Artificial Intelligence

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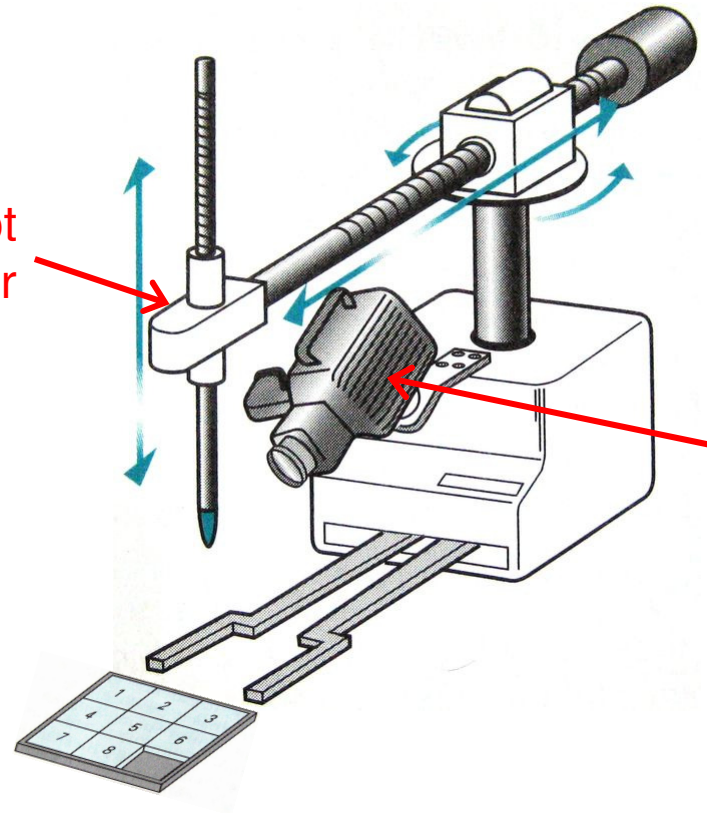
Intelligent Agent

- In AI, researchers try to build a device (an agent) that can sense-and-change its environment



Where is the brain?

Levels of Intelligent Behaviors

- Reflex
  - actions are predetermined responses to the input data
- Intelligent response
  - actions affected by knowledge of the environment
- Goal seeking
- Learning

Approaches in Artificial Intelligence

- Performance-oriented
  - Researcher tries to maximize the performance of the agents; the techniques used may not be “intelligent” by nature, but are effective in producing “intelligent” results
- Simulation-oriented
  - Researcher tries to derive theories about how a biological agent produce intelligent responses to the environment and try to build an artificial agent that use the theories to simulate the behaviors

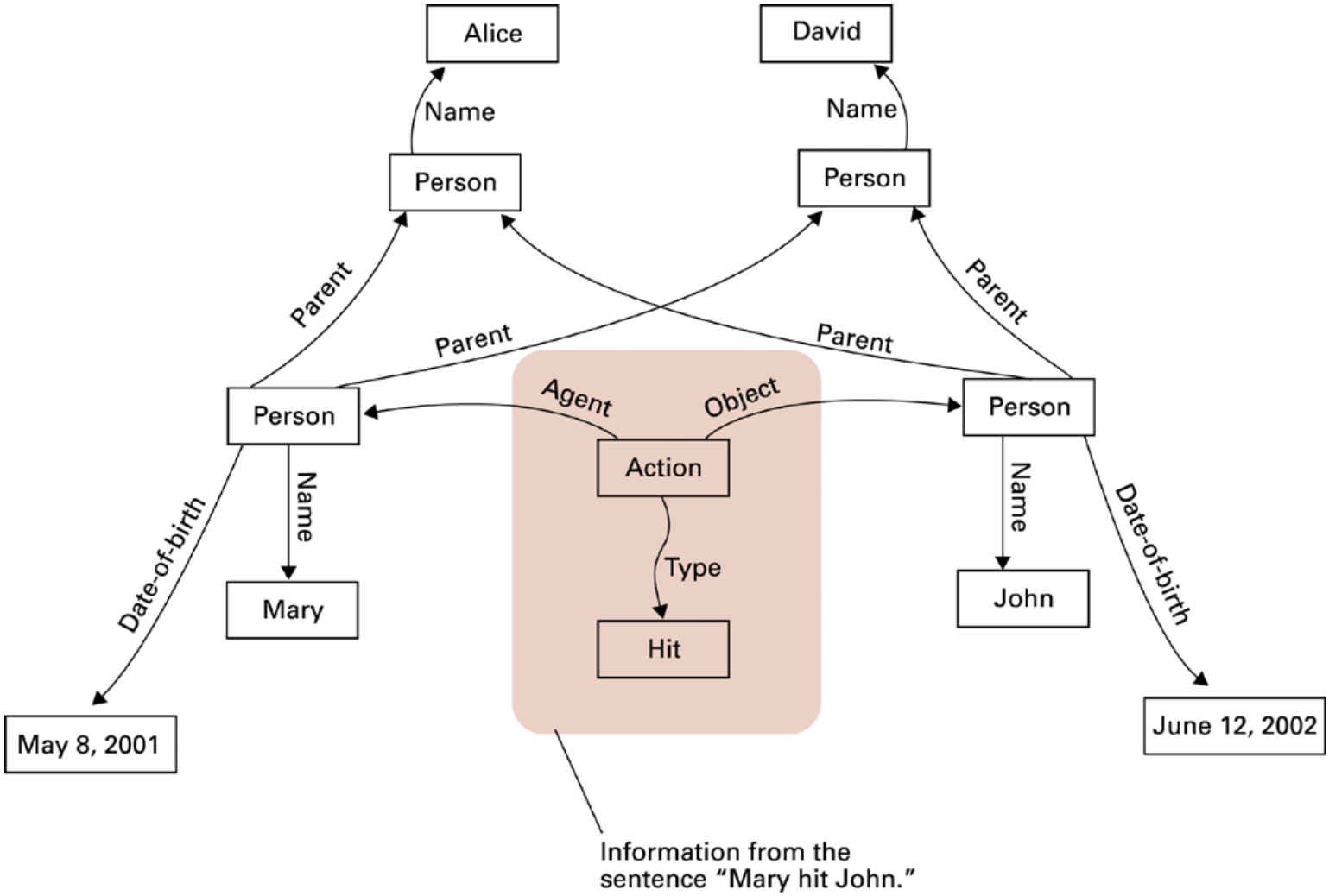
Turing Test

- Proposed by Alan Turing in 1950, a benchmark for progress in artificial intelligence
  - Test setup: human interrogator communicates with test subject by typewriter.
  - Test goal: can the human interrogator distinguish whether the test subject is human or machine?
- Examples
  - The DOCTOR program created by Joseph Weizenbaum in 1960s may fool some naive human interrogator; similar to today's MSN robots
  - Today, CAPTCHA are used to stop web-bots

Perception – Understanding the Input

- Image Understanding
  - Template matching
  - Image processing techniques
    - edge enhancement
    - region finding
    - smoothing
  - Image analysis
- Language Processing
  - Syntactic Analysis
  - Semantic Analysis
  - Contextual Analysis

Example: A Semantic Net



Reasoning Ability

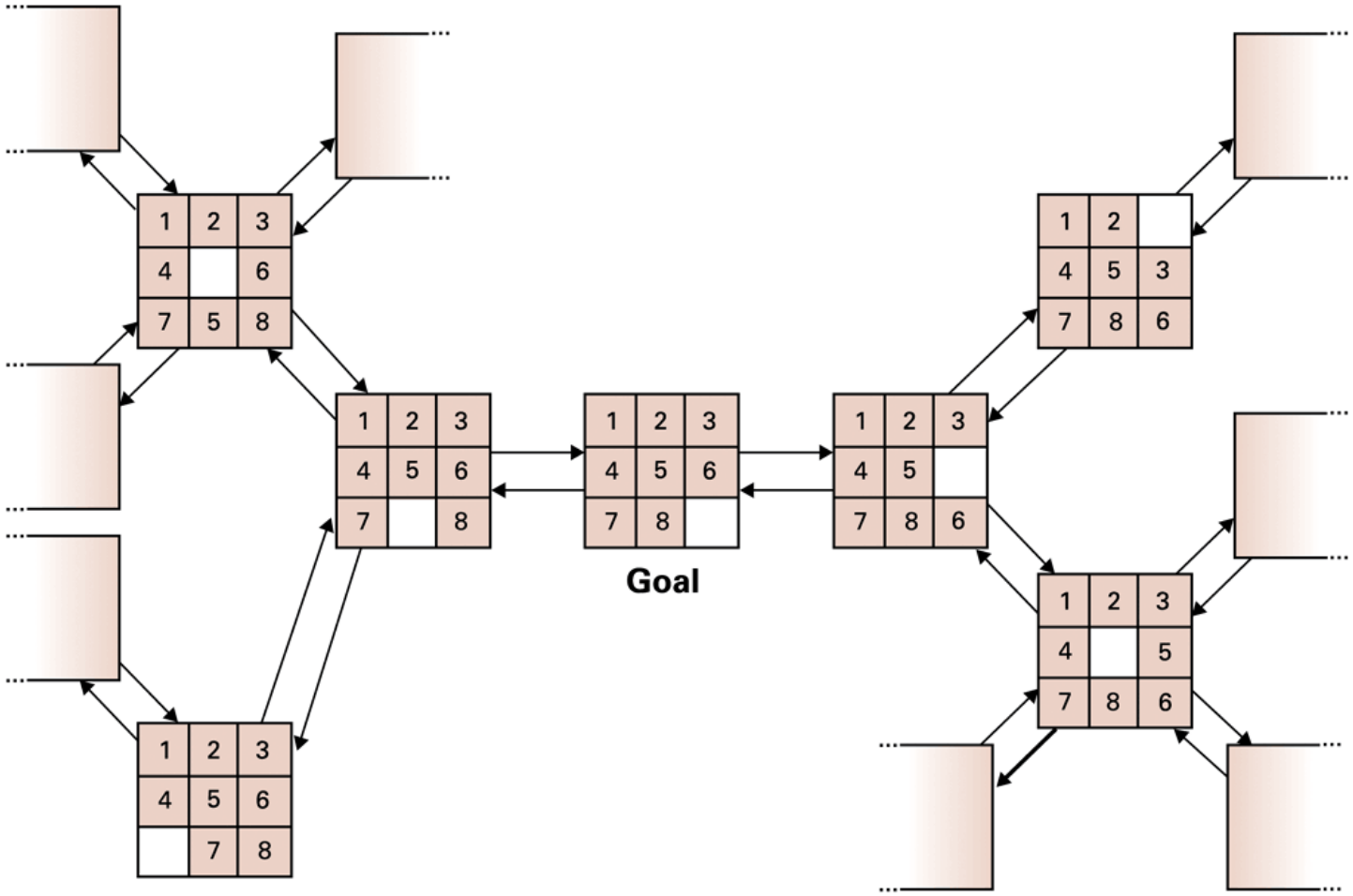
- Some AI researchers think that the ability to reason can be isolated in an abstract entity known as a **production system**:
  - Collection of states
  - Collection of productions (rules or actions)
  - Control system:
    decides which production to apply next given current states

Reasoning by Searching

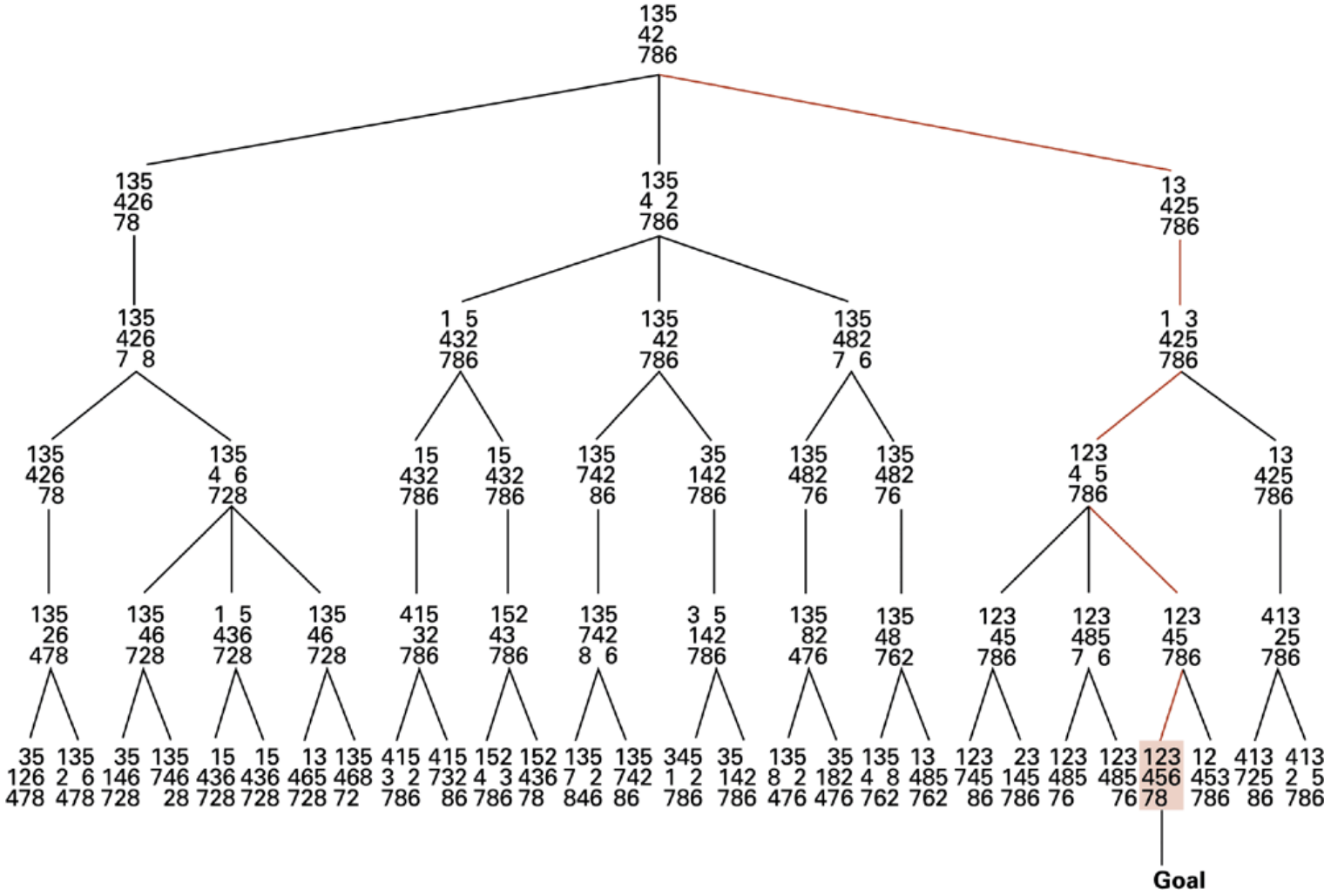
- State graph
  - a graph that representing all the states and productions
- Search tree
  - a record of state transitions explored while searching for a goal state
    - Breadth-first search
    - Depth-first search
- Example: the 8-puzzle problem

1	3	5
4	2	
7	8	6

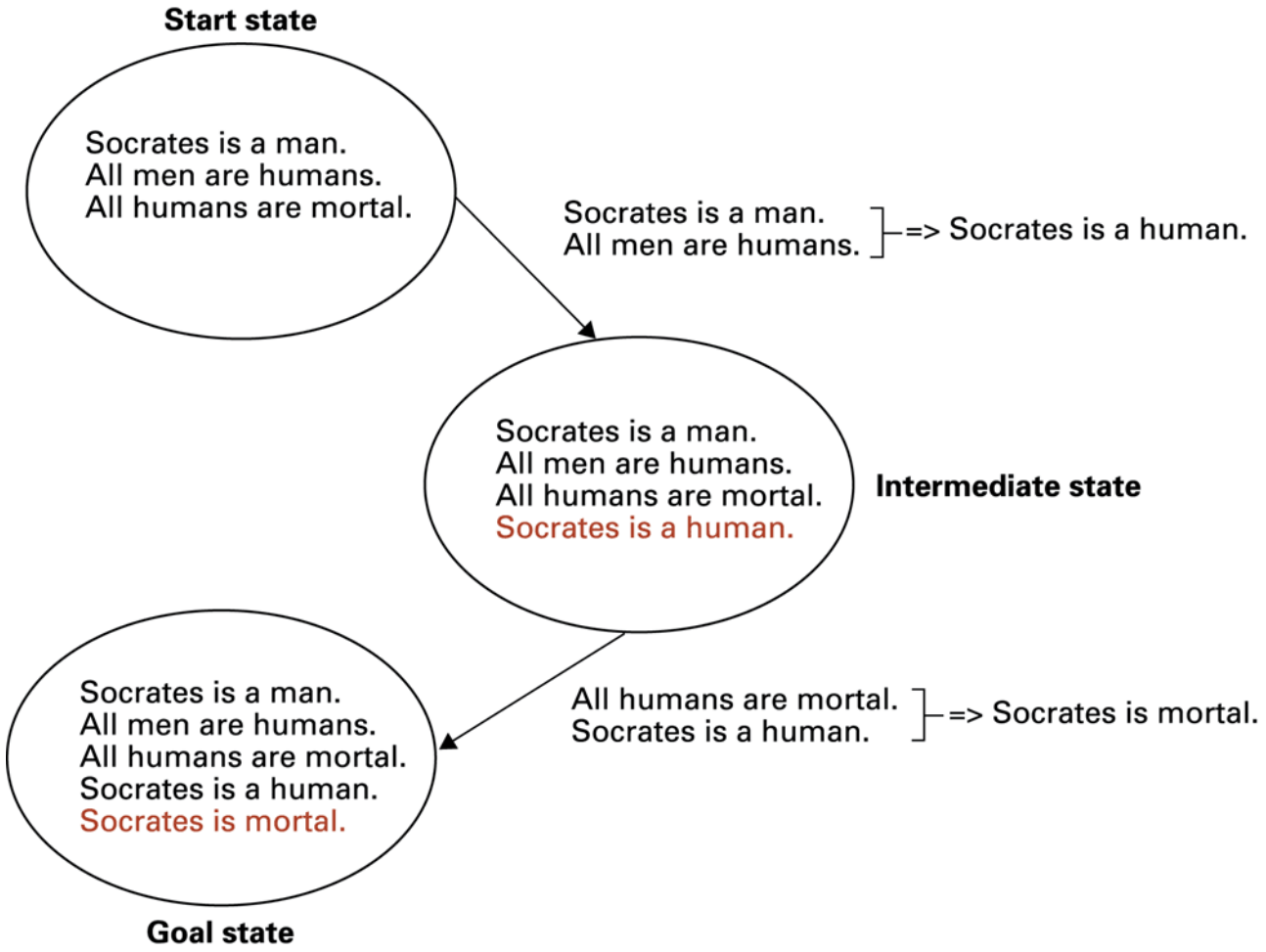
Partial State Graph of 8-Puzzle Problem



8-Puzzle Problem Search Tree



Deductive Reasoning

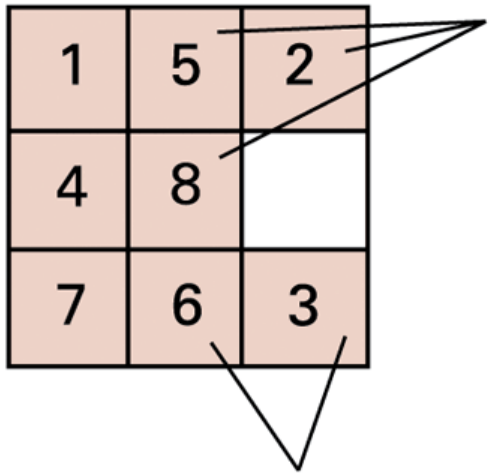


Heuristic Strategies

- Heuristic
  - A “quantitative estimate” of the distance to a goal
  - Not all reasons can be quantified, but with heuristic, we can “compute” our goal
- Requirements for good heuristics
  - Must be much easier to compute than a complete solution
  - Must provide a reasonable estimate of proximity to a goal

Eight-Puzzle Heuristic

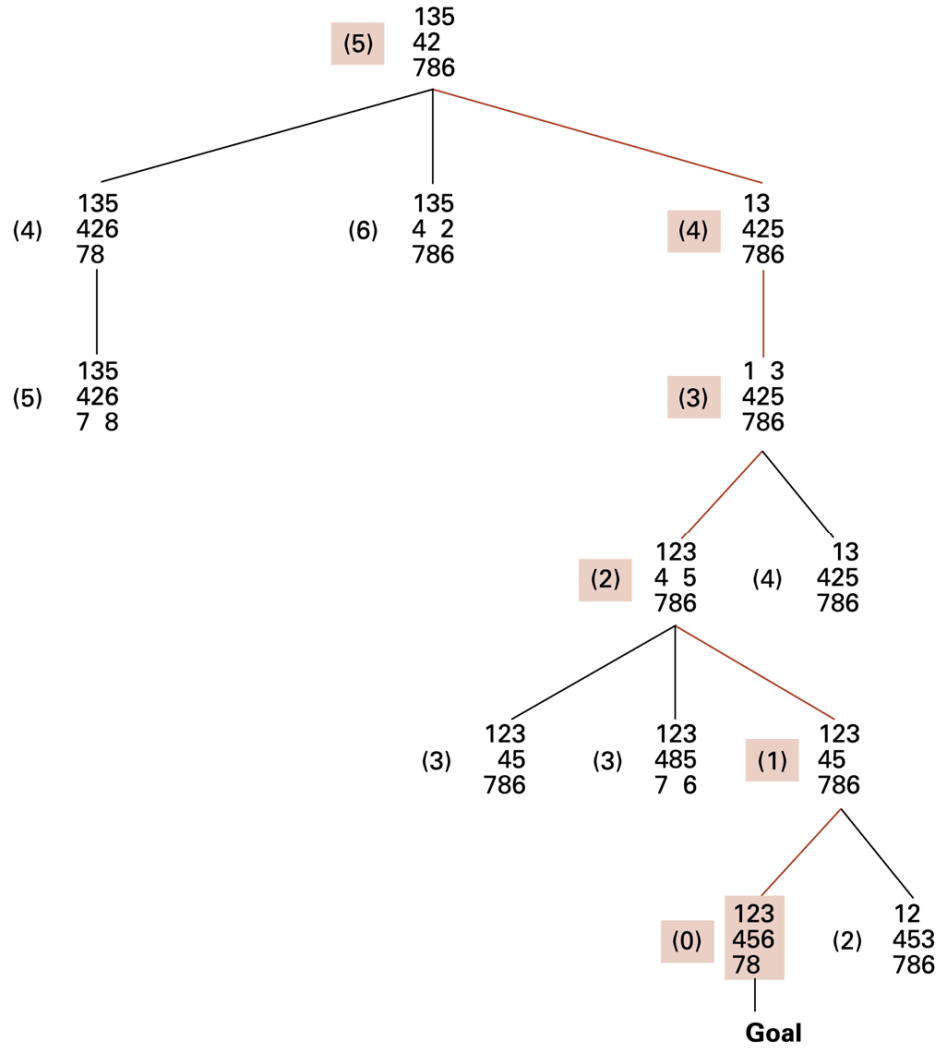
- How do we quantify the distance to our goal in an 8-puzzle problem?



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

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

Heuristic Search of 8-Puzzle Prob.

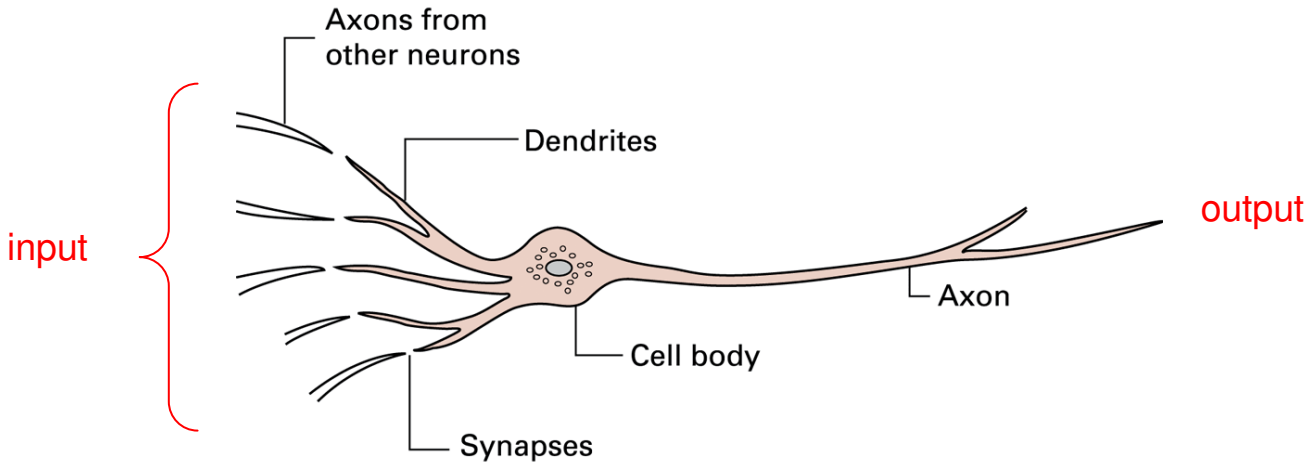


Key Issues in Intelligent Behavior

- Representation and storage of knowledge
  - How to access a piece of related information effectively?
  - Meta-reasoning and closed-world assumption enable us to access not only related but also relevant information
  - Frame problem: in a dynamic environment, how to update the stored knowledge due to the occurrence of some events?
- Learning
  - Imitation
  - Supervised training
  - Reinforcement

Artificial Neural Networks

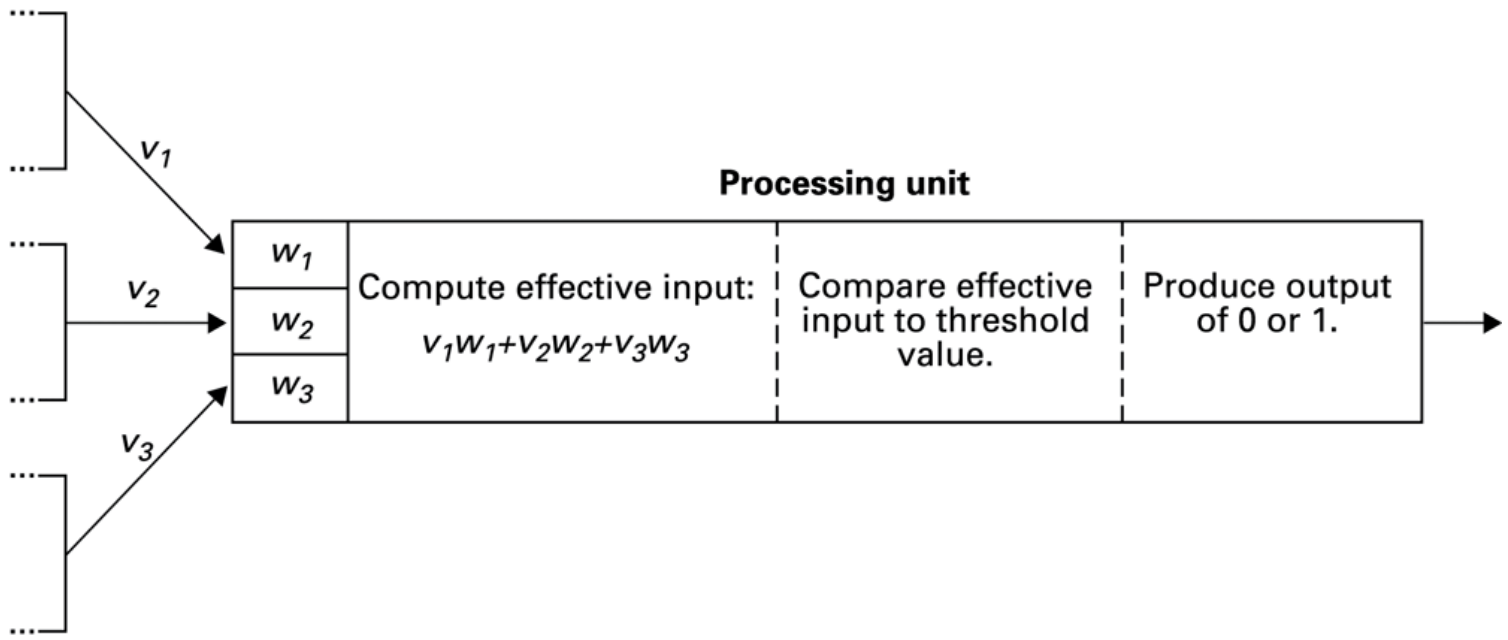
- A biological neuron:



- Artificial neural network:
  - Use electronic devices to simulate a biological neuron
  - Connecting multiple neurons to form a computing system

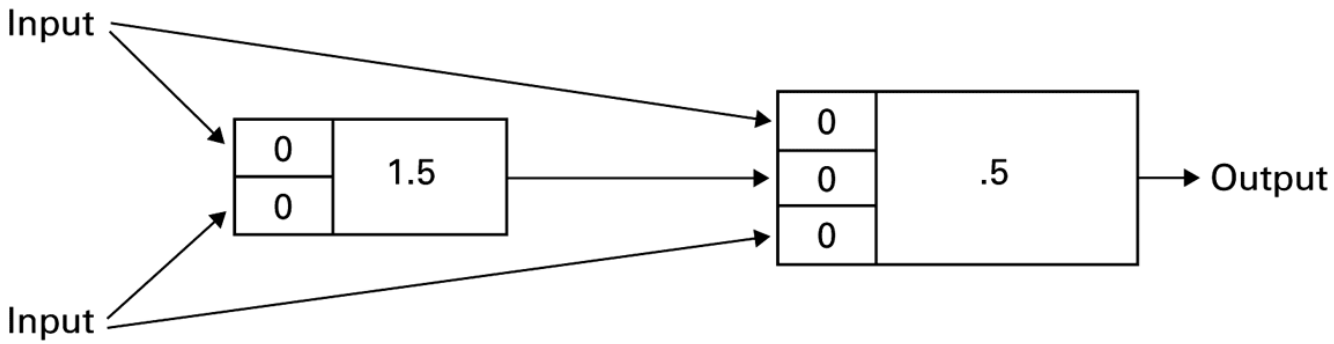
Artificial Neurons

- The activities within a processing unit (an artificial neuron)



Artificial Neural Network Topology

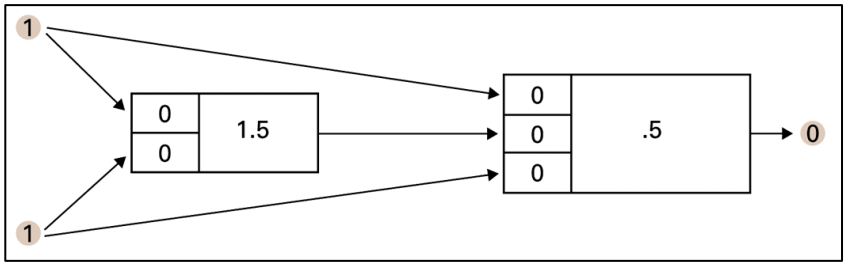
- The topology describes how individual neurons are connected together; for example, a two-neuron network:



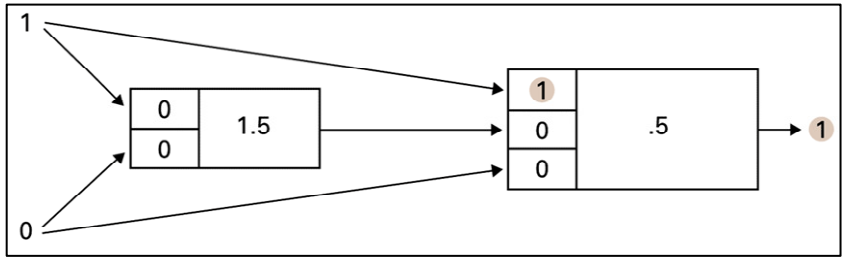
- Question: can we compute the XOR function using this artificial neural network?

Training of an Artificial Neural Net.

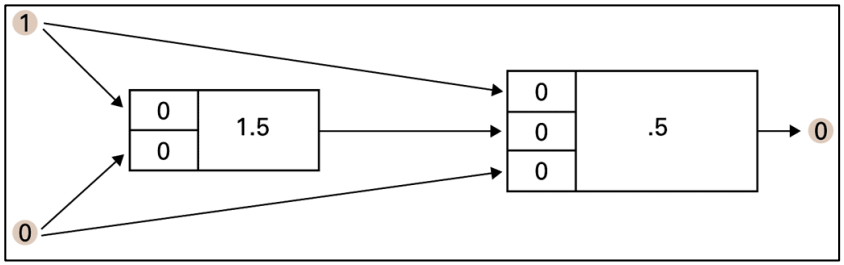
- To compute XOR, we have to train it!



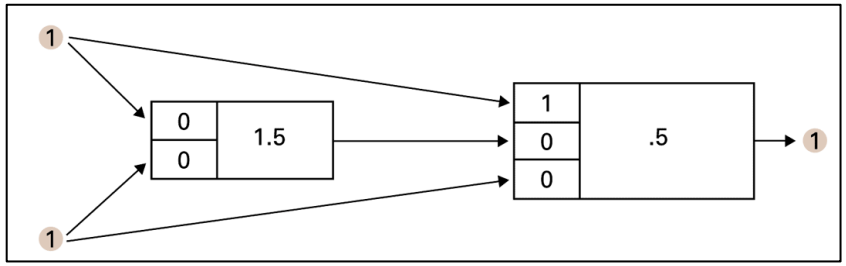
a. The network performs correctly for input 1, 1



c. The upper weight in the 2nd processing unit is adjusted



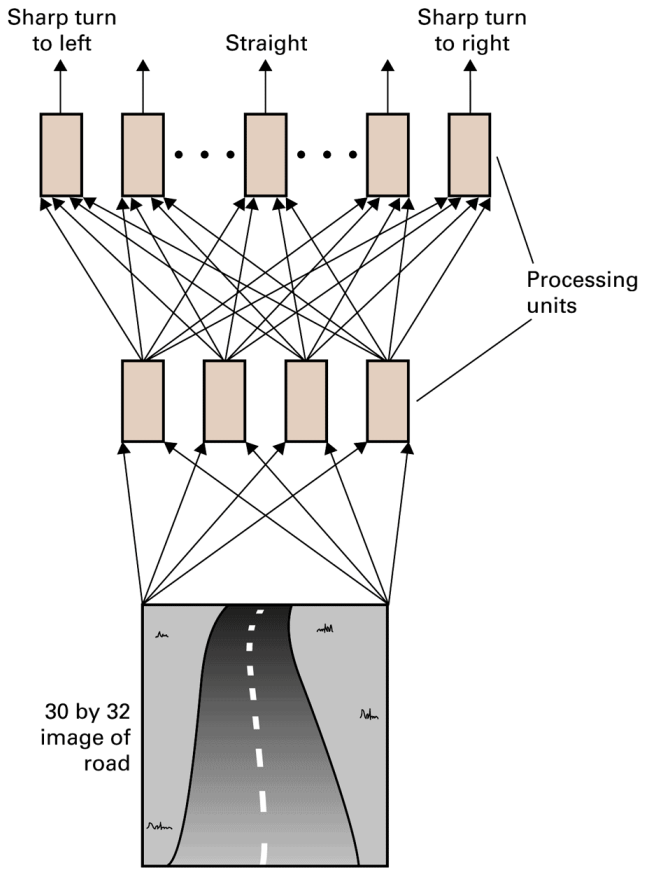
b. The network performs incorrectly for input 1, 0



d. But, the network no longer handles input 1, 1 correctly!

Automatic Vehicle Navigation

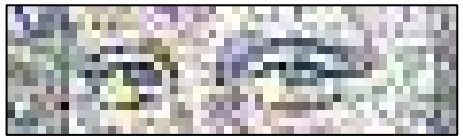
- ALVINN†: Autonomous Land Vehicle In A Neural Network



† Pomerleau, D. *A. Neural Network Perception for Mobile Robot Guidance*. Ph.D. dissertation, Carnegie Mellon Univ., Feb. 1992.

Associative Memory

- Associative memory
  - The retrieval of information that is most relevant to the information at hand
- One direction of research seeks to build associative memory using neural networks that when given a partial pattern, will transit it into a completed pattern



Robotics

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

Issues with 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?