SOLVING SUDOKU WITH MATLAB

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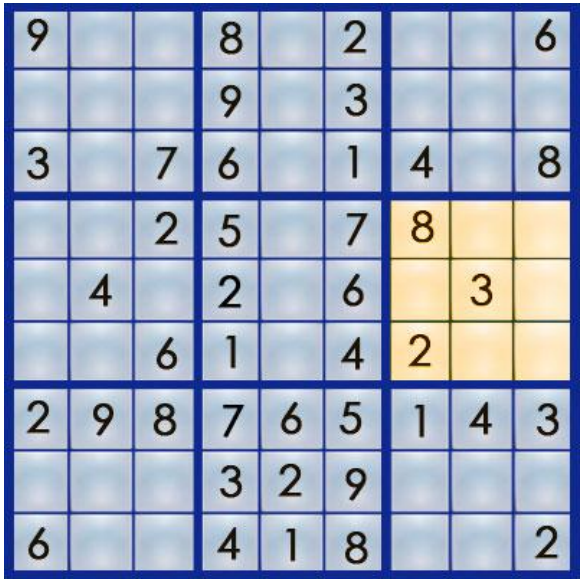
Background

- From the Japanese: ”SU”, means ”number” and ”DOKU”, means ”single”. The board is composed by a **9x9 grid**, sub-divided into 9 squares containing a **3x3** grid.

- The purpose of the game is to insert numbers (1-9) in the board **without repeating** a number in each row, column or sub-square.

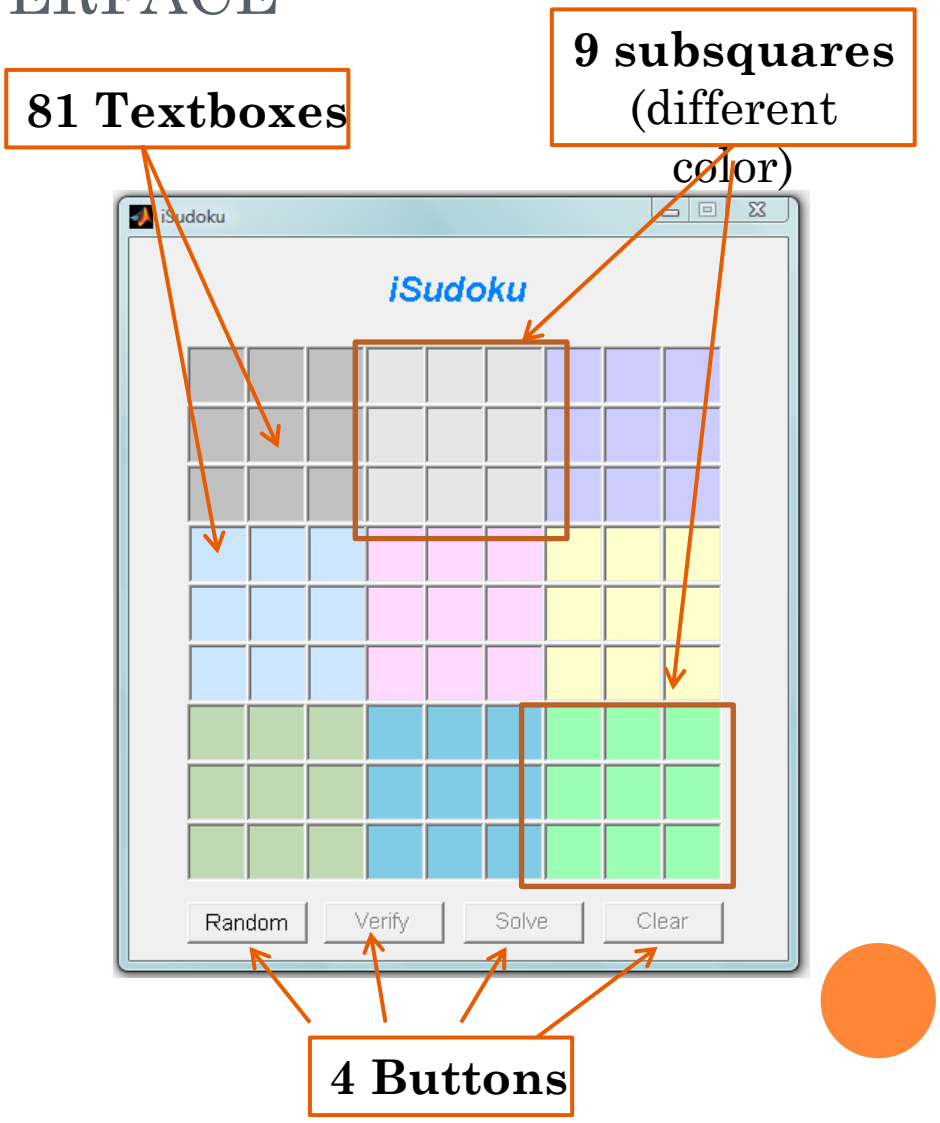
- Sudoku is classified as an **NP-complete** problem, which means there is no known efficient algorithm to solve the puzzles.

- It has led **researchers** to some advances in algorithm design and implementation.



Graphical User Interface

- Implemented using Matlab's GUI Design Environment (**GUIDE**).
- Used **drag & drop** components to create the layout.
- Each component has:
  - A list of properties that can be edited (color, size, position, etc)
  - **Callback functions** to model its behavior.



Random Button

Objective

- Creates and displays a **random game** on the board.
- Selects a game from a database of several games.

Characteristics

- The only button **enabled** when the application is **started**.
- Once a game has been displayed, the remaining buttons get enabled.

***Hint cells cannot be modified** by the user.*

Solve Button

Objective:

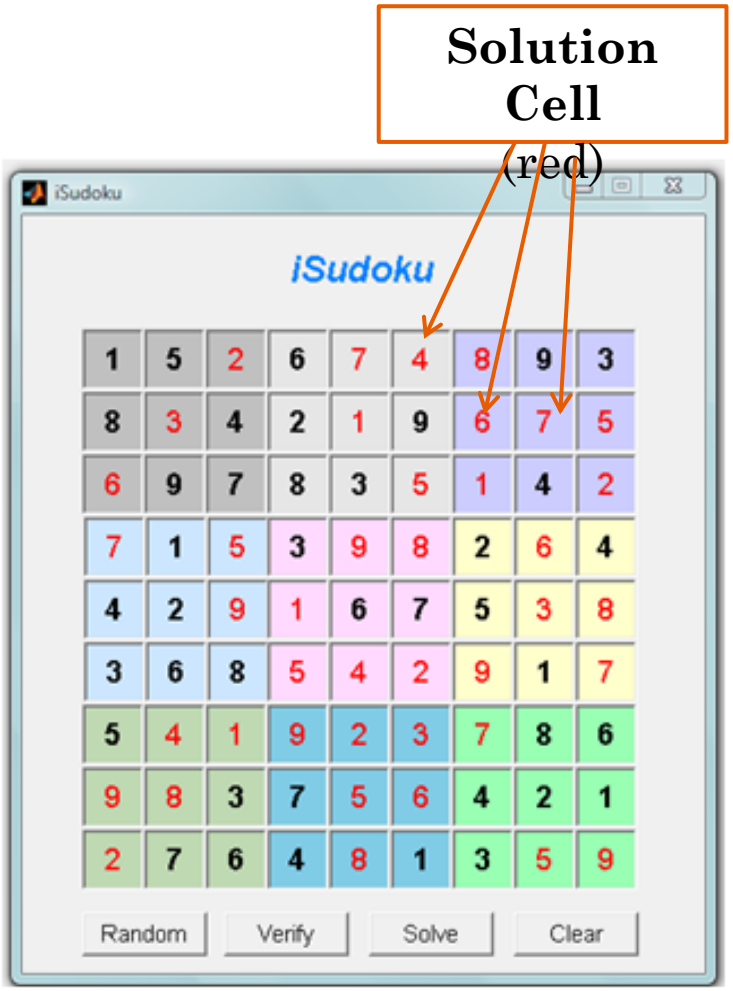
- Solves the current game and displays the solution on the board.

Three main steps:

1. **Read** the current game from the board and generate a **numerical matrix** of 81 elements. Empty cells are substituted by zeros. A **validation** of the **input data** is performed.*

2. **Execute** the Sudoku solver function, *iSudokuALG,* using the numerical matrix as an input.

3. **Retrieve** the solution provided by the Sudoku solver function and populate the board.

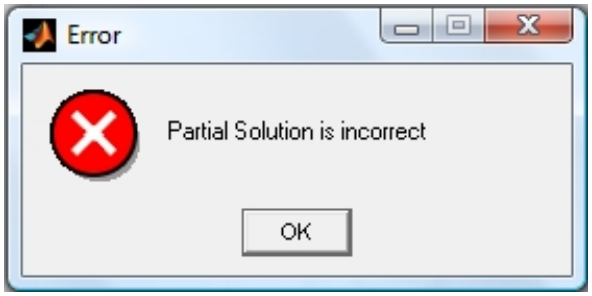


**Only integer values from 1-9 can be inserted in the cells.*

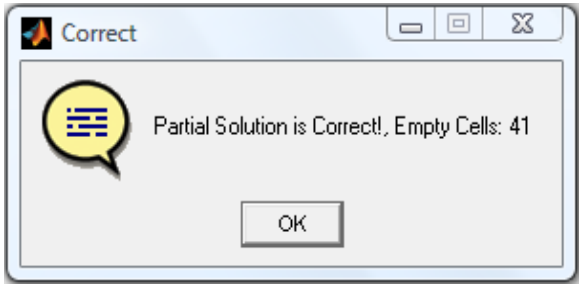
Verify Button

Objective

- Examines the **correctness** of either a partial game or a complete game.



In case of an **incorrect** game, the program will display a pop-up window with an **error message.**



In case of a **correct** game a pop-up window will state this. In a partial game, the **number of remaining empty cells** will also be stated.

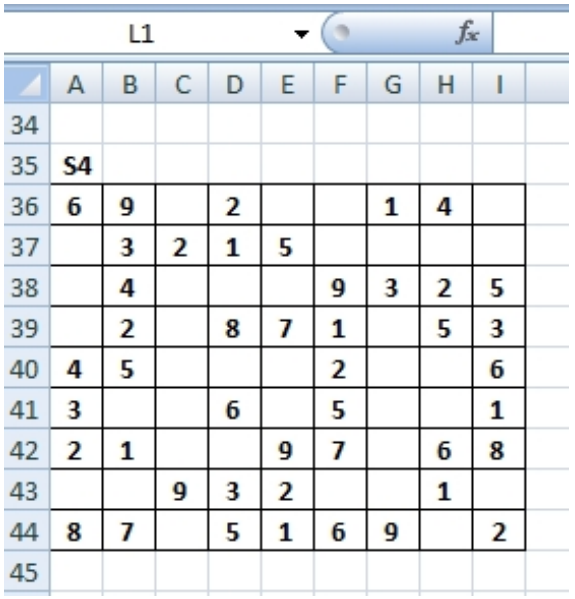
Clear Button

Objective

- It **clears** the board and **disables** all the buttons except the random button, returning the program to its initial state.

Game Database

- Created in to have different games to be **Microsoft Excel** solved.
- Includes games of **different levels** of difficulty.
- The games are **read** when the GUI is **initialized**.
- The reading process is performed by means of MATLAB's built-in function **xlsread**.




```
% Read predefined games from the input spreadsheet
[num, cellMat]= xlsread('sudoku.xls', 'Games');
```

VERIFICATION FUNCTION

- correctness verification of the puzzle:

```
function [val]=verific(A)
```

- checks if the current element appears twice in the same **line**, **column**, or in the **3-by-3 grid.**
- **Input:** the cell matrix A which contains the current puzzle.
- **Output:** variable ***val*** which can have two values:
  - 0 if the puzzle is correct
  - 1 otherwise

ALGORITHM

- Based on **constraint propagation**
- The key internal function is:

```
% Read predefined games and outputs the solved puzzle
function [A]= iSudokuALG(A)
```

- When a value is assigned to a cell that same value cannot be used as a possible assignment in all related cells;
- If a cell has only one single value for possible assignment, that value is immediately assigned.

ALGORITHM

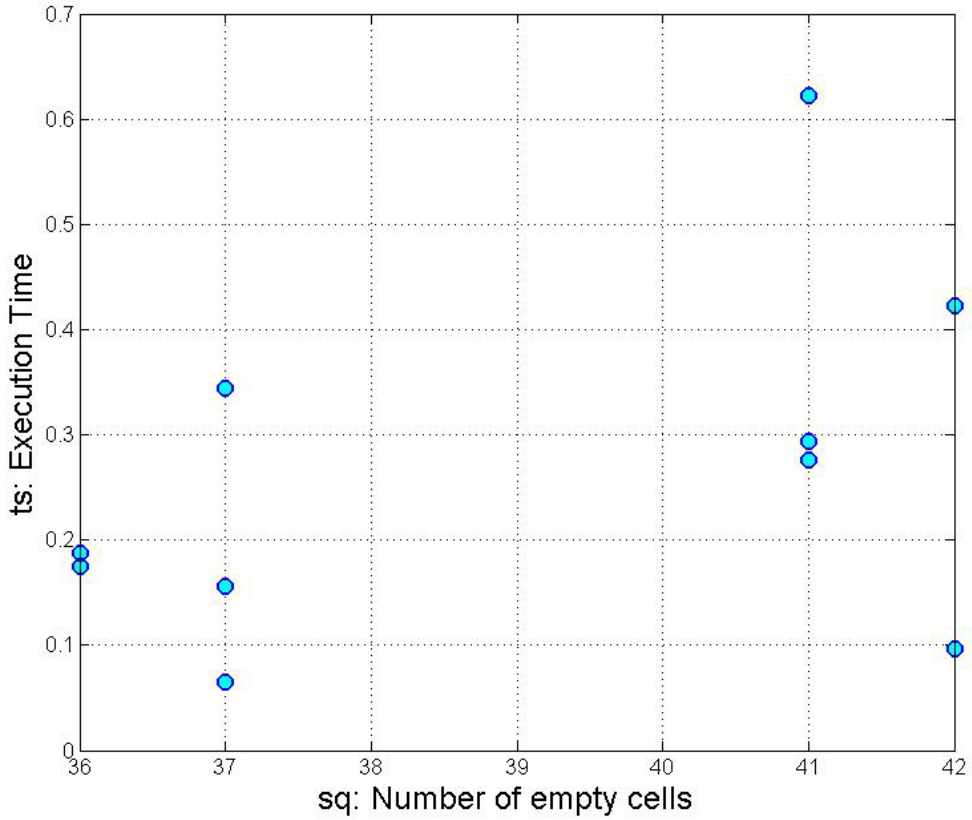
- **Steps:**
  1. Find all the possible values for all the empty cells;
  2. If there is a single possible value, we assign that value to the cell;
  3. Propagate constraints to other cells until you reach the end of the puzzle;
  4. If all the cells have more than one possible value we fill in a tentative value for that cell.
  5. *START AGAIN* ***(When do we stop?)***

ALGORITHM

- *When do we stop?*
  - When there are **no more empty cells** in the puzzle;
  - When for a cell we cannot place any possible value.

ALGORIHM TESTING

- Experimental results for different Sudoku puzzles:



Conclusions

- Implementing a Sudoku solver in MATLAB allowed us to use many tools and built-in functions presented during the course.

- The combination of a simple, yet effective algorithm with a graphical user interface allowed us to generate games, solve them and verify the given solutions in a simple and quick way.

- Good communication and coordination among the team members made possible the completion of the project before the established deadline.