Lehr- und Forschungsgebiet Informatik 5
RWTH Aachen

Prof. G. Lakemeyer, Ph.D.
J. Claßen, M. Liebenberg
08.11.2016

Introduction to Artificial Intelligence (Winter 2016)

2. Assignment

Submit your solution electronically via the L2P until 22.11.2016.

Homework assignments are optional but strongly recommended.

Exercise 2.1 (10 points)

Let $g(n)$ denote the path cost and $d(n)$ denote the depth of a node n in a search tree.

Which kind of search is emulated by greedy (best-first) search if the following functions are used as heuristic functions?

(a) $h(n) = g(n)$

(b) $h(n) = d(n)$

(c) $h(n) = 1/[1 + d(n)]$

Exercise 2.2 (20 points)

A heuristic h is called **consistent** if, for every node n and every successor n' of n generated by any action a, the estimated cost of reaching the goal from n is no greater than the step cost of getting to n' plus the estimated cost of reaching the goal from n', i. e.: $h(n) \leq c(n, a, n') + h(n')$.[1]

Prove that if a heuristic is consistent, it must be admissible.
Construct an admissible heuristic that is not consistent.

Exercise 2.3 (30 points)

One relaxation of the 8-puzzle is that a tile can move from one square to the blank square directly. The exact solution of this problem defines **Gaschnig's heuristic**. Explain why Gaschnig's heuristic is at least as accurate as the misplaced-tiles heuristic, and show cases where it is more accurate than both the misplaced-tiles heuristic and the Manhattan-distance heuristic. Can you suggest a way to calculate Gaschnig's heuristic efficiently?

[1] $c(n, a, n')$ is the step cost of taking action a to go from node n to node n'.

Exercise 2.4 (20 points)

Consider the "**water-jug puzzle**":

> There is a 3-liter water jug and a 4-liter water jug. At the beginning, both are empty. At the end, the 4-liter jug shall contain exactly 2 liter. A jug can be emptied or filled with water (completely). Water can be poured from one jug into the other. This must be done exactly until one jug is empty or full.

(a) Formalize this as a search problem where the costs of all actions are 1.

(b) The following is true for that problem in every state except goal states:

> If the 3-liter jug is full, then at least 3 steps are necessary to reach a goal state. If the 3-liter jug is empty and the 4-liter jug contains x liter, then at least x steps are necessary to reach a goal state. If both jugs are full or both jugs are empty, then at least 5 steps are necessary to reach a goal state.

Use this (and only this) information to find an admissible heuristic that is as good as possible.

(c) Solve the problem with A* search using your heuristic and draw the A* search tree. Label each node with the corresponding state and the estimated cost of the cheapest solution path through it. Additionally, mark in the tree the order of the expansion of the nodes.