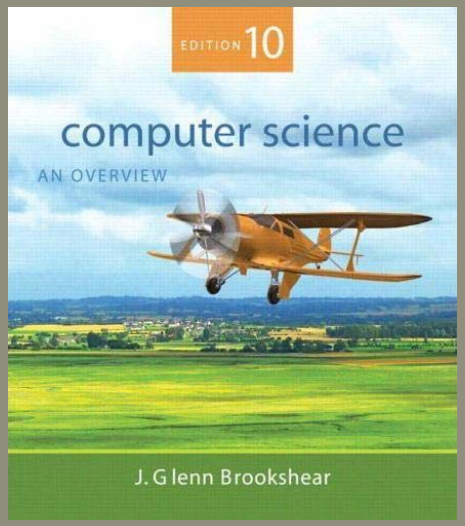
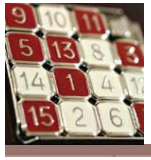
Chapter 11

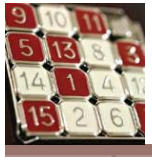
Artificial Intelligence





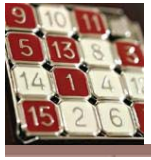
Intelligent Agents

- **Agent:** A "device" that responds to stimuli from its environment
  - Sensors
  - Actuators
- The goal of artificial intelligence is to build agents that behave intelligently



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



Levels of Intelligent Behavior

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

Figure 11.1 The eight-puzzle in its solved configuration

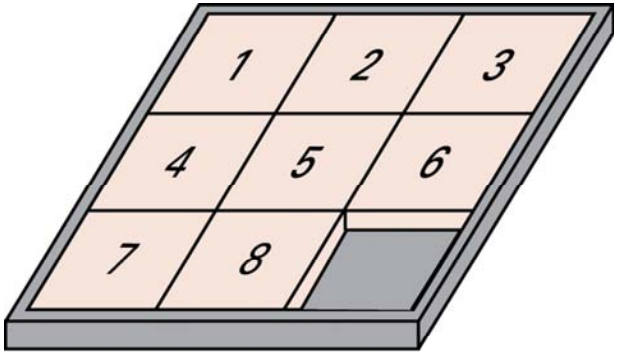
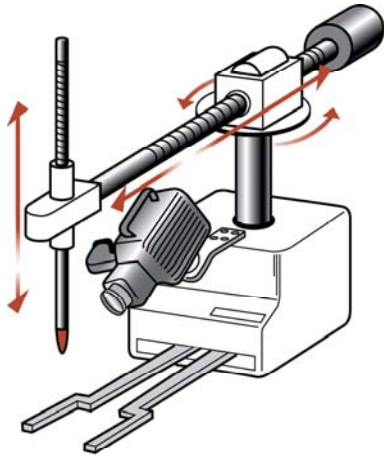


Figure 11.2 Our puzzle-solving machine



Approaches to Research in Artificial Intelligence

- Engineering track
  - Performance oriented
    - Researcher tries to maximize the performance of the agents.
- Theoretical track
  - Simulation oriented
    - Researcher tries to understand how the agents produce responses.

Turing Test

- Proposed by Alan Turing in 1950
- Benchmark for progress in artificial intelligence
- Test setup: Human interrogator communicates with test subject by typewriter.
- Test: Can the human interrogator distinguish whether the test subject is human or machine?

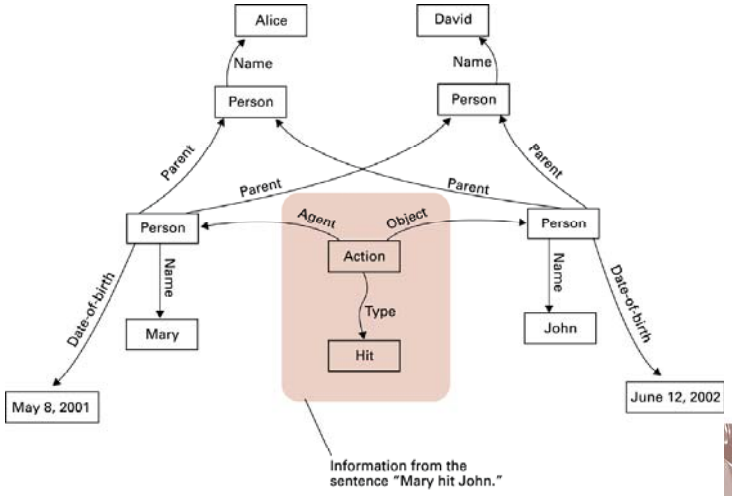
Techniques for Understanding Images

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

Language Processing

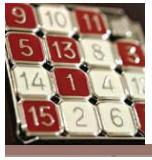
- Syntactic Analysis
- Semantic Analysis
- Contextual Analysis

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

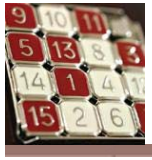
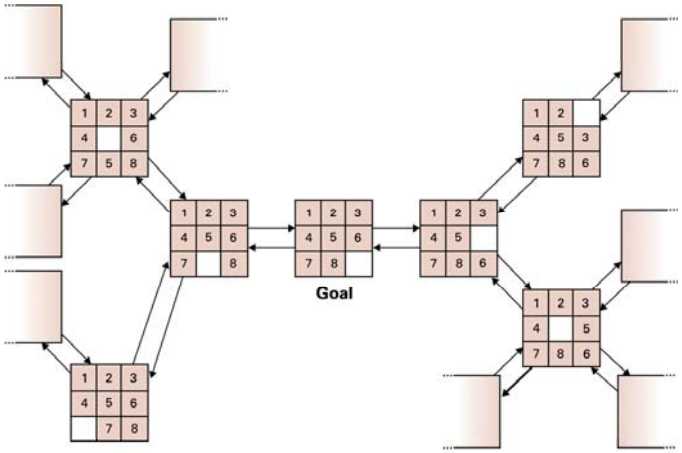


Figure 11.4 A small portion of the eight-puzzle's state graph



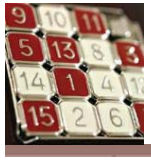
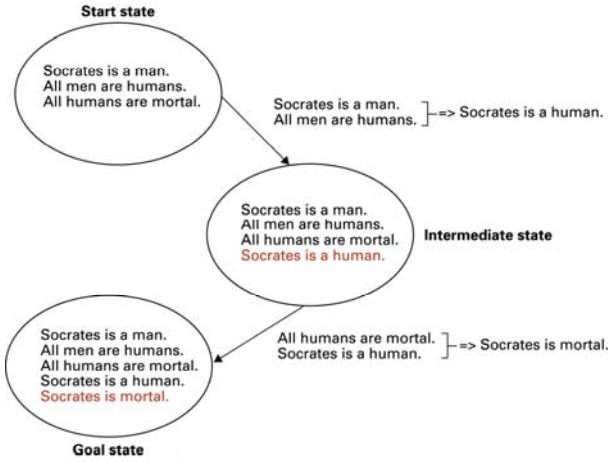


Figure 11.5 Deductive reasoning in the context of a production system



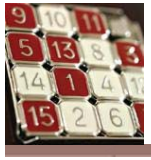


Figure 11.6 An unsolved eight-puzzle

1	3	5
4	2	
7	8	6

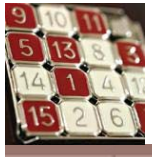
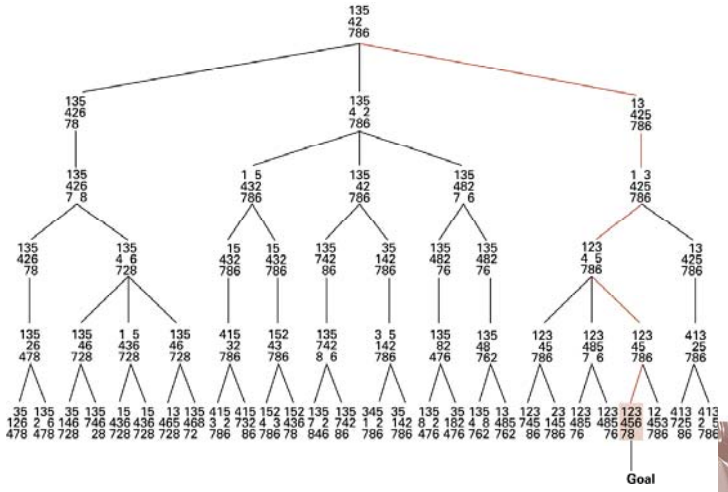
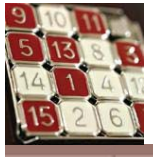


Figure 11.7 A sample search tree





Heuristic Strategies

- **Heuristic:** A quantitative estimate of the distance to a 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

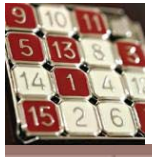


Figure 11.8 Productions stacked for later execution

Top of stack

1. Move the 5 tile down.
2. Move the 3 tile right.
3. Move the 2 tile up.
4. Move the 5 tile left.
5. Move the 6 tile up.

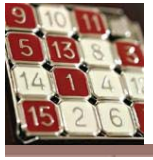
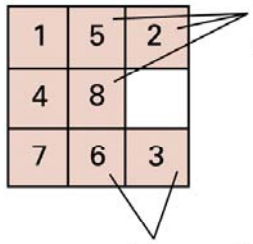


Figure 11.9 An unsolved eight-puzzle



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

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

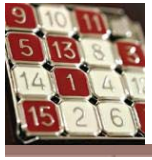


Figure 11.10 An algorithm for a control system using heuristics

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) **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.

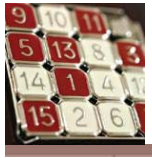
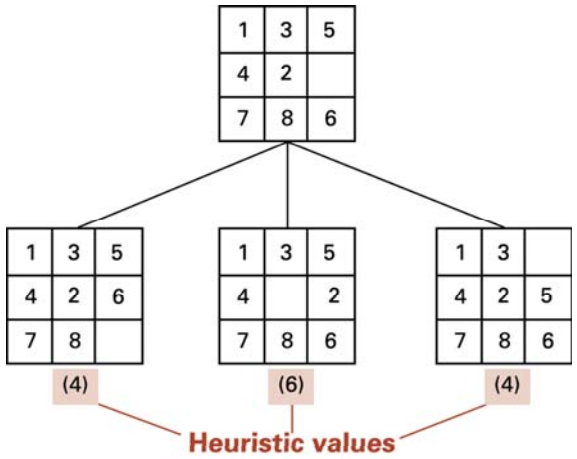


Figure 11.11 The beginnings of our heuristic search



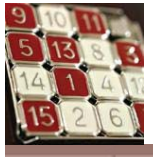
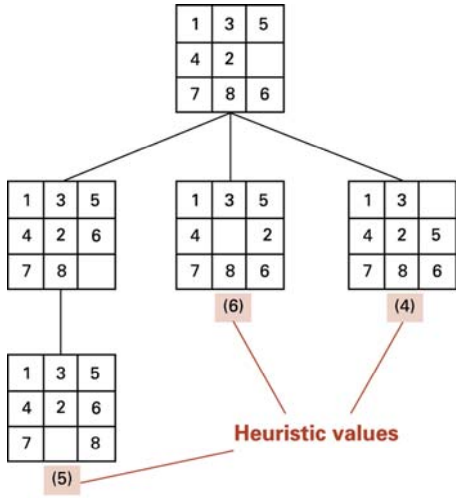


Figure 11.12 The search tree after two passes



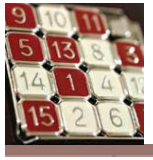


Figure 11.13 The search tree after three passes

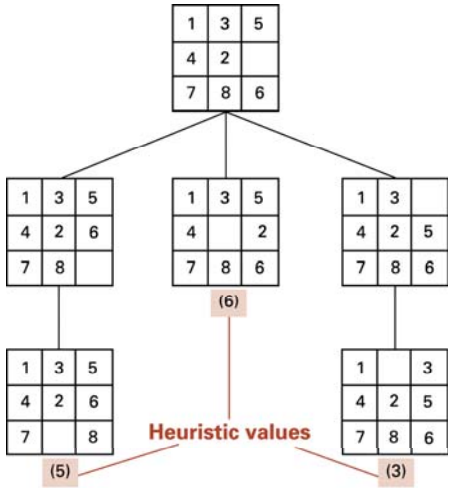
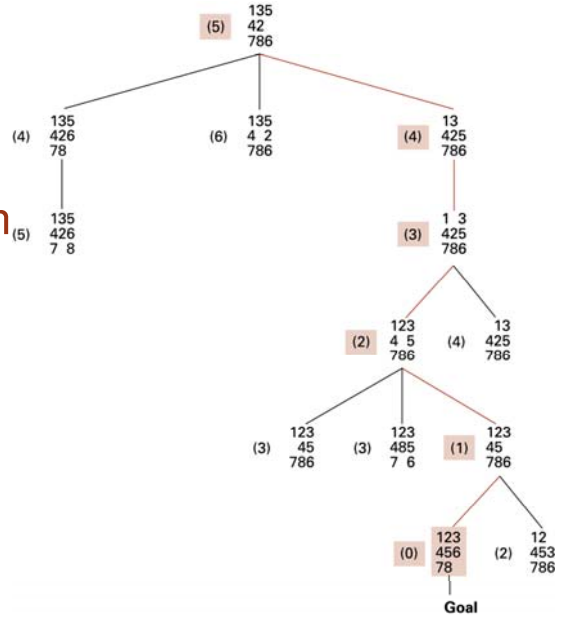
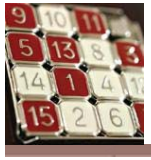


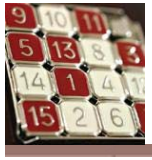
Figure 11.14
The complete search tree formed by our heuristic system





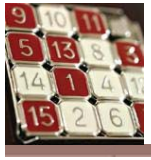
Learning

- Imitation
- Supervised Training
- Reinforcement
- Evolutionary Techniques



Handling Real-World Knowledge

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



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

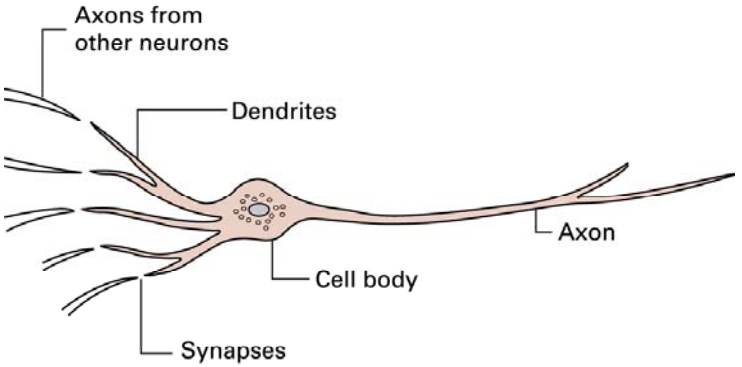


Figure 11.16 The activities within a processing unit

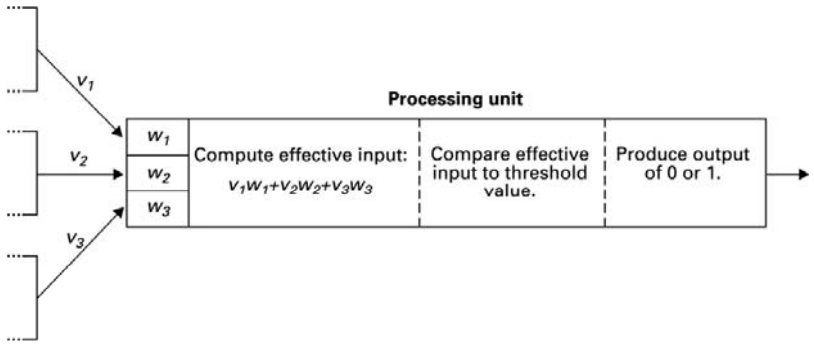


Figure 11.17 Representation of a processing unit

Figure 11.18 A neural network with two different programs

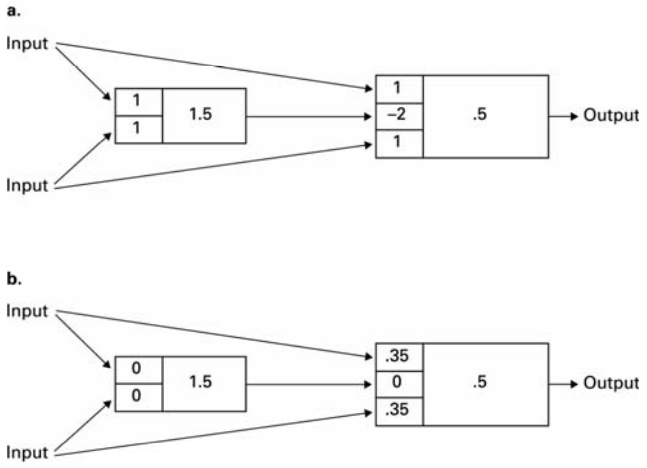


Figure 11.19 An artificial neural network

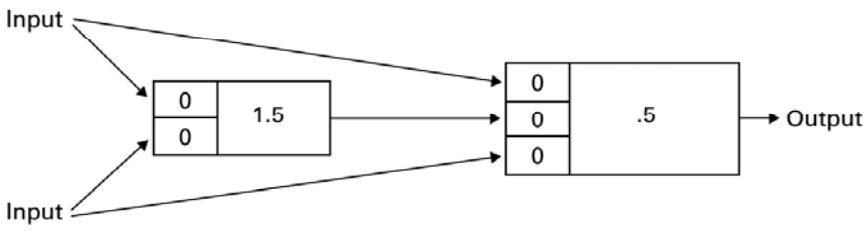
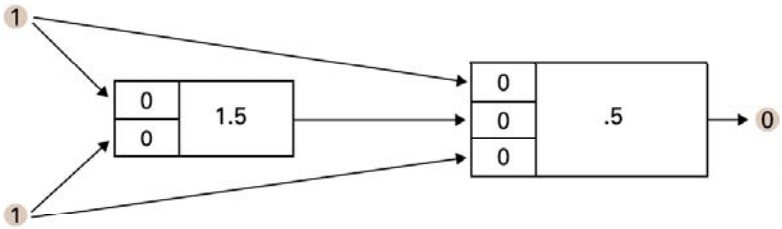
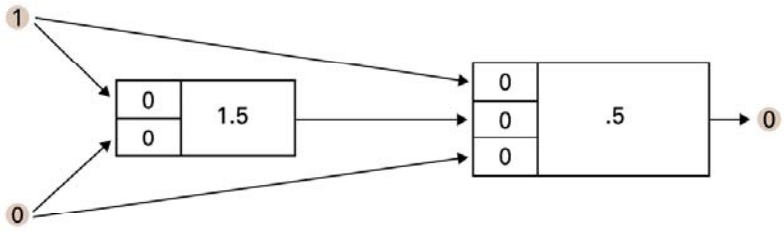


Figure 11.20 Training an artificial neural network



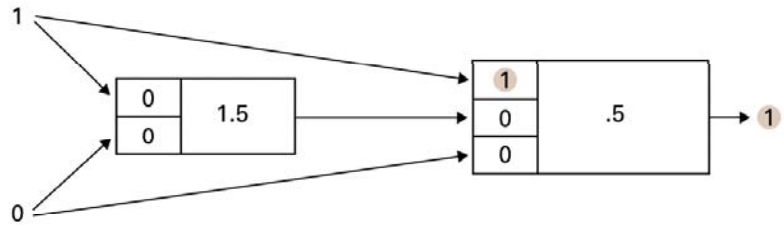
a. The network performs correctly for the input pattern 1, 1.

Figure 11.20 Training an artificial neural network (continued)



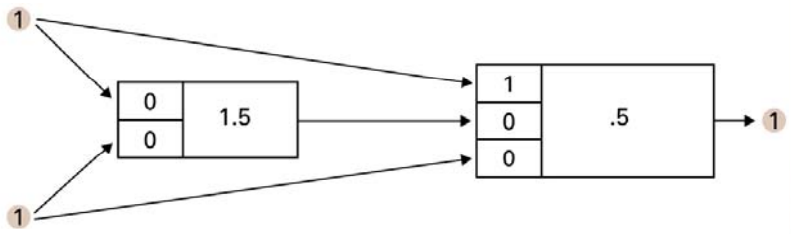
b. The network performs incorrectly for the input pattern 1, 0.

Figure 11.20 Training an artificial neural network (continued)



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

Figure 11.20 Training an artificial neural network (continued)



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

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 The structure of ALVINN

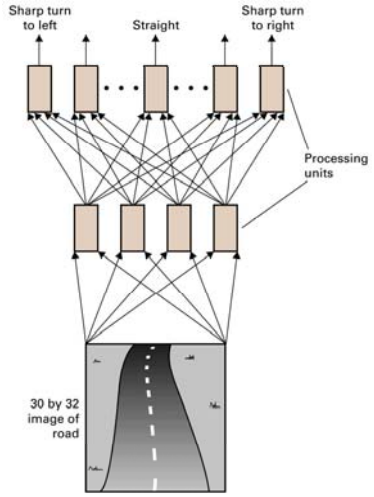


Figure 11.22 An artificial neural network implementing an associative memory

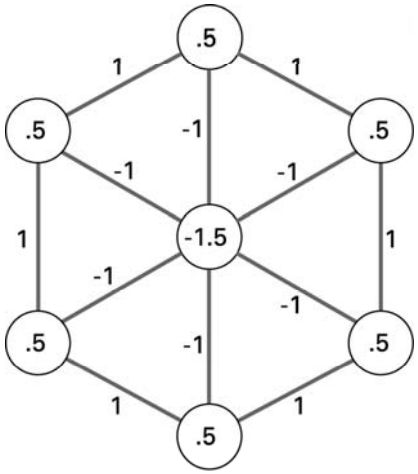
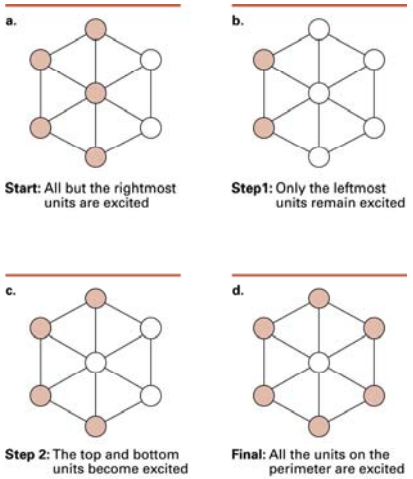


Figure 11.23 The steps leading to a stable configuration



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?