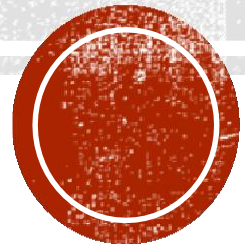
SUDOKU GAME SOLUTION USING GRAPH COLORING



By
Md Altaf Hussain (181IT226)
Sarthak Laghate (181IT141)
Sagar Choudhury (181IT140)
Sumit Gupta (181IT247)

INTRODUCTION

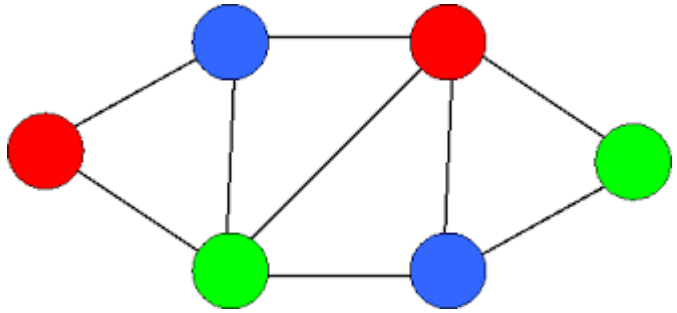
- The Sudoku puzzle has become a very popular puzzle.
- The puzzle consists of a 9×9 grid in which some of the entries of the grid have a number from 1 to 9.
- Filling the table with the numbers must follow these rules:
  - Numbers in rows are not repeated
  - Numbers in columns are not repeated
  - Numbers in 3 × 3 blocks are not repeated
  - Order of the numbers when filling is not important

A SAMPLE SUDOKU PUZZLE

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

WHAT IS GRAPH COLORING?

- Graph Coloring is the assignment of colors to vertices of a graph such that no two adjacent vertices have the same color.



CONVERTING SUDOKU TO COLORING PROBLEM

- The graph will have 81 vertices with each vertex corresponding to a cell in the grid.
- Two distinct vertices will be adjacent if and only if the corresponding cells in the grid are either in the same row, or same column, or the same sub-grid.
- Each completed Sudoku square then corresponds to a k-coloring of the graph.

CONTINUED..

- Consider an $n2 \times n2$ grid, To each cell in the grid, we associate a vertex labeled (i, j) with $1 \leq i,j \leq n2$.
- We will say that (i,j) and (i',j') are *adjacent* if $i = i'$ or $j = j'$

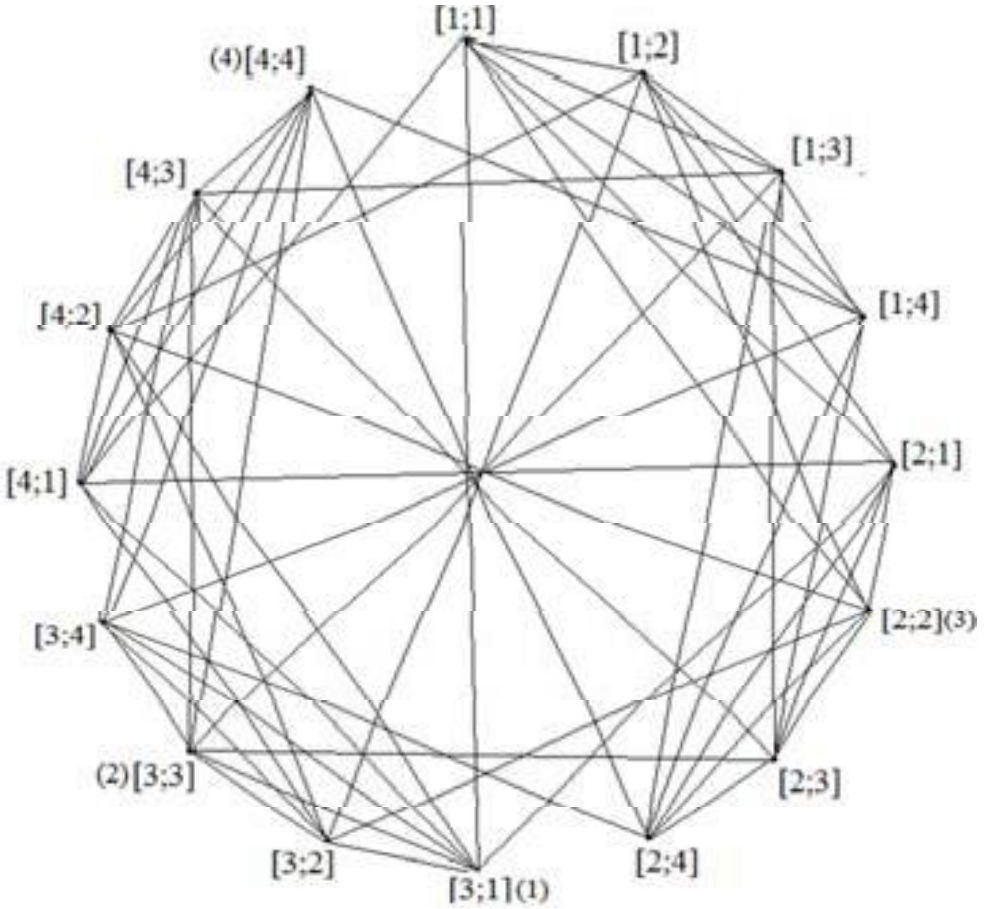
  or $\lfloor i/n \rfloor = \lfloor i'/n \rfloor$ *and* $\lfloor j/n \rfloor = \lfloor j'/n \rfloor$.

- Graph is called *regular* if the degree of every vertex is the same.
- Each vertex has degree 20, thus the number of edges is:
- | H | = 20 * 81 / 2 = 810

SAMPLE VERSION OF 4X4 SUDOKU

[1;1]	[1;2]	[1;3]	[1;4]
[2;1]	[2;2] 3	[2;3]	[2;4]
[3;1] 1	[3;2]	[3;3] 2	[3;4]
[4;1]	[4;2]	[4;3]	[4;4] 4

GRAPH CORRESPONDING TO THE 4*4 SUDOKU TASK



The above mentioned graph has 16 vertices and 56 edges.

GRAPH COLORING TECHNIQUE

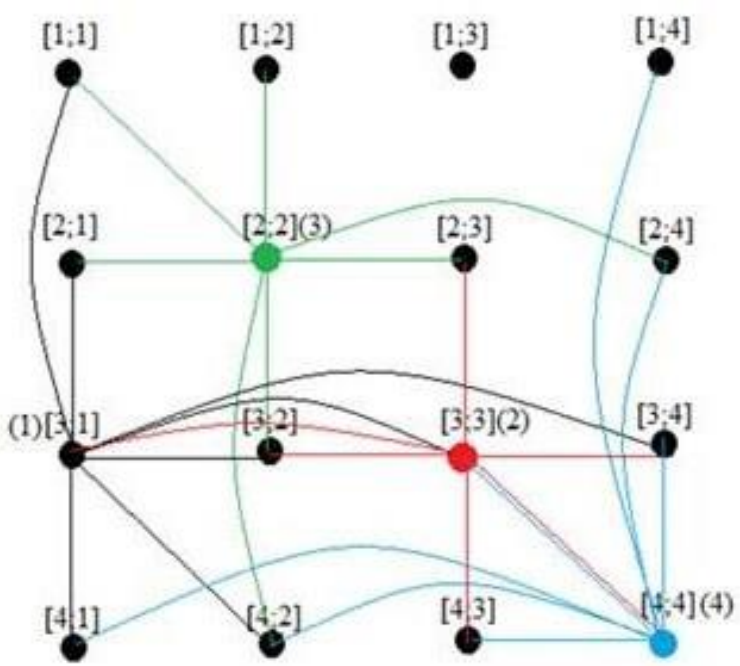
- The whole algorithm can be divided into the following steps:

1. The vertex that is already colored is selected and linked by edges of same color with all other vertices of sets in which the vertex is located. These vertices can no longer be colored with the same color. This is repeated for all the vertices for which hints aregiven.

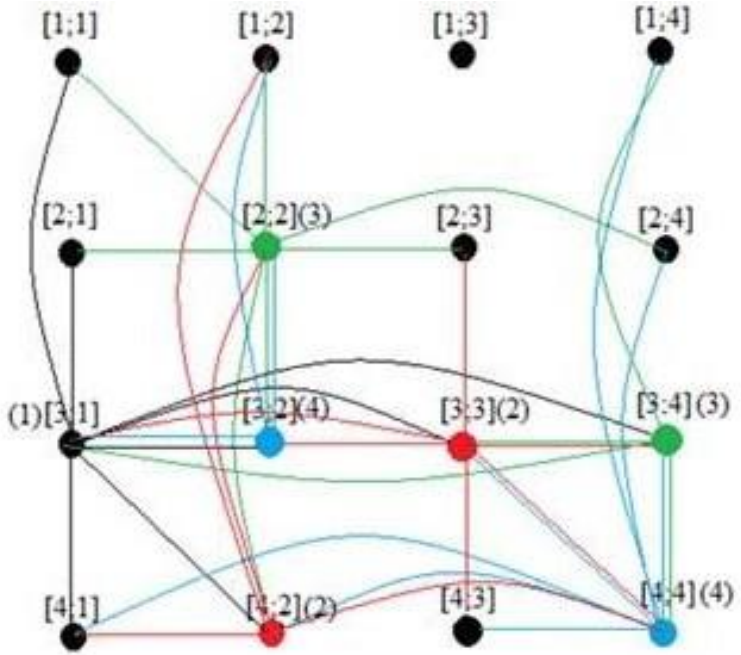
2. The vertices where the largest number of colored edges converge are found (it is most likely that there will be only one candidate).

- 3. If there are vertices among them that can be colored only by one color, then they are colored with it and the procedure continues from the first step (there is no need to draw those edges into the graph that lead to a vertex where there is already another edge of the same color). If there are no such vertices, the procedure continueswith the fourth step.

4. From the set of those selected vertices, the one that is adjacent to the largest number of uncolored vertices is chosen and colored to the color with the lowest value that is not used for its neighbors. If there are more such vertices one of them is selected randomly. In the next step the procedure continues from the first step.



Sudoku graph after step one



Sudoku graph after step two

MATRIX REPRESENTATION

List of vertices	Neighboring vertices						
[1;1]	[1;2]	[1;3]	[1;4]	[2;1]	[2;2] (3)	[3;1] (1)	[4;1]
[1;2]	[1;1]	[1;3]	[1;4]	[2;1]	[2;2] (3)	[3;2]	[4;2]
[1;3]	[1;1]	[1;2]	[1;4]	[2;3]	[2;4]	[3;3] (2)	[4;3]
[1;4]	[1;1]	[1;2]	[1;3]	[2;3]	[2;4]	[3;4]	[4;4] (4)
[2;1]	[1;1]	[1;2]	[2;2] (3)	[2;3]	[2;4]	[3;1] (1)	[4;1]
[2;2] (3)	[1;1]	[1;2]	[2;1]	[2;3]	[2;4]	[3;2]	[4;2]
[2;3]	[1;3]	[1;4]	[2;1]	[2;2] (3)	[2;4]	[3;3] (2)	[4;3]
[2;4]	[1;3]	[1;4]	[2;1]	[2;2] (3)	[2;3]	[3;4]	[4;4] (4)
[3;1] (1)	[1;1]	[2;1]	[3;2]	[3;3] (2)	[3;4]	[4;1]	[4;2]
[3;2]	[1;2]	[2;2] (3)	[3;1] (1)	[3;3] (2)	[3;4]	[4;1]	[4;2]
[3;3] (2)	[1;3]	[2;3]	[3;1] (1)	[3;2]	[3;4]	[4;3]	[4;4] (4)
[3;4]	[1;4]	[2;4]	[3;1] (1)	[3;2]	[3;3] (2)	[4;3]	[4;4] (4)
[4;1]	[1;1]	[2;1]	[3;1] (1)	[3;2]	[4;2]	[4;3]	[4;4] (4)
[4;2]	[1;2]	[2;2] (3)	[3;1] (1)	[3;2]	[4;1]	[4;3]	[4;4] (4)
[4;3]	[1;3]	[2;3]	[3;3] (2)	[3;4]	[4;1]	[4;2]	[4;4] (4)
[4;4] (4)	[1;4]	[2;4]	[3;4]	[4;1]	[4;2]	[4;3]	[3;3] (2)

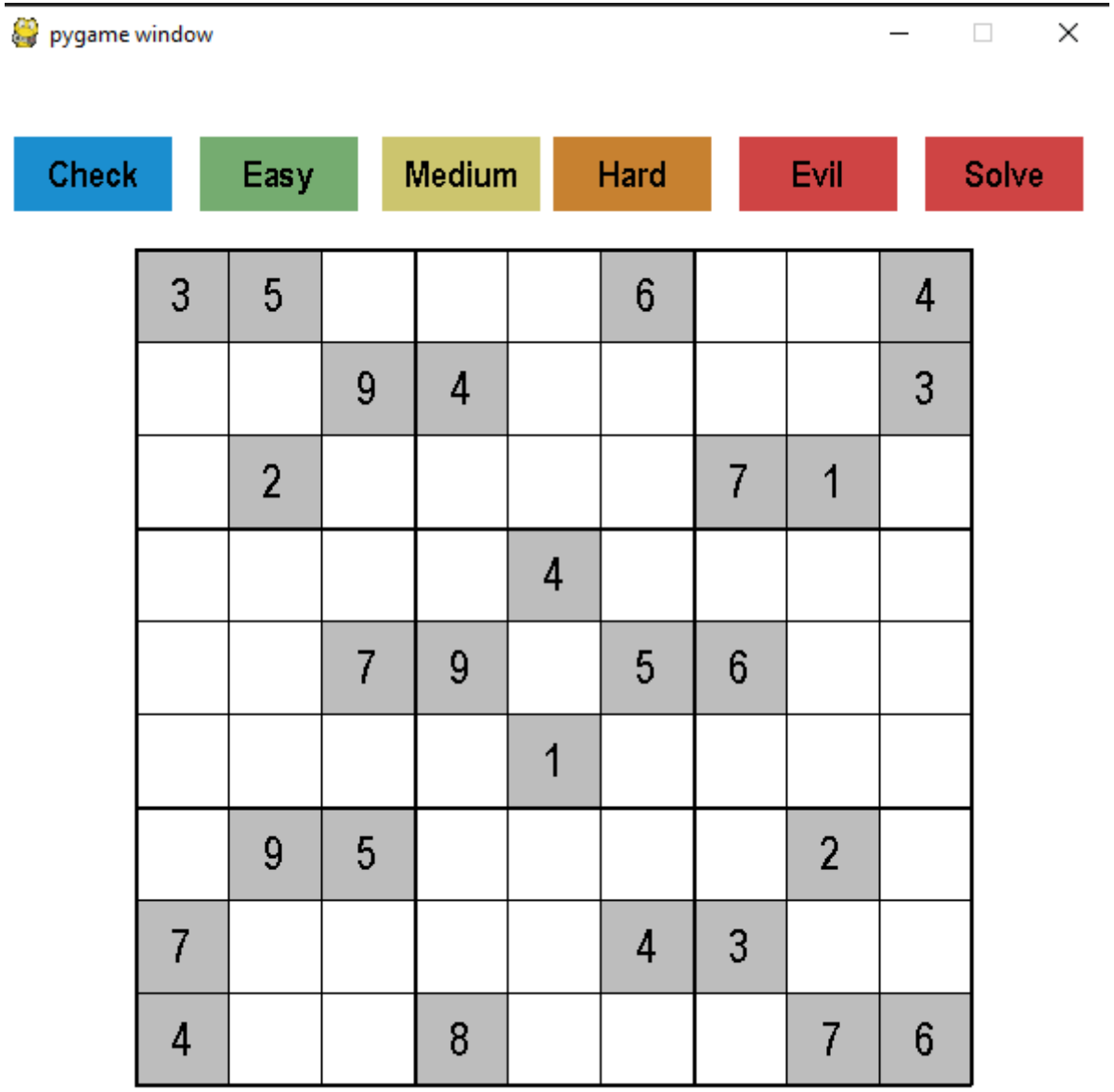
SUDOKU GENERATION

- Modules Used :

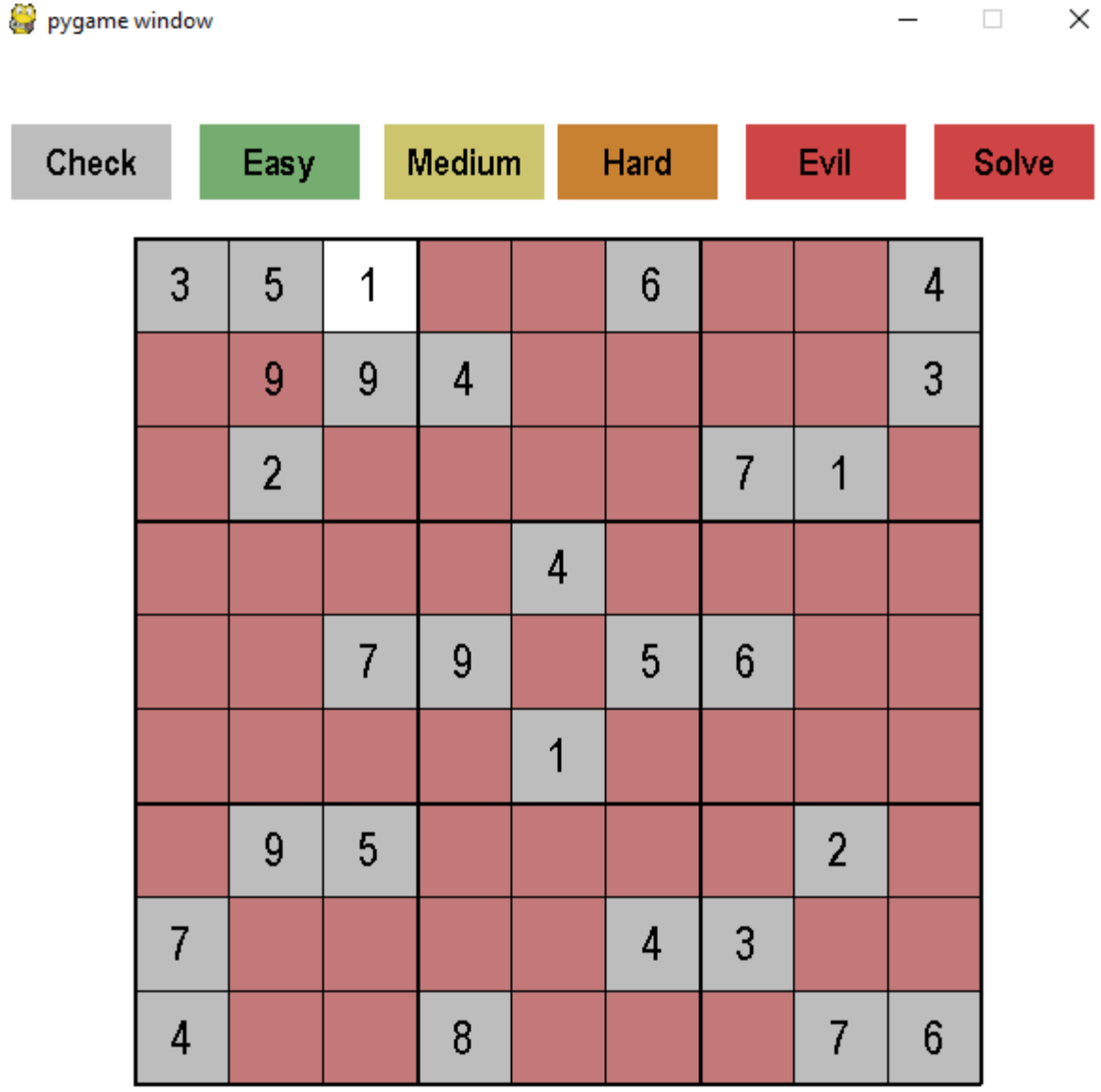
- pygame - for attractive interface and real-time playing
- requests - for extracting html page from https://nine.websudoku.com/
- bs4 – for extracting sudoku puzzle entries from the retrieved web page

CONTINUED...

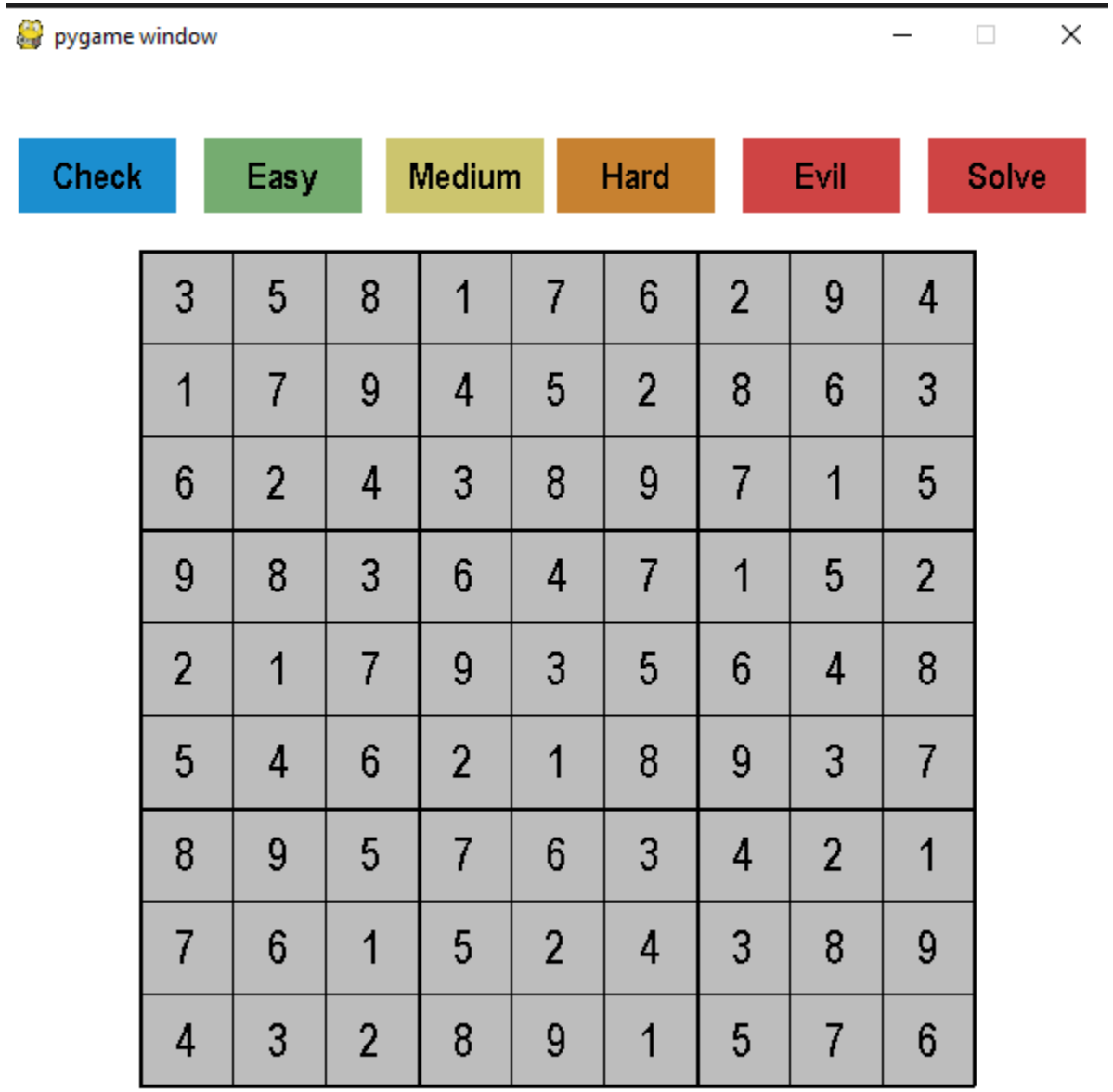
- Features
  - Input validation – only integer input between 1-9 are accepted
  - Check option for checking whether the entered integer satisfies the sudoku property or not
  - Four Difficulty Levels – Easy , Medium , Hard , Evil


pygame window
Check
Easy
Medium
Hard
Evil
Solve
3 5 6 4
9 4 3
2 7 1
4
7 9 5 6
1
9 5 2
7 4 3
4 8 7 6

SAMPLE GAME



INVALID ENTRIES ARE HIGHLIGHTED WITH RED COLOR



SOLUTION OF THE SUDOKU

THANK YOU