

# Assignment 4 - TDT4136

Olaf Rosendahl

October 03, 2022

## Easy board

```
C:\Users\olafr\Dropbox\IT\Master\TDT4136 - Artificial Intelligence\assignment4>python Assignment.py
Chose a task (easy|medium|hard|veryhard): easy
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
Backtrack called: 1
Backtrack failures: 0

C:\Users\olafr\Dropbox\IT\Master\TDT4136 - Artificial Intelligence\assignment4>python Assignment.py
Chose a task (easy|medium|hard|veryhard): easy
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
Backtrack called: 1
Backtrack failures: 0

C:\Users\olafr\Dropbox\IT\Master\TDT4136 - Artificial Intelligence\assignment4>python Assignment.py
Chose a task (easy|medium|hard|veryhard): easy
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
Backtrack called: 1
Backtrack failures: 0
```

After running the CSP-solver three times, the amount of backtrack calls was the same every time with no failures. This was as expected because of the low solving complexity

## Medium board

```
C:\Users\olafr\Dropbox\IT\Master\TDT4136 - Artificial Intelligence\assignment4>python Assignment.py
Chose a task (easy|medium|hard|veryhard): medium
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
Backtrack called: 2
Backtrack failures: 0

C:\Users\olafr\Dropbox\IT\Master\TDT4136 - Artificial Intelligence\assignment4>python Assignment.py
Chose a task (easy|medium|hard|veryhard): medium
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
Backtrack called: 3
Backtrack failures: 0

C:\Users\olafr\Dropbox\IT\Master\TDT4136 - Artificial Intelligence\assignment4>python Assignment.py
Chose a task (easy|medium|hard|veryhard): medium
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
Backtrack called: 2
Backtrack failures: 0
```

After running the CSP-solver three times, the amount of backtrack calls varied between 2 and 3 with no failures. The difference between easy and medium can be explained with the difference in complexity to find the solution.

## Hard board

```
C:\Users\olafr\Dropbox\IT\Master\TDT4136 - Artificial Intelligence\assignment4>python Assignment.py
Chose a task (easy|medium|hard|veryhard): hard
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
Backtrack called: 21
Backtrack failures: 16

C:\Users\olafr\Dropbox\IT\Master\TDT4136 - Artificial Intelligence\assignment4>python Assignment.py
Chose a task (easy|medium|hard|veryhard): hard
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
Backtrack called: 26
Backtrack failures: 18

C:\Users\olafr\Dropbox\IT\Master\TDT4136 - Artificial Intelligence\assignment4>python Assignment.py
Chose a task (easy|medium|hard|veryhard): hard
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
Backtrack called: 10
Backtrack failures: 5
```

After running the CSP-solver three times, the amount of backtrack calls varied from 10 to 26 and the failures-rate varying from 5/10 to 16/21. When the complexity increases and there is a need to explore more variables or test more possible solutions there will also be more failures. The difference in amount of backtrack calls can be explained with both the `select_unassigned_variable`-function which selects a random variable to explore, and the not implemented `ORDER-DOMAIN-VALUES`-function which in some cases could have selected a more promising value to test first.

## Very hard board

```
C:\Users\olafr\Dropbox\IT\Master\IDI4136 - Artificial Intelligence\assignment4>python Assignment.py
Chose a task (easy|medium|hard|veryhard): veryhard
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
Backtrack called: 17
Backtrack failures: 6

C:\Users\olafr\Dropbox\IT\Master\IDI4136 - Artificial Intelligence\assignment4>python Assignment.py
Chose a task (easy|medium|hard|veryhard): veryhard
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
Backtrack called: 87
Backtrack failures: 81

C:\Users\olafr\Dropbox\IT\Master\IDI4136 - Artificial Intelligence\assignment4>python Assignment.py
Chose a task (easy|medium|hard|veryhard): veryhard
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
Backtrack called: 77
Backtrack failures: 70
```

After running the CSP-solver three times, the amount of backtrack calls varied from 17 to 78 and the failures-rate varying from 6/17 to 81/87. Again, the increased complexity compared with hard explains why the backtrack-calls increased even more, while we in some cases are lucky and find a correct solution relatively quick when for example a good variable is explored early.