

# Foundations of Artificial Intelligence

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## Exercise Sheet 6

**Due: April 15, 2016**

### Exercise 6.1 (2+2 marks)

- Show that a solution that is computed with  $A^*$  with reopening is not necessarily optimal if the used heuristic is consistent but *not goal-aware*.
- Show that a solution that is computed with  $A^*$  without reopening is not necessarily optimal if the used heuristic is admissible but *not consistent*.

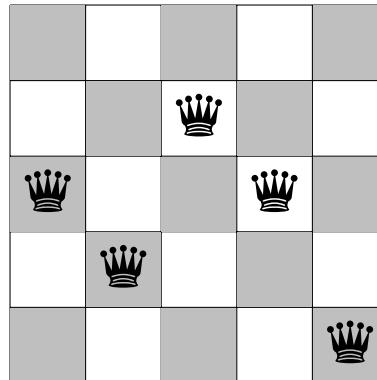
*Hint:* You can show both statements by specifying an example search problem and a heuristic and by showing that the corresponding algorithm computes a suboptimal solution.

### Exercise 6.2 (4 marks)

A *vertex cover* of a given input graph  $G$  is a subset of the vertices of  $G$  such that every edge of  $G$  has at least one of its end points in the subset. Formalize the combinatorial optimization problem of finding a vertex cover of minimal size. Choose a formalization such that the COP is neither a pure search problem nor a pure optimization problem.

### Exercise 6.3 (2+2 marks)

The 5-queens problem is the COP on a  $5 \times 5$  chess board that is analogous to the 8-queens problem that has been introduced in the lecture. In this exercise, we are interested in finding a solution for the 5-queens problem with different local search variants. Consider the following initial candidate:



- Depict the candidates that are considered by hill climbing with the heuristic and the neighbourhood that are introduced on slide 22 of Chapter 20 in the print version of the lecture slides. If necessary, break ties in favor of candidates where the leftmost possible queen is moved to a square that is as far up as possible. Annotate the candidates that are considered during search with the heuristic values of all neighbours.
- Now consider a hill climbing variant where the next candidate that is considered is selected by first picking a file at random and then moving the (unique) queen in that file to the square in that file with the best heuristic value (the variant is introduced on slide 9 of Chapter 21 in the print version of the lecture slides). Assume that the random generator is such that the file selection picks the third file first, and in each subsequent step the file that is to the left

of the file that had been selected last (if the leftmost file was selected last, the rightmost file is selected). Provide the candidates that are considered if the heuristic is used that counts the number of queens that threaten the queen in the selected file. If necessary, break ties in favor of candidates where the queen that is moved is as far up as possible. Annotate the candidates that are considered during search with the heuristic values of all neighbours.

Note that the file chess-board.tex, which you can find on the website, contains the LaTeX source code for the  $5 \times 5$  chess board depicted above.

*The exercise sheets can be submitted in groups of two students. Please provide both student names on the submission.*