21CS2213RA
AI for Data Science

Session -12

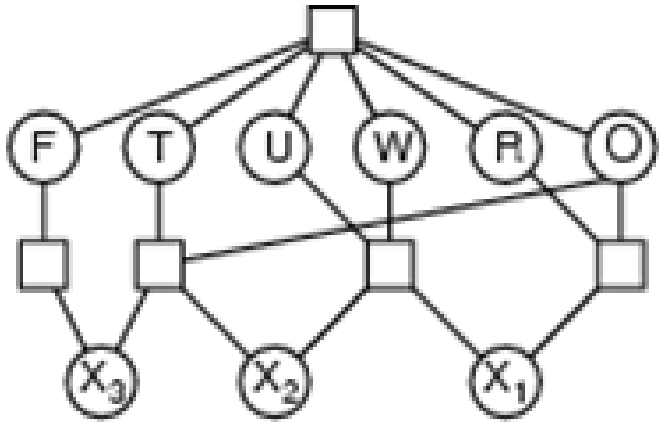
Contents:

1. *Backtracking search in CSPs*
2. *Forward tracking search in CSPs*

(DEEMED TO BE UNIVERSITY)

Example: Cryptarithmetic

$$\begin{array}{r} \,T\;W\;O \\ +\;T\;W\;O \\ \hline F\;O\;U\;R \end{array}$$



- Variables: *F T U W R O* X_1 X_2 X_3
- Domains: *{0,1,2,3,4,5,6,7,8,9}*
- Constraints: *Alldiff (F,T,U,W,R,O)*
-
  - $O + O = R + 10 \cdot X_1$
  -
  - $X_1 + W + W = U + 10 \cdot X_2$
  -
  - $X_2 + T + T = O + 10 \cdot X_3$
  - $X_3 = F$, $T \neq 0$, $F \neq 0$

Backtracking search

- Variable assignments are commutative, i.e.,

  [WA = red then NT = green] same as [NT = green then WA = red]

- => Only need to consider assignments to a single variable at each node

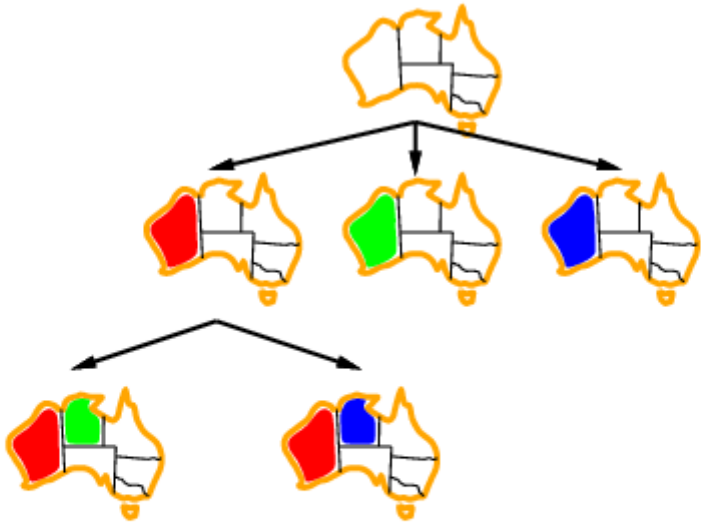
- Depth-first search for CSPs with single-variable assignments is called backtracking search

- Can solve *n*-queens for $n \approx 25$

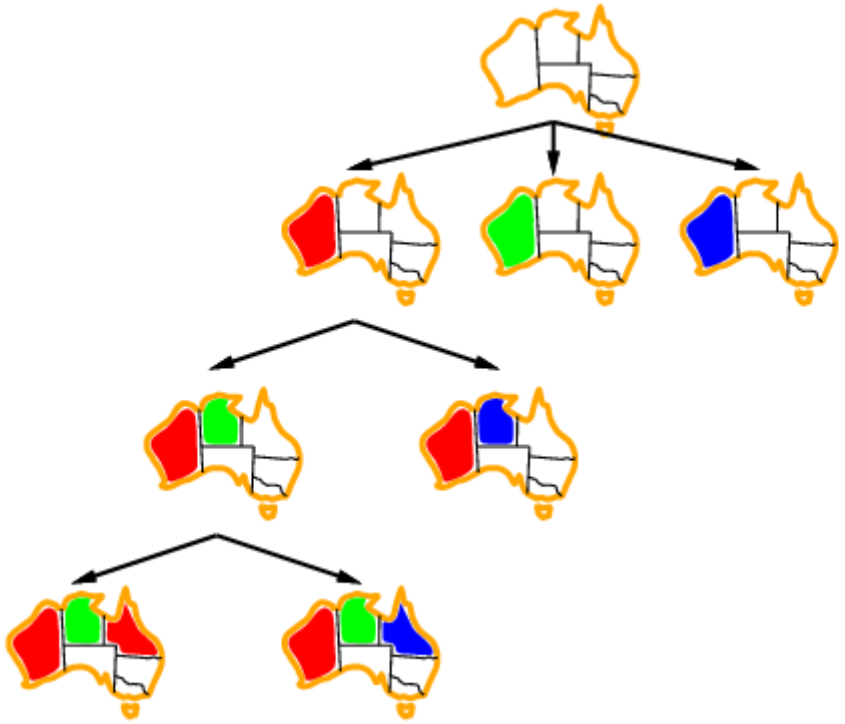
Backtracking example

Backtracking example

Backtracking example



Backtracking example- Graph Coloring

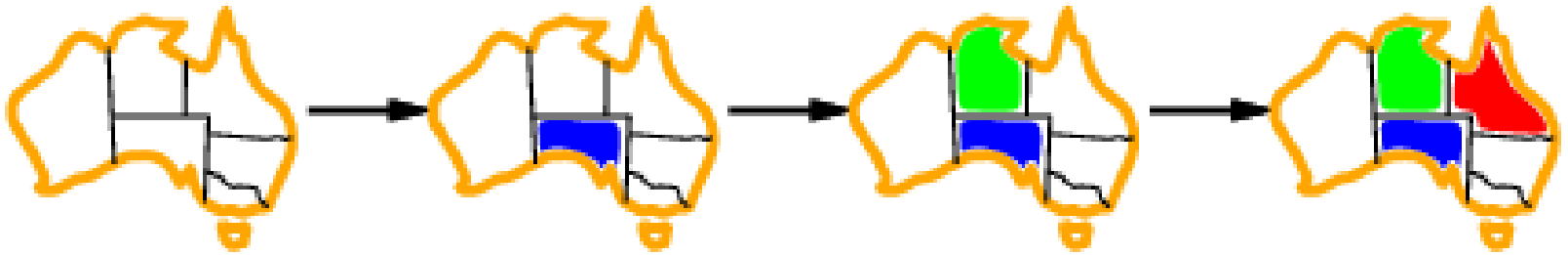


Improving backtracking efficiency

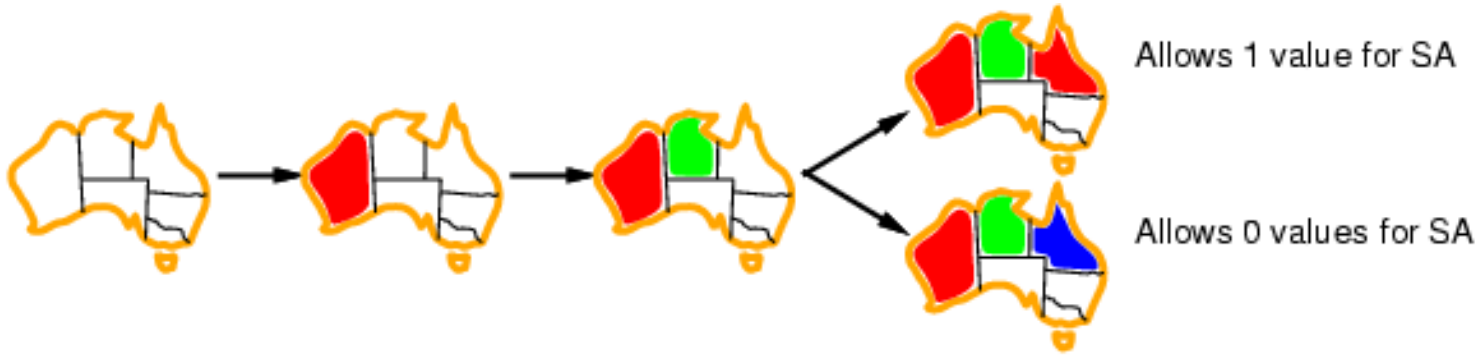
- General-purpose methods can give huge gains in speed:
  - Which variable should be assigned next?
  - In what order should its values be tried?
  - Can we detect inevitable failure early?

Most constraining variable

- A good idea is to use it as a tie-breaker among most constrained variables
- Most constraining variable:
  - choose the variable with the most constraints on remaining variables
  -



Least constraining value

- Given a variable to assign, choose the least constraining value:
  - the one that rules out the fewest values in the remaining variables
  -
- 

  feasible

En

Applications

- Time Tabling (class rooms, times)
- Configuration (hardware, cars…)
- Airplane Applications
  - (British airways uses Constraint Satisfaction to schedule aircraft)
- Image Processing
  - (Microsoft auto collage uses it to blend photos together)
- Spreadsheets
- Scheduling
- Floor Planning
- Sudoku etc.

Thank you