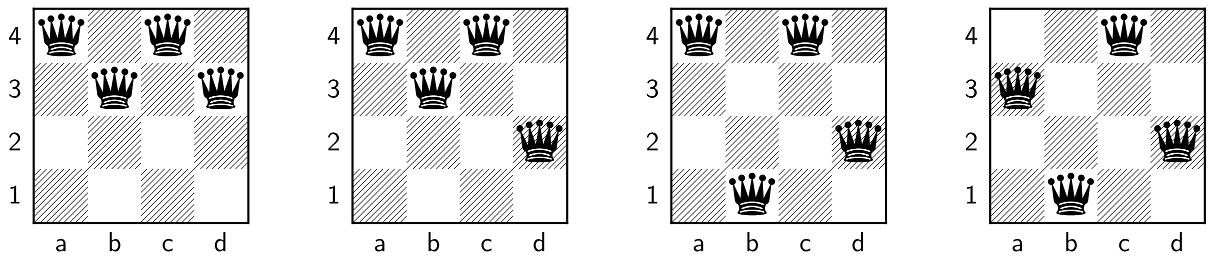
TP LSMM (Local Search and Min-Max algorithm)
Techniques of AI [INFO-H-410]

v1.0.0

Source files, code templates and corrections related to practical sessions can be found on the UV or on github (`https://github.com/iridia-ulb/INFOH410`).

Hill Climbing

Question 1. We want to solve the N-queens problem. Suppose you want to place N queens of a $N \times N$ chess board so that no queen can attack another queen.



a) What would be a good heuristic for this problem ? Calculate this heuristic for each of the above board.

b) How many board arrangments are there ?

c) What would be a good state representation for this puzzle ?

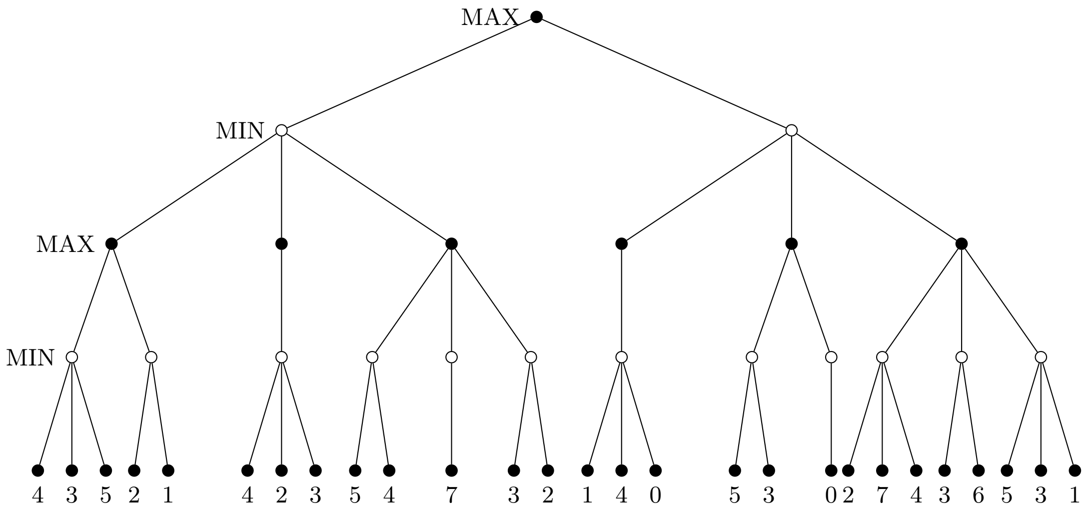
d) Given a clever state representation, how many board arrangments are there ?

Question 2. Implement exhaustive search in python (you can use the template (see page 1)) for the aforementioned puzzle.

Question 3. Implement (stochastic) Hill Climbing local search in python for this puzzle. Now compare your results with exhaustive search, what happens if N = 10, 15, 20 ? Why ?

The Minimax algorithm

Question 4. Perform the minimax algorithm on the following tree, first without and then with $\alpha\beta$-pruning.



Question 5. Implement the tic tac toe game using python so that you can play against an AI using the minimax algorithm (you can use the template (see page 1)).

X	X	O
O	X	X
O	X	O

Local search applied to graphs: Kernighan-Lin

Kernighan-Lin is an algorithm to split a graph $\mathcal{G} = (\mathcal{V}, \mathcal{E})$ into two partitions P_1 and P_2 with a minimal cutisze. The cutsize c is computed as $\sum_{i \in P_1, j \in P_2} w(e_{i,j})$, where $e_{i,j}$ is an edge $\in \mathcal{E}$ connecting two vertices $i, j \in \mathcal{V}$ in different partitions and w the weight of said edge.

The algorithm will be swapping pairs of vertices across the partition boundary in order to gradually improve the cutsize, as described in aglo 1. The costs and gains it refers to are computed as follows:

- External cost of vertex $x \in P_1$: $E_x = \sum_{i \in P_2} w(e_{x,i})$
- Internal cost of vertex $x \in P_1$: $I_x = \sum_{i \in P_1} w(e_{x,i})$
- Gain of swapping x and y: $gain(x, y) = (E_x - I_x) + (E_y - I_y) - 2 \cdot w(e_{x,y})$

Question 6. Using the given template `q_bonus_kl_template.py`, implement the KL partitioning algorithm. Each line of the input file `graph.txt` describes an edge of the graph and is formatted as follows: `<edge weight> <vertex i> <vertex j>`

Algorithm 1 Kernighan-Lin

Partition randomly into P_1 and P_2 ▷ Same size partitions
Compute initial cutsize
repeat
    Unlock all vertices
    Update costs E_x and I_x
    while Unlocked cells **do**
        for all Unlocked vertices $x \in P_1$ **do**
            for all Unlocked vertices $y \in P_2$ **do**
                Compute gain(x,y)
        Swap pair with highest gain ▷ Local search
        Lock those two vertices
    Accept n first swaps leading to minimal cutsize ▷ Hill climbing
until Cutsize is not improved