Chapter 11: Artificial Intelligence

Computer Science: An Overview
Eleventh Edition

by
J. Glenn Brookshear
Dennis Brylow

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Chapter 11: Artificial Intelligence

- 11.1 Intelligence and Machines
- 11.2 Perception
- 11.3 Reasoning
- 11.4 Additional Areas of Research
- 11.5 Artificial Neural Networks
- 11.6 Robotics
- 11.7 Considering the Consequences

Intelligent Agents

- **Agent:** A “device” that responds to stimuli from its environment
  - Sensors
  - Actuators
- Much of the research in artificial intelligence can be viewed in the context of building agents that behave intelligently

Levels of Intelligent Behavior

- Reflex: actions are predetermined responses to the input data
- More intelligent behavior requires knowledge of the environment and involves such activities as:
  - Goal seeking
  - Learning

Figure 11.1 The eight-puzzle in its solved configuration

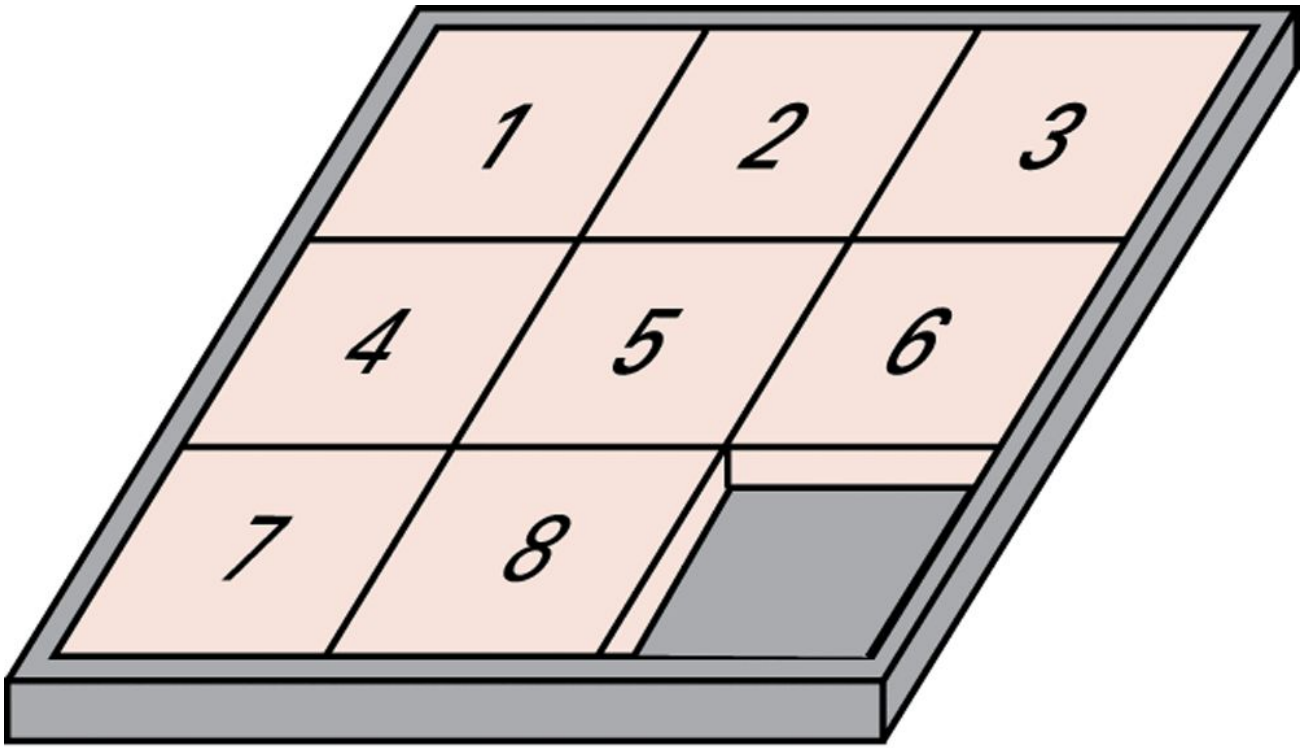
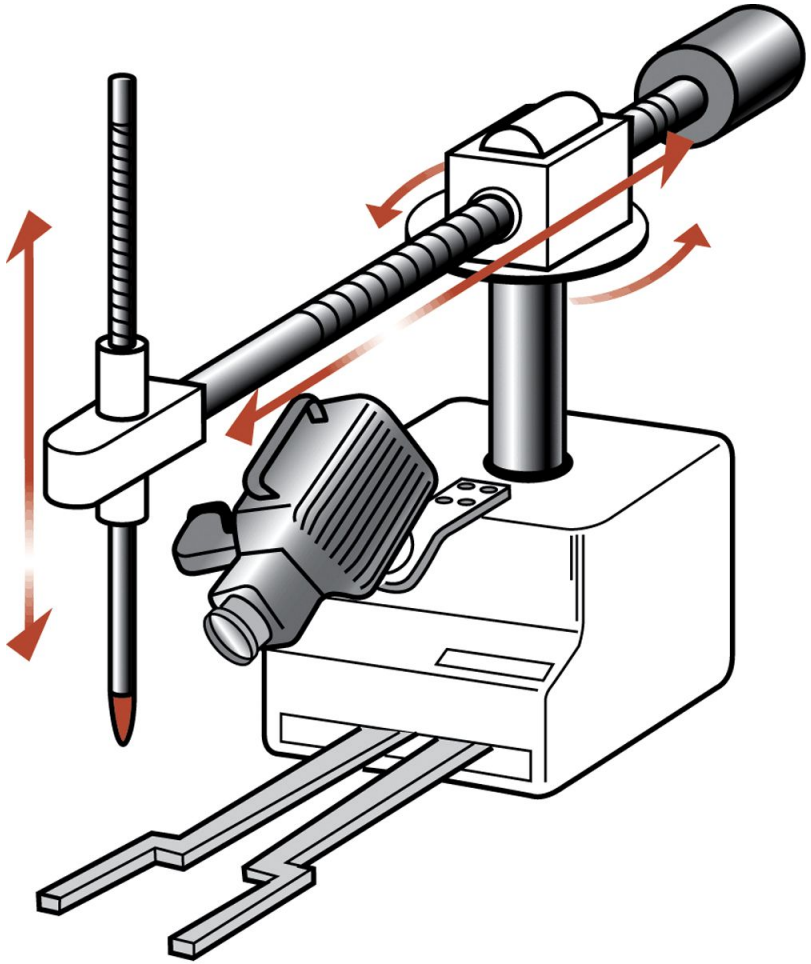


Figure 11.2 Our puzzle-solving machine



Approaches to Research in Artificial Intelligence

- Engineering track
  - Performance oriented
- Theoretical track
  - Simulation oriented

Turing Test

- Test setup: Human interrogator communicates with test subject by typewriter.
- Test: Can the human interrogator distinguish whether the test subject is human or machine?

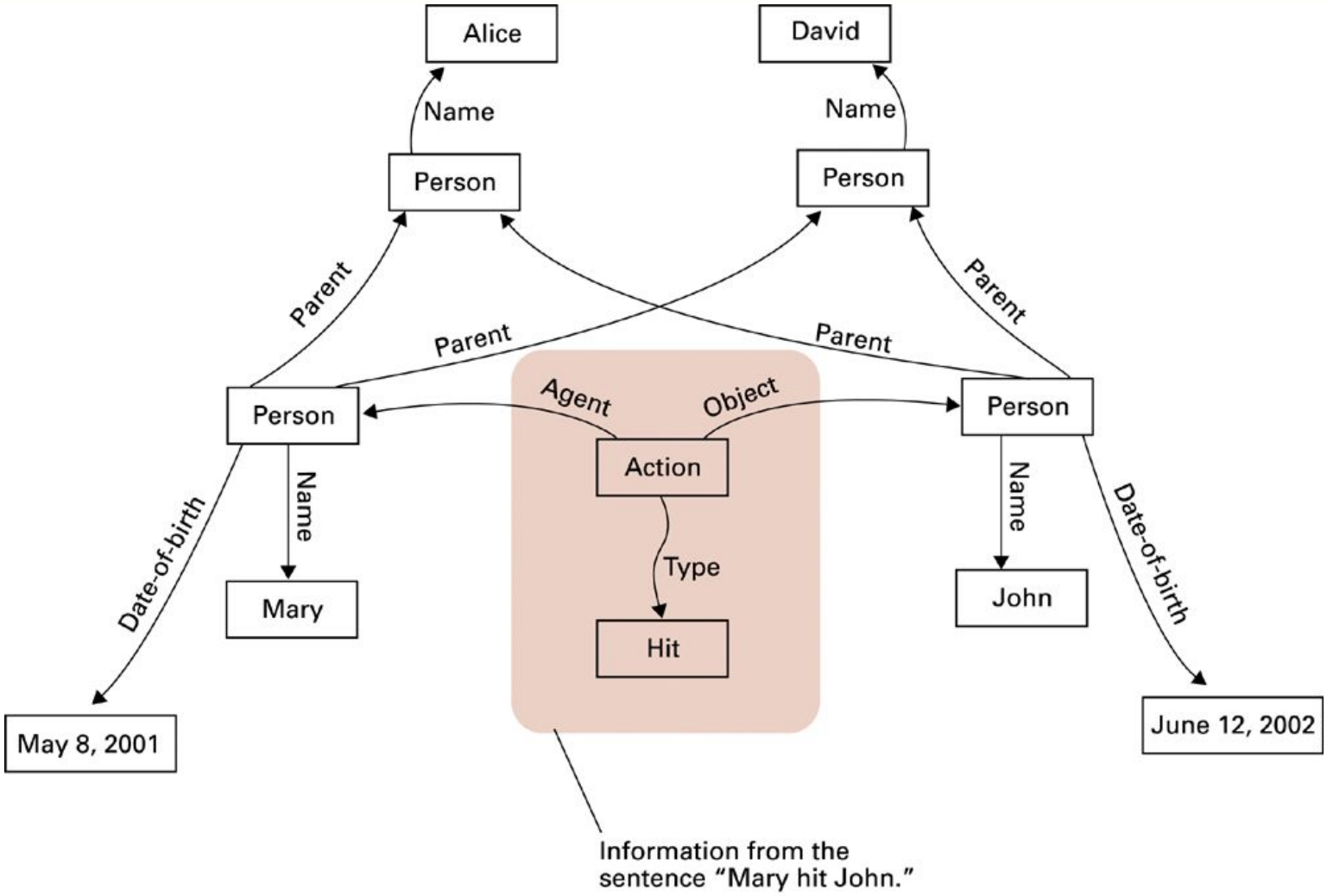
Techniques for Understanding Images

- Template matching
- Image processing
  - edge enhancement
  - region finding
  - smoothing
- Image analysis

Language Processing

- Syntactic Analysis
- Semantic Analysis
- Contextual Analysis

Figure 11.3 **A semantic net**



Components of a Production Systems

1. Collection of states
   - Start (or initial) state
   - Goal state (or states)
2. Collection of productions: rules or moves
   - Each production may have preconditions
3. Control system: decides which production to apply next

Reasoning by Searching

- **State Graph:** All states and productions
- **Search Tree:** A record of state transitions explored while searching for a goal state
  - Breadth-first search
  - Depth-first search

Figure 11.4 A small portion of the eight-puzzle's state graph

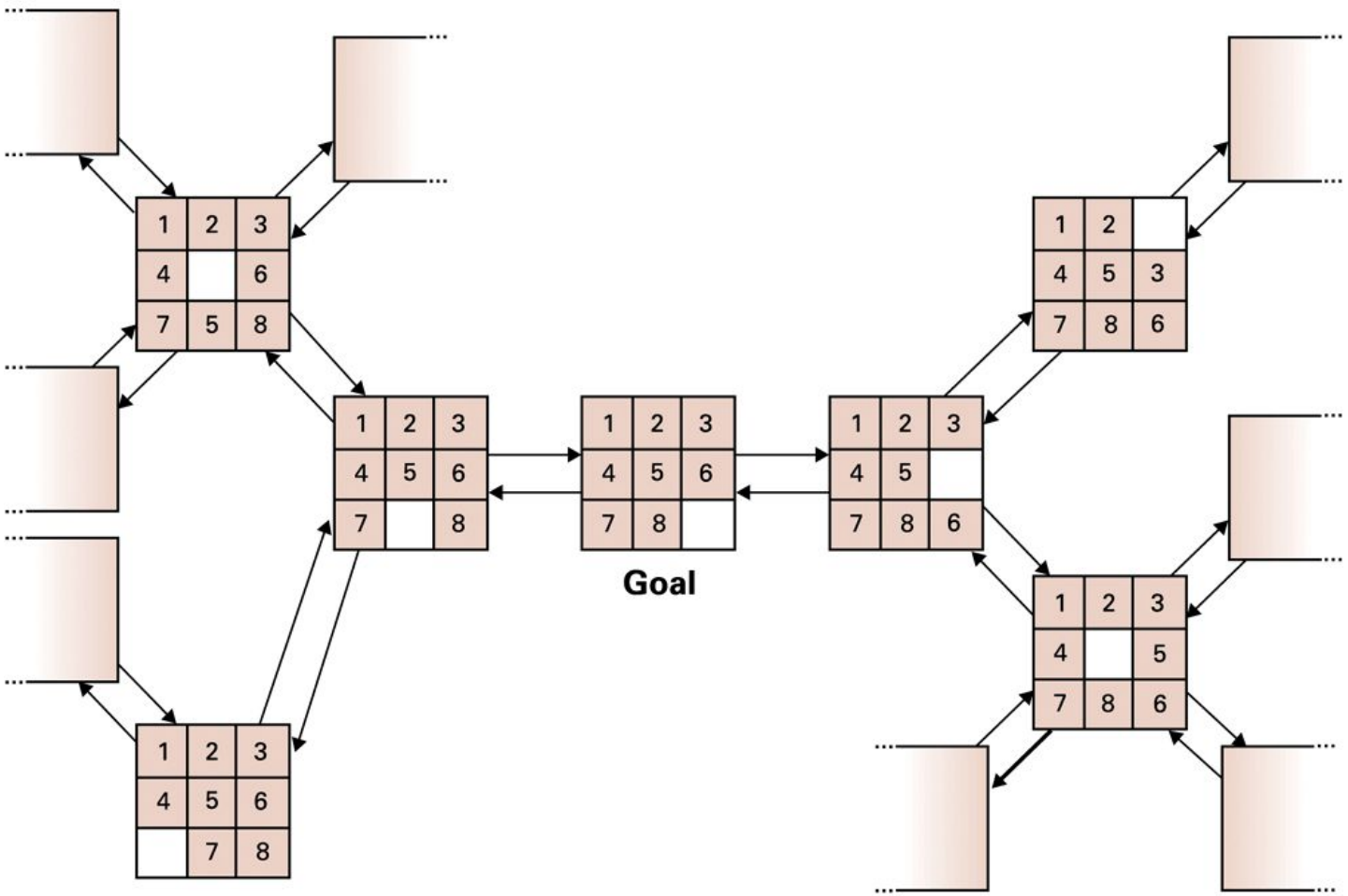


Figure 11.5 Deductive reasoning in the context of a production system

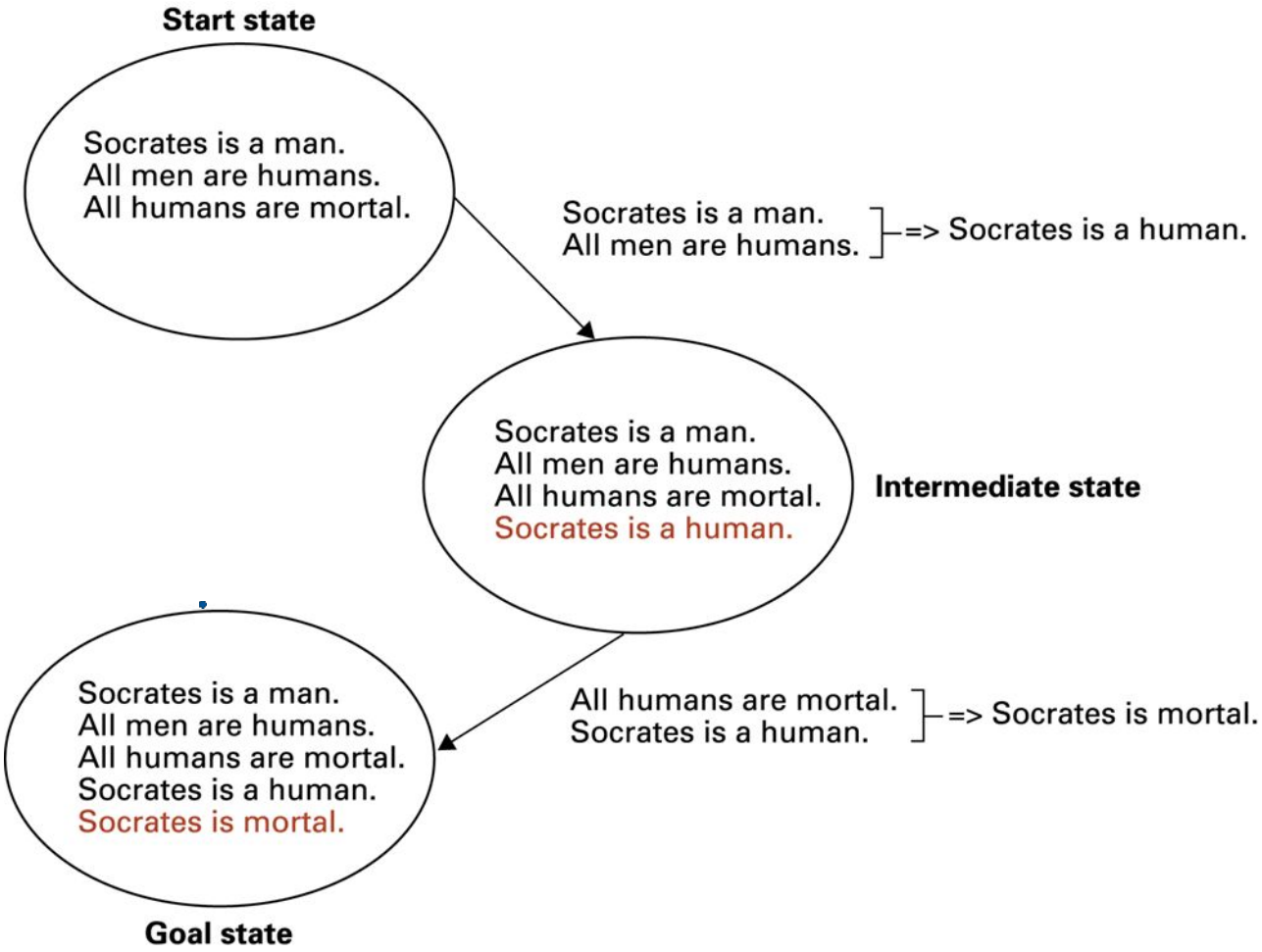


Figure 11.6 An unsolved eight-puzzle

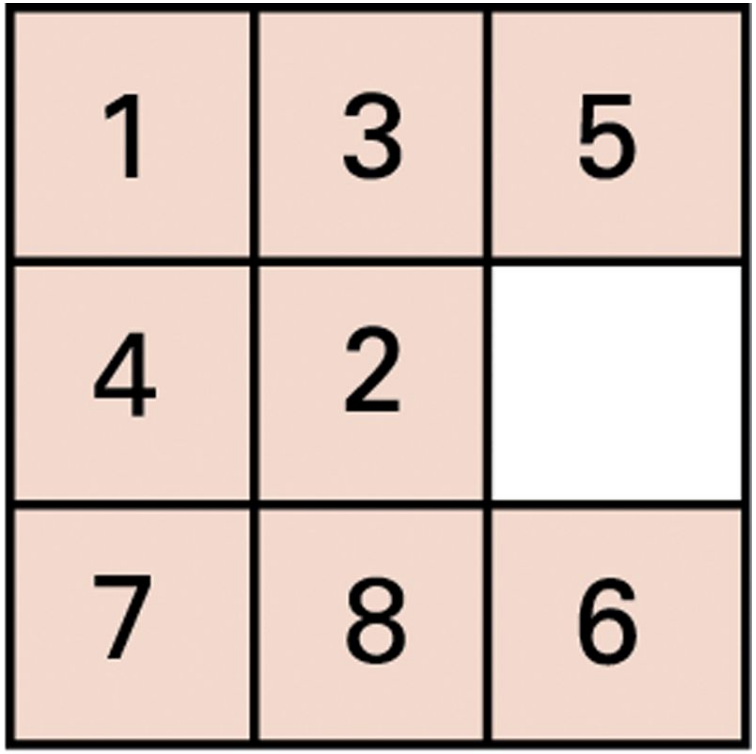


Figure 11.7 **A sample search tree**

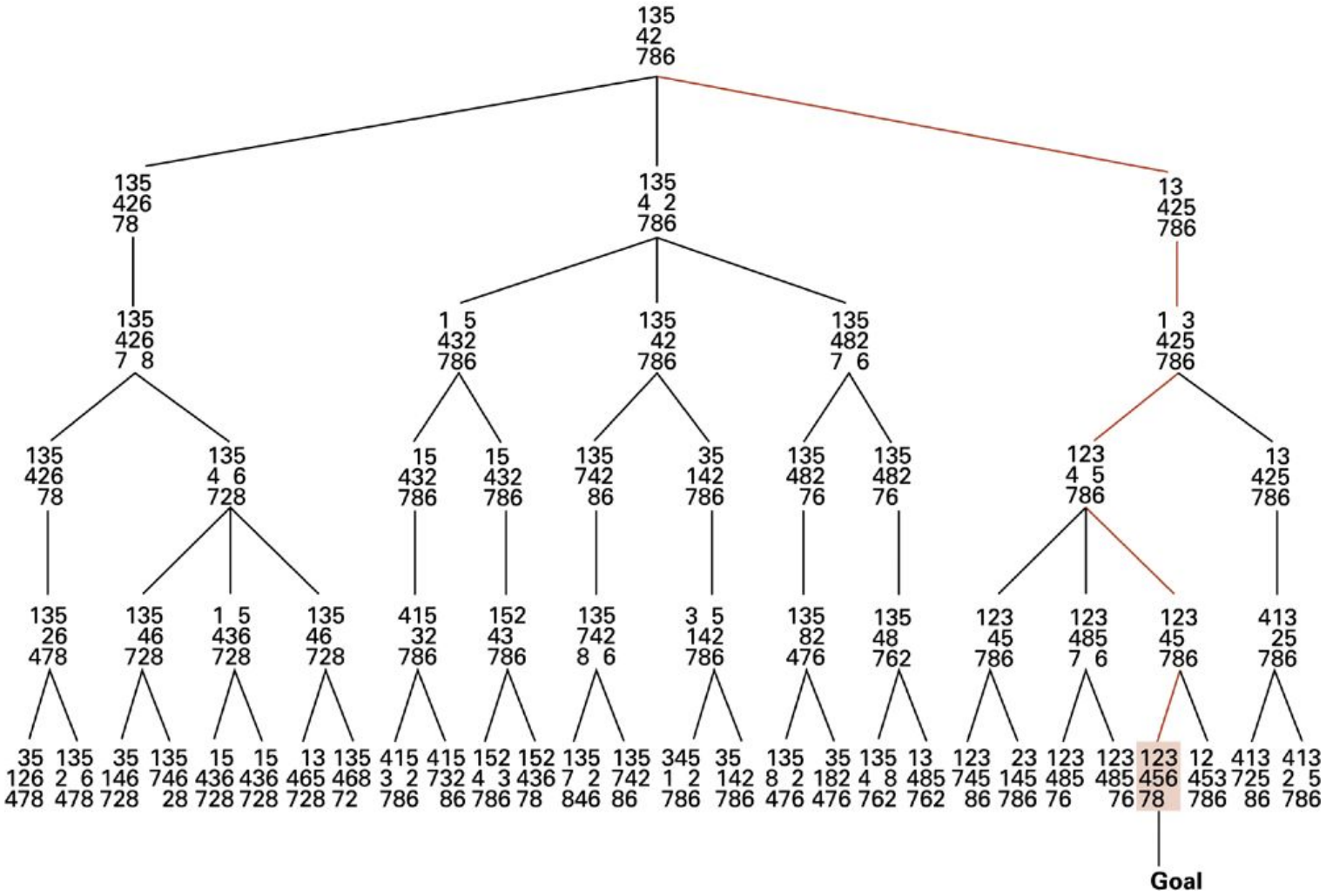
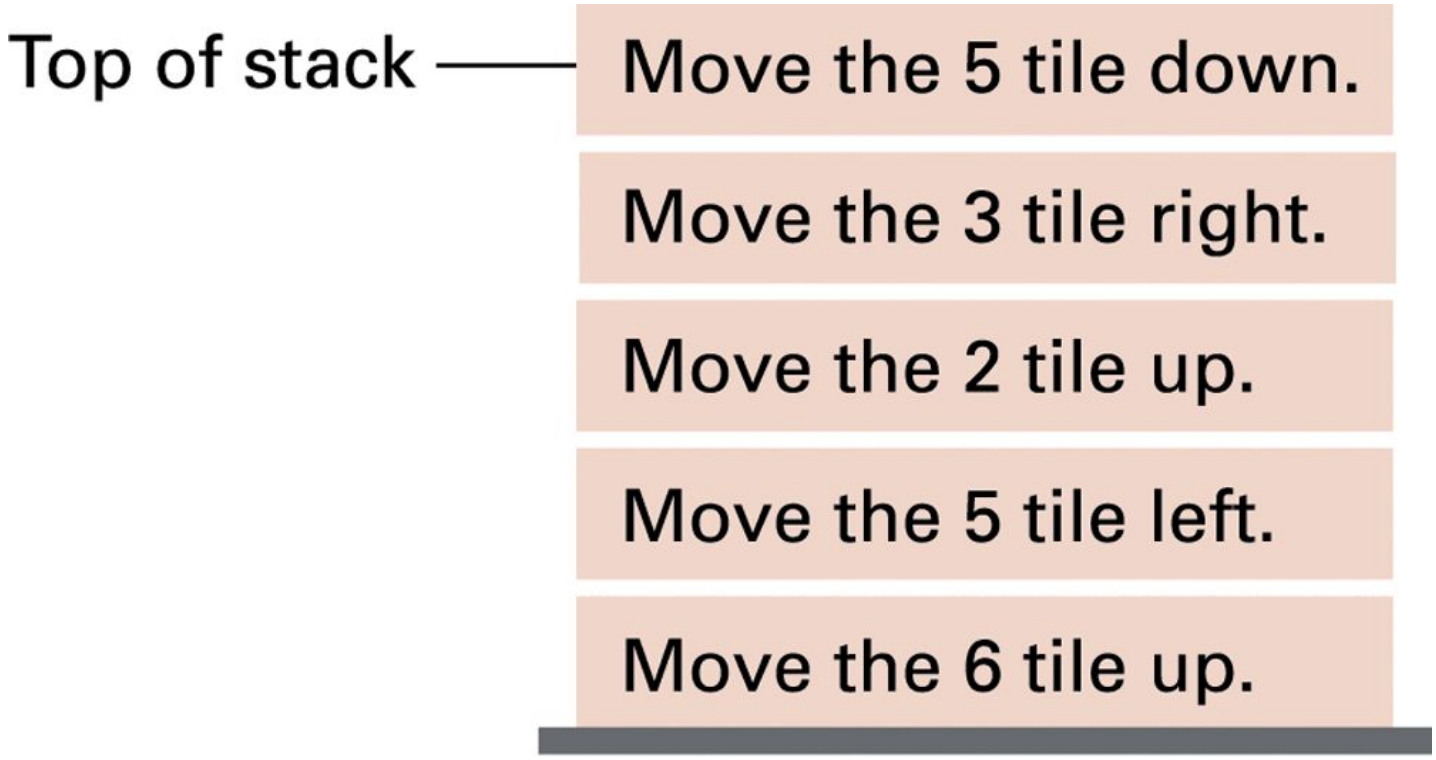


Figure 11.8 Productions stacked for later execution



Heuristic Strategies

- **Heuristic:** A “rule of thumb” for making decisions
- Requirements for good heuristics
  - Must be easier to compute than a complete solution
  - Must provide a reasonable estimate of proximity to a goal

Figure 11.9 An unsolved eight-puzzle

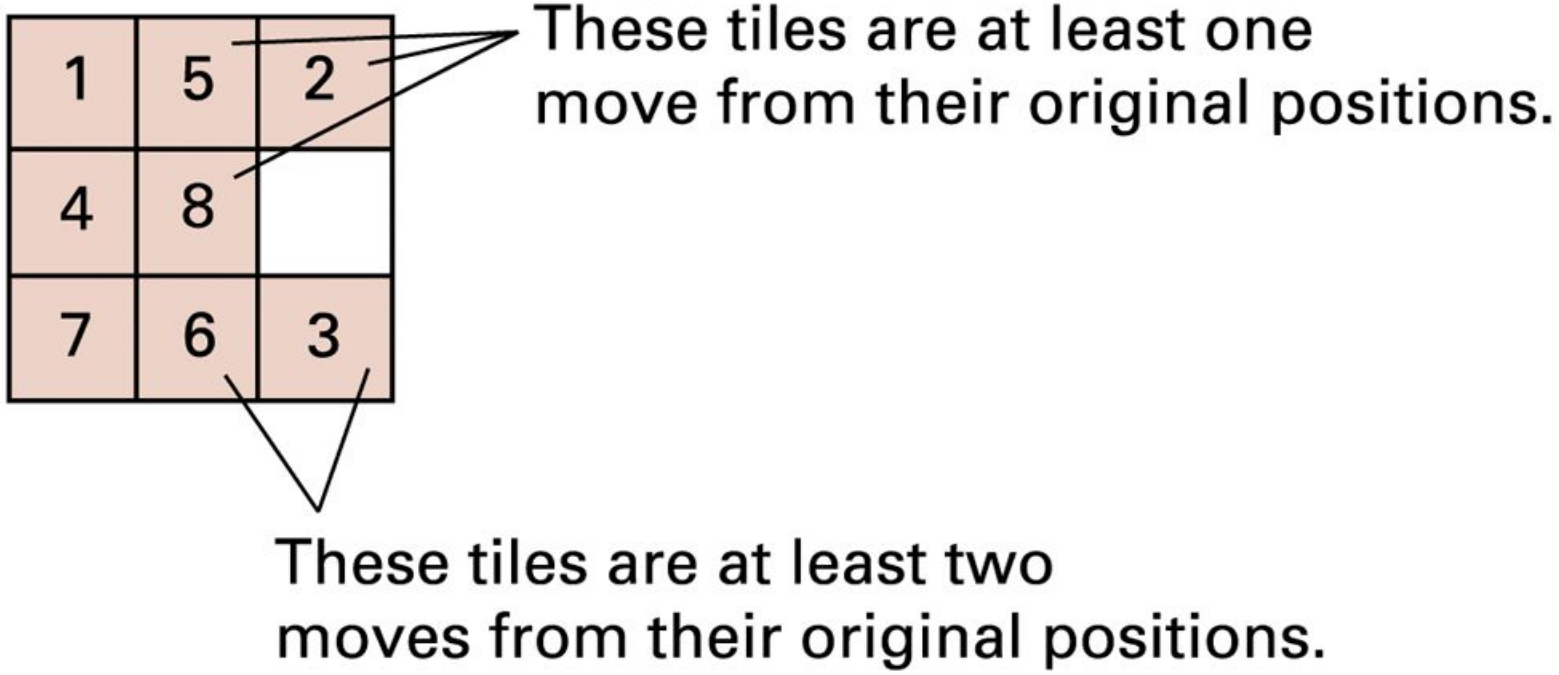


Figure 11.10 An algorithm for a control system using heuristics

```
Establish the start node of the state graph as the root
of the search tree and record its heuristic value.
while (the goal node has not been reached):
    Select the leftmost leaf node with the smallest
    heuristic value of all leaf nodes.
    To this selected node attach as children those nodes
    that can be reached by a single production.
    Record the heuristic of each of these new nodes next
    to the node in the search tree.
Traverse the search tree from the goal node up to the
root, pushing the production associated with each arc
traversed onto a stack.
Solve the original problem by executing the productions
as they are popped off the stack.
```

Figure 11.11 The beginnings of our heuristic search

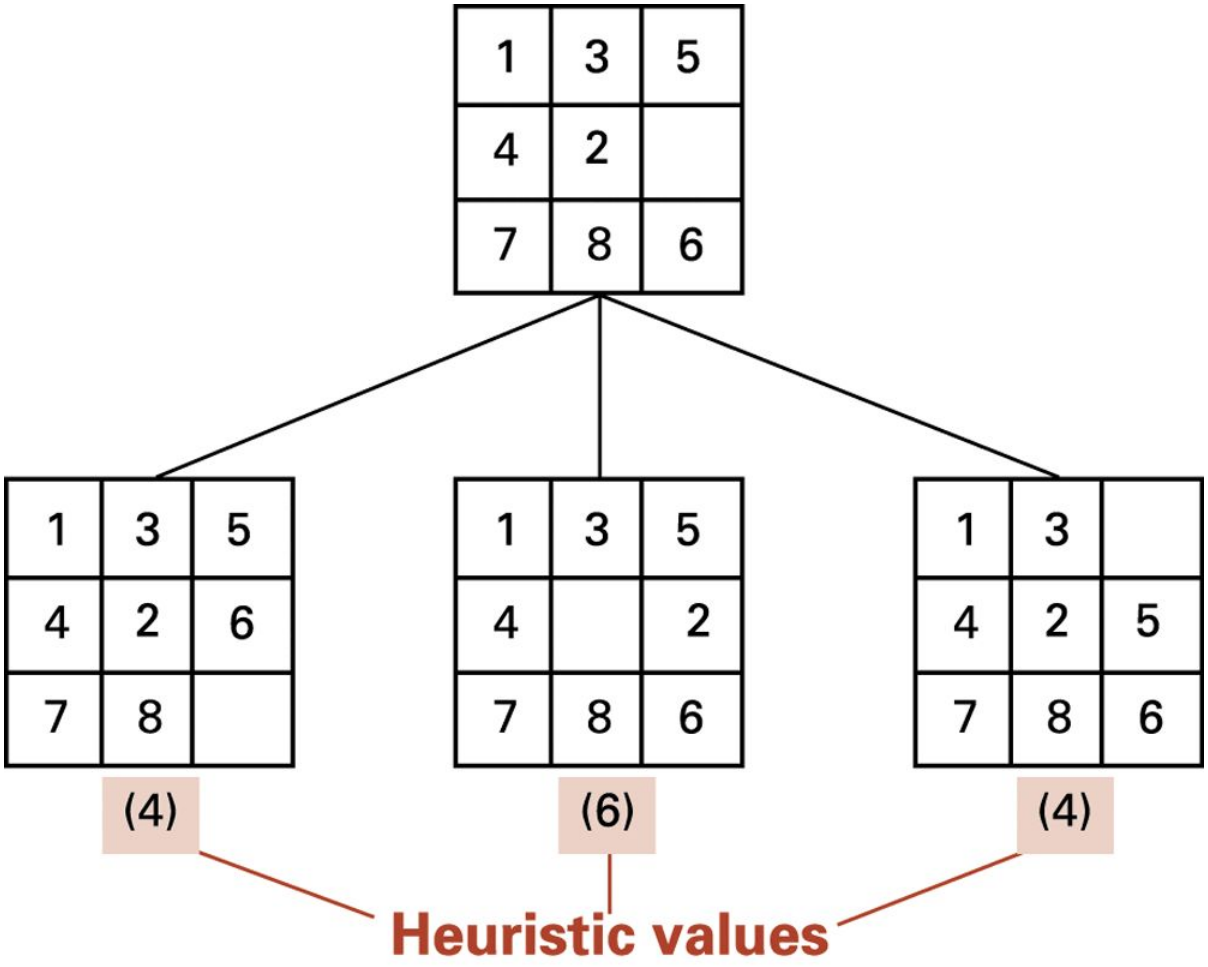


Figure 11.12 The search tree after two passes

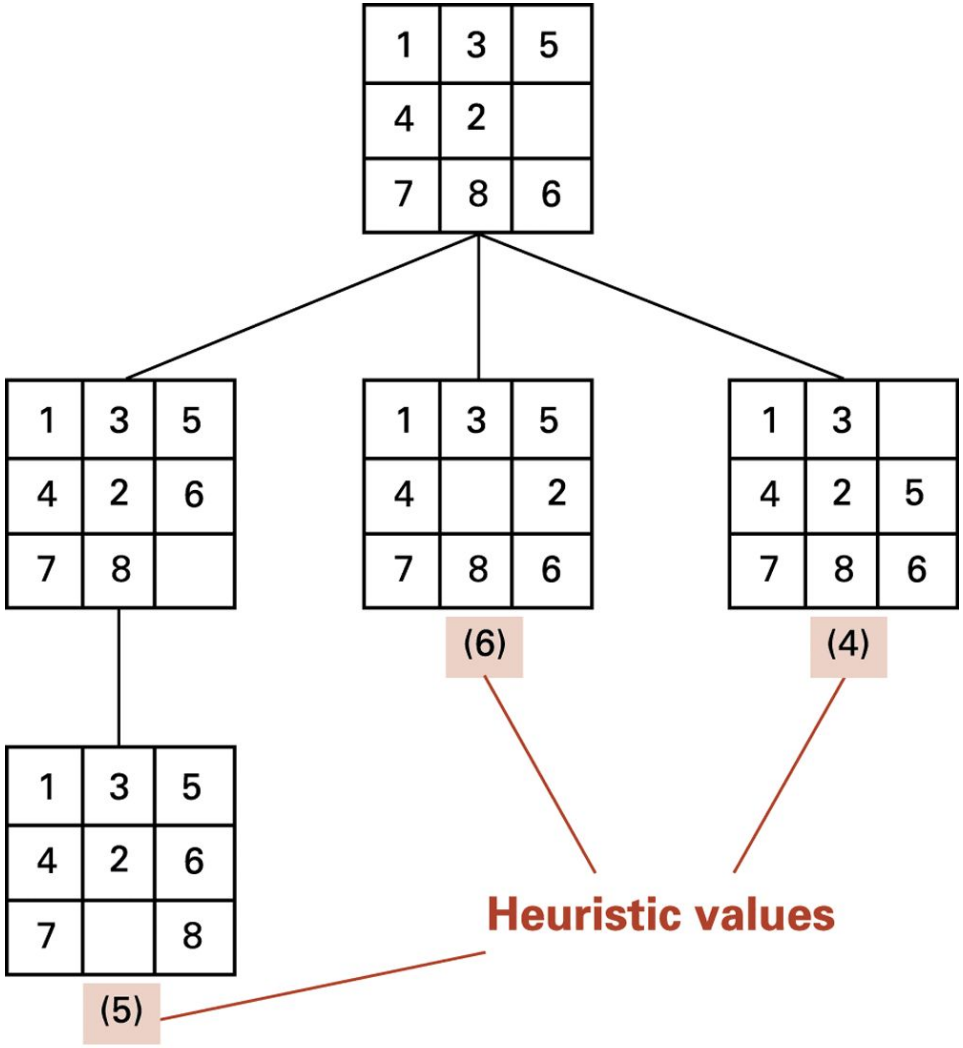


Figure 11.13 The search tree after three passes

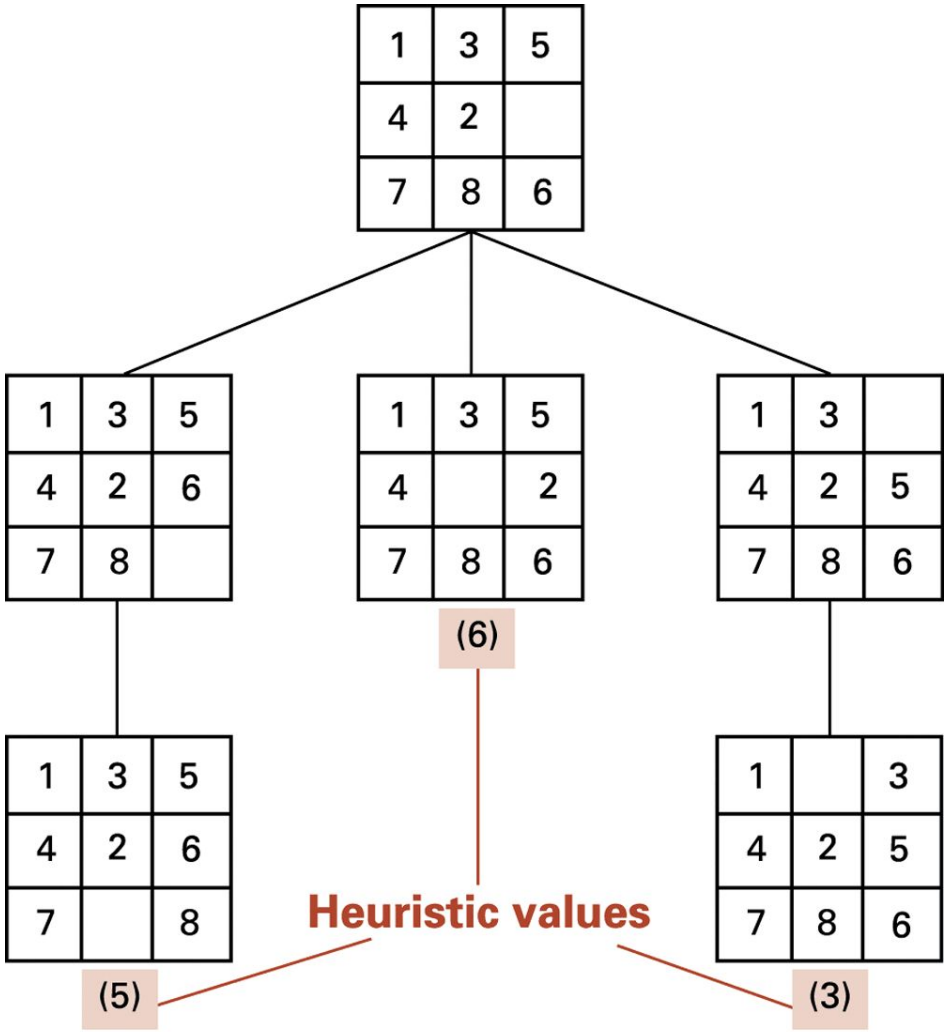
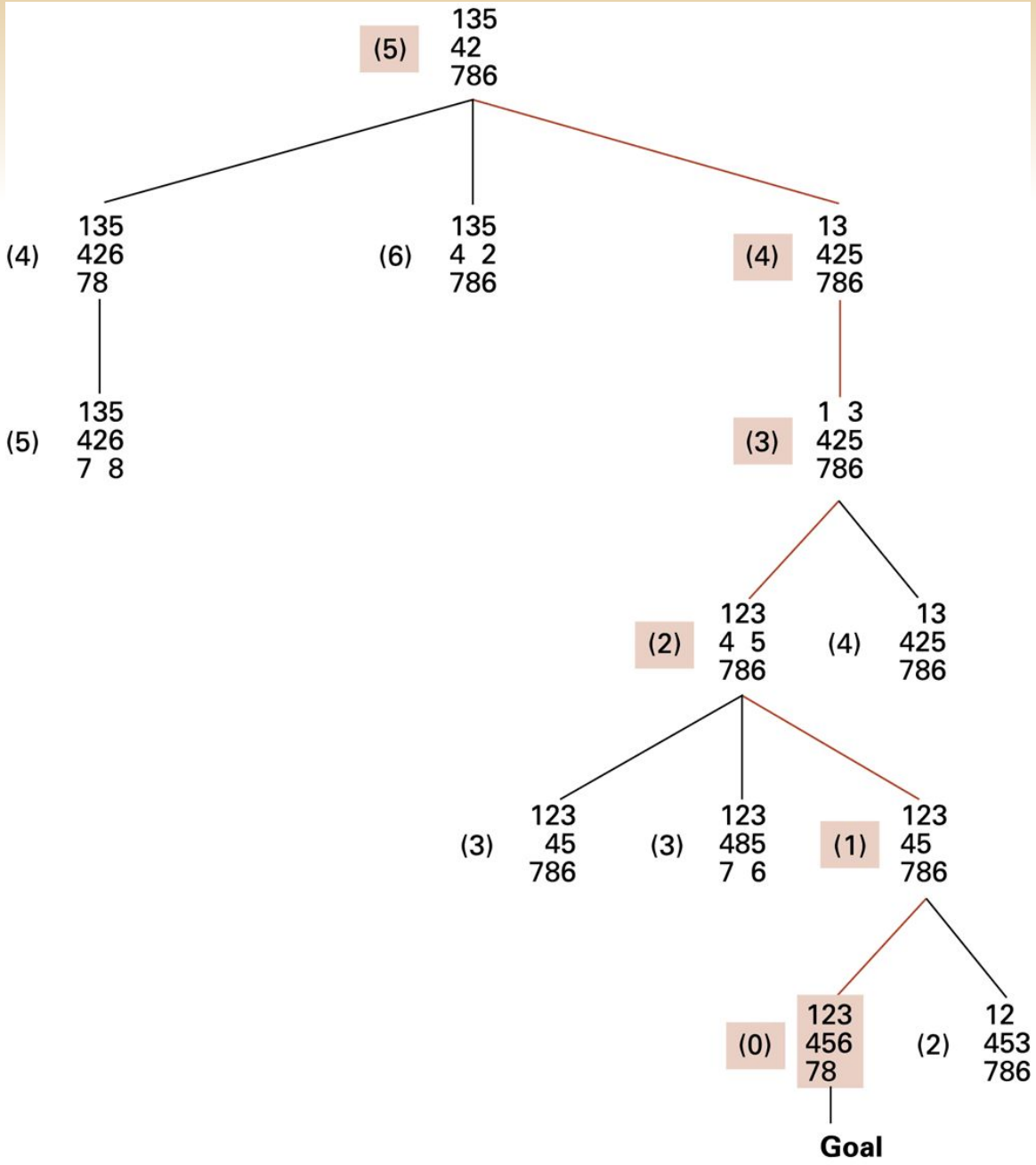


Figure 11.14 The complete search tree formed by our heuristic system



Handling Real-World Knowledge

- Representation and storage
- Accessing relevant information
  - Meta-Reasoning
  - Closed-World Assumption
- Frame problem

Learning

- Imitation
- Supervised Training
  - Training Set
- Reinforcement

Genetic Algorithms

- Begins by generating a random pool of trial solutions:
  - Each solution is a **chromosome**
  - Each component of a chromosome is a **gene**
- Repeatedly generate new pools
  - Each new chromosome is an offspring of two parents from the previous pool
  - Probabilistic preference used to select parents
  - Each offspring is a combination of the parent's genes

Artificial Neural Networks

- Artificial Neuron
  - Each input is multiplied by a weighting factor.
  - Output is 1 if sum of weighted inputs exceeds the threshold value; 0 otherwise.
- Network is programmed by adjusting weights using feedback from examples.

Figure 11.15 A neuron in a living biological system

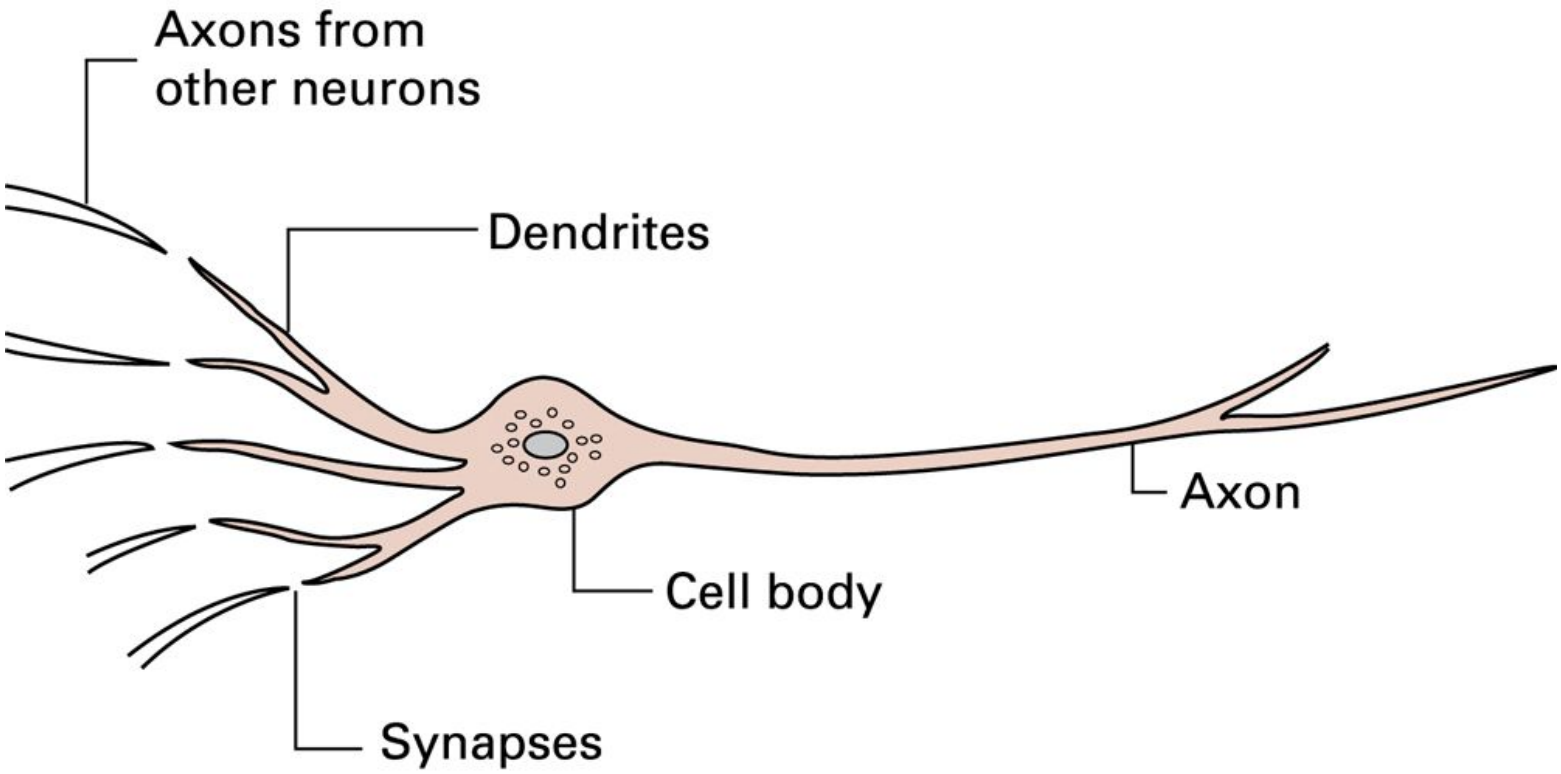


Figure 11.16 The activities within a processing unit

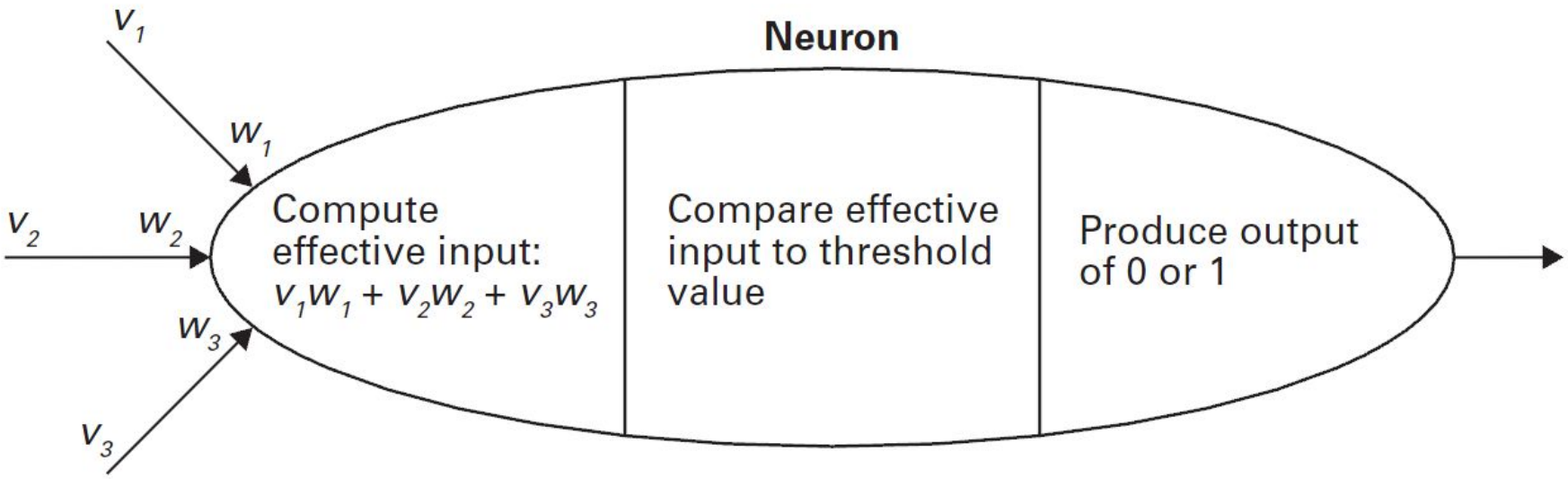


Figure 11.17 Representation of a processing unit

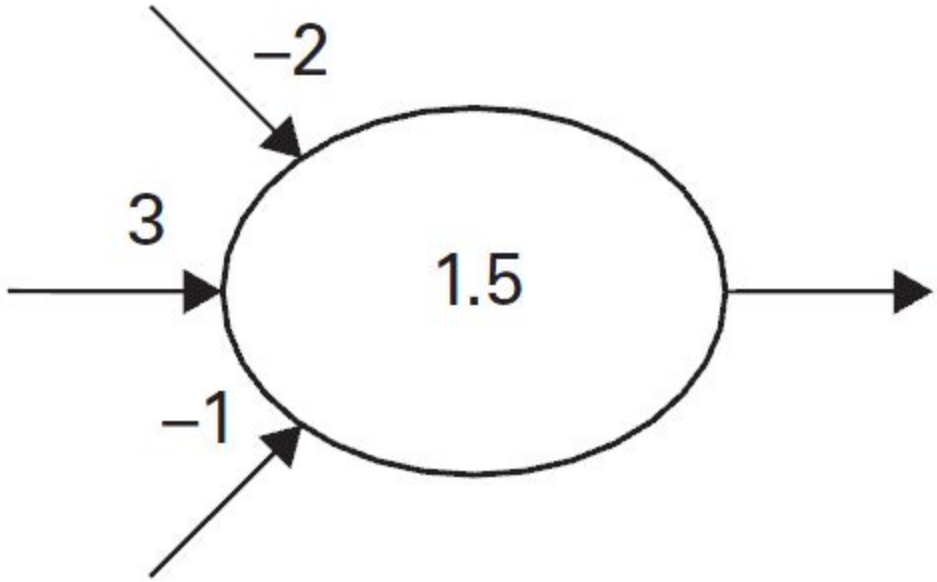


Figure 11.18 A neural network with two different programs

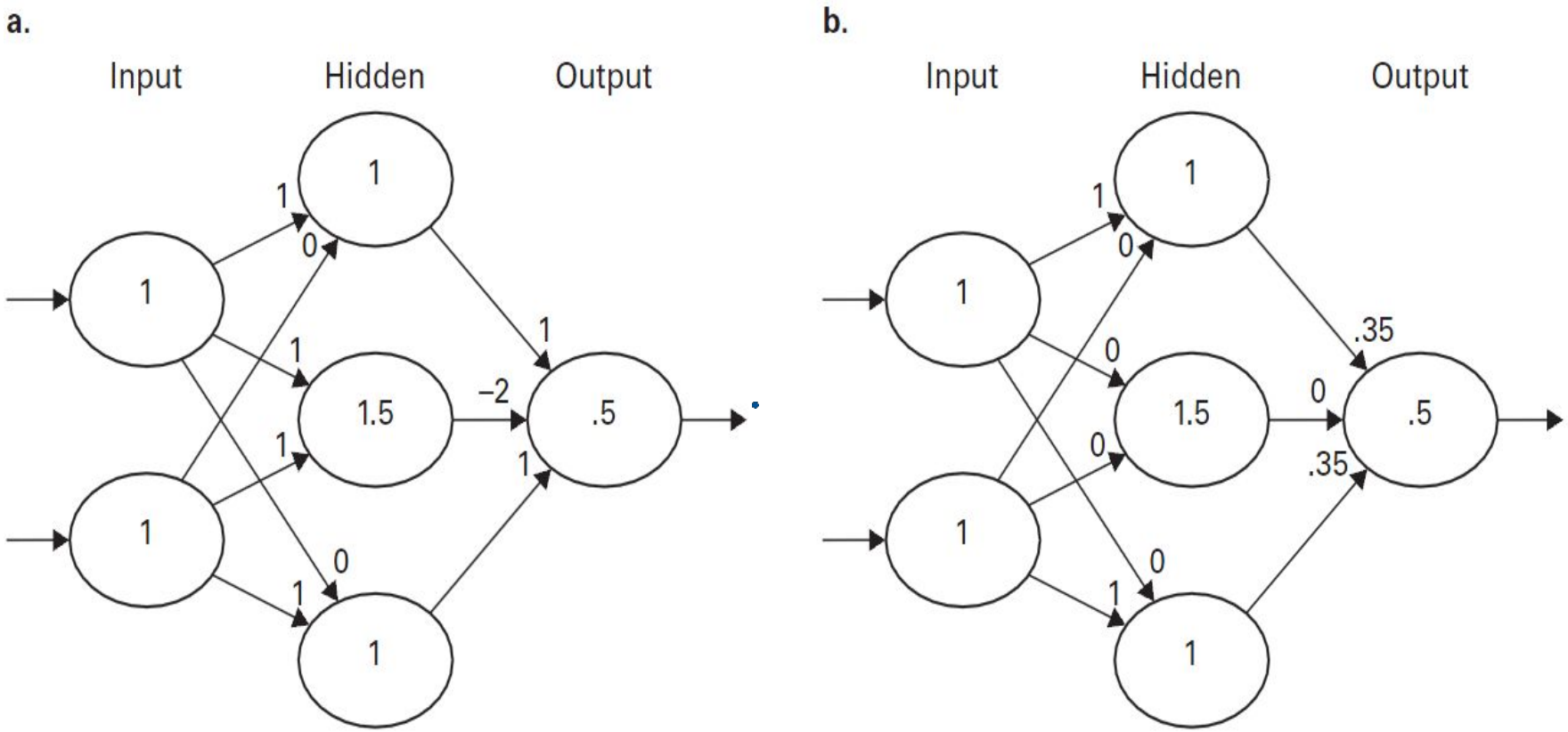
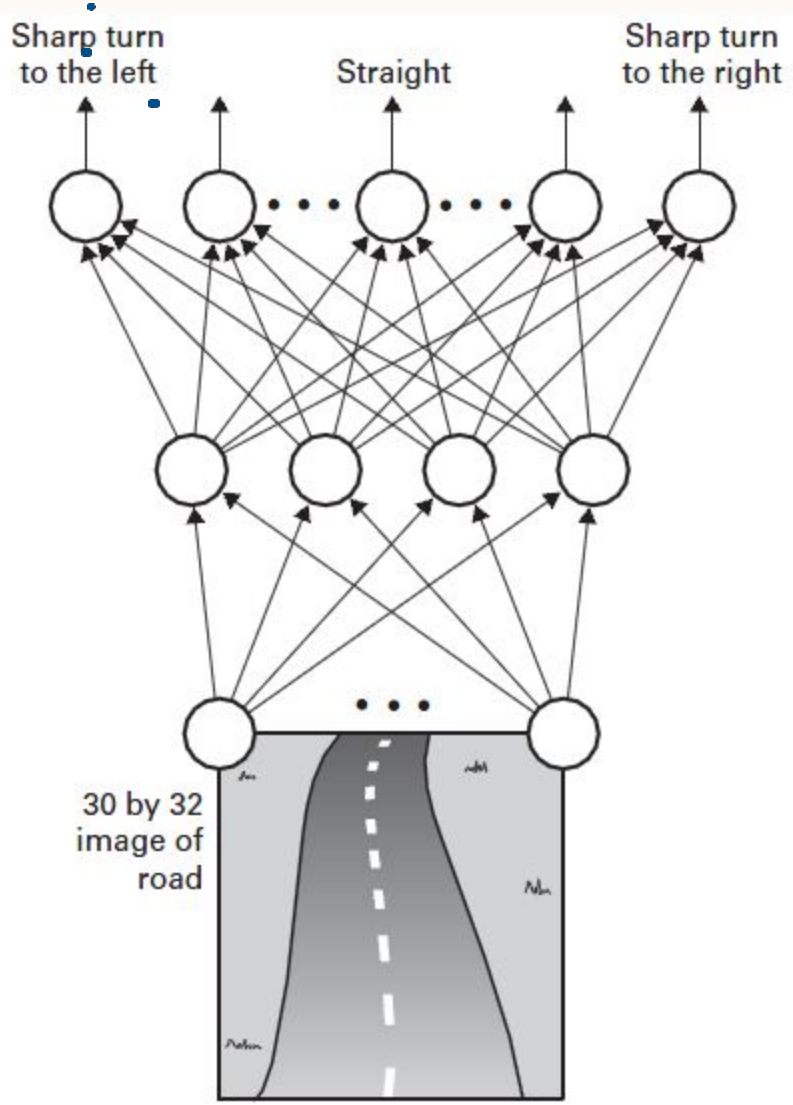


Figure 11.20 The structure of ALVINN



Associative Memory

- **Associative memory:** The retrieval of information relevant to the information at hand
- One direction of research seeks to build associative memory using neural networks that when given a partial pattern, transition themselves to a completed pattern.

Figure 11.21 An artificial neural network implementing an associative memory

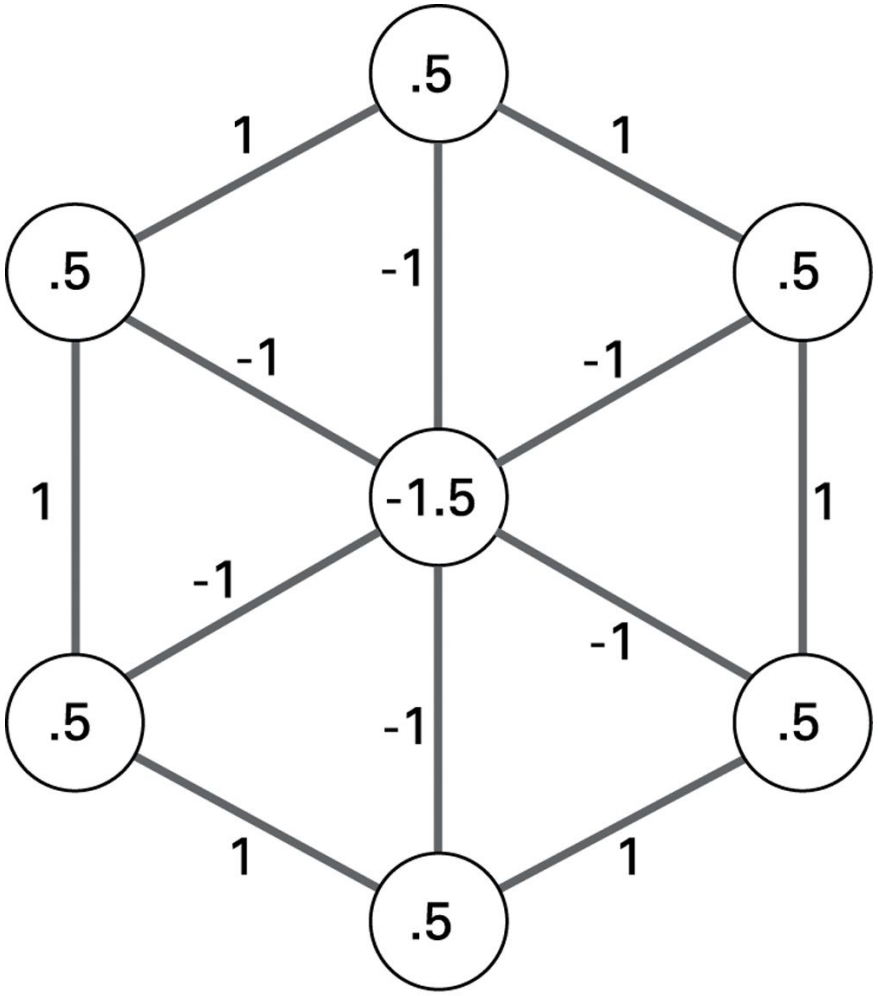
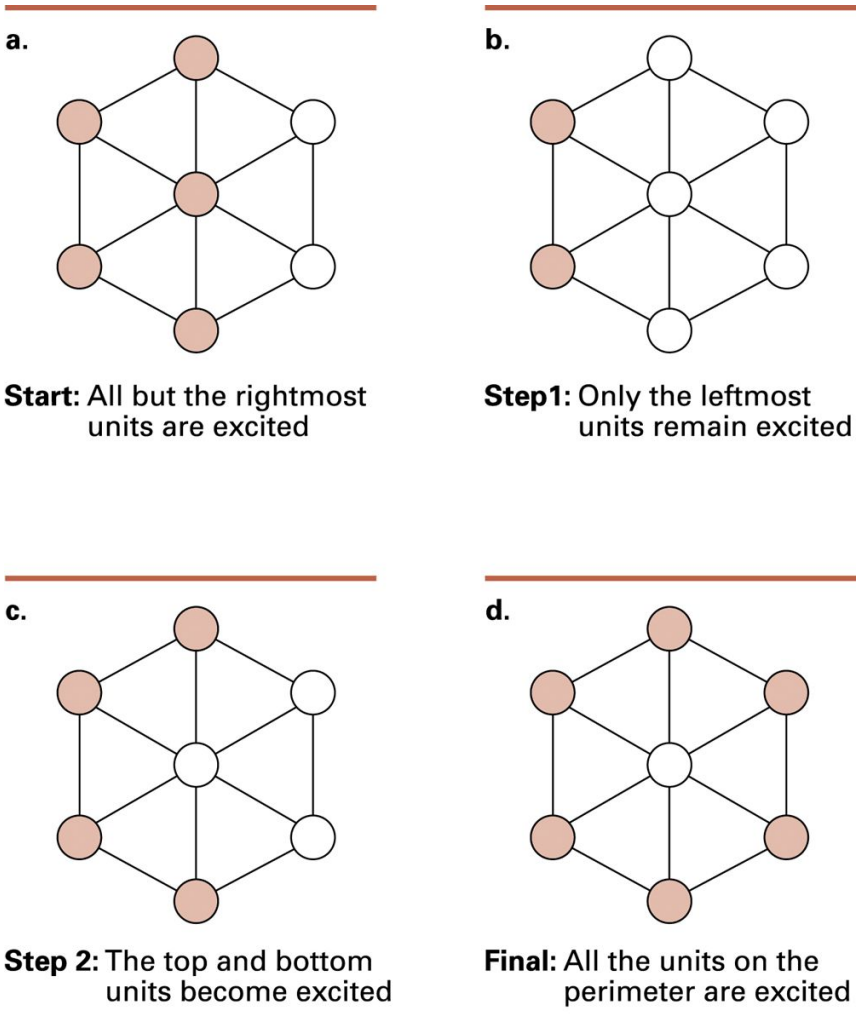


Figure 11.22 The steps leading to a stable configuration



Robotics

- Truly autonomous robots require progress in perception and reasoning.
- Major advances being made in mobility
- Plan development versus reactive responses
- Evolutionary robotics

Issues Raised by Artificial Intelligence

- When should a computer's decision be trusted over a human's?
- If a computer can do a job better than a human, when should a human do the job anyway?
- What would be the social impact if computer "intelligence" surpasses that of many humans?