Wisdom is not the product of schooling but the lifelong attempt to acquire it.
- Albert Einstein

Solving Problems by Search

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Chapter 3 in Russell / Norvig Book

Gerhard Fischer

AI Course, Fall 1996, Lecture September 16

Overview

- **problem solving agents:** goals, goal formulation, problem formulation
- **formulating problems:** knowledge and problem types, well- and ill-defined problems
- **example problems:** toy problems and real world problems, semantically poor and rich problems
- **searching for solutions:** generating action sequences, data structures for search tress
- **search strategies:** breath first, depth first, bi-directional search
- **avoiding repeated states:** record the states which have been visited
- constraint satisfaction search: states are defined by variables, goal test specifies a set of constraints

Well-Defined versus Ill-Defined Problems

- **Well-Defined Problems:**
  - the essential conditions of the problem are stated
  - their solutions are the same for all problem solvers
  - examples: school problems, mutilated checker board, implementing given algorithms

- **Ill-Defined (or Wicked) Problems:**
  - problem solver takes an active role what the problem is
  - fill gaps in the problem definition
  - jump into the problem
  - use information gained while trying to solve the problem
  - examples: architects, engineers, lawyers, legislators, software, designers, writers, teachers, ...

Semantically Rich Domains versus Semantically Poor Domains

- **“poor”**
  - knowledge in cryptarithmetic problems: numbers, how to add and subtract, facts about parity
  - puzzles (missionaries and cannibals)

- **“rich”**
  - driving a taxi in a big city
  - medicine
  - law
  - using Unix, Word, Excel, ...(high functionality applications)

- **questions: what is**
  - chess
  - programming

Problem Solving and Search — Cryptarithmetic Problems

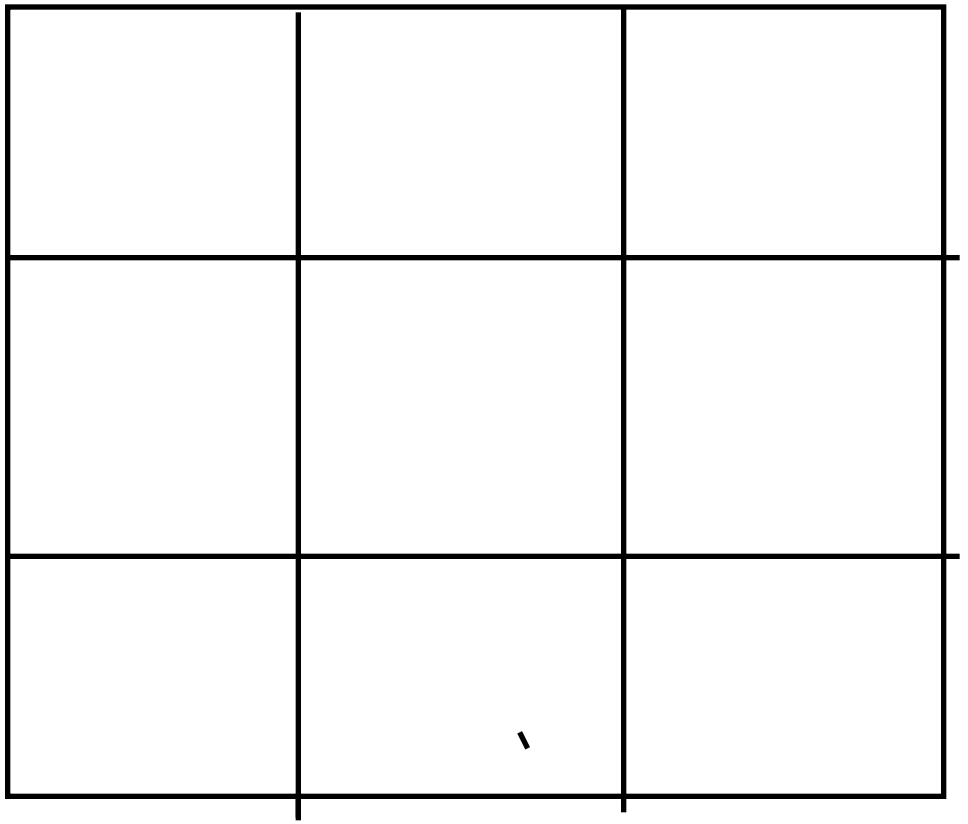
```
   DONALD                                  CROSS
+ GERALD          D=5                   + ROADS
   ------------                          ------------
   ROBERT                                DANGER
```

- sophisticated strategy (= more knowledge) ----> less search
- brute force search: 10! = 3,628,800 possibilities
- with D = 5 ----> 9! = 362,880

Number Scrabble

- two person game
- nine cards: 1, 2, 3, 4, 5, 6, 7, 8, 9
- cards are placed face up
- players draw alternately, one at a time, selecting any of the remaining cards
- goal: to have drawn cards so three of them add up to 15 (before the opponent can do so)

Tic-Tac Toe



Search Strategies

completeness: is the strategy guaranteed to find a solution when there is one?

time complexity: how long does it take to find a solution?

space complexity: how much memory does it need to perform the search?

optimality: does the strategy find the highest-quality solution when there are several different solutions?

uninformed search: no information about the number of steps or the path cost from the current state to the goal — all they can do: distinguish a goal state from a non-goal state

informed search (or heuristic search): use information, heuristics, guesses about the search space (chapter 4 in Russell / Norvig)

Example Problem

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Going from the Engineering Center to the Flagstaff House

- well-defined or ill-defined?
- breath-first search
- depth first search