**Chapter 15**

**Artificial Intelligence**

**A Guide to this Instructor’s Manual:**

We have designed this Instructor’s Manual to supplement and enhance your teaching experience through classroom activities and a cohesive chapter summary.

This document is organized chronologically, using the same headings that you see in the textbook. Under the headings you will find: Lecture Notes that summarize the section, Teaching Tips, Class Discussion Topics, and Additional Projects and Resources. Pay special attention to teaching tips and activities geared toward quizzing your students and enhancing their critical thinking skills.

In addition to this Instructor’s Manual, our Instructor’s Resources also contain PowerPoint Presentations, Test Banks, and other supplements to aid in your teaching experience.

|  |
| --- |
| **At a Glance** |

**Instructor’s Manual Table of Contents**

* Overview
* Learning Objectives
* Teaching Tips
* Class Discussion Topics
* Additional Projects
* Additional Resources
* Key Terms

|  |
| --- |
| Lecture Notes |

**Overview**

Chapter 15 explores the field of artificial intelligence (AI). People working in AI create programs that exhibit “intelligent behavior.” This chapter gives a definition of AI and discusses a range of example techniques and applications. It discusses the issue of knowledge representation and provides examples of some typical kinds of representation. This chapter describes how artificial neural networks work, their inspiration from real neurons, and the kinds of problems they can solve. The chapter explains how to describe problems in terms of a state space, and how state-space search algorithms work. It uses the Watson program as a case study. Watson is a question-answering system designed to play the Jeopardy! game show; it competed successfully against champion players of the show. The chapter ends with a discussion of the current and future applications of robots and drones.

# **Learning Objectives**

* Describe the two types of artificial intelligence
* Explain the pros and cons of various knowledge representation methods
* Explain the parts of a simple neural network, how it works, and how it can incorporate machine learning
* Describe how intelligent state-space search algorithms work
* Give examples of possible usage for each of the following: swarm intelligence, intelligent agents, and expert systems
* Explain what a robot is, and list some tasks for which robots are currently suited
* Explain what a drone is, and list some tasks drones can perform

# **Teaching Tips**

**15.1 Introduction**

1. Introduce the term **artificial intelligence (AI)** and discuss the various types out there.
2. Point out that research into AI has made significant contributions to cognitive science.
3. Emphasize to students that AI cannot yet capture all aspects of human intelligence and most gains in AI over the past several years have been more modest and more focused in solving specific problems.
4. Introduce the term **Turing test**, and discuss how it would work.

|  |  |
| --- | --- |
| ***Teaching Tip*** | Demonstrate online chat-bots in discussing the Turing Test: <http://alice.pandorabots.com/> or <http://nlp-addiction.com/eliza/> |

**15.2 A Division of Labor**

1. Divide tasks a human might perform into three categories:
   1. Computational tasks such as adding a column of numbers or sorting a list of numbers
   2. Recognition tasks such as recognizing your best friend and understanding spoken language
   3. Reasoning tasks like planning what to wear or running a triage center in a hospital emergency room after an earthquake
2. Note that computers are better at computational tasks and humans at recognition and reasoning tasks.
3. Note that recognition tasks require processing large amounts of sensory information and connecting the result to large amounts of information in memory.
4. Recognition of necessity involves uncertainty and approximation.
5. Reasoning tasks require accessing memory, as well as cause and effect information.
6. Show Figure 15.2 and discuss the lines on the graph.

**15.3 Knowledge Representation**

1. Compare and contrast the four different methods of representing knowledge discussed in this chapter:
   1. Natural language that requires a deep understanding of the meaning of the words.
   2. **Formal language** like that of formal logic requires specific notation that has meaning within logic.
   3. Pictorial like that of image files that can enhance the knowledge discussed in natural and formal language.
   4. Graphical as in the use of graphs with nodes and connecting arcs, also referred to as a **semantic net**.
2. Emphasize that any knowledge representation method must have the following four characteristics:
   1. Adequacy—The representation method must be adequate to capture all the relevant knowledge.
   2. Efficiency—The representational form must be minimalist, avoiding redundancies when possible.
   3. Extendibility—It should be relatively easy to extend the representation to include new knowledge as it is acquired.
   4. Appropriateness—The representation used should be appropriate for the knowledge domain being represented.

**Quick Quiz 1**

1. Name two of the characteristics any knowledge representation must have.

Answer: Any two of adequacy, efficiency, extendability, and appropriateness.

1. (True or False) Images and sounds easily represent general information about categories of objects.

Answer: False

1. (True or False) Graph representations easily represent relationships between objects.

Answer: True

1. Another term for a graphical representation of knowledge is \_\_\_\_\_\_\_\_\_\_.

Answer: semantic net.

**15.4 Recognition Tasks**

1. Introduce the terminology for the parts of a neuron: dendrites, axons, and synapses. Talk about the scale of neurons in the human nervous system (one trillion neurons). Explain how neurons receive activation and fire, and make the analogy to a massively parallel network of extremely simple computing devices.
2. Introduce the term **connectionist architecture** to describe this computational model.
3. Introduce the term **neural network**, sometimes called “artificial neural network,” to distinguish it from biological nervous systems. Neurons may be simulated with either hardware or software. Connections between neurons are given weights; the input to a neuron is the weighted sum of neighbor activations multiplied by the weight on the connection. Neurons produce output when their activation passes a threshold value.
4. Show Figure 15.5 to show an example of neuron with three inputs, and then Figure 15.6 with an example of a neural network model.
5. Simple networks consisting of an input layer of neurons and an output can solve many problems, but have been proven incapable of solving a large category of problems, including the XOR Boolean operation: A XOR B is true if one or the other is true, but not both. More advanced networks are required.
6. Neural networks are trained to produce the correct output for a given input. Introduce the term **training data** and describe the training process: presenting the data multiple times, each time making small changes to network weights. Emphasize that the goal is usually for the network to generalize beyond the specific examples it was trained on.
7. Introduce the term **back propagation** for training more sophisticate networks.
8. Discuss some real-world applications of neural networks including predicting credit risk for loans, image segmentation for medical imaging, and handwriting analysis.

**Quick Quiz 2**

1. The \_\_\_\_\_\_\_\_\_\_\_\_\_\_ algorithm trains neural networks by passing errors from the output toward the input.

Answer: backpropagation

1. (True or False) Artificial networks are programmed by determining, by hand, the weights between neurons in the network.

Answer: False

1. (True or False) A connectionist architecture includes many simple computing devices connected in a complex network.

Answer: True

1. The back propagation algorithm is an example of \_\_\_\_\_\_\_\_\_\_.

Answer: machine learning

|  |  |
| --- | --- |
| ***Teaching Tip*** | Demonstrate neural networks using some of the links from this page: <http://www.cim.mcgill.ca/~jer/courses/java.html> |

**15.5 Reasoning Tasks**

1. Introduce the comparison of different search algorithms using the idea of a decision tree.
2. Introduce the term **state-space graph** as a way of conceiving of a reasoning problem and define the parts of the state space. Nodes in the decision tree represent states of the problem, and we can move from one node to another when one state follows from another. Solving the problem becomes searching through the state space: **state-space search**. Intelligent search tries to guide the search toward promising alternatives. Chess-playing programs use intelligent search
3. Introduce the term **heuristic**, meaning “educated guess” and how it applies to AI, and the brute force approach to finding a solution path.
4. Introduce the term **swarm intelligence model**. Swarm intelligence models are inspired by insects that live and operate in large communities. These creatures are simple individually and produce complex behavior as a collective. Ant colony optimization is one technique that has been applied to Internet network routing, image processing, and data analysis.
5. Introduce the term **intelligent agents**. This term describes computer programs that perform actions for a human user, acting as the user’s assistant. Such programs can generate personalized searches for online information. Future applications include agents that may be authorized to make purchases for the human user.
6. Discuss **push technology** and how you can create a personalized web search engine.
7. Discuss how **recommendation software** can personalize an ecommerce user’s experience.
8. Introduce the term **expert systems**. These systems are designed to incorporate the knowledge of an expert in a particular field, in order to perform reasoning for that field. Use theexample in the text on pages 737–738, where the domain of inquiry is Presidents and the chronology of their time served as an example of how expert systems might work using modus ponens and either forward or backward chaining.
9. Introduce the terms **explanation facility** and **knowledge engineering**.

|  |  |
| --- | --- |
| ***Teaching Tip*** | There are many great videos of robots online. In addition to picking one or two to show, have a class activity where students look for interesting robot videos, and discuss what level of autonomy each robot has, and what its requirements are. A great starter video is: <http://www.youtube.com/watch?v=W1czBcnX1Ww> |

1. Puzzles and board games have been a long-term area of study for artificial intelligence. Simple board games like tic-tac-toe can be managed with state-space search. More complex games like checkers or chess use state-space search, but depend more on heuristics, because the game space cannot be searched entirely. Games like Go are very difficult for computers to play because of the size and complexity of the search space.
2. Discuss the evolution of game-playing AI, from tic-tac-toe to checkers to chess. Discuss the growing differences from the Chinook project, to Deep Blue, to Deep Junior, and finally Watson, IBM’s AI built for Jeopardy, but has now been put to use solving other problems in various fields.

**15.6 Robots and Drones**

1. Introduce the idea of Robots beyond the science fiction presentation of them.
2. Discuss the various types of robots and the kinds of autonomy afforded to them. Talk about the various application areas they can be used in, from manufacturing to lab work and more.
3. Robots can be varying sizes to perform various duties, including research, and information gathering.
4. Go over the advent of driverless cars and how each vehicle could be considered a robot.
5. Introduce the term **deliberative strategy**, which maintains a sophisticated model of the real world within the program, updates the model based on sensor information, and reasons about the action to take in response.
6. Introduce the term **reactive strategy**, which uses rapid heuristics and little or no internal model of the world to allow the robot to quickly respond to sensor inputs, and rapidly change responses as sensor inputs change.
7. Define **drone**, more properly called a UAV for Unmanned Aerial Vehicle,and discuss their uses. Discuss the ethical implications of their use.

**15.7 Conclusion**

1. AI has many potential uses from web searching, to speech-recognition, and more.
2. AI has not yet reached a point of “true human intelligence.”
3. In 20 years, AI will look radically different than it does today.

# **Class Discussion Topics**

1. How much information would a computer need to complete a particular task? Think about tasks like: packing a box for shipment, choosing the best route from home to work, searching for a particular person in a set of pictures, and mowing the lawn.
2. In what ways does an artificial neural network, as described here, accurately model a natural nervous system? In what ways does it differ?
3. Suppose a research built a robot that acted exactly like an insect, like a cockroach. Would that count as “intelligent?” What if it acted exactly like a cocker spaniel?
4. Talk about the impact of military drone piloting done by civilians on the other side of the world. How does making combat decisions affect their psyche?

# **Additional Projects**

1. Have students play “The Robot Game.” This activity requires that the instructor provide some materials: boxes and blindfolds. Divide students into groups of four. In each group, one student takes on the role of the Brain, one is the Eyes, one is the Left Arm, and one is the Right Arm. Blindfold the two arms, and have the brain sit facing away from the others. Using agreed-upon questions, answers, and commands, have the brain instruct the others to pick up one box from the table surface and set it on top of the second box. The brain’s information comes mostly from questions asked of the eyes. In order to lift the box, both arms must work together to press inward on the two sides of the box.
2. Working with one or two partners, design an expert system to determine what kind of outerwear, if any, a person should wear, based on information about the weather. What rules and facts would the system need?

# **Additional Resources**

1. Home page of the Loebner Prize: <http://www.loebner.net/Prizef/loebner-prize.html>
2. An online reference for AI aimed at professionals and novices: <http://www.aaai.org/home.html>
3. Website about the Robocup competitions: <http://www.robocup.org/>

**Key Terms**

* **Artificial intelligence (AI)**: The branch of computer science that explores techniques for incorporating aspects of intelligence into computer systems.
* **Back propagation algorithm**: A training algorithm for neural networks that passes error estimates from the output layer back to earlier neurons so they can adjust connection weights.
* **Connectionist architecture**: A system with a large number of simple processors that are heavily interconnected; describes the human brain with its many simple interconnected neurons.
* **Deliberative strategy**: An approach to robotics that says a robot must have an internal representation of its environment that guides a reasoned response to some stimulus from that environment.
* **Drone**: An aircraft under autonomous control via a computer system on board or controlled

by a human controller at a remote site.

* **Expert system**: Software that mimics the expertise of a human in a certain area, using facts and rules of inference to draw conclusions from those facts.
* **Explanation facility**: A process within an expert system that allows the user to see the assertions and rules used in arriving at a conclusion.
* **Formal language**: The language of formal symbolic logic, as opposed to natural languages such as English, Japanese, Spanish, etc.
* **Heuristic**: An educated guess from available data.
* **Intelligent agent**: Software designed to interact collaboratively with a user as a personal assistant.
* **Knowledge engineering**: Acquiring information for a knowledge base by consulting “experts” in the domain and mining their expertise.
* **Machine learning**: Where computing agents learn and improve from past errors made on known training data without specific step-by-step programming instructions.
* **Neural network**: A massively parallel network of hardware devices simulating individual biological neurons or, alternatively, a software system that simulates an interconnected arrangement of biological neurons; sometimes called an artificial neural network.
* **Push technology**: The download of personalized information to your screen or smartphone to be displayed.
* **Reactive strategy**: An approach to robotics that says a robot should respond directly to environmental stimuli using heuristics but no chain of reasoning.
* **Recommendation software**: An intelligent agent that makes suggestions to a customer based on available data regarding that customer and others who have purchased the same item.
* **Robot**: A device which may or may not be humanlike in form that has the ability to gather sensory information from its surroundings and to autonomously perform mechanical actions of sort in response.
* **Semantic net**: A graphical representation of classes, objects, properties, and relationships.
* **State-space graph**: A representation of a set of “states” representing different configurations in a problem.
* **State-space search**: The process of finding a path through a state-space graph from an initial state to the goal state.
* **Swarm intelligence model**: A model of artificial intelligence based on a group of simple agents (like an ant colony) that operate independently but can communicate in some way to perform cooperative tasks.
* **Training data**: Sets of input values for a neural network for which correct output values are known; weights and thresholds in the neural network are repeatedly adjusted until the network output is sufficiently close to the correct output.
* **Turing test**: A test for intelligent behavior of machines, proposed by Alan Turing in 1950; if a human can interrogate a person and a computer and not be able to detect which is which, then the computer has passed the test.
* **Winograd schema**: A sentence that involves two entities and a pronoun that refers back to one of the two entities.

**Solutions to End-of-Chapter Exercises**

**1.** a. For example: Evan asked Hank when the assignment is due because he had forgotten. Who had forgotten, Evan or Hank?

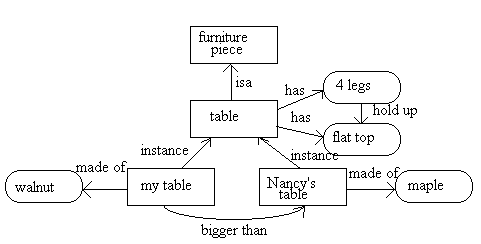
Answer: Evan

b. Evan asked Hank when the assignment is due but he had forgotten. Who had forgotten, Evan or Hank?

Answer: Hank

**2.** a. Jeremiah is a bullfrog.  
 b. All bullfrogs are green.

**3**. For example,



**4**. a. McIntosh is an apple.

All apples are red

All bananas are yellow.

Apples are fruit.

All bananas are fruit

All fruit is food

All meat is food

All food is eaten.

b. McIntosh is an apple, so it is red, it is a fruit and a food, and is eaten.

All apples are food and are eaten.

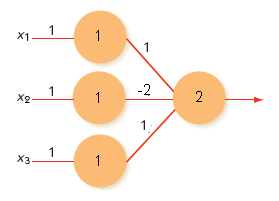
All bananas are food and are eaten.

All fruit is eaten.

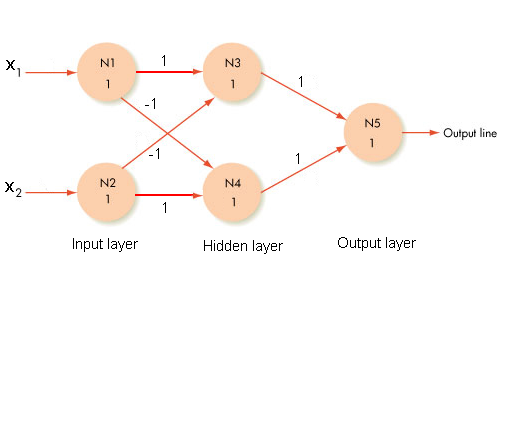
All meat is eaten.

**5**. If x2 = 1 and x4 = 1, then N3 will fire, regardless of the values for x1 and x3.

**6**.



**7.**  The following network produces results equal to the XOR truth table.



**8**. Provide leads to sources about mobile devices or tablet PC’s, and pattern recognition software.

**9**. Students should be able to find material on the Web, but will have to distinguish between natural phenomena and artificial attempts to mimic natural phenomena.

**10**. For example,

How do you go about processing a loan?

What do you look for on the application?

What makes you suspicious that a loan applicant should not be granted the loan?

What do you look for to make you feel that the applicant should be granted the loan? Does one factor weigh more heavily than others in your decision?

**11**. The parse method described in Chapter 11 corresponds to backward chaining; it starts with the result of applying productions (similar to rules in knowledge-based systems) and tries to work back to the goal symbol (similar to assertions in knowledge-based systems).

**12**. Yes. Adopt the following notation:

A: hero is a spy

B: heroine is an interpreter

C: one scene should take place in Berlin

D: one scene should take place in Paris

E: heroine must speak English

F: heroine must speak Russian

G: there can be no car chase

H: there can be no crash scene

I: the hero is European

J: the hero must speak French

The assertions and rules can be symbolized as follows:

A

B

A → C and D

B → E

B → F

C → G

G → H

C → I

D → J

Since A is true and A implies C and D, both C and D are true. Since D is true and D implies J, then J is true. Since C is true and C implies G, then G is true. Since G is true and G implies H, then H is true. Therefore both J (Hero must speak French) and H (there can be no crash scene) are true.

**13**. No; if the hero is American, then he is not European, which means that I is not true. But since C is true and C implies I, then I is true. I cannot be both true and false.

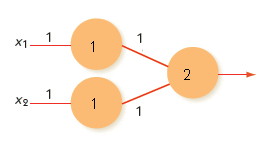
**14**. Freeware versions of Prolog are available, such as the Toy Prolog program at

www.csse.monash.edu.au/~ lloyd/tildeLogic/Prolog.toy

**Challenge Work**

**1.** This is fairly heavy-duty philosophical stuff, so may be of interest only to your best students.

**2.** a.



b. The complete table is

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| w1 | w2 | θ | x1 | x2 | y | t | α(t - y) | w1' | w2' | θ' |
| 0.6 | 0.1 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0.6 | 0.1 | 0.5 |
| 0.6 | 0.1 | 0.5 | 0 | 1 | 0 | 0 | 0 | 0.6 | 0.1 | 0.5 |
| 0.6 | 0.1 | 0.5 | 1 | 0 | 1 | 0 | -0.2 | 0.4 | 0.1 | 0.7 |
| 0.4 | 0.1 | 0.7 | 1 | 1 | 0 | 1 | 0.2 | 0.6 | 0.3 | 0.5 |
| 0.6 | 0.3 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0.6 | 0.3 | 0.5 |
| 0.6 | 0.3 | 0.5 | 0 | 1 | 0 | 0 | 0 | 0.6 | 0.3 | 0.5 |
| 0.6 | 0.3 | 0.5 | 1 | 0 | 1 | 0 | -0.2 | 0.4 | 0.3 | 0.7 |
| 0.4 | -.3 | 0.7 | 1 | 1 | 0 | 1 | 0.2 | 0.6 | 0.5 | 0.5 |
| 0.6 | 0.5 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0.6 | 0.5 | 0.5 |
| 0.6 | 0.5 | 0.5 | 0 | 1 | 0 | 0 | 0 | 0.6 | 0.5 | 0.5 |
| 0.6 | 0.5 | 0.5 | 1 | 0 | 1 | 0 | -0.2 | 0.4 | 0.5 | 0.7 |
| 0.4 | 0.5 | 0.7 | 1 | 1 | 1 | 1 | 0 | 0.4 | 0.5 | 0.7 |
| 0.4 | 0.5 | 0.7 | 0 | 0 | 0 | 0 | 0 | 0.4 | 0.5 | 0.7 |
| 0.4 | 0.5 | 0.7 | 0 | 1 | 0 | 0 | 0 | 0.4 | 0.5 | 0.7 |
| 0.4 | 0.5 | 0.7 | 1 | 0 | 0 | 0 | 0 | 0.4 | 0.5 | 0.7 |

After the heavy line, the network has learned a solution. The bottom four rows of the table indicate that the network is completely trained.

**3**. Students should be able to find lots of information on these topics.