Norwegian University of Science and Technology

Assignment Title

Assignment 5

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Solving Constraint Satisfaction Problems

Course

TDT4136 Introduction to Artificial Intelligence

Semester

FALL 2018

Date Submitted

06/11/2018

Submitted by

Dusan Jakovic

Task : Sudoku boards as CSPs

		4		3			5	
6		9	4					
		5	1			4	8	9
				6		9	3	
3			8		7			2
	2	6		4				
4	5	3			9	6		
					4	7		5
	9			5		2		

Figure 1: Easy board (`easy.txt`)

				3			4	
1		9	7					
			8	5	1		7	
		2	6		7	8	3	
9		6		1		2		7
	3	1	5		2	9		
	1		3	6	9			
					5	7		3
	9			7				

Figure 2: Medium board (`medium.txt`)

1		2		4				7
				8				
		9	5			3		4
			6		7	9		
5	4						2	6
		6	4		5			
7		8			3	4		
				1				
2				6		5		9

Figure 3: Hard board (`hard.txt`)

		1			7			
6			4			3		
				3			6	4
3	8			7	6			
							3	6
2	7			1	5			
				2			5	1
7			1			2		
		8			9			

Figure 4: Very hard board (`veryhard.txt`)

1. Well-commented source code for a CSP solver based on backtracking search and AC-3, that is able to solve Sudoku boards.

Source code: “sudokuCSP.py”

2. Your program’s solution for each of the four boards shown above.

board: #1
7 8 4 | 9 3 2 | 1 5 6
6 1 9 | 4 8 5 | 3 2 7
2 3 5 | 1 7 6 | 4 8 9
------+-------+------
5 7 8 | 2 6 1 | 9 3 4
3 4 1 | 8 9 7 | 5 6 2
9 2 6 | 5 4 3 | 8 7 1
------+-------+------
4 5 3 | 7 2 9 | 6 1 8
8 6 2 | 3 1 4 | 7 9 5
1 9 7 | 6 5 8 | 2 4 3
Number of backtracking calls: 1
Number of backtracking failures: 0

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board: #2
8 7 5 | 9 3 6 | 1 4 2
1 6 9 | 7 2 4 | 3 8 5
2 4 3 | 8 5 1 | 6 7 9
------+-------+------
4 5 2 | 6 9 7 | 8 3 1
9 8 6 | 4 1 3 | 2 5 7
7 3 1 | 5 8 2 | 9 6 4
------+-------+------
5 1 7 | 3 6 9 | 4 2 8
6 2 8 | 1 4 5 | 7 9 3
3 9 4 | 2 7 8 | 5 1 6
Number of backtracking calls: 3
Number of backtracking failures: 0

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board: #3
1 5 2 | 3 4 6 | 8 9 7
4 3 7 | 1 8 9 | 6 5 2
6 8 9 | 5 7 2 | 3 1 4
------+-------+------
8 2 1 | 6 3 7 | 9 4 5
5 4 3 | 8 9 1 | 7 2 6
9 7 6 | 4 2 5 | 1 8 3
------+-------+------
7 9 8 | 2 5 3 | 4 6 1
3 6 5 | 9 1 4 | 2 7 8
2 1 4 | 7 6 8 | 5 3 9
Number of backtracking calls: 4
Number of backtracking failures: 0

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board: #4
4 3 1 | 8 6 7 | 9 2 5
6 5 2 | 4 9 1 | 3 8 7
8 9 7 | 5 3 2 | 1 6 4
------+-------+------
3 8 4 | 9 7 6 | 5 1 2
5 1 9 | 2 8 4 | 7 3 6
2 7 6 | 3 1 5 | 8 4 9
------+-------+------
9 4 3 | 7 2 8 | 6 5 1
7 6 5 | 1 4 3 | 2 9 8
1 2 8 | 6 5 9 | 4 7 3
Number of backtracking calls: 43
Number of backtracking failures: 35

3. The number of times your BACKTRACK function was called, and the number of times your BACKTRACK function returned failure, for each of the four boards shown above. Comment briefly on these numbers for each of the four boards.

Board #1
Number of backtracking calls: 1
Number of backtracking failures: 0

Board #2
Number of backtracking calls: 3
Number of backtracking failures: 0

Board #3
Number of backtracking calls: 4
Number of backtracking failures: 0

Board #4
Number of backtracking calls: 43
Number of backtracking failures: 35

Comment:
We can see that the number of backtracking calls and failures increase as the difficulty of the boards increase.