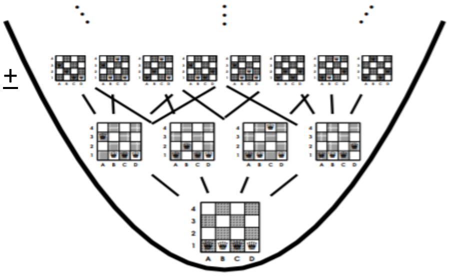
Week 9

Local Search

In computer science, **local search** is a heuristic method for solving computationally hard optimization problems. Local search can be used on problems that can be formulated as finding a solution maximizing a criterion among a number of candidate solutions. Local search algorithms move from solution to solution in the space of candidate solutions (the *search space*) by applying local changes, until a solution deemed optimal is found or a time bound is elapsed.

- **State Space** collection of all possible **solutions** and **non-solutions**

  (*e.g.* all possible ways of placing eights / four queens on a chessboard)

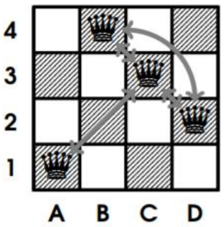


- **Successor Function** All the **'locally' accessible** states

  (*e.g.* all configurations that differ by one vertical move)

- **Heuristic Function** Assigns a **'score'** to each state in the state space

  h : search space $\rightarrow$ possible score



Heuristic
$h(x) = 4$

(*e.g.* the number of pairs currently in conflict)

Hill-climbing Local Search

Step 1) Guess an initial configuration,

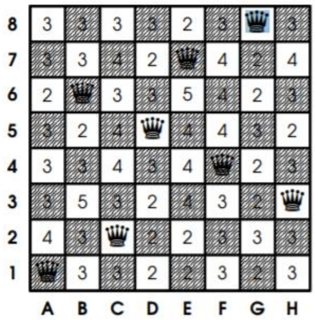
Step 2) Evaluate the heuristic function of the successor states,

Step 3) Move to a successor state with a better heuristic 'score'.

Step 4) Repeat until no further improvement to the score are possible.

(the Greedy SAT algorithm from last week employed Hill-climing)

- **Potential Pitfalls:** The Hill-climbing search may get **'stuck'** in a local maximum/minumum!



(there is only one conflict – (D5,G8) – but no local improvements!)

- The happens with The Eight Queens about **86% of the time!**

  (...so only successful 14% of the time!)

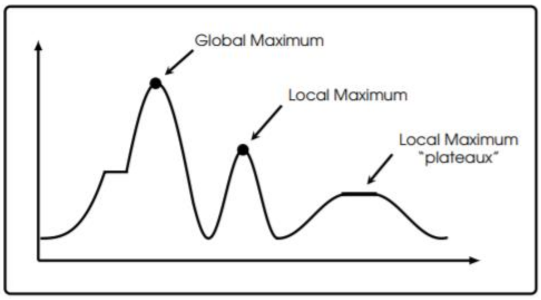
- However each paths are typically **quite short**,

  (takes about 3 moves on average to get stuck!)

  - Can quickly **stop** and **re-search** from a random configuration,
  - I was able to get **577 successes** out of **4160 runs** in $<$20 seconds

- **Global and Local Maxima**
  - **Global Maximum** $h(x^*) \geq h(x)$ for all $x \in X$

    (x^* is attains the greatest value *anywhere*)
  - **Local Maximum** $h(x^*) \geq h(x)$ for all *'neighbouring'* $x \in X$



(similarly, we may define global and local minima)

Week 9

Decision vs Optimisation Problems