ST0247 - Data Structures and Algorithms 2 Final project: Sudoku

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Abstract

Algorithmic problem solving is a key skill for a computer scientist. In fact, the algorithmic approach to solve problems, besides been the base of computational thinking, has strong ties with the foundations of mathematics and logic. Further more, its limitations have far-reaching epistemological and methodological consequences[2]. In this project, you will deal with an NP-Complete problem to test your algorithmic skills.

1 Introduction

Sudoku is *"is a logic-based, combinatorial number-placement puzzle"*[3]. In 2003, Yato and Seta shown sudoku to be an NP-Complete problem[1]. Number puzzles appeared in newspapers in late 19th century[3]. Sudoku, is one of the most successful number puzzles but, in its general form, a very difficult one. In this project you will design and implement algorithms that should solve the creation, solution and validation of a classic 9x9 Sudoku, or 3-sudoku.

In the generic version, given an $n \in \mathbb{Z}$, an n-Sudoku is an $n^2 \times n^2$ square that has to be filled using n^2 *symbols*[1]. Been a $n^2 \times n^2$ square, it has n^2 rows, n^2 columns and can be divided in n^2 squares of size $n \times n$. In order to solve

[1] In this context, a symbol is a natural number between 1 and n^2

a n-sudoku, you must fill each row, each column and each square using n^2 different symbols. In other words, in each row, each column and each square, you must use all n^2 different symbols.

2 Problem statement

The project is divided in three independent, but correlated parts:

1. An algorithm for validating an n-sudoku
2. An algorithm for solving an n-sudoku
3. An algorithm for creating a n-sudoku with only one solution

The project will be tested with a 3-sudoku initially, but, in order to verify that the algorithms are valid for any n-sudoku, the grading process may include any n-sudoku.

2.1 Deliverables

For each algorithm, you must provide:

- The source code with the appropriate documentation.
- The analysis of the complexity of the algorithm.
- Description of the heuristics used.

2.2 Input and Output format

All sudokus must be read and write in text format. Depending the value of n, the number of *symbols* available can be very big. So, each *symbol* will be represented with $\log_{10}(n^2 + 1)$ digits (why?), using trailing zeros (0) when needed. An empty cell is represented using $\log_{10}(n^2 + 1)$ dash (-) symbols.

References

[1] Kendall, G., Parkes, A., and Spoerer, K. A survey of np-complete puzzles. *ICGA Journal 31*, 1 (2008), 13–34.

[2] Murawski, R. *Recursive Functions and Metamathematics: Problems of Completeness and Decidability, Gödel's Theorems*, vol. 286. Springer Science & Business Media, 2013.

[3] Wikipedia. Sudoku. https://en.wikipedia.org/wiki/Sudoku, Mar 2022.