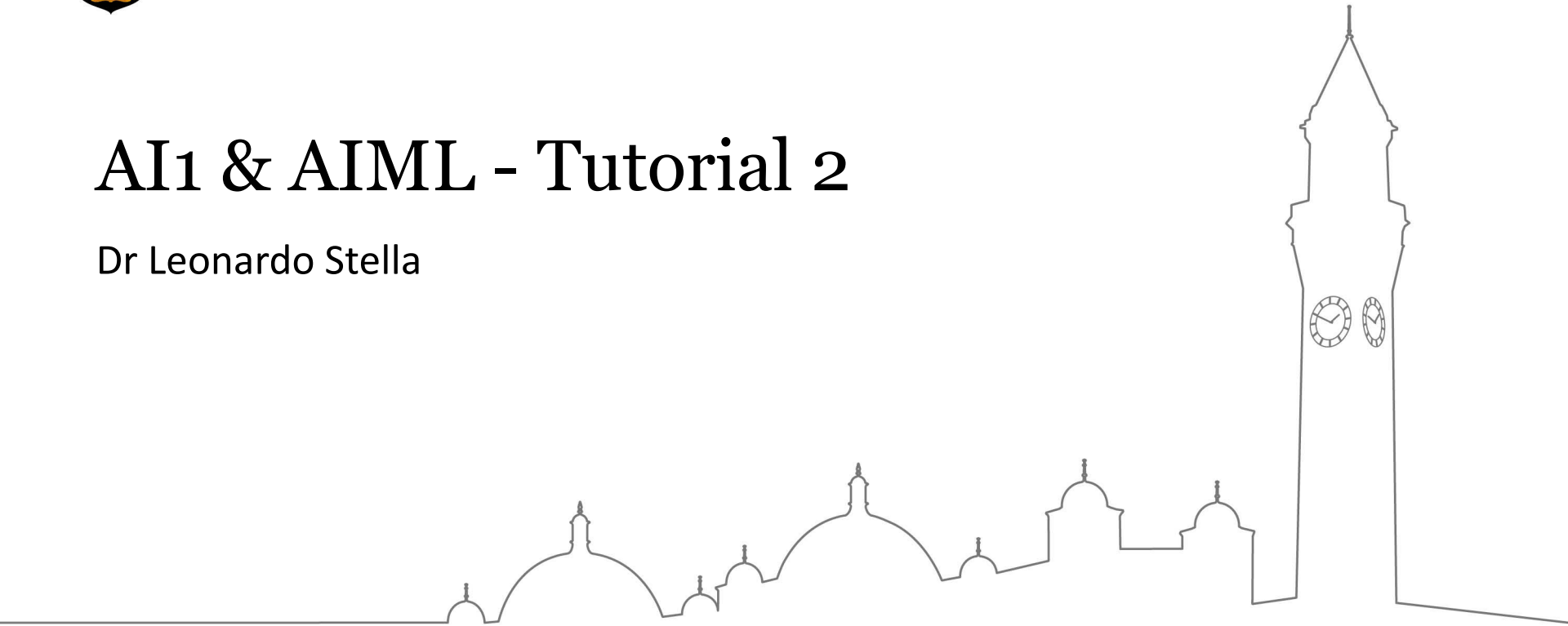
UNIVERSITY OF BIRMINGHAM

AI1 & AIML - Tutorial 2

Dr Leonardo Stella

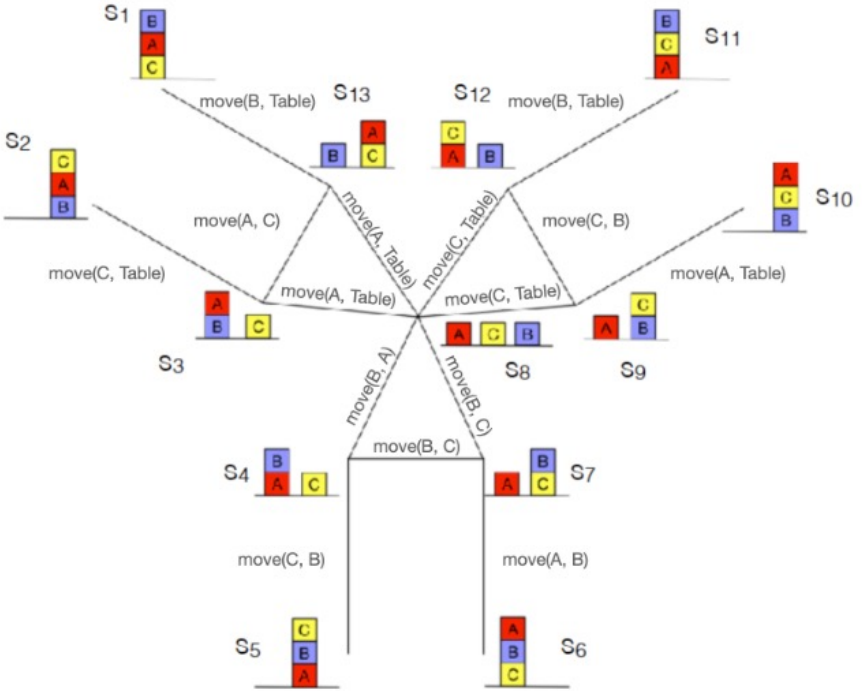


Exercise 1 - Recap

Activity. Recall the search problem formulation for the three-block world [5’]

Solution: (one possible solution)

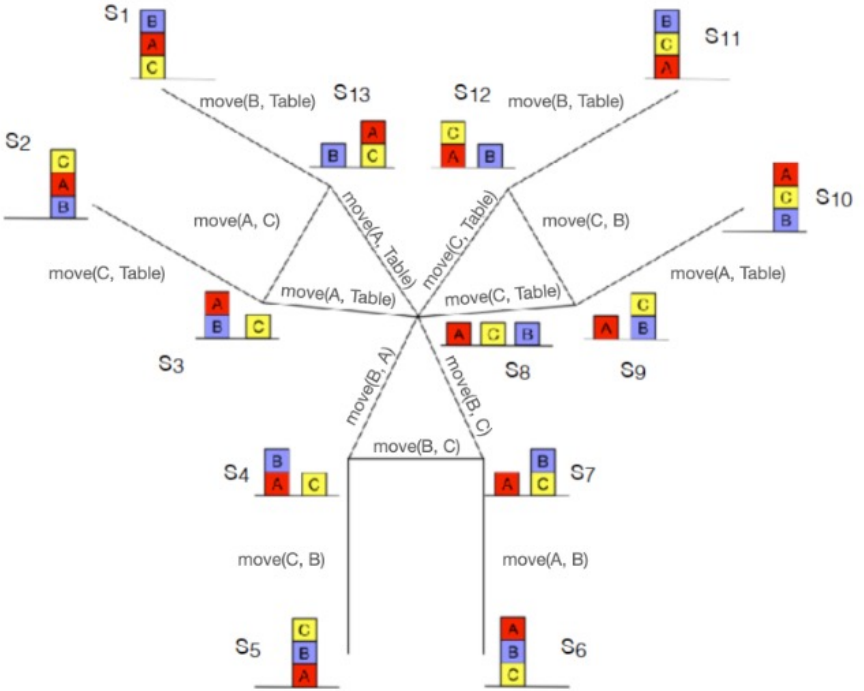
- **Initial state**: any of the 13 states
- **Actions**: move(X, Y), where X and Y can be A, B, C, Table with X ≠ Y
- **Transition model**: see image, e.g., from s3 -> s13 via move(A, C)
- **Goal test**: check if state is a goal (any)
- **Path cost**: each step costs 1



Exercise 2

Activity. In pairs or small groups, consider the following state space graph for the three-block world [15’]:

Assume that the initial state is node s_1 and the goal state is node s_6. The possible moves are represented by the functions move(X,Y) in the graph, which means to move X from where it is to sit on top of Y. Assume that the cost of each move is 1

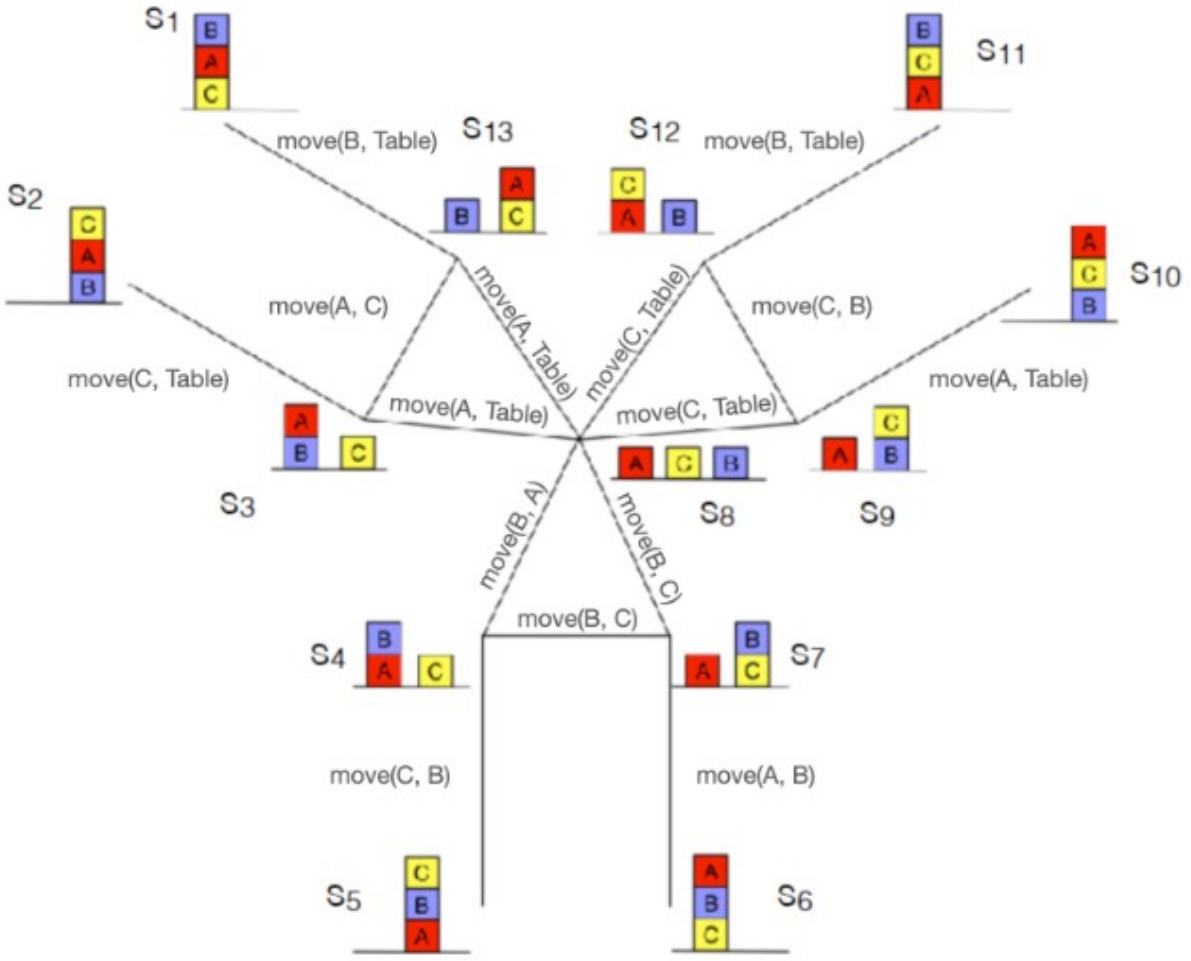


Exercise 2

Activity. Generate the DFS tree until the goal state is found and write down the sequence of nodes in the order they are visited by DFS

1. When two frontier nodes are at the same depth of the tree, consider that the one with the smaller identifier is expanded first
2. For the sequence of visited nodes, use lowercase letters and commas to separate the node identifiers without any space, e.g., s1,s2,s3,s4,s5,s6

Exercise 2

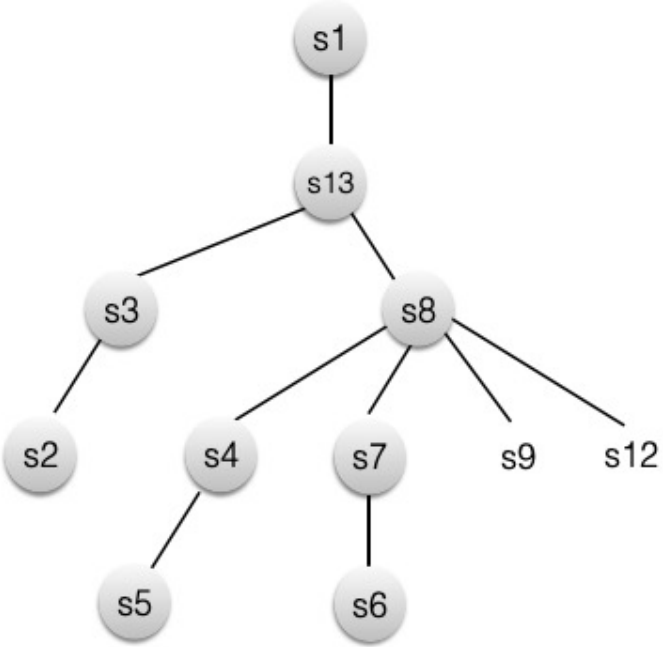

S1
S11
move(B, Table)
S13
S12
move(B, Table)
S2
S10
move(A, C)
move(A, Table)
move(C, Table)
move(C, B)
move(C, Table)
move(A, Table)
move(A, Table)
move(C, Table)
S3
S8
S9
move(B, A)
move(B, C)
move(B, C)
S4
S7
move(C, B)
move(A, B)
S5
S6

Exercise 2

Solution: the order of expansion is: s1,s13,s3,s2,s8,s4,s5,s7,s6

The visited nodes are shown within a circle, whereas the nodes not in a circle represent the frontier

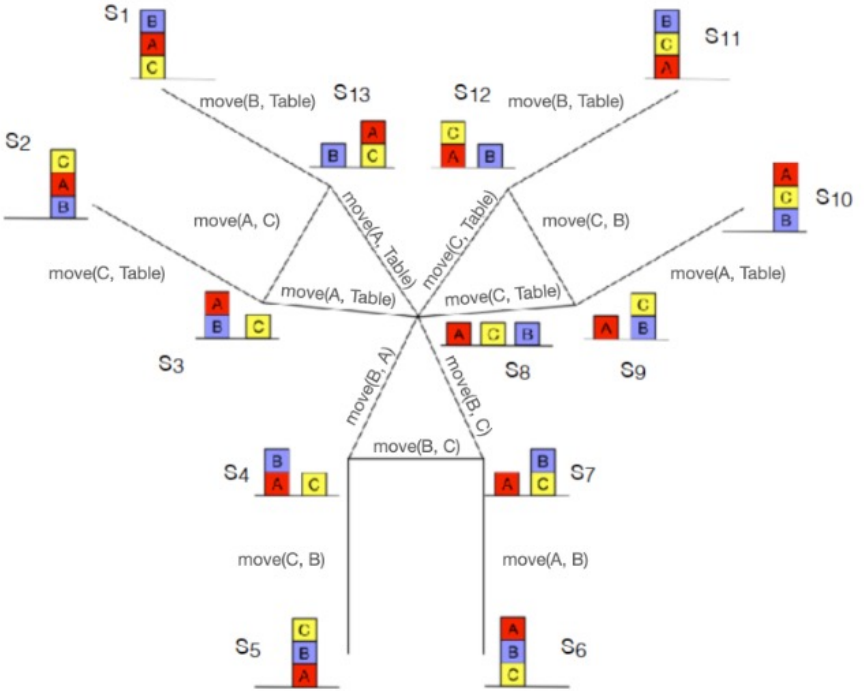
The nodes are visited in the following order: s1,s13,s3,s2,s8,s4,s5,s7,s6. Note that s9 and s12 do not need to be visited, because the search process stops when s6 is visited



Exercise 3

Activity. In pairs or small groups, consider the following state space graph for the three-block world [5’]:

Assume that the initial state is node s_1 and the goal state is node s_6. The possible moves are represented by the functions move(X,Y) in the graph, which means to move X from where it is to sit on top of Y. Assume that the cost of each move is 1



Exercise 3

Activity. Write down the cost of the solution corresponding to the DFS algorithm. What is the cost of this solution? What is the path corresponding to the solution?

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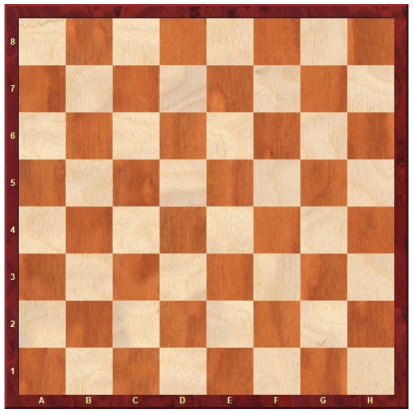
Solution: the solution is the sequence of actions, namely, move(B, Table), move(A, Table), move(B,C), move(A,B)

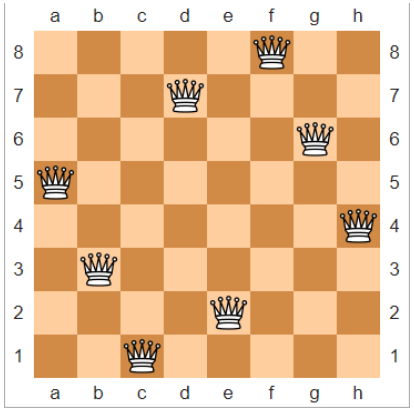
Since each action has cost 1, the cost of the above solution is 4

The path in the state space graph corresponding to this solution is: S1, S13, S8, S7, S6

Exercise 4

Activity. Consider the 8-queen puzzle. What is the minimum length ℓ such that depth-limited search is complete for this puzzle [5']?

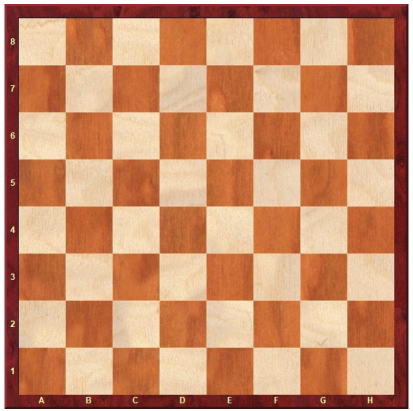


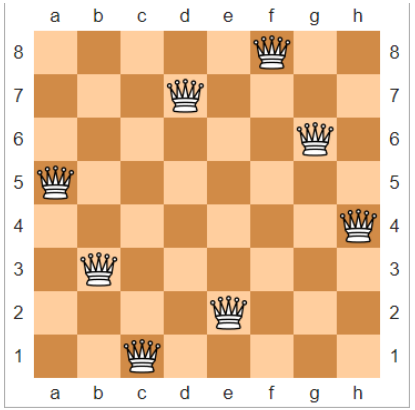


Exercise 4

Activity. Consider the 8-queen puzzle. What is the minimum length ℓ such that depth-limited search is complete for this puzzle [5']?

Solution : Since the depth of the shallowest node is d = 8, then the minimum depth is ℓ = 8

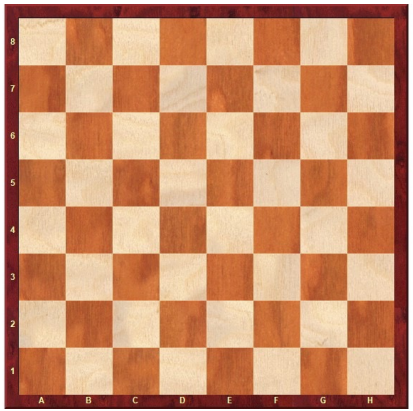


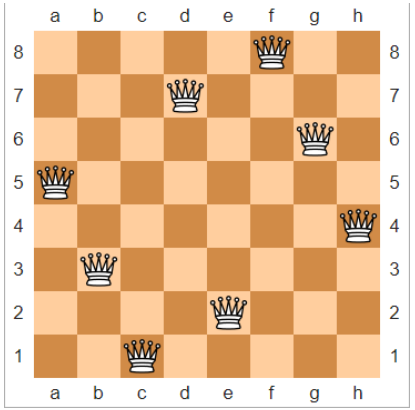


Exercise 5 - Recap

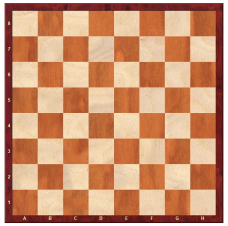
Activity. Consider the 8-queen puzzle. Recall the problem formulation [5']:

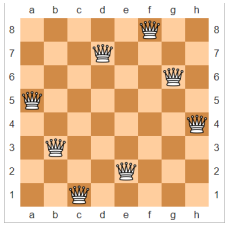
- **Initial state**: empty board
- **Actions**: place a queen on an empty square
- **Transition model**: the corresponding board after taking the action
- **Goal test**: all 8 queens placed on the board; no conflicts
- **Path cost**: each step costs 1





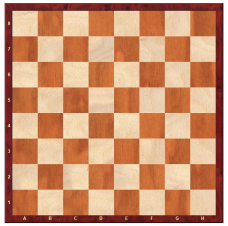
Exercise 6

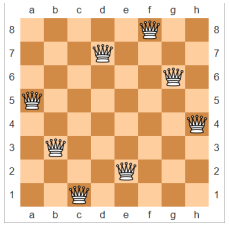




Activity. In pairs or small groups, do some research on possible heuristic functions that can be used for an implementation of A* and evaluate their performance in terms of time and quality of the result [15’]

Exercise 6

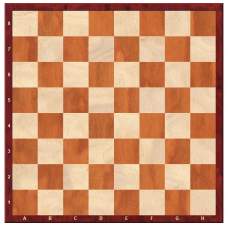


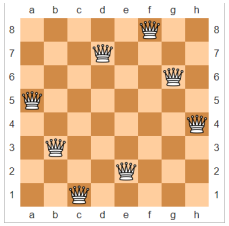


Activity. In pairs or small groups, do some research on possible heuristic functions that can be used for an implementation of A* and evaluate their performance in terms of time and quality of the result [15’]

- **H1**: Different column (row) from previously placed queen(s)
  - Quick, but not very informed

Exercise 6

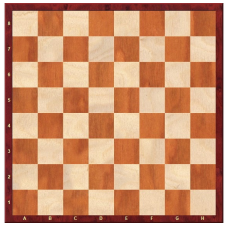


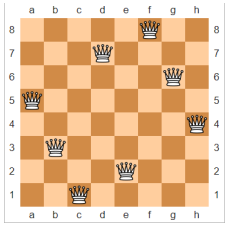


Activity. In pairs or small groups, do some research on possible heuristic functions that can be used for an implementation of A* and evaluate their performance in terms of time and quality of the result [15’]

- **H1**: Different column (row) from previously placed queen(s)
  - Quick, but not very informed
- **H2**: Distance from previously placed queen
  - Quick, but not very informed

Exercise 6

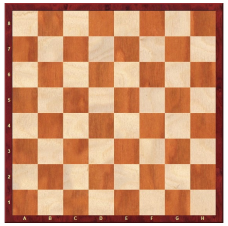


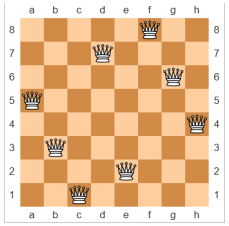


Activity. In pairs or small groups, do some research on possible heuristic functions that can be used for an implementation of A* and evaluate their performance in terms of time and quality of the result [15’]

- **H1**: Different column (row) from previously placed queen(s)
  - Quick, but not very informed
- **H2**: Distance from previously placed queen
  - Quick, but not very informed
- **H3**: Number of future feasible slots
  - Slower than previous ones, but more informed

Exercise 6

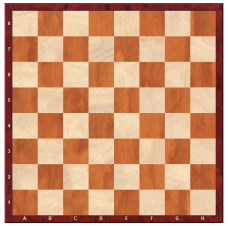


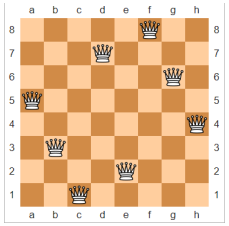


Activity. In pairs or small groups, do some research on possible heuristic functions that can be used for an implementation of A* and evaluate their performance in terms of time and quality of the result [15’]

- **H4**: Mean distance between previously placed queens
  - Mean of H2, a reasonable compromise between speed and quality

Exercise 6





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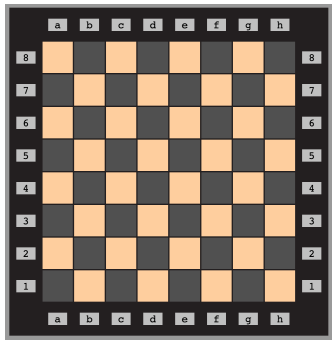
- **H4**: Mean distance between previously placed queens
  - Mean of H2, a reasonable compromise between speed and quality
- **H5**: More…

Exercise 6

- **H1**: Different row from previously placed queens



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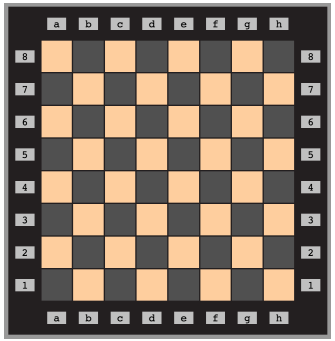
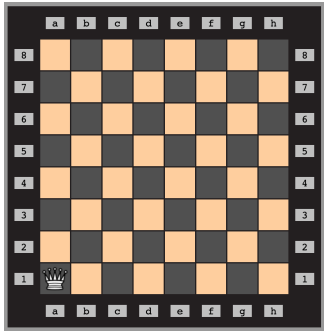
- **H1**: Different row from previously placed queens





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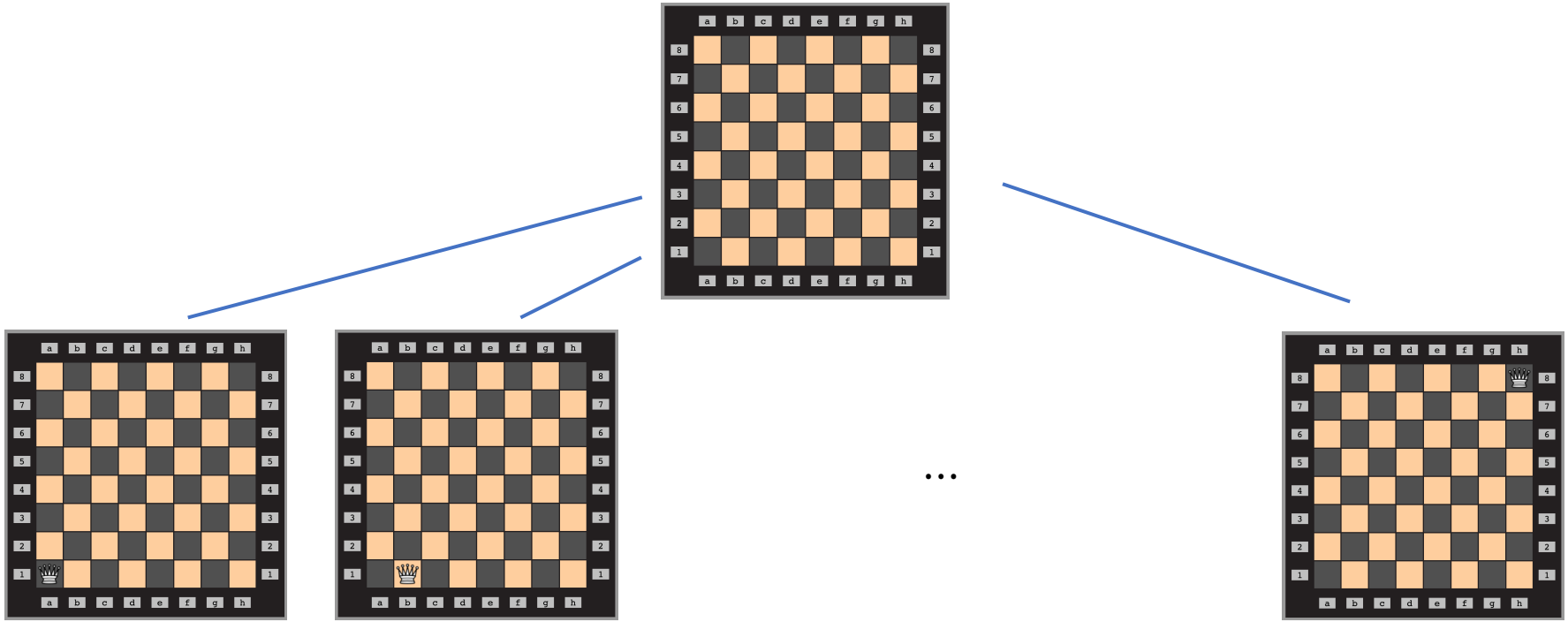

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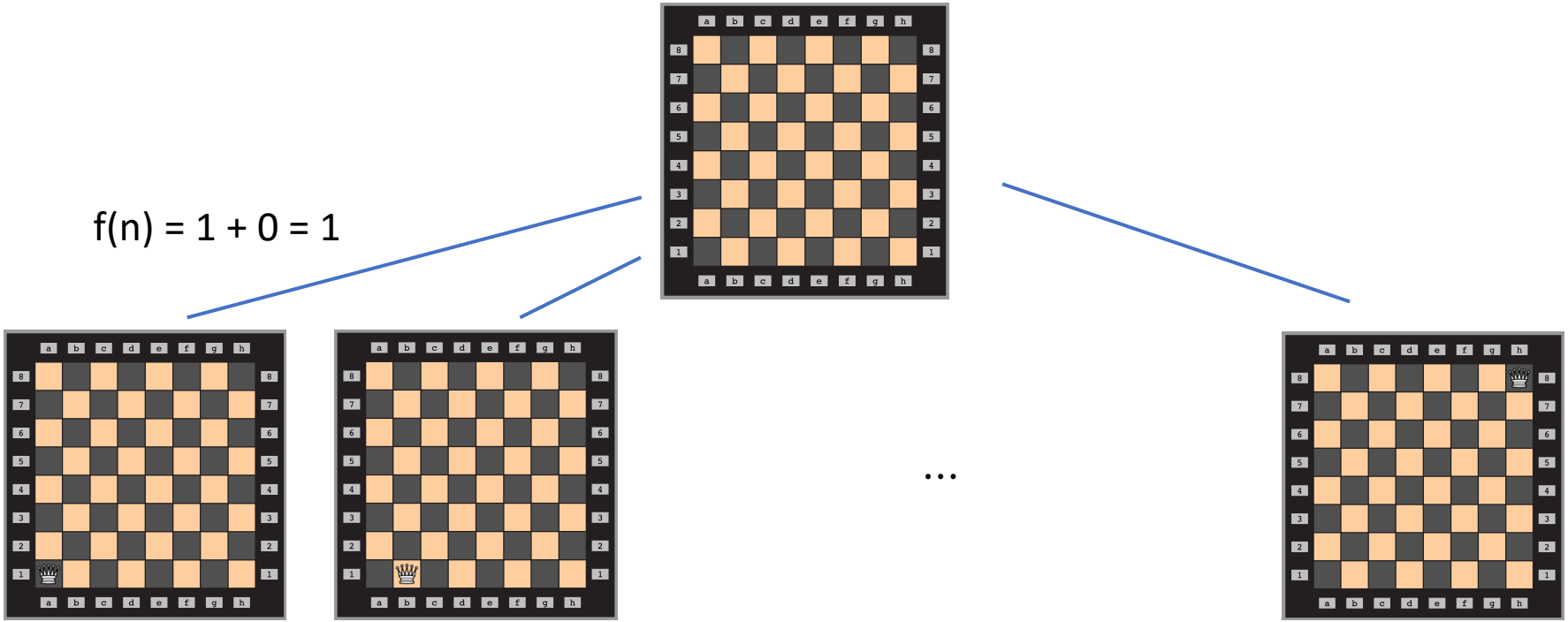

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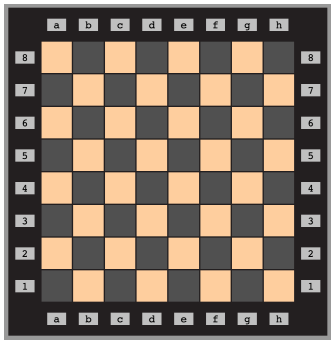
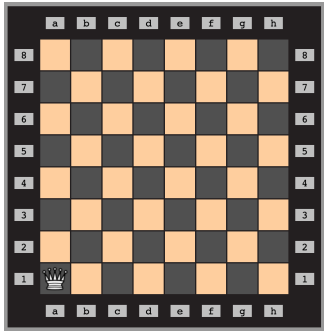
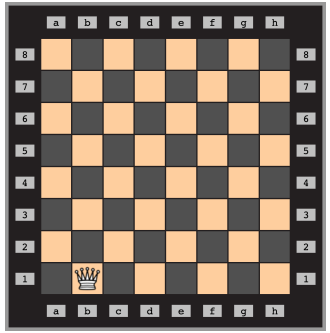


f(n) = 1 + 0 = 1





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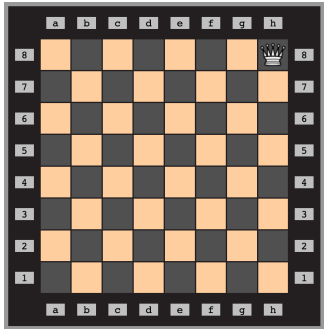

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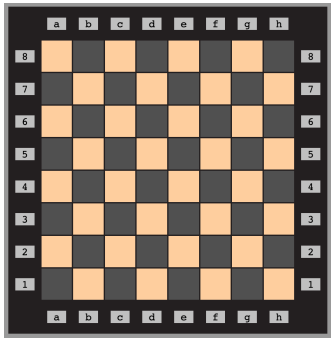

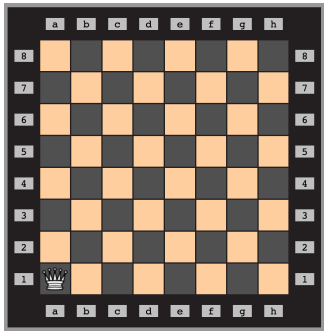

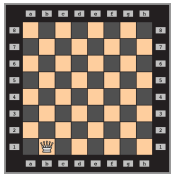

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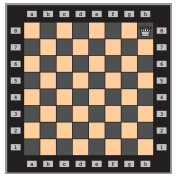

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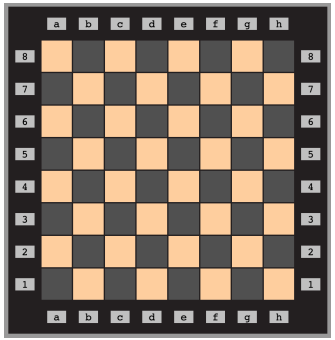

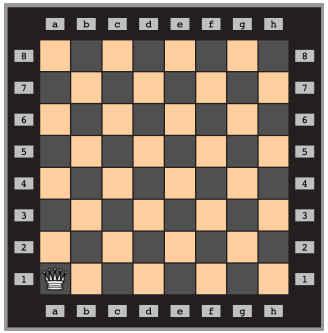

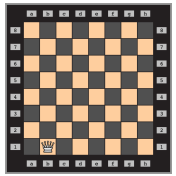

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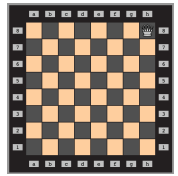

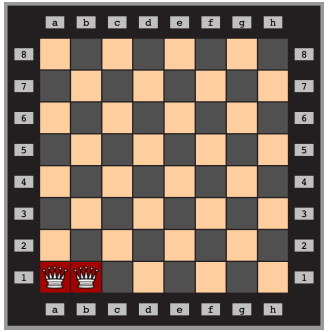

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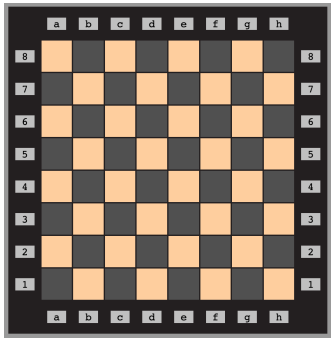

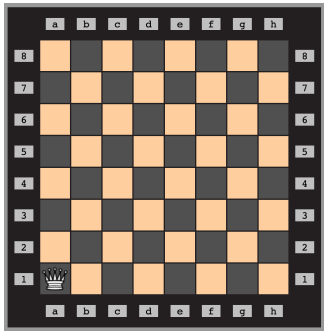

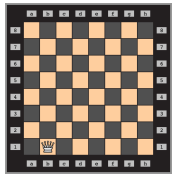

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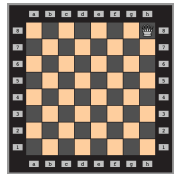
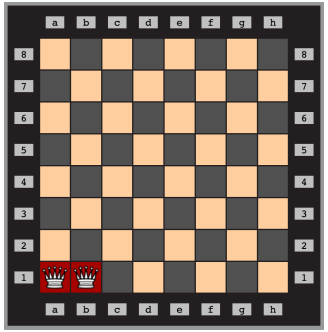


f(n) = 2 + 1 = 3



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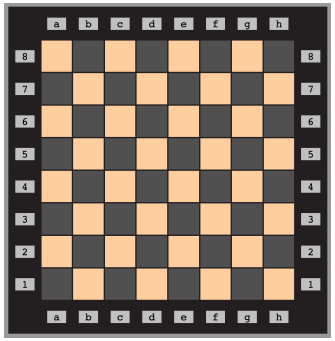

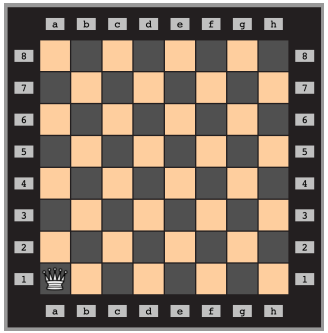

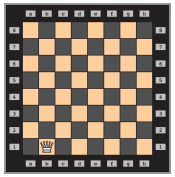

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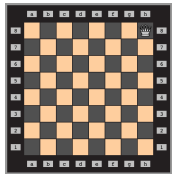
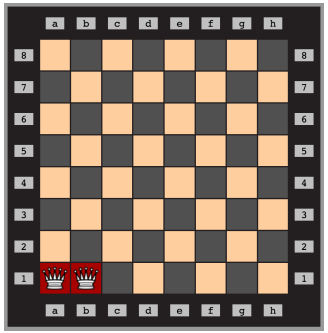


f(n) = 2 + 1 = 3



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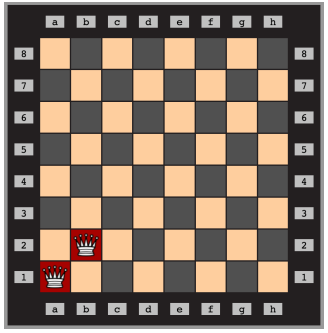
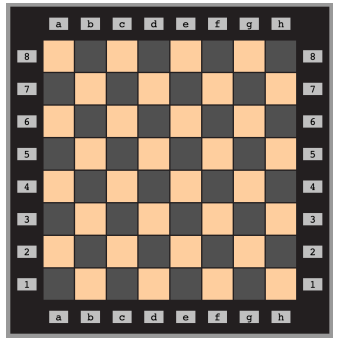
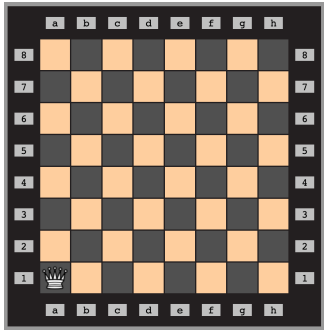
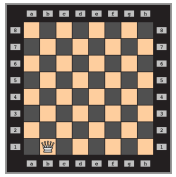




f(n) = 1 + 0 = 1





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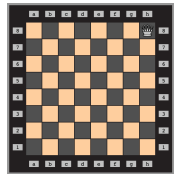
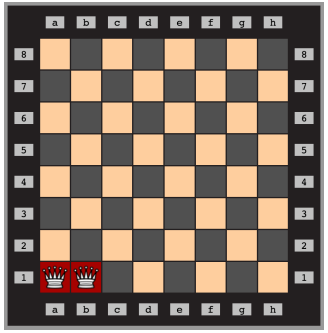


f(n) = 2 + 1 = 3

f(n) = 2 + 0 = 2



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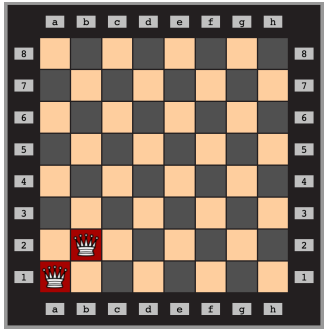
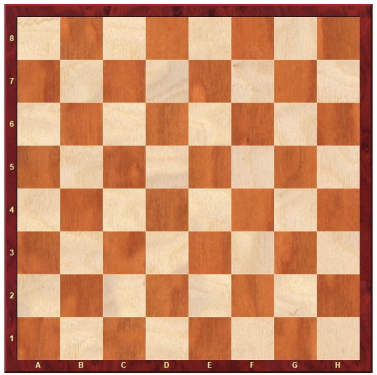
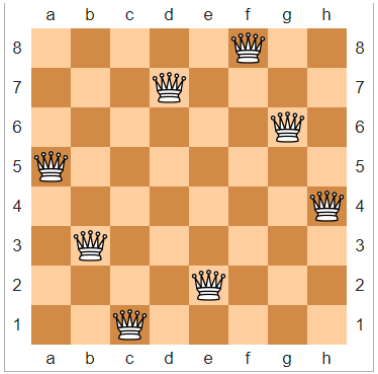


Tutorial Exercises: Final Remarks

- Finding a good heuristic is not easy, many candidate heuristics can exist
- Different heuristics lead to different results in terms of performance
- Trade-off between computational costs and level of information (path cost in general)
- https://datagenetics.com/blog/august42012/index.html





Tutorial Exercise: Final Remarks

- This problem was first posed in mid-19th century
- 4,426,165,368 possible arrangements
- If you use a rule of thumb (one queen per column), this reduces to 16,777,216 (that is, 8^8)
- 92 solutions, one symmetric
- Generalised to n-queen