Introduction to Artificial Intelligence Exercises (WS 23/24)

Assignment 2: Local Search and Constrained Satisfaction Problems

Prof. Dr. Mathias Niepert, mathias.niepert@ki.uni-stuttgart.de
Vinh Tong, vinh.tong@ki.uni-stuttgart.de
Mario Kalimuthu, mario.kalimuthu@ki.uni-stuttgart.de

Submit your solution in ILIAS as PDF. Submit either a (LaTeX) typeset PDF or legibly done handwritten solution. Please DO NOT forget to write your full names and matriculation numbers of each group member. Please name your *.pdf* submission files using the following format containing your Groupnumber_Lastname1_Lastname2_Assignmentnumber.pdf
e.g. G1_Alpha_Manolache_Lukashina_Tong_Assignment1.pdf
If there are any questions, please do not hesitate to ask them in the exercise forum on ILIAS.

1 Theoretical — 11 points

a. Provide an explanation of how gradient descent operates and discuss its limitations. Can you identify any types of objective functions where gradient descent consistently converges to the global minimum? If so, please provide an example.
4 points

b. Explain the relationship between parallel hill climbing and local beam search.
3 points

c. Explain why it is a good heuristic to choose the variable that is *most* constrained but the value that is *least* constraining in a CSP search **4 points**

2 Search algorithm equivalent — 10 points

Provide the name and explanation of the algorithm that results from each of the following special cases:

a. Local beam search with $k = 1$. **2 points**

b. Local beam search with one initial state and no limit on the number of states retained. **4 points**

c. Simulated annealing with $T = 0$ at all times (and omitting the termination test). *For this question, any division by 0 can be considered taking the limitation when* $T \to 0$ **4 points**

3 Hill-climbing search — 20 points

You are given a 3x3 grid with 8 values and one empty space. The initial state and the goal state are provided. To solve the problem using the hill climbing approach, begin with the initial state and progress based on the heuristic value (the number of misplaced tiles).

	1	3
4	2	5
7	8	6

Initial

1	2	3
4	5	6
7	8	

goal

Does the algorithm successfully reach the goal state? If not, what is the local optimum value achieved? Answer the same question in the event that we swap the positions of 7 and 8 in the goal state.

4 Crossword puzzles — 18 points

Consider the problem of constructing (not solving) crossword puzzles: fitting words into a rectangular grid. The grid, which is given as part of the problem, specifies which squares are blank and which are shaded. Assume that a list of words (i.e., a dictionary) is provided and that the task is to fill in the blank squares by using any subset of the list. Formulate this problem precisely in two ways.

a. As a general search problem (*state space, initial state, actions, transition model, goal state*). Choose an appropriate search algorithm and specify a heuristic function.

9 points

b. As a constraint satisfaction problem (*variables, domains, constraints, objective*).

9 points