TDT4136 Introduction to Artificial Intelligence
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Assignment 4: Solving Constraint Satisfaction Problems

Solution for the easy board is as follows:

```
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
```

The BACKTRACK function was called a total of 1 times, and the BACKTRACK function returned failure a total of 0 times.

Solution for the hard board is as follows:

```
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
```

The BACKTRACK function was called a total of 12 times, and the BACKTRACK function returned failure a total of 4 times.

Solution for the medium board is as follows:

```
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
```

The BACKTRACK function was called a total of 3 times, and the BACKTRACK function returned failure a total of 0 times.

Solution for the very hard board is as follows:

```
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
```

The BACKTRACK function was called a total of 68 times, and the BACKTRACK function returned failure a total of 57 times.

Discussion surrounding the results above

The CSP algorithm performed well against all of the sudoku boards. For the easy board, the algorithm found a solution on the very first try. As the boards become harder to solve, i.e less initial numbers are given, the algorithm will find more and more dead ends in its traversal. This yields a larger number of backtracks and failures.

One way to visualise the algorithms path is as a tree. The difference between the sudoku boards and their failures and backtrack calls is the depth of the solution. The more difficult boards take a longer time because the number of potential paths increases with the number of blanc spots. As the height of the tree increases, the number of potential branches that might lead to a solution also increases. With fever given initial values, the algorithm is more likely to go deeper in each of these branches before it realises it is not a solution and backtracks.