In the next chapter we discuss the use of heuristics to focus search on the "best" possible portion of the state space. Chapter 6 discusses the production system and other software "architectures" for controlling state-space search.

3.4 Epilogue and References

Chapter 3 introduced the theoretical foundations of state space search, using graph theory to analyze the structure and complexity of problem-solving strategies. The chapter compared data-driven and goal-driven reasoning and depth-first and breadth-first search. And/or graphs allow us to apply state space search to the implementation of logic-based reasoning.

Basic graph search is discussed in a number of textbooks on computer algorithms. These include *Introduction to Algorithms* by Thomas Cormen, Charles Leiserson, and Ronald Rivest (1990), *Walls and Mirrors* by Paul Helman and Robert Veroff (1986), *Algorithms* by Robert Sedgewick (1983), and *Fundamentals of Computer Algorithms* by Ellis Horowitz and Sartaj Sahni (1978). Finite automata are presented in Lindenmayer and Rosenberg (1976). More algorithms for and/or search are presented in Chapter 14, *Automated Reasoning*.

The use of graph search to model intelligent problem solving is presented in *Human Problem Solving* by Alan Newell and Herbert Simon (1972). Artificial intelligence texts that discuss search strategies include Nils Nilsson's *Artificial Intelligence* (1998), Patrick Winston's *Artificial Intelligence* (1992), and *Artificial Intelligence* by Eugene Charniak and Drew McDermott (1985). *Heuristics* by Judea Pearl (1984) presents search algorithms and lays a groundwork for the material we present in Chapter 4. Developing new techniques for graph search are often topics at the annual AI conferences.

3.5 Exercises

1. A Hamiltonian path is a path that uses every node of the graph exactly once. What conditions are necessary for such a path to exist? Is there such a path in the Königsberg map?

2. Give the graph representation for the farmer, wolf, goat, and cabbage problem:

   A farmer with his wolf, goat, and cabbage come to the edge of a river they wish to cross. There is a boat at the river's edge, but, of course, only the farmer can row. The boat also can carry only two things (including the rower) at a time. If the wolf is ever left alone with the goat, the wolf will eat the goat; similarly, if the goat is left alone with the cabbage, the goat will eat the cabbage. Devise a sequence of crossings of the river so that all four characters arrive safely on the other side of the river.

   Let nodes represent states of the world; e.g., the farmer and the goat are on the west bank and the wolf and cabbage on the east. Discuss the advantages of breadth-first and depth-first search for this problem.

3. Build a finite state acceptor that recognizes all strings of binary digits a) that contain "111", b) that end in "111", c) that contain "111" but not more that three consecutive "1"s.