Artificial Intelligence (COMP111)

Exercise 2

Your answer to Questions 10 and 11 should be submitted on canvas for assignment *Exercise 2* either as a text entry, a text file (txt), a pdf file, or a photo of the handwritten solution. The deadline is Monday, 26th of October, at 6pm. You should also attempt to answer the other questions before your tutorial (but not submit them).

You obtain 1 point (1 percent of the final mark) if you make a reasonable attempt to answer Questions 11 and 12 *and* actively participate in your tutorial in the week starting Monday 26th of October.

We would like to encourage you to discuss the questions with your fellow students, but do not copy your answer from anybody else.

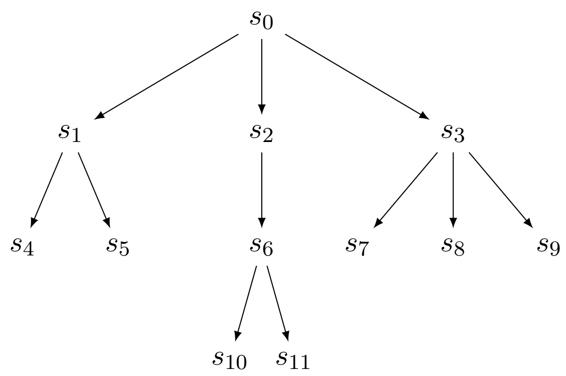
1. Consider a search graph in which every state has exactly 6 successors. Argue that there are exactly $1 + 6 + 6^2 + 6^3 + 6^4$ paths of length at most 4 starting with the start state.

   In general, if d is a positive integer, then there are $1+6+6^2+6^3+\cdots+6^d$ paths of length at most d starting with the start state. You do not have to prove this, but it should be plausible now.

   Even more general, if b is the exact number of successors of each state, then there are $1+b+b^2 \cdots + b^d$ paths of length at most d starting from the start state. Again, you do not have to prove this, but it should be plausible now.

2. Assume that the number of atoms in the observable universe is roughly 10^{80}. Define a search graph with a most 10 states such that the number of paths of length 80 from its start state roughly coincides with the number of atoms in the observable universe.

Questions 3–9 refer to the following search graph with $s_{\text{start}} = s_0$.



3. Suppose A is a search algorithm applied to the search graph. If

$$s_0 s_1 s_2 s_3 s_4 s_5 s_6 s_7 s_8 s_9 s_{10} s_{11}$$

is the sequence in which the states are expanded by A, then A

(A) performs a depth-first search strategy

(B) performs a breadth-first search strategy

(C) does not perform either a depth-first or a breadth-first search strategy

4. Assume A performs a depth-first strategy. Give a (possible) sequence in which the states are expanded by A.

5. Suppose A is a search algorithm applied to the search graph. Before A terminates the frontier contains the following paths $\{s_0s_1, s_0s_2, s_0s_3\}$, and s_0s_1 is the path selected to continue the search. Is it possible to decide whether A is a depth-first or a breadth-first search algorithm? Explain your answer.

6. Suppose A is a search algorithm applied to the search graph. Before A terminates the frontier contains the following paths

$$\{s_0s_2, s_0s_3, s_0s_1s_4, s_0s_1s_5\}$$

and $s_0s_1s_4$ is the path selected to continue the search. Is it possible to decide whether A is a depth-first or a breadth-first search algorithm? Explain your answer.

7. Suppose A is a search algorithm applied to the search graph. Before A terminates the frontier contains the following paths

$$\{s_0s_2, s_0s_3, s_0s_1s_4, s_0s_1s_5\}$$

and s_0s_2 is the path selected to continue the search. Is it possible to decide whether A is a depth-first or a breadth-first search algorithm? Explain your answer.

8. Suppose A is a search algorithm applied to the search graph. Assume A performs a depth 2 limited search strategy. Give a (possible) sequence in which the states are selected by A.

9. Suppose A is a search algorithm applied to the search graph. Assume A performs an iterative deepening strategy. Give a (possible) sequence in which the states are selected by A.

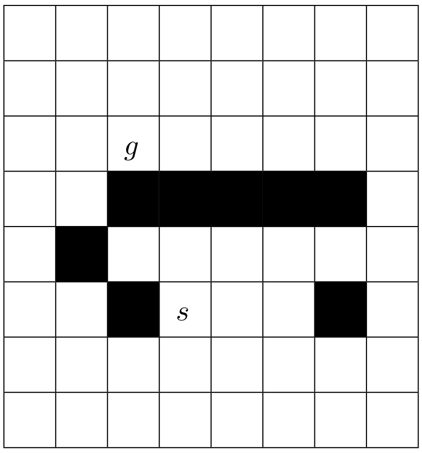
Consider the following search graph with states $\{a, b, c\}$, start state $s_{\text{start}} = a$, and a single goal state c.

$$\begin{tikzcd} a \arrow[r, bend left] & b \arrow[l, bend left] \arrow[r] & c \end{tikzcd}$$

10. Assume a breadth-first search algorithm is applied to this search graph. Give a sequence of frontiers that could be computed by the algorithm. Explain your answer.

11. Assume a depth-first algorithm is applied to the search graph. Give two sequences of frontiers that could be computed by the algorithm. Explain your answer.

12. Consider the problem of finding a path from position s to position g in the grid shown in the following figure:



The robot can move on the grid horizontally or vertically, one square at a time. No step may be made into a forbidden shaded area. Number the states expanded for a depth-first search from start state s to goal state g, given that the order of the actions is up, left, right, down. Assume the search algorithm *avoids repeating states* in the sense that for the expansion of a path no successor is considered that is already on the path. Thus, at Line 11 of our depth first search algorithm (Comp111 slides), only those $s_0 \cdots s_k s$ are added to the frontier for which s does not occur in $s_0 \cdots s_k$.

13. Determine the space complexity of iterative deepening: given the branching factor b of the search tree and the depth d of the shortest path to a goal state, what is the maximal number of paths in the frontier?

    Compare this to the maximal size of the frontier for breadth-first search.