Problem Solving

- **Ways of solving problems**
  - Means-end analysis
  - Analogy
  - Brainstorming

- **Pitfalls in problem solving**
  - Functional fixedness
  - Mental set
  - Wrong representation
  - Starting at wrong point
Means-end Analysis

• Problem solving as search
  – For solving well-defined problem
    • Start
    • Goals & Subgoals
    • Operators - methods for moving from state to state

• Heuristics
  – Strategies for choosing an operator to apply
  – Not guaranteed to be correct, but generally helpful

• Hillclimbing
  – Choose operator that moves closest to the goal
  – Can get stuck in local maxima - states that are closer to the goal than any neighboring states, but still are not the goal
  – Leave local maxima by back-tracking or adding randomness
Problem solving as search

Start

A

B

C

D

E

F

G

Goal
Heuristics

For winning tic-tac-toe
   Play in the middle

For solving anagrams like: GAKBNI
   Try placing letters together that often occur together

For dating a person met at a coffee house
   Ask what they are drinking
The eight-tiles puzzle

Start

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Goal

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Operators: Move space up, down, left, or right

Heuristic: Choose operator that makes more tiles in correct space
Backtracking

Backtrack by taking back recent moves and applying new operators

Goal = global maximum

Stuck at local maximum by hill climbing
According to the hill-climbing strategy, the dog should, at each step, choose a path that moves it closer and closer to the goal. However, this strategy will *fail* here, since the dog needs first to move *away* from the bone in order to reach the bone.
So near & yet so far
Problem solving by analogy

• Use solved problem to solve new problem

• Analogy = Superficial features are different, but same at a deep level
  – Solar system and atom

• Analogies are missed unless people are given hints that they are related, or multiple related stories

• People are too influenced by superficial similarities
  – Use word processor commands that were learned with superficially similar documents (bibliographies, menus)
  – Decision making is influenced by superficial features
    • Does the scenario remind people of Vietnam or WWII?
Table 12-5  RADIATION AND ATTACK DISPERSION PROBLEMS

**Radiation Problem**

Suppose you are a doctor faced with a patient who has a malignant tumor in his stomach. It is impossible to operate on the patient, but unless the tumor is destroyed the patient will die. There is a kind of ray that can be used to destroy the tumor. If the rays reach the tumor all at once at a sufficiently high intensity, the tumor will be destroyed. Unfortunately, at this intensity the healthy tissue that the rays pass through on the way to the tumor will also be destroyed. At lower intensities the rays are harmless to healthy tissue, but they will not affect the tumor either. What type of procedure might be used to destroy the tumor with the rays without destroying the healthy tissue?

**Attack Dispersion Story**

A small country was controlled by a dictator. The dictator ruled the country from a strong fortress. The fortress was situated in the middle of the country, surrounded by farms and villages. Many roads radiated outward from the fortress like spokes on a wheel. A general arose who raised a large army and vowed to capture the fortress and free the country of the dictator. The general knew that if his entire army could attack the fortress at once it could be captured. The general's troops were gathered at the head of one of the roads leading to the fortress, ready to attack. However, a spy brought the general a disturbing report. The ruthless dictator had planted mines on each of the roads. The mines were set so that small bodies of men could pass over them safely because the dictator needed to be able to move troops and workers to and from the fortress. However, any large force would detonate the mines. Not only would this blow up the road and render it impassable, but the dictator would then destroy many villages in retaliation. It therefore seemed impossible to mount a full-scale direct attack on the fortress.

**Solution to the Radiation Problem**

The ray can be divided into several low-intensity rays, no one of which will destroy the healthy tissue. If these several rays are positioned at different locations around the body and focused on the tumor, their effect will combine, thus being strong enough to destroy the tumor.

**Solution to the Attack Dispersion Story**

The general, however, knew just what to do. He divided his army up into small groups and dispatched each group to the head of a different road. When all was ready he gave the signal, and each group marched down a different road. Each group continued down its road to the fortress, so that the entire army finally arrived together at the fortress at the same time. In this way, the general was able to capture the fortress and thus overthrow the dictator.
**Study 2 (Experiment IV originally)**

Subjects in group A are given the general hint (as above). Subjects in group B are given no hint whatsoever.

<table>
<thead>
<tr>
<th>Group</th>
<th>Order of Stories</th>
<th>Percentage of Subjects Who Used the Analogy on the Radiation Problem</th>
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</thead>
<tbody>
<tr>
<td>Group A (hint)</td>
<td>Attack dispersion, radiation</td>
<td>92%</td>
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<tr>
<td>Group B (no hint)</td>
<td>Attack dispersion, radiation</td>
<td>20%</td>
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Radiation beams target tumors, bypass healthy tissue

LOS ANGELES (AP)—A treatment has been unveiled at the University of California Los Angeles that allows doctors to create beams of radiation that fit a tumor’s dimension exactly, leaving other tissue unharmed, hospital officials said.

UCLA’s Jonsson Cancer Center is the only U.S. facility to offer Novalis, a German-developed system that focuses thin rays of radiation through healthy tissue that unite on a brain tumor—like spokes meeting at the center of a wheel.

Each beam conforms to the dimensions of a patient’s tumor—unlike conventional beam radiation—and leaves neighboring healthy tissue unharmed.

Problem Solving by Brainstorming

• Generate ideas without critical examination
• Useful for ill-defined problems
• Creativity with SCAMPER
  – Substitute, Combine, Add, Magnify/minify
  – Place, Eliminate, Reverse/Reorder
• Divergent thinking - explore many possibilities
  – 100 uses for a brick
  – Remote associates test

Type  Ghost  Story  Writer
Food  Catcher  Hot  Dog
Canadian  Golf  Sandwich  Club
Tug  Gravy  Show  Boat
People are often too influenced by existing solutions.
Pitfalls of Problem Solving

• **Functional fixedness**
  – Tendency to view things in terms of their familiar uses
  – Two-string problem, candle problem
  – Better solutions if objects not “pre-utilized”
  – Young children don’t suffer as much fixedness

• **Mental set**
  – Bias to solve problems in a way that has worked in the past
  – Luchins’ water jugs
  – Priming of solutions
You enter a room in which two strings are hanging from the ceiling. Your task is to tie the two strings together. Unfortunately, though, the strings are positioned

Fewer solutions when tools were used (as tools) previously
Problem: Attach the candle to the wall somehow
Solution: use tacks’ box as a support
More solutions when tacks are outside of box
Avoid functional fixedness by looking at the world with fresh eyes
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<th>REQUIRED AMOUNT (CUPS)</th>
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Pitfalls of Problem Solving

• **Wrong representation**
  – Experts spend more time figuring out how to represent a problem than novices (40% compared to 7%)
  – The monk problem
  – The missing dominoes problem

• **Starting at the wrong point**
  – Often it is useful to go from goal to start
  – Choose the starting point that has fewer choice points
THE BUDDHIST MONK PROBLEM.

Exactly at sunrise one morning, a Buddhist monk set out to climb a tall mountain. The narrow path was not more than a foot or two wide, and it wound around the mountain to a beautiful, glittering temple at the mountain peak.

The monk climbed the path at varying rates of speed. He stopped many times along the way to rest and to eat the fruit he carried with him. He reached the temple just before sunset. At the temple, he fasted and meditated for several days. Then he began his journey back along the same path, starting at sunrise and walking, as before, at variable speeds with many stops along the way. However, his average speed going down the hill was greater than his average climbing speed.

Prove that there must be a spot along the path that the monk will pass on both trips at exactly the same time of day. (The answer is found in Figure 10.2.)
A Graphic Representation of the Buddhist Monk Problem.

Altitude

6:00 A.M.  9:00 A.M.  12:00  3:00 P.M.  6:00 P.M.

Time

2000

1500

1000

500

0
Can 31 dominoes cover the checkerboard with two missing squares?
Reasoning backwards is helpful if there are more choice points from starting point than from goal.