DEPARTMENT OF COMPUTER ENGINEERING
UNIVERSITY OF PERADENIYA

CO541: Artificial Intelligence - 2024

ASSIGNMENT 2

May 10, 2024

1. Define in your own words the following terms: agent, agent function, agent program, rationality, autonomy, reflex agent, model-based agent, goal-based agent, utility-based agent, learning agent.

2. The differences between agent functions and agent programs.
   a) Can there be more than one agent program that implements a given agent function? Give an example, or show why one is not possible.
   b) Are there agent functions that cannot be implemented by any agent program?
   c) Given a fixed machine architecture, does each agent program implement exactly one agent function?
   d) Given an architecture with n bits of storage, how many different possible agent programs are there?
   e) Suppose we keep the agent program fixed but speed up the machine by a factor of two. Does that change the agent function?

3. Explain why problem formulation must follow goal formulation.

4. The GENERAL-SEARCH algorithm consists of three steps: goal test, generate, and ordering! function, in that order. It seems a shame to generate a node that is in fact a solution, but to fail to recognize it because the ordering function fails to place it first.
   a) Write a version of GENERAL-SEARCH that tests each node as soon as it is generated and stops immediately if it has found a goal.
   b) Show how the GENERAL-SEARCH algorithm can be used unchanged to do this by giving it the proper ordering function.

5. Describe a search space in which iterative deepening search performs much worse than depth-first search.

6. Give a complete problem formulation for each of the following. Choose a formulation that is precise enough to be implemented.
   a) Using only four colours (e.g., R/G/B/W), you have to colour a planar map in such a way that no two adjacent regions have the same colour.
   b) A 3-foot-tall monkey is in a room where some bananas are suspended from the 8-foot ceiling. He would like to get the bananas. The room contains two stackable, movable, climbable 3-foot-high crates.
   c) You have three jugs, measuring 12 gallons, 8 gallons, and 3 gallons, and a water faucet. You can fill the jugs up or empty them out from one to another or onto the ground. You need to measure out exactly one gallon.

7. The missionaries and cannibals problem is usually stated as follows. Three missionaries and three cannibals are on one side of a river, along with a boat that can hold one or two people. Find a way to get everyone to the other side without ever leaving a group of missionaries in one place outnumbered by the cannibals in that place. This problem is famous in Al because it was the subject of the first paper that approached problem formulation from an analytical viewpoint (Amarel, 1968).
   a) Formulate the problem precisely, making only those distinctions necessary to ensure a valid solution. Draw a diagram of the complete state space.
   b) Implement and solve the problem optimally using an appropriate search algorithm. Is it a good idea to check for repeated states?
   c) Why do you think people have a hard time solving this puzzle, given that the state space is so simple?

8. Both the performance measure and the utility function measure how well an agent is doing. Explain the difference between the two.

9. Define in your own words the following terms: state, state space, search tree, search node, goal, action, successor function, and branching factor.

10. Does a finite state space always lead to a finite search tree? How about a finite state space that is a tree? What types of state spaces always lead to finite search trees?

11. Consider a state space where the start state is number 1 and the successor function for state n returns two states, numbers $2n$ and $2n + 1$.
    a) Draw the portion of the state space for states 1 to 15
    b) Suppose the goal state is 11. List the order in which nodes will be visited for breadth-first search, depth-limited search with limit 3, and iterative deepening search.
    c) Would bidirectional search be appropriate for this problem? If so, describe in detail how it would work.
    d) What is the branching factor in each direction of the bidirectional search?
    e) Does the answer to (c) suggest a reformulation of the problem that would allow you to solve the problem of getting from state 1 to a given goal state with almost no search?

12. There are two basic versions of the successor function for the 8-puzzle: one that generates all the successors at once by copying and editing the 8-puzzle data structure, and one that generates one new successor each time it is called and works by modifying the parent state directly (and undoing the modifications as needed). All search strategies (e.g., breadth-first, depth-first, etc.) could use either of these successor functions.
    a) Discuss the expected performance difference between utilizing these two succession functions within breadth-first, depth-first and iterative deepening algorithms
    b) Will your arguments above still be valid for n x n puzzle, as n keep increasing? Justify your answer.

13. You are asked to write a program as input two Web page URLs and find a path of links from one to the other
    a) Identify an appropriate search strategy for this problem. Justify your answer.
    b) Will bidirectional search provide a good solution? If so, how? If not, why?
    c) Could a search engine be used to implement a predecessor function for this problem?

14. In the class, during problem formulation, we did not consider problems with negative path costs. In this question, we explore this in more depth.
    a) Suppose that actions can have arbitrarily large negative costs; explain why this possibility would force any optimal algorithm to explore the entire state space.
    b) Does it help if we insist that step costs must be greater than or equal to some negative constant C? Consider both trees and graphs.
    c) Suppose that there is a set of operators that form a loop, so that executing the set in some order results in no net change to the state (i.e., you can always come back to the exact same state, repeatedly). If all of these operators have negative cost, what does this imply about the optimal behaviour for an agent in such an environment?
    d) One can easily imagine operators with high negative cost, even in domains such as route finding. For example, some stretches of road might have such beautiful scenery as to far outweigh the normal costs in terms of time and fuel. Explain, within the context of state-space search, why humans do not drive round scenic loops indefinitely, and explain how to define the state space and operators for route finding so that artificial agents can also avoid looping.

DEADLINE: 10:00 pm on Friday, May 17, 2024