

Constraint Satisfaction

N-queens Solver
Brute-force Search
Forward Checking

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What is Constraint Satisfaction?

- It is a decisions problem
 - With limited choices in each decision
 - Constraints on combination of choices
- It's about solving problems efficiently
- Combinatorial explosion limits our ability to solve large problems
- Heuristics can sometimes help us to find the first solution quickly
 - Useful for many practical applications

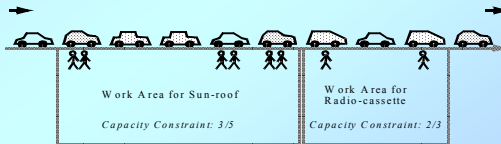
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A Car-sequencing Problem

Production Requirements:

Options (1=required, 0=not):

Sun-roof	0	1	1	0	
Radio-cassette	1	0	1	1	
Air-conditioning	1	1	0	1	
Anti-rust paint	0	1	1	1	
Power-brake	1	0	1	0	
number of cars required:	30	30	20	40	Total: 120



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The 8-Queens Constraint Satisfaction Problem

Sample Solution

	A	B	C	D	E	F	G	H
1	♚							
2				♚				
3								♚
4					♚			
5		♚						
6						♚		
7	♚							
8				♚				

- Task: to put 8 queens on in the board such that no queen attacks others
- No two queens appear in the same row, column and diagonal

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Backtracking Search In The 8-Queens Problem

Complete search, till solution found, or "no solution" is concluded

- Place one queen per row
- Place one queen at a time
- Examine each column

Backtrack at dead-ends

	A	B	C	D	E	F	G	H
1	♚							
2	♚	♚	♚					
3	♚	♚	♚	♚	♚			
4	♚	♚						
5	♚	♚	♚	♚	♚	♚	♚	♚
6	♚	♚	♚	♚	♚	♚	♚	♚
7								
8								

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Forward Checking Search

- Problem reduction – a major technique
- Combined with search methods
- Reduce domain of future variables
- Detect dead-ends – To backtrack early

Dead-end detected after Queen 4 – no legal space for row 6, backtrack...

	A	B	C	D	E	F	G	H
1	♚							
2	✗	✗	♚					
3	✗	✗	✗	✗	♚			
4	✗	♚	✗	✗	✗	✗		
5	✗	✗	✗		✗	✗	✗	
6	✗	✗	✗	✗	✗	✗	✗	✗
7	✗	✗	✗		✗		✗	✗
8	✗	✗	✗		✗			✗

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Forward Checking Principles

- Maintain a Domain for each variable
 - Domain = list of available values remaining
- Every time a variable x is assigned a value v
- For every unassigned variable y :
 - Remove from domain of y all values that is inconsistent with “ $x = v$ ”
 - Backtrack immediately if any domain is empty

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Constraint Techniques Overview

- **Problem Reduction**
 - To reduce domain size
 - To add or tighten constraints
 - Aims:
 - To reduce the problem to an easier one
 - To detect dead-ends
- **Search**
 - backtracking search
 - Lookahead search
 - Learning nogoods at dead-ends
 - Intelligent Backtracking at dead-ends
 - stochastic methods
- **(Solution Synthesis)**

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Simple Backtracking, Implementation

- Delete one column at a time
- Make it the column for the next row from the last
- Backtrack if necessary

1	2	3	4	5	6	7	8
	2	3	4	5	6	7	8
							1
	2		4	5	6	7	8
						3	1

Program Nqueens.plg

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