Tutorial - Week 5

CSP & Local Search

Activity 1.

Solve the famous Cryptarithmetic puzzle:

$$\begin{array}{r} S\ E\ N\ D\ + \\ M\ O\ R\ E\ \ \ \\ \hline M\ O\ N\ E\ Y\ \ \ \end{array}$$

What heuristics and strategies did you use along the way?

The sum of two 4-digit numbers cannot exceed 19998 (9999+9999), so M=1.
10+O = S+1 or S+1+1, i.e. S = O+9 or O+8, but 1 has already been used, so O=0.

Therefore S=9, because there is no possibility of a carry from E+O.

Then we then E+1 = N and 10+E = N+R or N+R+1, so R = 8 or 9, but 9 has already been assigned, so R=8.

(Note how Minimum Remaining Values has been used at each step)
The puzzle now looks like this:

$$\begin{array}{r} 9\ E\ N\ D\ + \\ 1\ 0\ 8\ E\ \ \ \\ \hline 1\ 0\ N\ E\ Y\ \ \ \end{array}$$

This gives us two constraints:
E+1 = N
D+E = 10+Y

The remaining values are 2,3,4,5,6,7.

We have D+E <= 6+7 = 13, so Y = 2 or 3. (Note: MRV again).

But if Y=3 (Most Constraining Value) then all three variables D,E,N would need to take values 6 or 7, which is impossible (Constraint Propagation).

Therefore Y=2, E=5, N=6 and D=7.

Activity 2

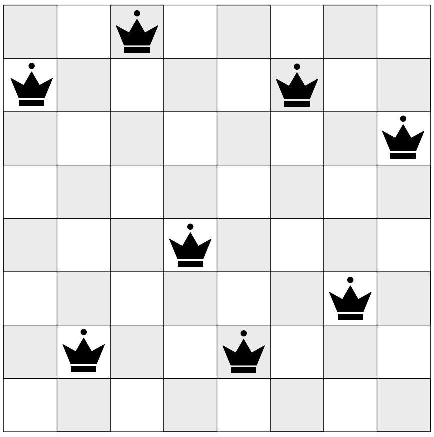
Use Forward Checking to show that the Australia map-colouring problem has no solution when we assign WA=green, V=Red, NT=Red.

	WA	*NT*	*Q*	*NSW*	*V*	*SA*	*T*
initial domains	*R G B*	*R G B*	*R G B*	*R G B*	*R G B*	*R G B*	*R G B*
WA=Green	*G*	*R B*	*R G B*	*R G B*	*R G B*	*R B*	*R G B*
V = Red	*G*	*R B*	*R G B*	*G B*	*R*	*B*	*R G B*
NT = Red	*G*	*R*	*G B*	*G B*	*R*	*B*	*R G B*
SA = Blue	*G*	*R*	*G*	*G*	*R*	*B*	*R G B*
Q = Green	*G*	*R*	*G*		*R*	*B*	*R G B*

No options remain for NSW, so there is no solution.

Activity 3

1) What is the heuristic value for this N-queens problem, using "number of conflicts".

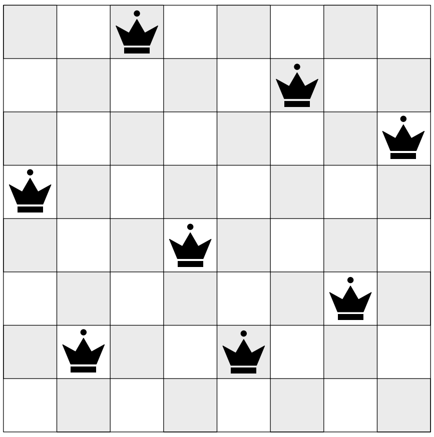


Answer: 4 (Q1-Q5, Q1-Q6, Q2-Q4, Q2-Q5)

2) Search for a solution using Hill-Climbing Algorithm, starting with Q1.

The heuristic for different values for Q1:
{Q1=1: h=3, Q1=2: h=4, Q1=3: h=5, Q1=4: h=2, Q1=5: h=3, Q1=6: h=3, Q1=7: h=4, Q1=8: h=4}

Q1=4 leads to the smallest h=4.



The heuristic for different values for Q2:
{Q2=1: h=2, Q2=2: h=1, Q2=3: h=2, Q2=4: h=1, Q2=5: h=2, Q2=6: h=2, Q2=7: h=2, Q2=8: h=0}

Q2=8 leads to the smallest h=0. The solution is the state below: