Search Techniques in AI and Robotics

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Note: Some of the pictures in this talk have been taken from the WWW but the source is no longer known.

AI and Robotics

Planning and search (almost) started with robotics:
- Shakey [1966-1972]: Box Pushing
- GPS: [1957]: Towers of Hanoi
- SHRDLU [1968-1970]: Blocksworld

Search in AI

Search Problems in AI
- States are given and discrete
- Off-line search
- One can concentrate on planning (execution follows)
- Real-time constraints do not exist
- Search space does not fit into memory

Search in Robotics

Search Problems in Robotics
- States are not given, continuous and often hard to characterize
- On-line search
- Planning and execution have to be intereaved
- Real-time constraints exist
- Search space might or might not fit into memory

20(!) megahertz RAD6000 processor
Speeding Up A* Search

How to search faster and faster is important:

2d (x, y) planning
- 54,000 states
- Fast planning
- Slow execution

4d (x, y, Ө, v) planning
- More than 20,000,000 states
- Slow planning
- Fast execution

Work vs Configuration Space

- Configuration spaces are often
  - continuous
  - high-dimensional

Discretize them with:
- Skeletonization methods (roadmaps)
- Cell-decomposition methods

Discretizing Configuration Space

- Skeletonization methods

[from Maxim Likhachev]

[from Stuart Russell and Peter Norvig – the figure has slight problems]
Voronoi graph

Visibility graph
Discretizing Configuration Space

- Skeletonization methods:
  roadmap using random points [Kavraki et al., 1994]
  (there are also roadmaps using RRTs [LaValle, 1998])

Work vs Configuration Space

- Configuration spaces are often
  □ continuous
  □ high-dimensional
- Discretize them with
  □ Skeletonization methods (roadmaps)
  □ Cell-decomposition methods

Discretizing Configuration Space

- Cell decomposition methods:
  vertical strips
  grid
  [from Stuart Russell and Peter Norvig]

Discretizing Configuration Space

- Non-uniform cell decomposition
  coarse-grained discretization
  might not be able to find a path
  fine-grained discretization
  is very inefficient

Discretizing Configuration Space

- Non-uniform cell decomposition
  non-uniform discretization
  avoids these problems

Discretizing Configuration Space

- Any-angle planning methods
  grid path
  any-angle path
Planning and Execution

- Incomplete information (knowledge of the robot changes)
  - About the location of the robot (localization)
  - About the configuration space (mapping)
  - About teammates and competitors
- Dynamically changing terrain (terrain changes)
- Uncertainty about actuation and sensing

Planning and Execution

Planning and Execution
Incremental heuristic search speeds up A* searches for a sequence of similar search problems by exploiting experience with earlier search problems in the sequence. It finds shortest paths.

These problems are not specific to robotics. They occur whenever one interfaces to the world!