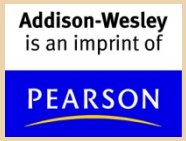
# Artificial Intelligence

Slides derived from those available for the book:

**Computer Science: An Overview, 11th Edition, by J. Glenn Brookshear**



# Artificial Intelligence

- Intelligence and Machines
- Perception
- Reasoning
- Additional Areas of Research
- Artificial Neural Networks
- Robotics
- Considering the Consequences

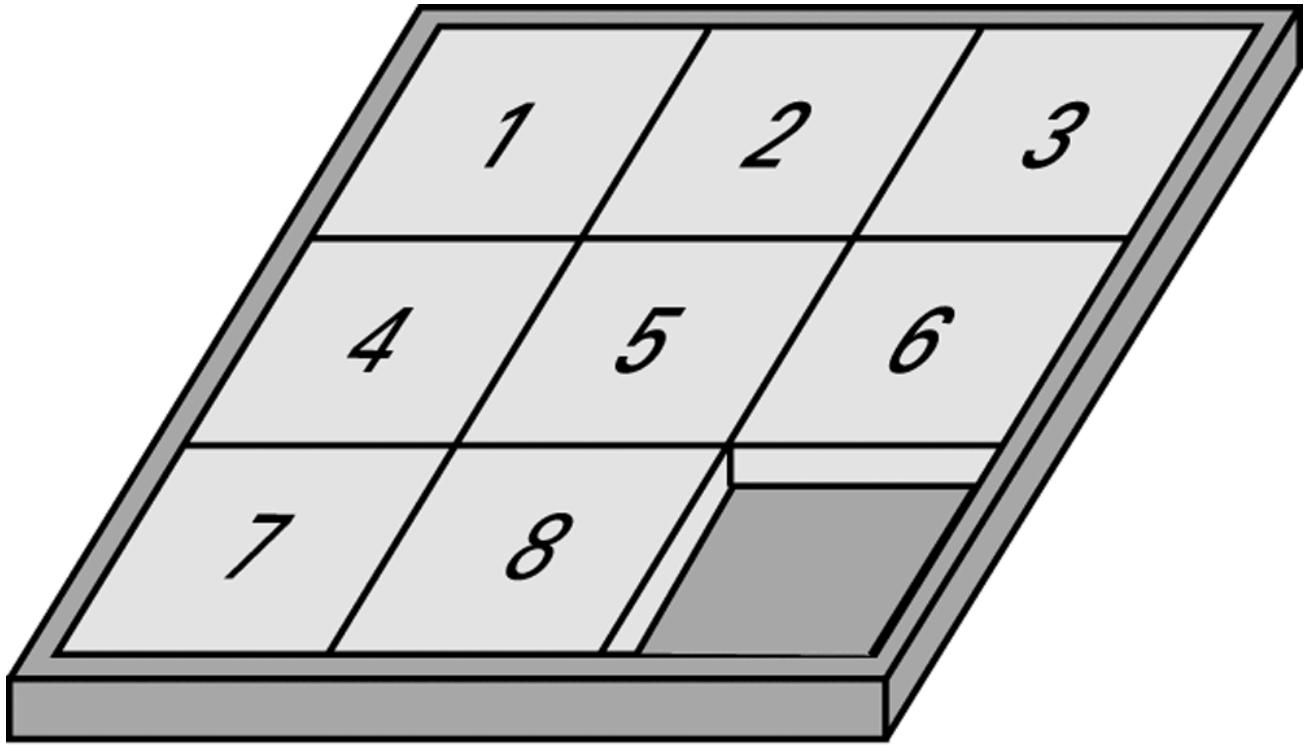
# Intelligent Agents

- **Agent:** A “device” that responds to stimuli from its environment
  - Sensors (Temperature, air, or soil sampling device… )
  - Actuators (Wheel, Leg, …)
- Much of the research in artificial intelligence can be viewed in the context of building agents that behave intelligently

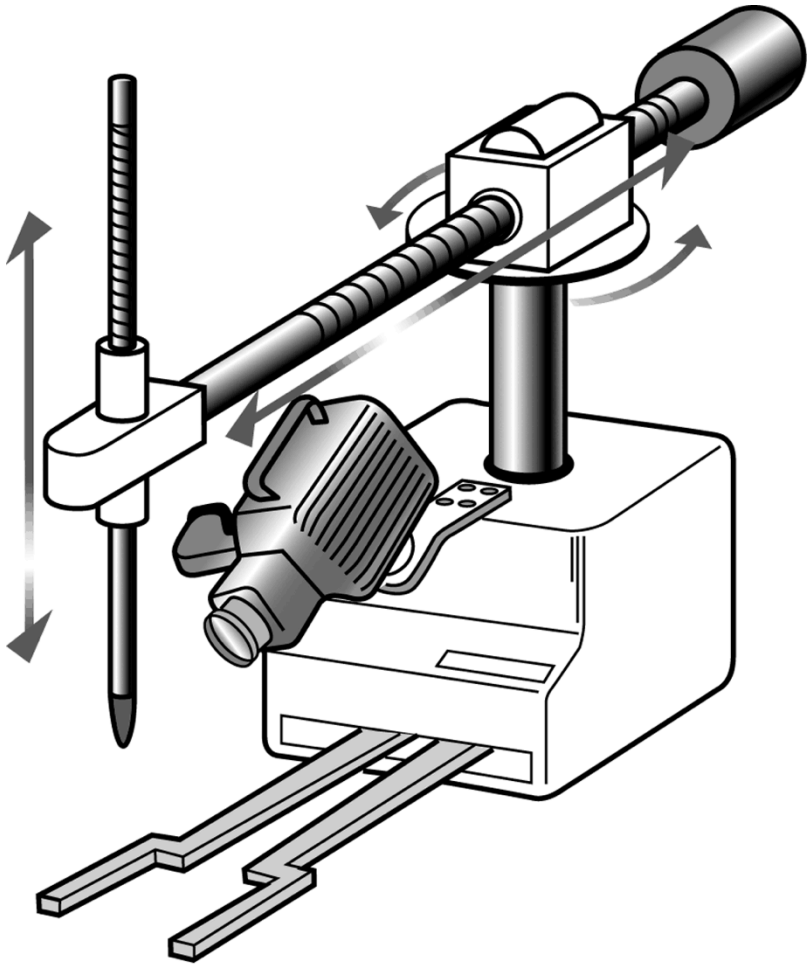
# Levels of Intelligent Behavior

- 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

# The eight-puzzle in its solved configuration



# Our puzzle-solving machine



# Approaches to Research in Artificial Intelligence

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

Natural Language Processing versus Linguistics

# 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?
- Turing predicted: "*By the year 2000 machines would have a 30% chance of passing a five-minute Turing test.*"
  - E.g., "Dr. Computer"

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# Techniques for Understanding Images

- Template matching
  - Compare with Samples
  - Matching geometric characteristics
- Understand an image
  1. Image processing
     - edge enhancement (clarify boundary)
     - region finding (Find areas with common properties)
     - Smoothing (Removing flaws from the image)
  2. Image analysis
     - What is the meaning of the image?

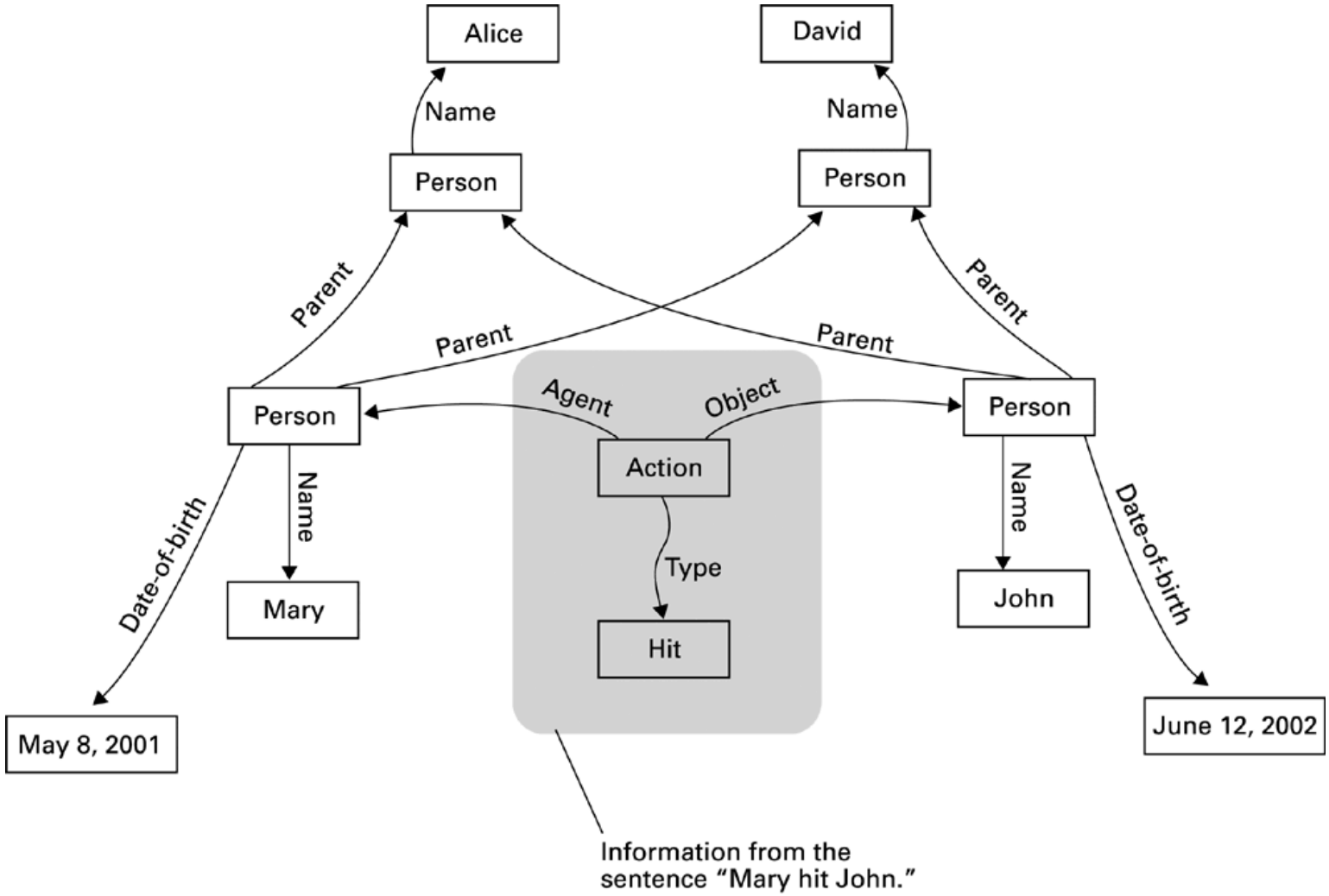
# Language Processing

- Syntactic Analysis
  - Parsing (Grammatical role of each word)
- Semantic Analysis
  - Identify the semantic role of each world
- Contextual Analysis
  - Context of the sentence should be considered, e.g., “Do you know what time it is?”

# Information Retrieval and Extraction

- Information Retrieval:
  - Identifying documents that relate to the topic at hand (e.g., Google)
- Information Extraction
  - Extracting information from documents useful for other applications (use different template to extract information from different text, e.g., “natural disaster” vs “coup”)

# A semantic net



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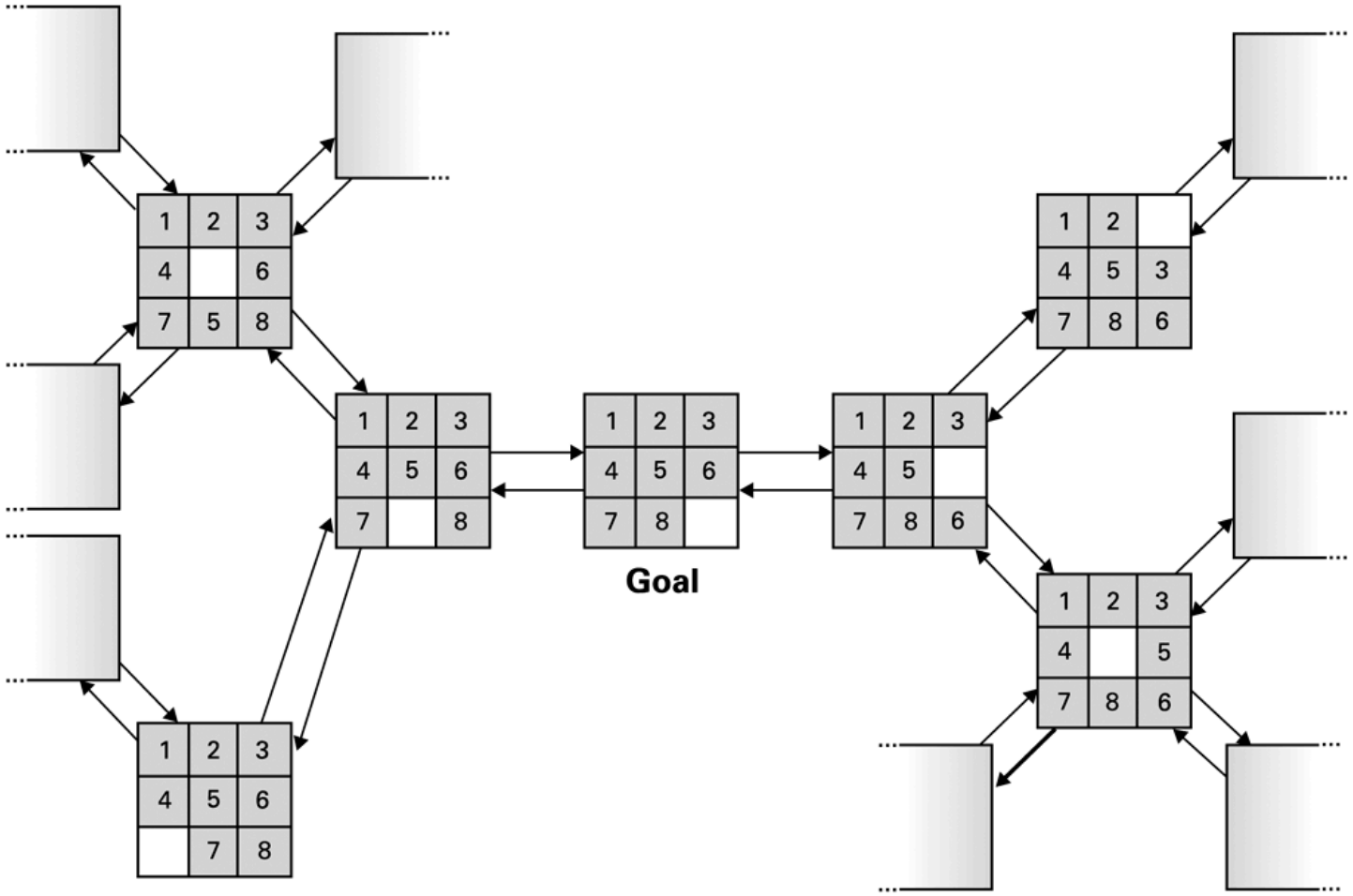
# Components of a Production Systems

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

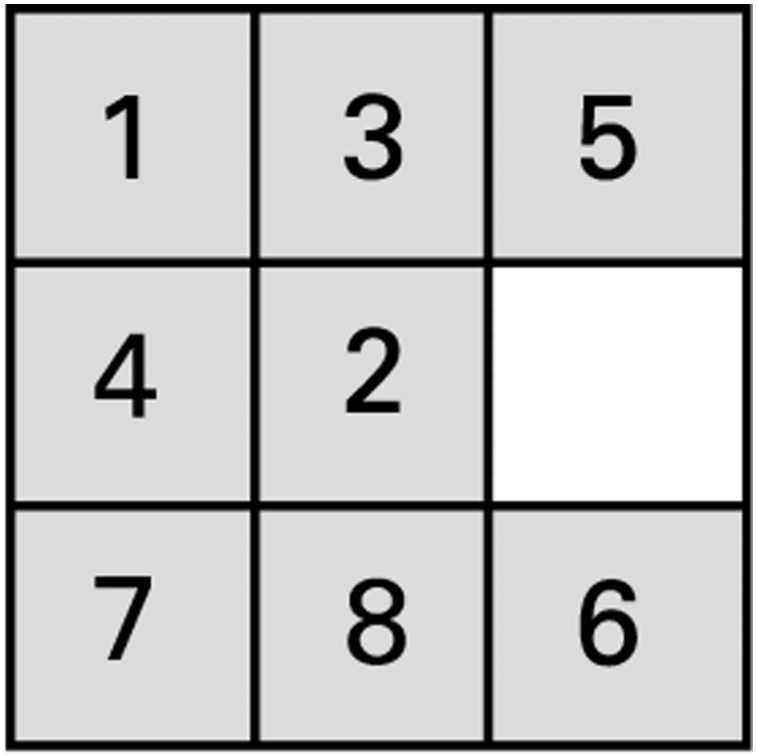
# Reasoning by Searching

- **State Graph:** All states and productions
- **Search Tree:** A record of state transitions explored while searching for a goal state
  - Breadth-first search
    - Make tree layer by layer
  - Depth-first search
    - Build vertical path rather than horizontal path

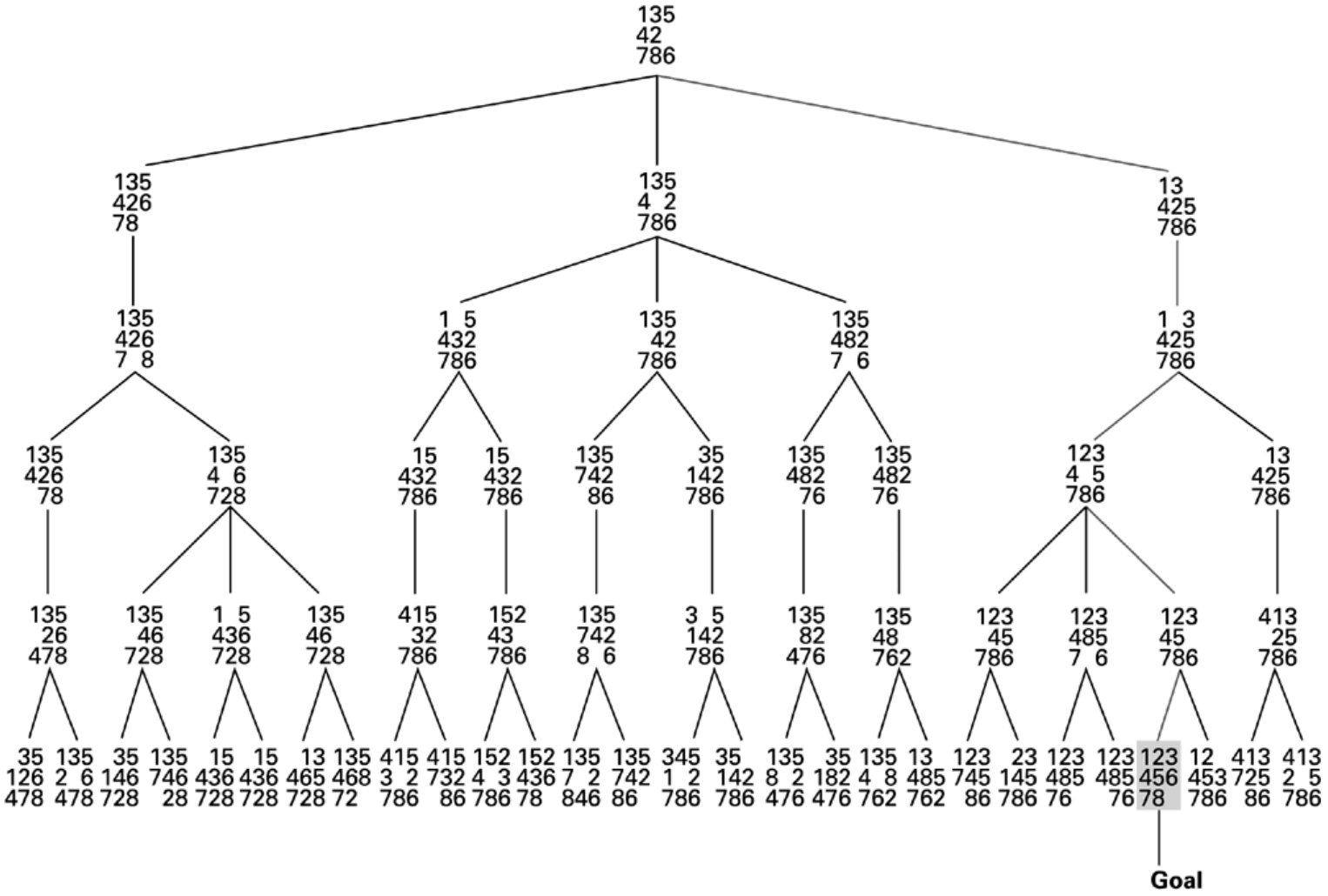
# A small portion of the eight-puzzle's state graph



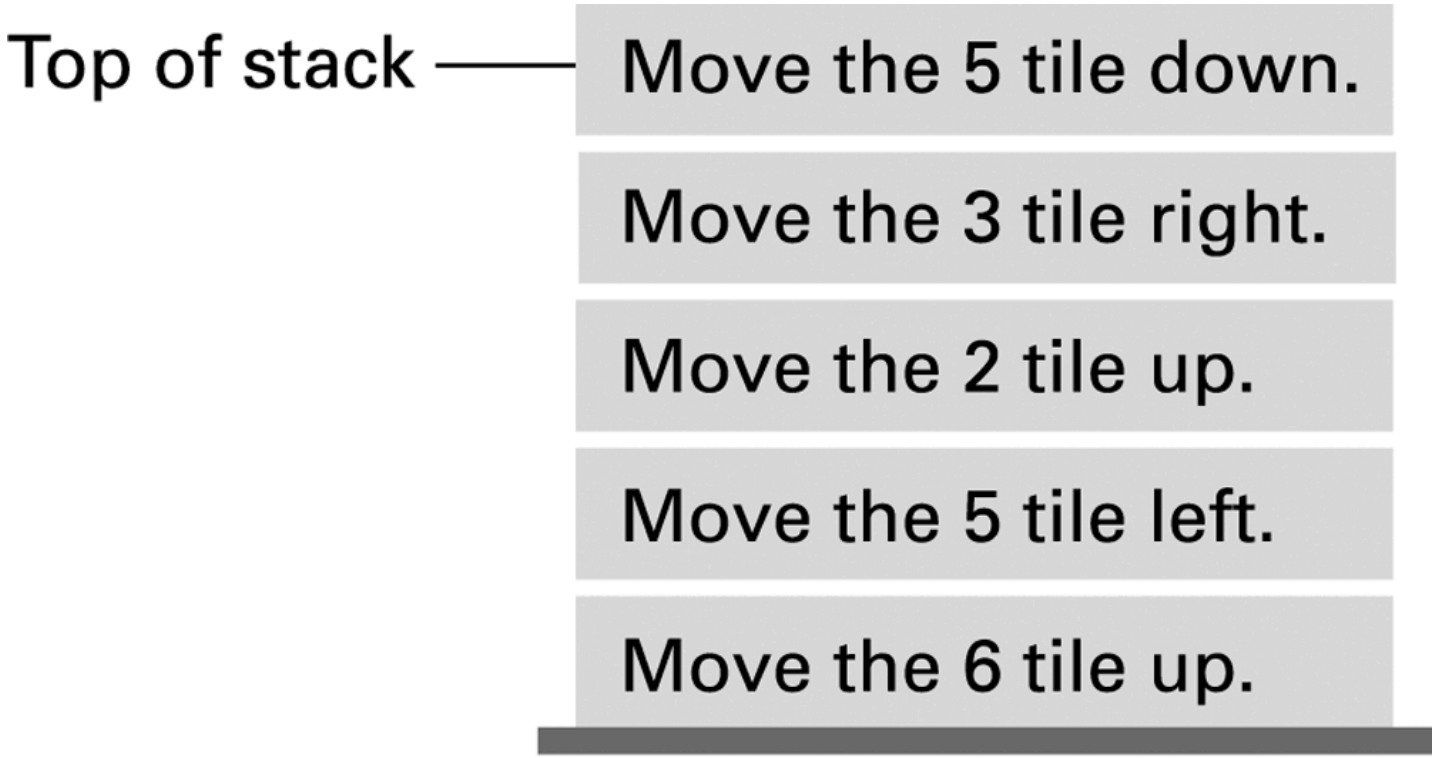
# An unsolved eight-puzzle



# A sample search tree



# Productions stacked for later execution



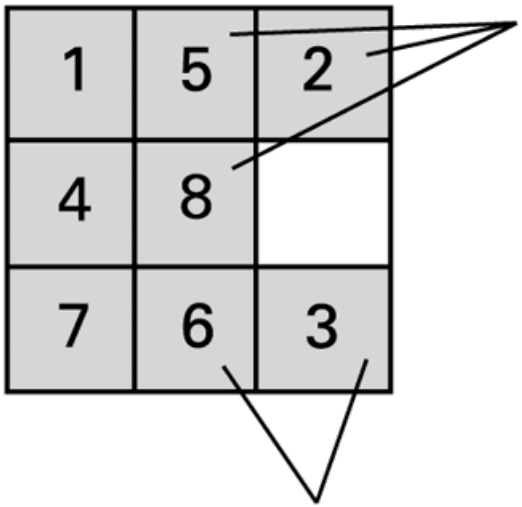
# Heuristic Strategies

- **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

# Find a Good Heuristic

- Distance to the goal (Count the number of tiles out of their place)
- Measure the distance each tile has from its destination

# An unsolved eight-puzzle



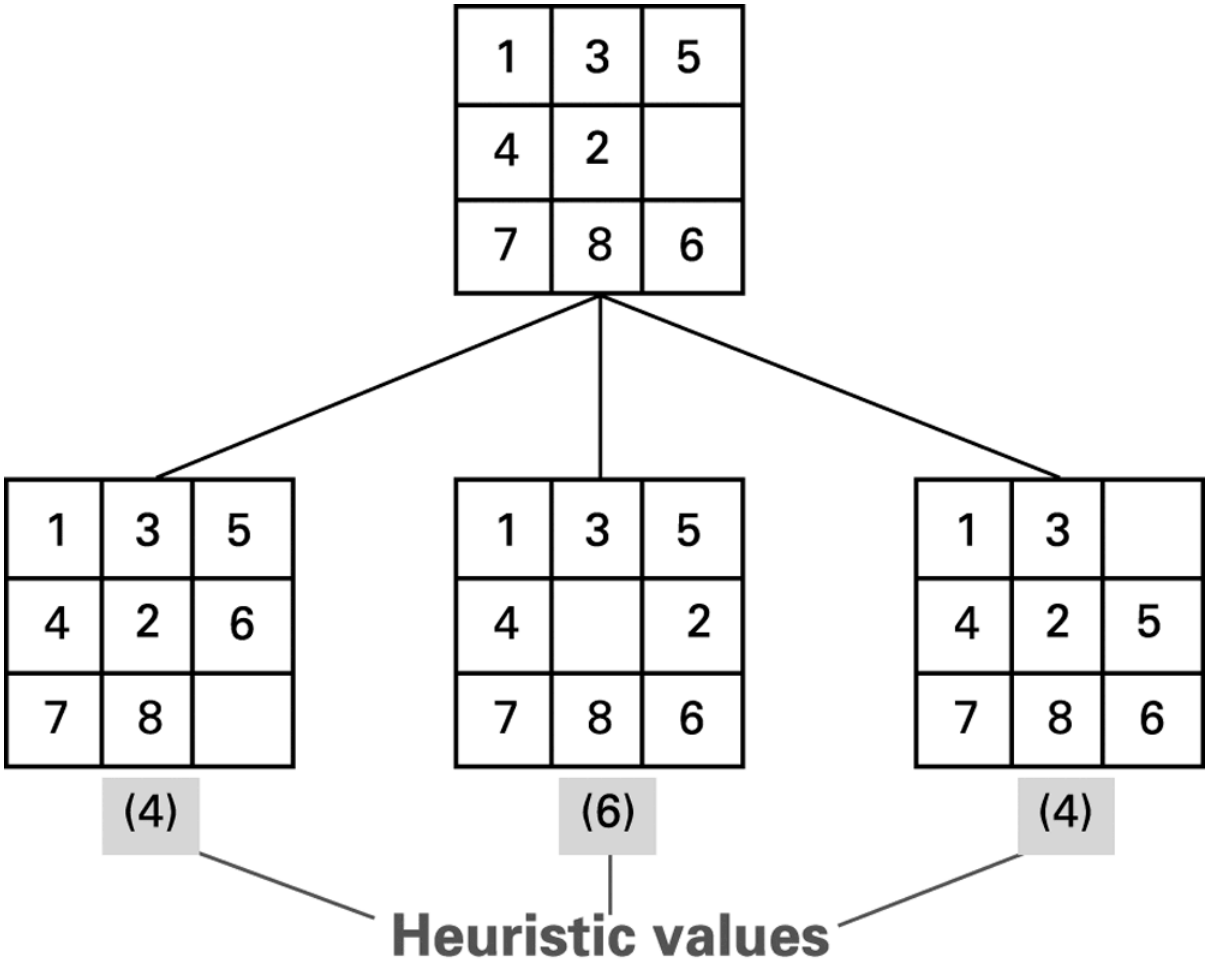

These tiles are at least one move from their original positions.

These tiles are at least two moves from their original positions.

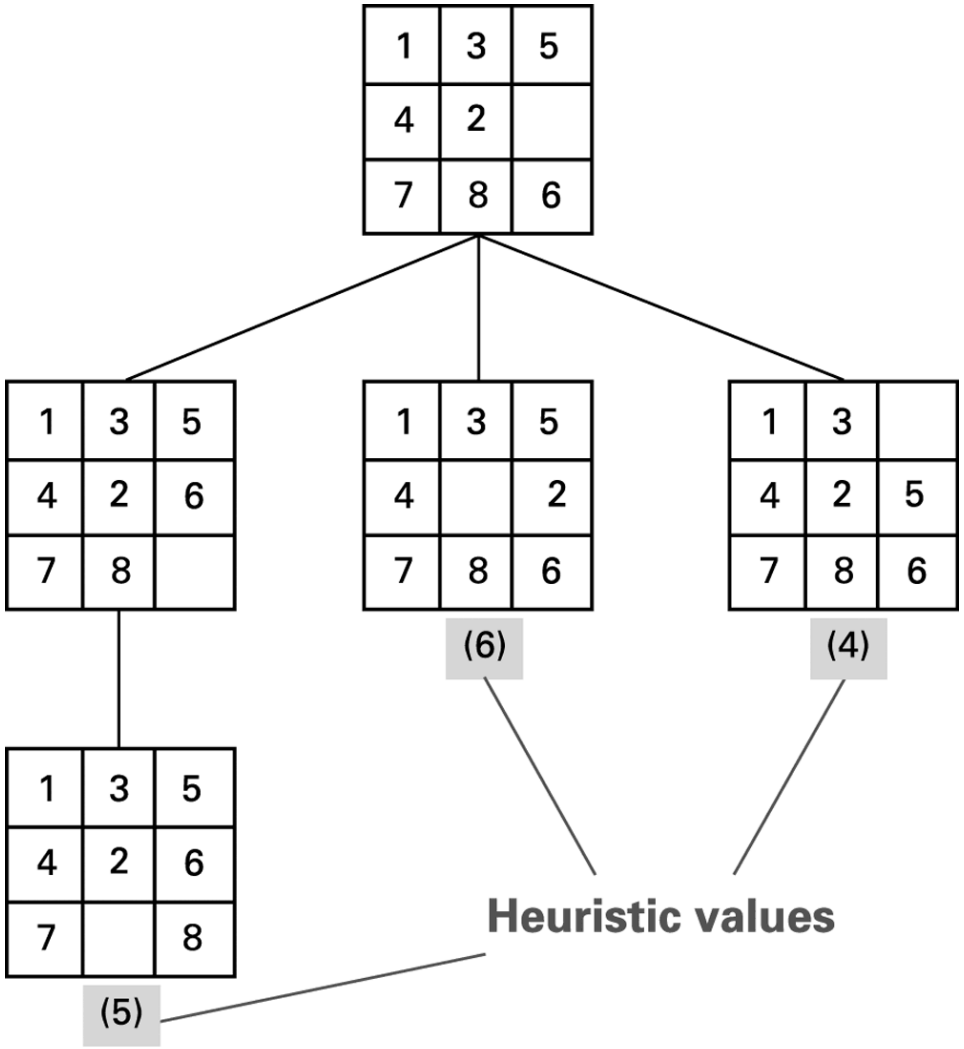
# An algorithm for a control system using heuristics

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) **do**
[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.

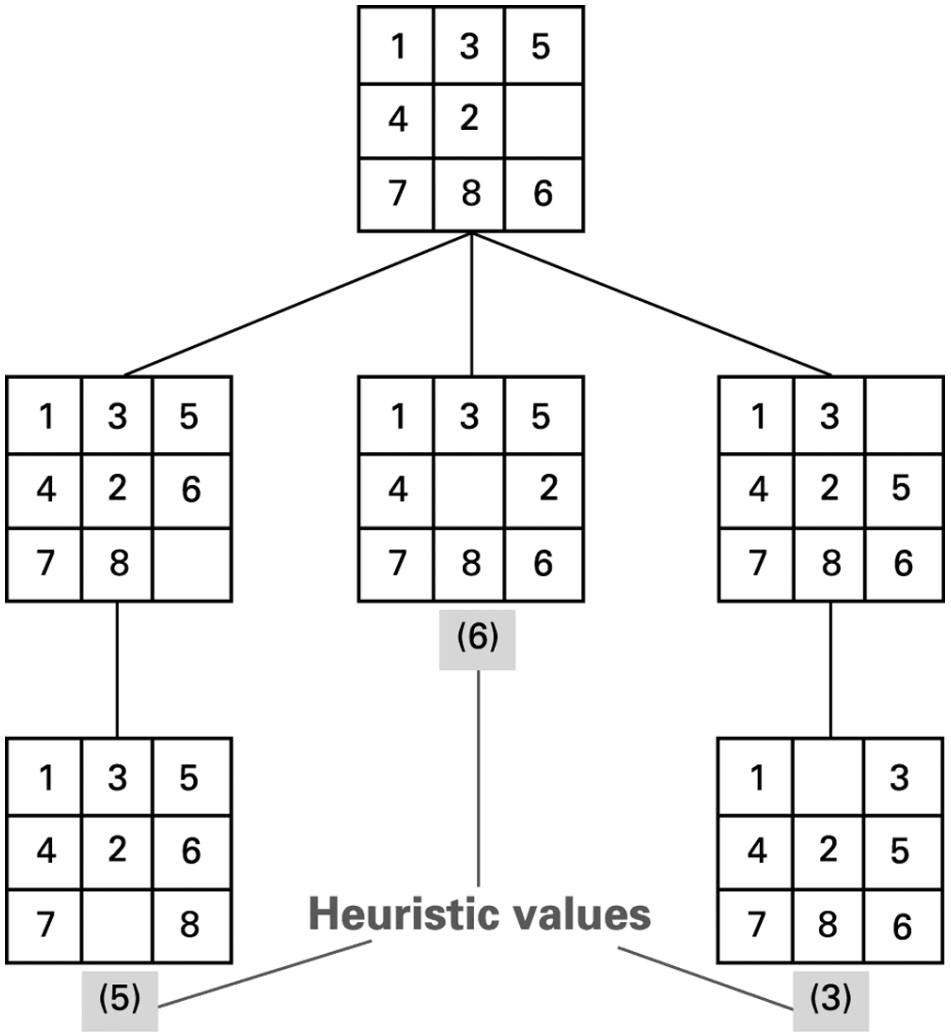
# The beginnings of our heuristic search



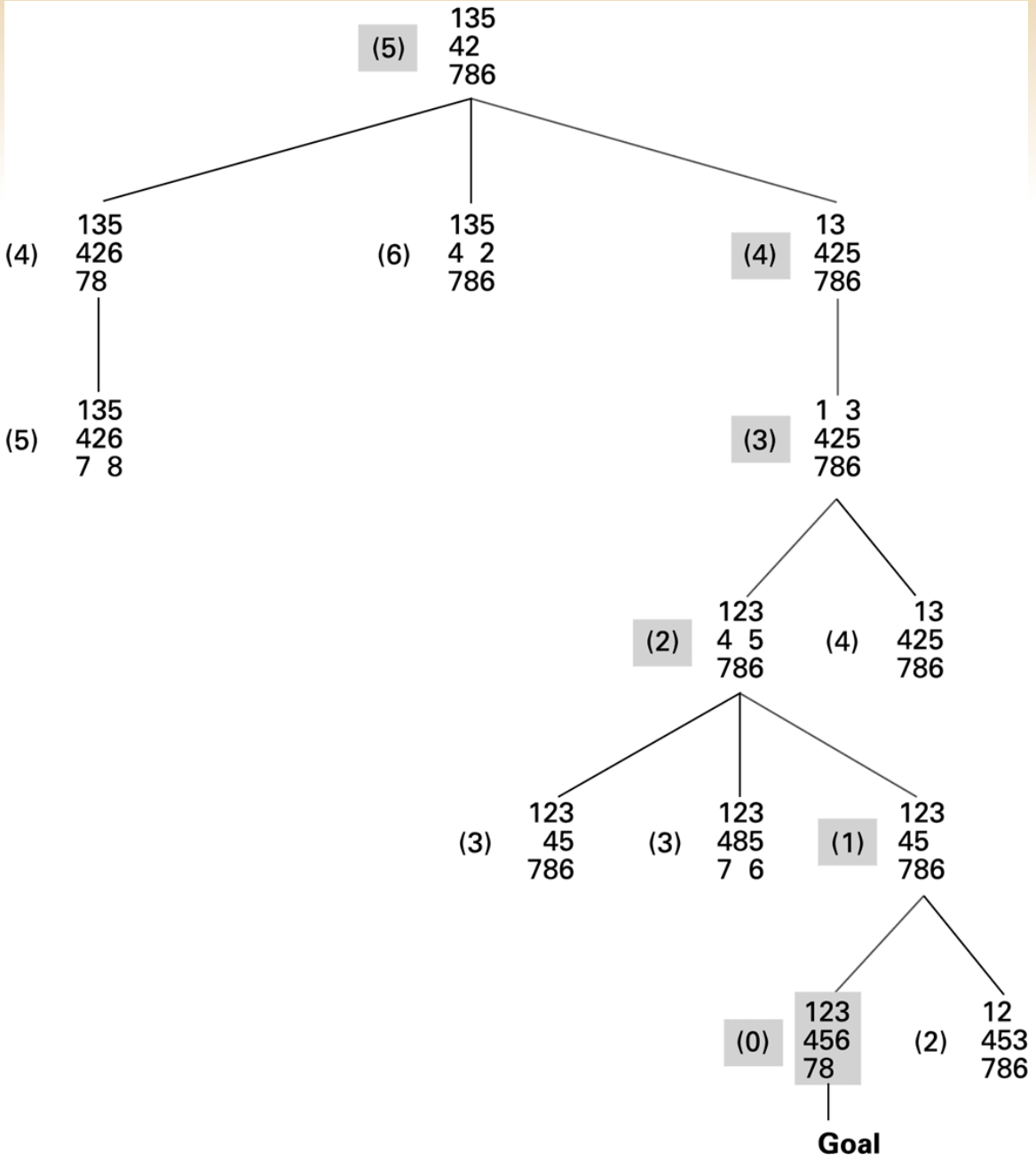
# The search tree after two passes



# The search tree after three passes



# The complete search tree formed by our heuristic system



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# Handling Real-World Knowledge

- Representation and storage
- Accessing relevant information
  - Meta-Reasoning
  - Closed-World Assumption
- Frame problem
  - Keeping stored knowledge up to date in a changing environment

# Learning

- Imitation
  - A person demonstrates the steps in a task and the computer records the steps(e.g., spreadsheets and word processors)
- Supervised Training
  - Training Set (e.g., learning to distinguish between junk and welcome emails, identify a disease from a set of symptoms)
- Reinforcement
  - The agent is given a general rule to judge for itself (e.g., play chess)

# 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

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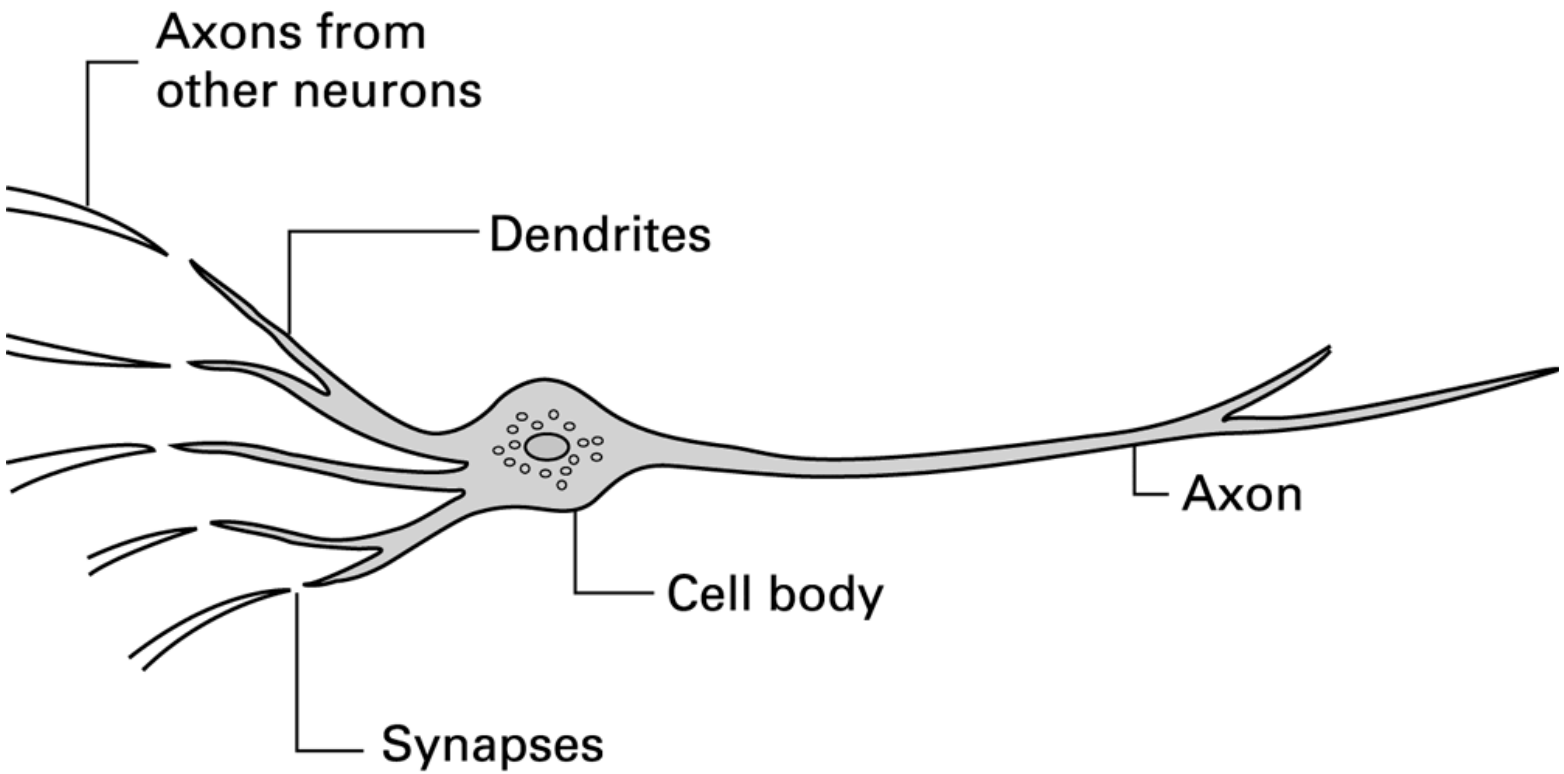
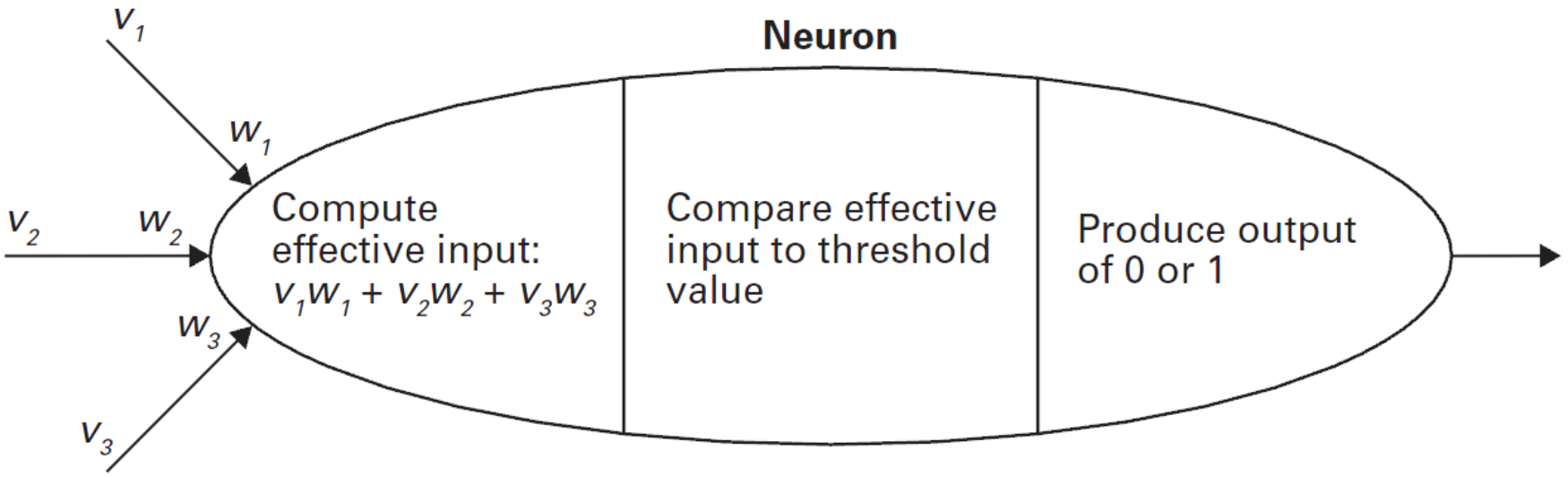
# Artificial Neural Networks

- 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.

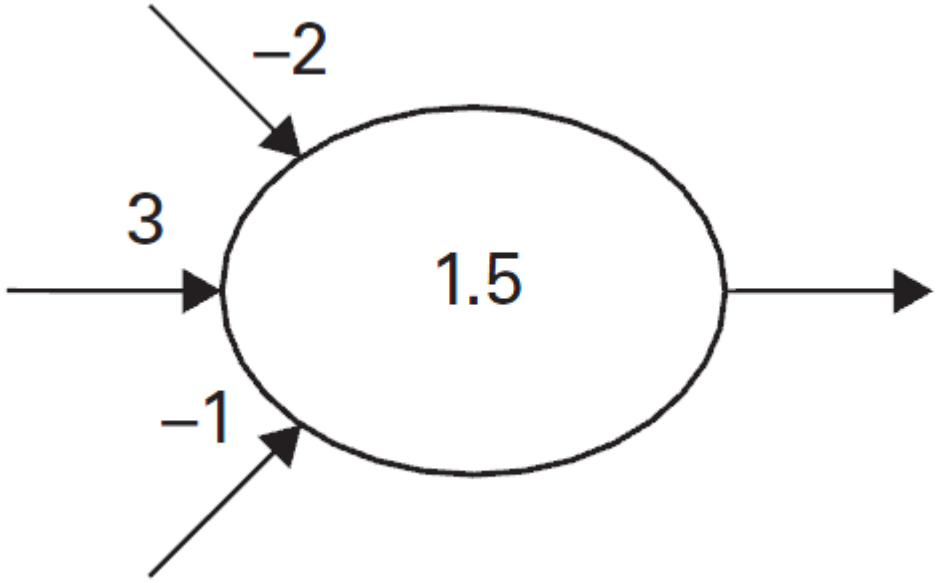
# A neuron in a living biological system



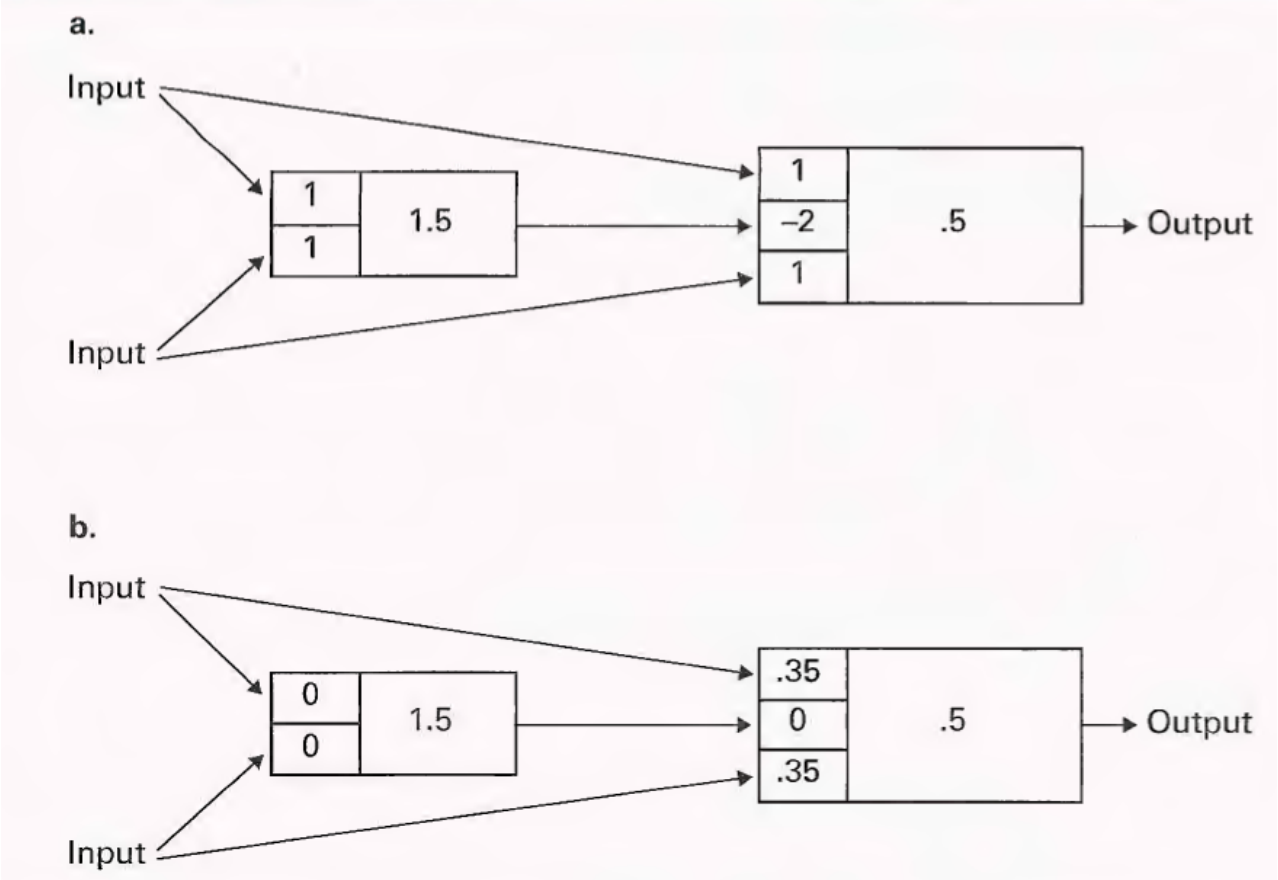
# The activities within a processing unit



# Representation of a processing unit



# Neural Network with Two Different Program

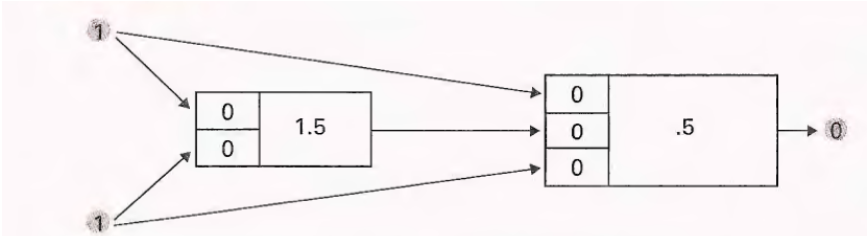



Produce output “1”
if its two inputs differ

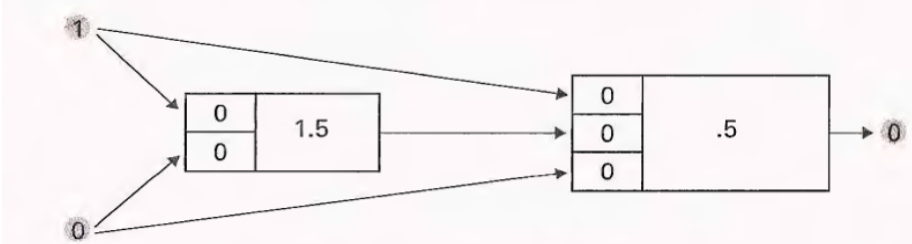
Produce output “1”
if its two inputs are “1”

# Training an Artificial Neural Network

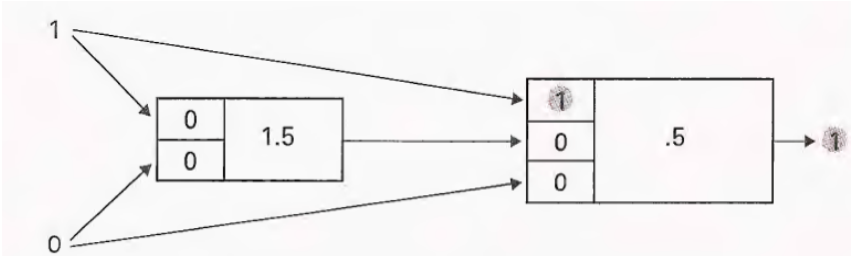
## Produce output 1 when the inputs are different



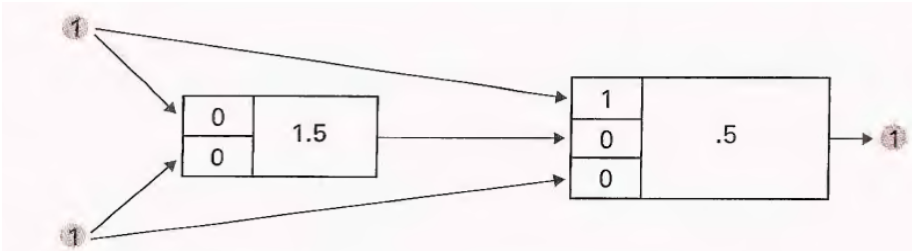

a. The network performs correctly for the input pattern 1, 1.




b. The network performs incorrectly for the input pattern 1, 0.



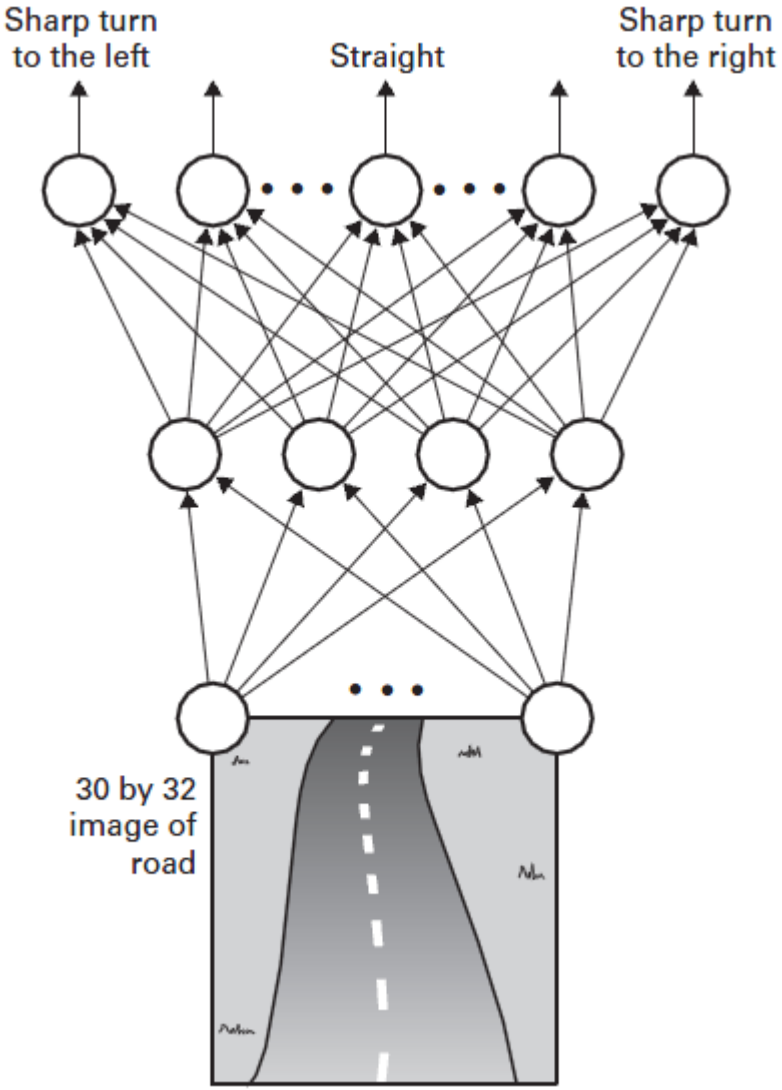

c. The upper weight in the second processing unit is adjusted.




d. However, the network no longer performs correctly for the input pattern 1, 1.

# The structure of ALVINN

## Autonomous Land Vehicle in a Neural Net



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# Robotics

- Truly autonomous robots require progress in perception and reasoning.
- Major advances being made in mobility
  - Wheeled and Legged robots
- Plan Development versus Reactive Responses
- Robocup Competition (beat human soccer teams by 2050)
- Evolutionary robotics

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# 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?