CS-C1000 – Introduction to Artificial Intelligence

Search, Logic, and Symbolic AI

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March 30, 2021

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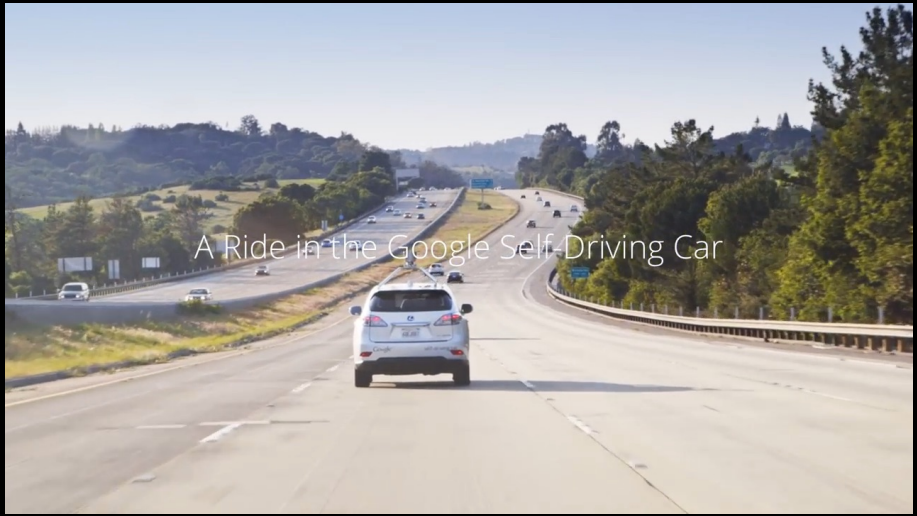
Outline and intended learning goals

- Symbolic AI
- Search and optimization
- Uninformed search
- Informed search and heuristics

Artificial Intelligence



A Ride in the Google Self Driving Car:
https://www.youtube.com/watch?v=TsaES--OTzM

Sub-Symbolic AI

- Concerned with problems that cannot be formalized
  (*pretty much the kind of models we have been looking into this far*)

⊕ Basic scheme straightforward:
Teach and deploy

⊕ No need to understand the domain (perfectly)

⊖ Hard to debug (black/gray-box)

⊖ Quality guarantees only by testing

⊖ Risky in safety-critical applications (cars?)

Symbolic AI

- Concerned with problems that can be formalized
  (*rules, logic, symbols, search, . . .*)

⊕ Understandable

⊕ Debuggable

? Quality follows design

⊖ Difficult if problem poorly understood
  (e.g., speech recognition, image classification)

Symbolic AI

“Good Old-Fashioned Artificial Intelligence”

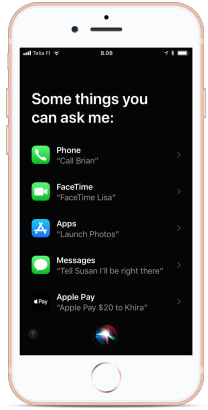
John Haugeland, 1985

Symbolic AI

- Methods in AI research that are based on high-level ‘symbolic’ (human-readable) representations of problems, logic, and search.
- Dominant paradigm of AI research from the mid-1950s until the late 1980s.
- Still an active research and application area.

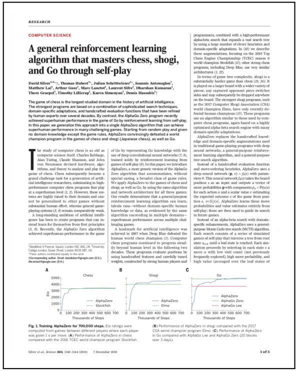
Application areas

- Logical systems:
  - Theorem provers
  - Fault diagnosis
  - Question answering
- Methods:
  - Deduction systems
  - Constraint satisfaction
  - Satisfiability solvers



Search and optimization

- Many problems in AI can be solved in *theory* by intelligently searching through many possible solutions.
- Reasoning can be reduced to performing a search.
- Even many machine learning algorithms use search algorithms based on optimization (finding parameters ≈ learning).


RESEARCH

COMPUTER SCIENCE

A general reinforcement learning algorithm that masters chess, shogi, and Go through self-play

Remember this?

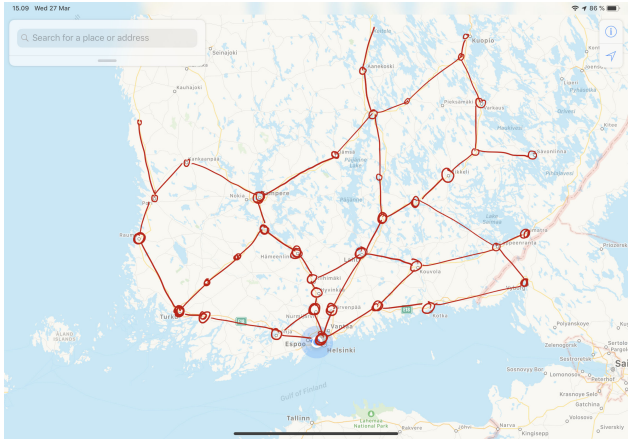
Search and optimization

- Example:
  A logical proof can be viewed as searching for a path that leads from premises to conclusions, where each step is the application of an inference rule.
- Example:
  Planning algorithms search through trees of goals and subgoals, attempting to find a path to a target goal.
- Example:
  Robotics algorithms for moving limbs and grasping objects use local searches (recall the lecture last week).

Applications of search / decision making

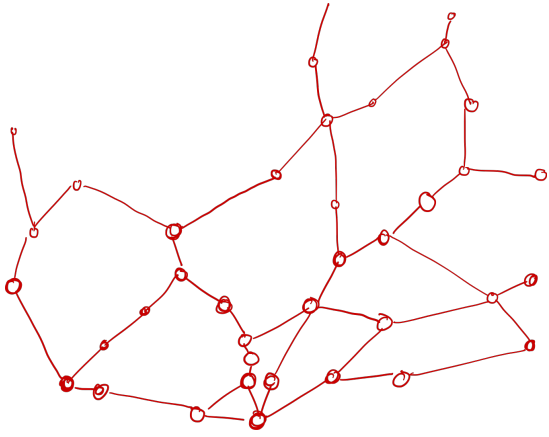
- Scheduling
  (e.g., airline routing)
- Route planning
  (e.g., Google Maps)
- Medical diagnosis
  (e.g., matching symptoms)
- Web search engines
  (e.g., Google)
- Spam classifiers
  (e.g., rule-based matching)
- Automated help desks
  (e.g., chat bots)
- Fraud detection
  (e.g., for credit cards)
- Product recommendations
  (e.g., matching purchase history)

Yes, but how to do it?



Find the route to Turku.

Depth-first search (DFS)



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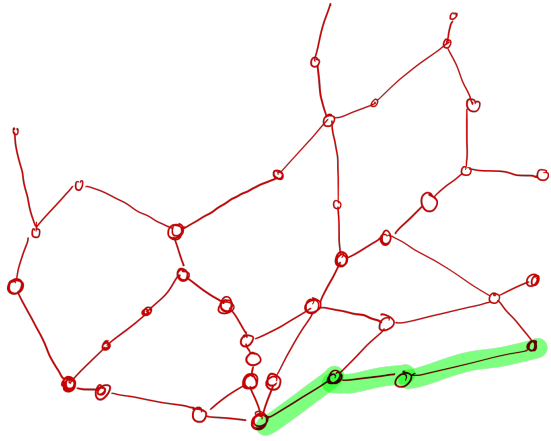

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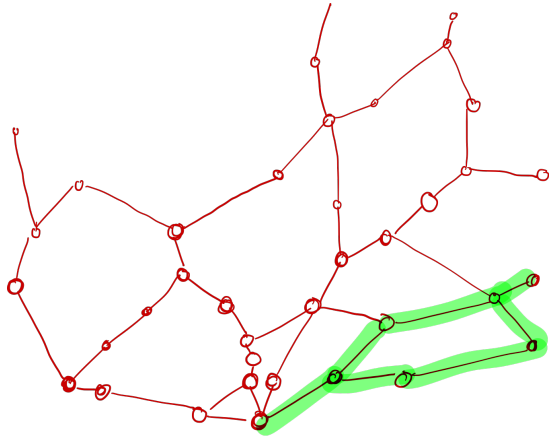

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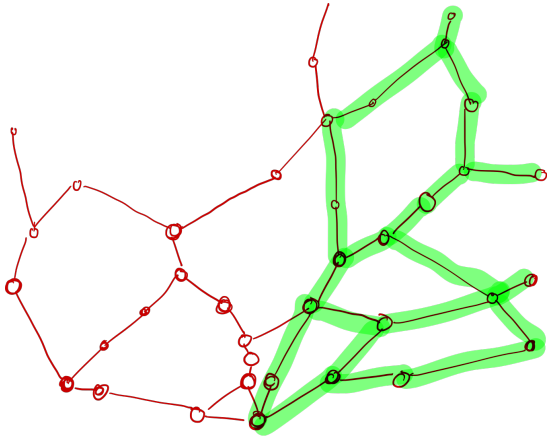

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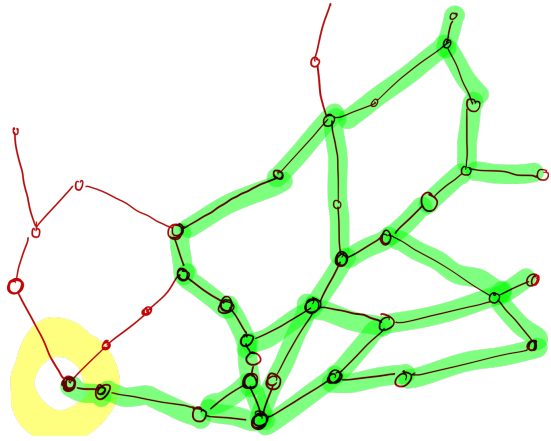
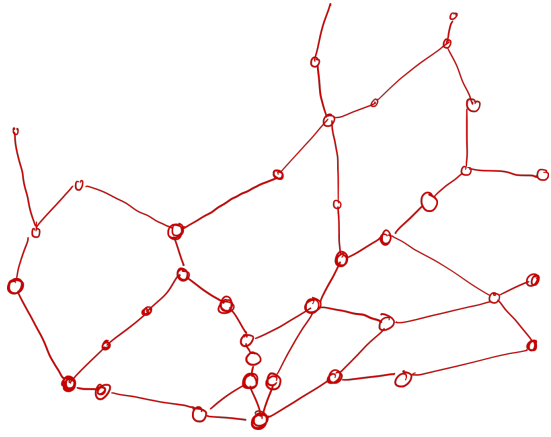


Breadth-first search (BFS)



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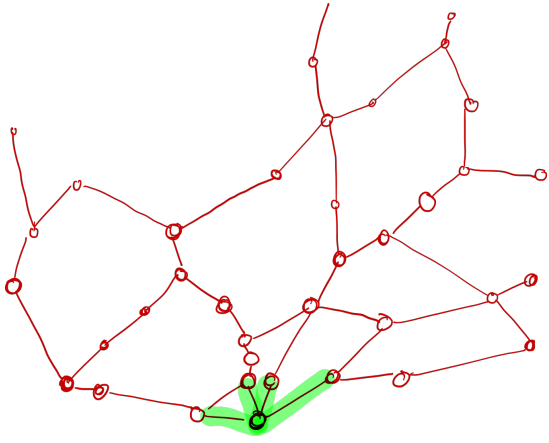

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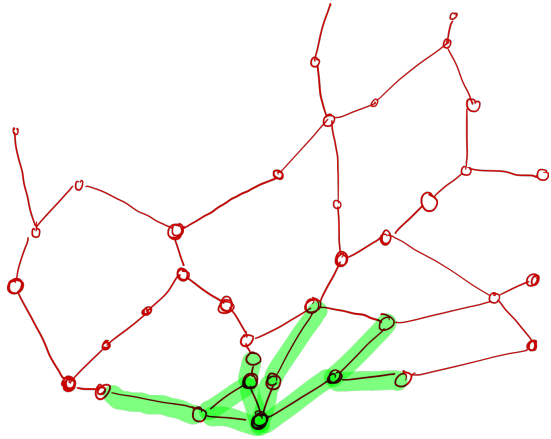

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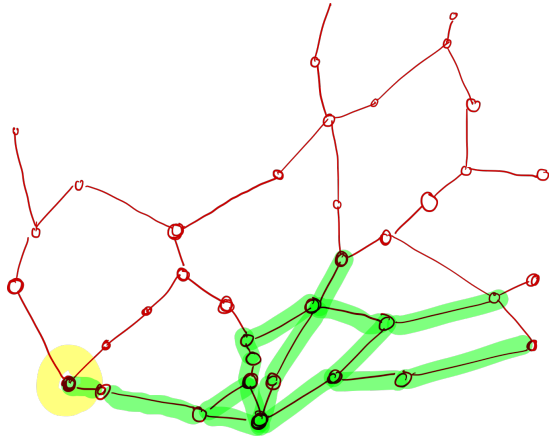
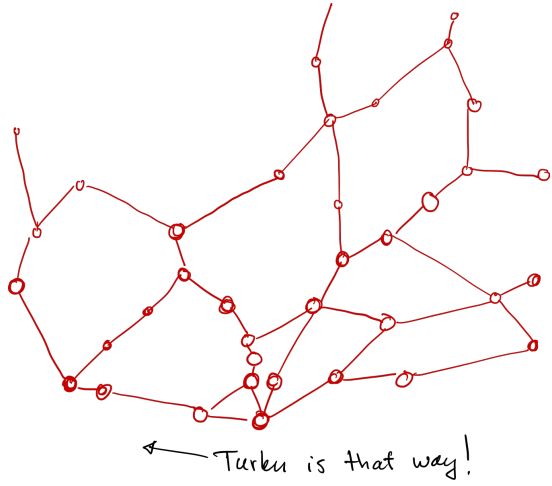


Uninformed vs. informed search

- Both DFS and BFS are examples of uninformed search.
- Not very practical for large systems.
- Instead, good to apply some heuristics for making the search smarter.
- With additional knowledge, can make the graph traversal more efficient (i.e., informed search).

The celebrated A* algorithm



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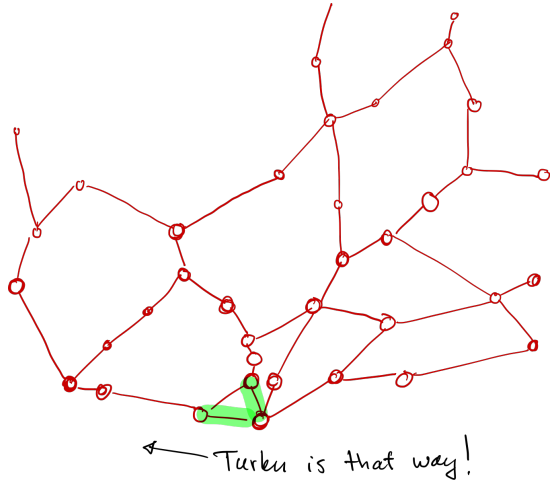

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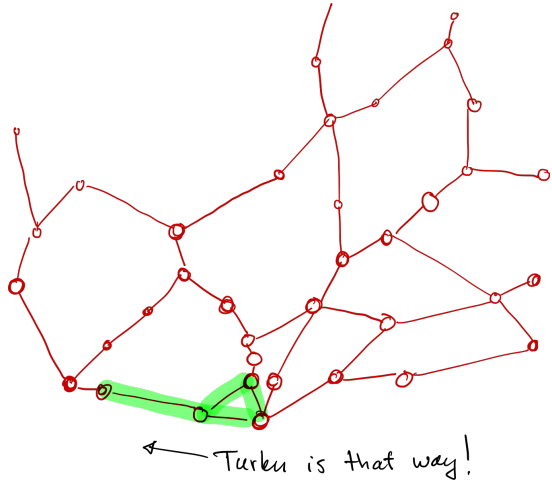

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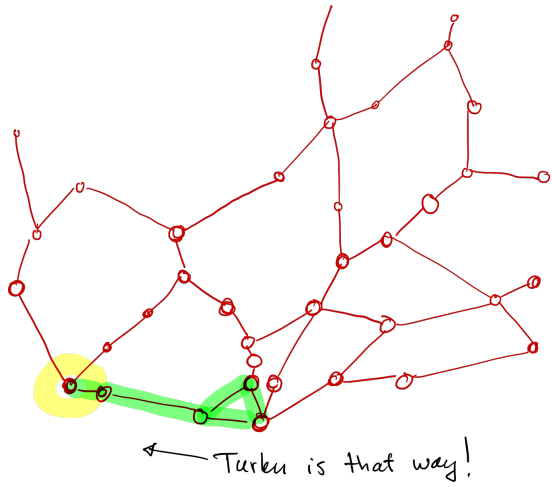

Solving Rubik's cube

- The cube has $\sim 4.3 \cdot 10^{19}$ states.
- Provably always solvable with max 20 moves.
- An optimal solution can be reached by iterative deepening A*.
- Most games/puzzles (and isn't life just a big puzzle as well!) can be formulated as a similar sequential decision-making process.

Recap

- Symbolic vs. Sub-Symbolic AI
- Learning through optimization
- Decision making through search
- Improving efficiency through heuristics

What next?

- The last exercise session is next Tuesday
  - Help with the computer exercise if needed
  - Instructions for Course Essay and
- The last lecture is on Friday next week
  - Ethics and impact of AI
  - Recap of the course
- I have been told that a teaching evaluation committee will attend the next lecture and also ask you for feedback on my teaching

AI