Adversarial planning.
- Distributed & coordinated planning & scheduling.
- Plan recognition, reuse and modification.
- Learning in planning.