SAARLAND UNIVERSITY
Prof. Jana Koehler
Prof. Jörg Hoffmann

ARTIFICIAL INTELLIGENCE

Theoretical Exercise Sheet 1

Solutions due Tuesday, May 12, 23:59.
Total points of the sheet: 20

Exercise 1: Planning a Trip from Kaiserslautern to Saarbrücken — 5 Points

You want to drive from Kaiserslautern to Saarbrücken by car. However, your car is not equipped with an automated navigation system. The only thing you carry with you is an up-to-date highway map of Germany. The map shows numerical values to indicate traffic intensity in certain highway segments. Your aim is to find a fast route that is unlikely to encounter high traffic.
Specify the state space, the initial state, the goal state and goal test and the set of actions. How could your action costs reflect the length and the traffic intensity of a route?

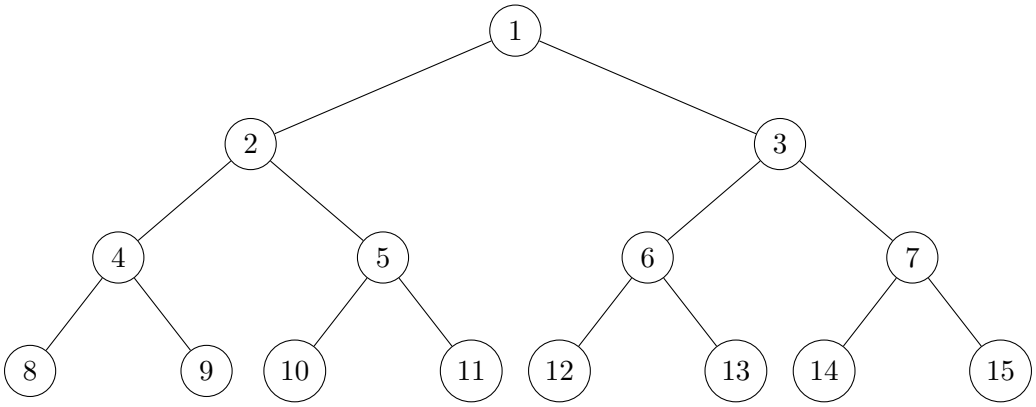
Solution:

- *States: cities on the map connected by highways*
- *Initital state: Kaiserslautern*
- *Goal test: in Saarbrücken?*
- *Actions: drive from 1 city to another*
- *Action costs: e.g. weighted sum of route length + travel density*

Total points: 5

Exercise 2: BFS and DLS — 2 Points

Consider the following state space:



Suppose the goal state is 11. List the order in which nodes will be visited for

(i) Breadthfirst search,

Solution: 1 2 3 4 5 *;*

(ii) Depth-Limited search with limit 3,

Solution: 1 2 4 8 9 5 10 11*;*

Exercise 3: State Space 4 Points

Consider the state space depicted in Figure 1, where A is the initial state, and F and I are goal states. The transitions are annotated by their costs. List all states that are

1. Solvable

   Solution: *A, C, F, G, H, I*

2. Dead-ends

   Solution: *B, D, E*

3. Not reachable from G

   Solution: *A, C, H*

4. Reachable from H

   Solution: *B, E, F, H, I*

Total points: 4

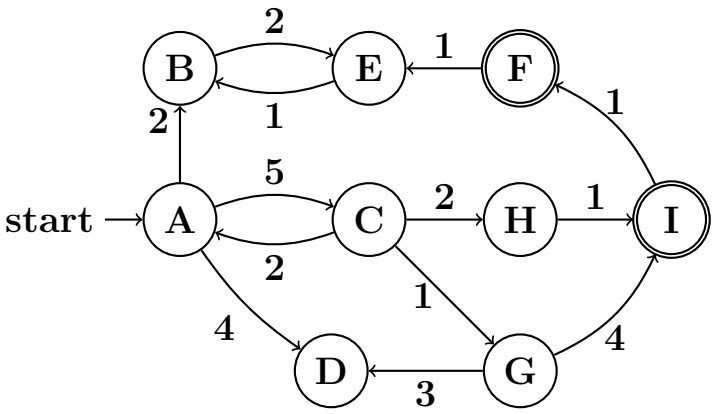


Figure 1: State space used throughout this sheet.

Solution:

(i) A, C, F, G, H, I.

(ii) B, D, E.

(iii) A, C, H.

(iv) B, E, F, H, I.

Total points: 4

Exercise 4: IDS and UCS 9 Points

Consider the state space depicted in Figure 1.

(a) (i) Run uniform-cost search on this problem. Draw the search graph and annotate **each node** with its g **value and the order in which states are selected for expansion**. Draw duplicate nodes, and mark them accordingly by crossing them out. If the choice of the next state to be expanded is not unique, expand the lexicographically smallest state first. (e.g., a before d).

(ii) Give the solution found by uniform-cost search.

(iii) Is this solution guaranteed to be optimal? Justify your answer.

(b) (i) Run iterative-deepening search until it finds a solution. For each depth depict the corresponding search tree. Annotate each state with the **order in which states are selected for expansion**. If the choice of the next state to be expanded is not unique, expand the lexicographically smallest state first.

(ii) Give the solution found by iterative-deepening search.

(iii) Is this solution guaranteed to be optimal? Justify your answer.

Solution:

(a) (i) Search graph is given in Figure 2.

(ii) The solution is A, C, H, I.

(iii) The solution is optimal because uniform cost search is guaranteed to find the optimal solution. The numbers in parenthesis indicate the order of expansion. Crossed-out states are duplicates. The cost of I *reached via* G *is updated when expanding* H. *This* I *is then discarded.*

(b) (i) Search graph is given in Figure 3.

(ii) The solution is A, C, G, I.

(iii) It is not optimal, because it has a cost of 10 *instead of* 8. *This is due to the fact that iterative deepening search returns the first solution found, which is guaranteed to be a shortest solution (3 steps in this case). However, this is not necessarily a cheapest solution because the algorithm ignores action costs.*

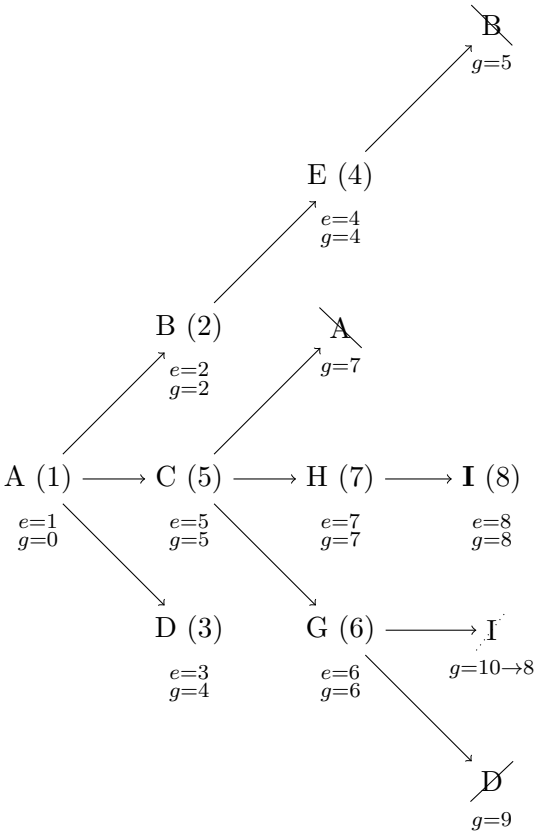


Figure 2: Solution to Exercise 4 (a)

Total points: 9

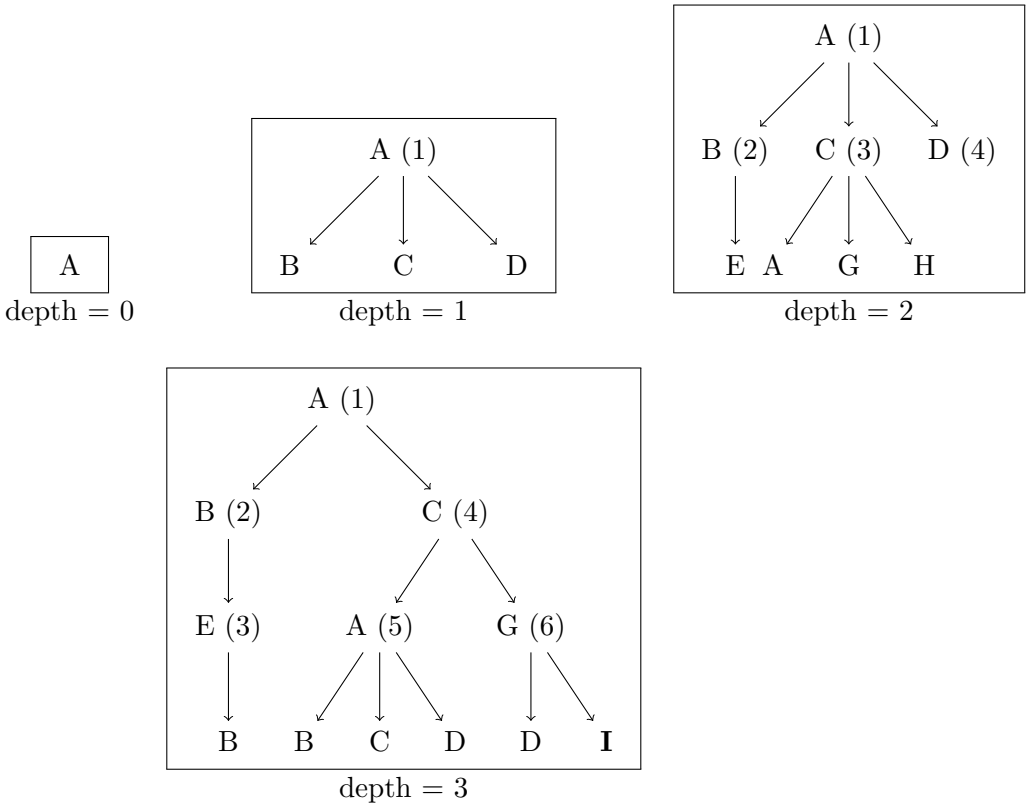


Figure 3: Solution to Exercise 4 (b)

Submission Instructions

Solutions need to be packaged into a `.zip` file and uploaded in the AI CMS. The `.zip` file has to contain a single folder with name:
`AI2020_TE1_mat1_mat2_mat3` where `mat1, mat2 , mat3` are the matriculation numbers of the students who submit together. This folder must contain the following files:

- `authors.txt` listing the names and matriculation numbers of all students who submit together. Use one line per student and no spaces: Name;Matriculation number.
- The `.pdf` file containing your solutions.

Do not add any other folder or sub folder, this means place all files directly into `AI2020_TE1_mat1_mat2_mat3`. Do not place any file outside of `AI2020_TE1_mat1_mat2_mat3`.

Only one student of each group needs to do the submission! Remember that this sheet can be submitted in groups of up to three members (all members of the group must

however be assigned to the same tutorial). If you are still looking for submission partners, it is recommended to ask in the forum of the CMS in the category “Student Room”.