Assignment 8: Rule-based AI

Due October 23, 2023 at 13:00

1 Instructions

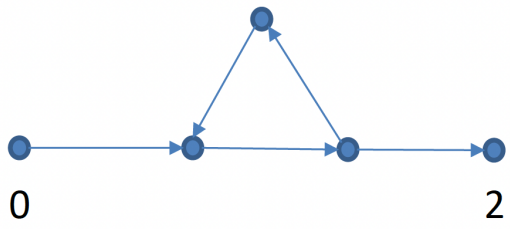
This assignment is about problem solving only. There is no programming component. Your answers should be given as a written report. Answer each question with adequate discussion, justification, and analysis.

1. The branching factor d of a directed graph is the maximum number of children (outer degree) of a node in the graph. Suppose that the shortest path between the initial state and the goal is of length r.

   (a) What is the maximum number of breadth first search (BFS) iterations required to reach the solution in terms of d and r?

   (b) Suppose the storing each node requires one unit of memory and the search algorithm stores each entire path as a list of nodes. Hence, storing a path with k nodes requires k units of memory. What is the maximum amound of memory required for BFS in terms of d and r?

2. Take the following graph where 0 and 2 are respectively the initial and the goal states. The nodes are to be labelled by 1, 3, and 4.



   Suppose that we use the depth first search (DFS) method and, in the case of a tie, we choose the smaller label.

   (a) Find all the labellings of these three nodes where DFS will never reach the goal.

   (b) Discuss how DFS should be modified to avoid this situation.

3. A publisher allows teachers to "build" customized textbooks for their courses by concatenating the text from different books in their catalog. The catalog contains the books listed in the table below, together with the number of pages that the book contains, and the topics covered in that book. Suppose we define a node to be a pair *(Topics, Books)* where *Books* is a list of the books that will make up a customized textbook and *Topics* is a lsit of topics that must be covered by the customized textbook but are not already covered by *Books*. Therefore, a node is only valid if none of the books in *Books* cover any of the topics in *Topics*.

Book	Number of Pages	Topics Covered
book1	20	[introduction to AI]
book2	60	[regression, classification]
book3	100	[introduction to AI, search, classification]
book4	80	[machine learning, neural networks]
book5	100	[regression, classification]

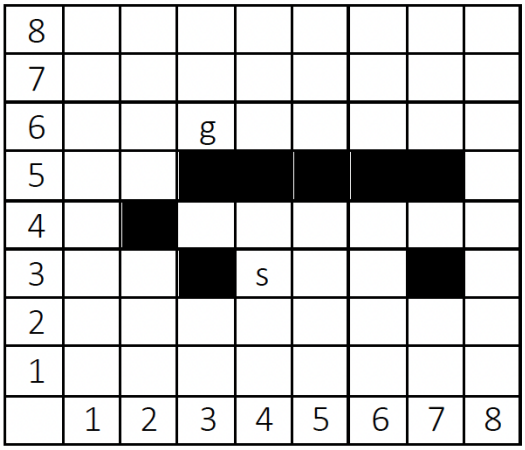
Child nodes are obtained by selecting a topic from *Topics*, then selecting a book that covers this topic, then adding this book to *Books* and finally removing all of the topics that are covered by this book from the *Topics* list. For example, if we have the node *([introduction to AI, classification],[])* and we select the topic *introduction to AI*, then the child nodes will be *([],[book3])* and *([classification],[book1])*. Thus, each arc in the graph adds one book which covers one or more topics. Suppose that the cost of an arc is equal to the number of pages in the selected book.

The goal is to design a customized textbook that covers all of the topics requested by the teacher, i.e., the topics in list *Topics*. The start node is *(Topics,[])* and the goal nodes have the form *([],CustomizedTextbook)*, where *CustomizedTextbook* is a list of books selected from the catalog. The cost of the path from the start node to a goal node is equal to the total number of pages in the customized textbook, and an optimal customized textbook is one that covers all of the requested topics (i.e., all of the topics in *Topics*) with the fewest pages.

(a) Suppose a teacher requests a customised textbook that covers the topics *[introduction to AI, regression, classification]* and that the algorithm always selects the leftmost topic when generating child nodes of the current node. Draw (by hand) the search space as a tree expanded for a lowest-cost-first search, until the first solution is found. This should show all nodes expanded. Indicate which node is a goal node, and which node(s) are at the frontier when the goal is found.

(b) Give a non-trivial heuristic function h that is admissible. ($h(n) = 0$ for all n is the trivial heuristic function.)

4. Consider the problem of finding a path in the grid shown below from the position s to the position g.



A piece can move on the grid horizontally or vertically, one square at a time. No step may be made into a forbidden shaded area. Each square is denoted by the xy coordinate. For example,

s is 43 and g is 36. Consider the Manhattan distance as the heuristic. State and motivate any assumptions that you make.

(a) Write the paths stored and selected in the first five iterations of the A* algorithm, assuming that in the case of tie the algorithm prefers the path stored first.

(b) Solve this problem using the software in http://qiao.github.io/PathFinding.js/visual/ Use Manhattan distance, no diagonal step and compare A*, BFS, and best-first search. Describe your observations. Explain how each of these methods reaches the solution. Discuss the efficiency of each of the methods for this situation/scenario.

(c) Using a board like the board used in question 4a) or in http://qiao.github.io/PathFinding.js/visual/, describe and draw a situation/scenario where BFS would find a shorter path to the goal compared to greedy best-first search. Consider that a piece can move on the grid horizontally or vertically, but not diagonally. Explain why BFS finds a shorter path in this case.

1.1 What To Submit

For this final assignment, please submit:

- A PDF report that includes the answers, discussion, and motivation that are requested in the questions.

In each file that you submit, **give the names of the people submitting the work**. On the first page of the report state how many hours each person spent working on the assignment. Remember that we check for plagiarism, and we are obliged to report suspected cases.

Ensure that all group members have joined the Assignment Group in Canvas before submitting your solution.

2 Self-Check: *Please read this before submitting your report*

Please perform the following self-checks before submission:

☐ Have you answered all questions to the best of your ability?

☐ Is all the required information on the front page (e.g., you and your partner's names, the hours each partner worked, the correct file name, etc)

☐ Anything else you can easily check? (e.g., clearly labeled axes in figures, clearly labeled units, clear terminology and arguments, clearly stated answers, etc)

Do not submit an incomplete assignment! We teachers are available to help you, and you can receive a short extension if you contact us.