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A Review on Different Strategies of Solving Sudoku Puzzles

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Abstract: ***Magic square creates interest in numbers who are less interested in arithmetic. Sudoku is a logic-based number placement puzzle. Solving Sudoku is great time pass in all over the world. It captured the fans of all age in the whole world. There are a number of algorithms and techniques for solving sudoku puzzles. So we reviewed here different strategies to solve the Sudoku puzzle in less time. The current paper explains the only selected pattern of solving Sudoku puzzles- Naked singles, Hidden singles, Naked pairs, Hidden pairs, and the implementation of a Sudoku solver using MATLAB.***

Keywords: Naked singles, Hidden singles, Naked pairs, Hidden pairs, MATLAB

1. Origin of Sudoku

The journey of Sudoku puzzles traced from China through Persia to Europe and then across the Atlantic to Japan it then became a great craze in the U.S. and in Europe. In the world most of the number puzzles are published in magazines and news papers with championship. The first number puzzle published by Dell puzzle magazine New-York in 1979. The American name became translated by Japan in Japanese SUDOKU (SU means number and DOKU means single) i.e. number single or number only. The variety of strategies are explained by the puzzle solvers. But human required a logic, to solve it. In current paper we examine the selected patterns to get fast solutions of the Sudoku puzzles in limited time period.

2. Introduction

Definition of Magic square: A table of numbers with the same amount of rows and columns, in which the sum of each column, row or main diagonal is always equal to the same number. Sudoku puzzle have total number of 81 cells divided into 9×9 grid with 9 subdivision of 3× 3 subgrids or boxes which containing the numbers 1 to 9 once only in rows, columns and 9 subgrids (boxes) also. Sudoku has led other researcher to some advances in algorithm design and implementation. This work motivated b the intresting mathematical concepts behind it. This paper describes the development of a Sudoku solver using MATLAB. Which use only one pattern-singltons-together with a basic computer science technique.

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

Figure 1: Sample Sudoku puzzle of 9×9 grid 40 positions contains given numbers, the other 41 position should be solved

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

Figure 2: Solution of the given sample Sudoku puzzle

Strategies in Sudoku

Here our approach of solving Sudoku puzzle quickly using Naked singles, Hidden singles, Naked pairs, Hidden pairs and MATLAB.

1) Naked Singles

This is one of the simplest Sudoku solving techniques. It is also known as "Lone number". For finding lone number solver should examine the values of filled cells in the rows, columns and box to which the cell belongs. If the empty cell has just one single digit then this must be the required digit of the cell. In the given example below:

3	5	7			1	2		9
1 3	6	8	2	9				
4	123 9	1 2 9		6				

Figure 3: Identification of Naked single digits.

Solver should examine the left most corner empty cell the digits of the filled cell in the same row, column, and box. Now as in R1C1 cell is the empty cell it has the single digit where all other possible digits are already used.

2) Hidden Singles

The puzzles which are categorized easy, solved completely using these method. Hidden singles can be found by "cross hatching" (means one digit and one cell) method. Out of 9×9 grid consider the left top first 3×3 grid such that concentrate on one digit and one block. Draw lines through the all rows and columns that already have an instance of that digit set. which contains the left digits in this if only one cell is remained in respective grid then the respective digit is the Hidden single for that cell.

3) Naked pairs

In this technique the Sudoku is scanned for a pair of cells in a row, column or box containing only the same two digits. That means these two digits must go in these cells, therefore they can be removed from the digit lists of all other unsolved cells in that row, column, or box. Reducing digit lists may a hidden or naked single in another unsolved cell, respective technique is use for the next cell.

The highlighted cells in the example below show a naked pair containing the digits (2, 5) in the fourth column. This is a naked pair that can be removed from all other unsolved cells in the column. Also in the fourth row naked pair containing the digits (7, 9) This is a naked pair that can be removed from all other unsolved cells in the row. continuing in this way the digit lists of other unsolved cells in the same box reveals a naked single.

Refer the figure 4

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

Figure 4: Identification of Naked pairs

4) Hidden pairs

In this technique if two cells in a group contain a pair of candidates hidden amongst other digits that are not found in any other cells in that row or column then other digits in those two cells can be excluded safely. In example below the digits 1 and 9 are only located in two highlighted cells of a box, and therefore form a hidden pair . All digits except 1 and 9 can safely be excluded from these two cells as one cell must be the 1 while the other must be 9.

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

Figure 5: Identification of hidden pairs

The Sudoku Solving Algorithm in MATLAB

Our **MATLAB** program involves just four steps:
1. Fill in all singletons. 2. Exit if a cell has no candidates. 3. Fill a tentative value for an empty cell. 4. Call the program recursively.

The key internal function is candidates. Each empty cell starts with z = 1:9 and uses the numeric values in the associated rows, column and block to zero element in z. The non zeros that remain are the candidates.

For example,
Consider the (1,1) cell in fig: 1 we start with

Z = 1 2 3 4 5 6 7 8 9

The values in the first row change z to

Z = 1 0 3 4 0 6 7 0 0

Then the first column changes z to

Z = 1 0 3 0 0 0 7 0 0

The (1, 1) block does not make any further changes, so the candidates for this cell are

C{1,1} = [1 3 7]

Refer Fig: 1 C {1,1} highlighted empty cell with the possible options.

3. Conclusion

Finding a suitable algorithm to solve Sudoku puzzle proved to be difficult. Some algorithms are designed to solve the puzzles as quick as possible while some are designed to solve them on the basis of memory and computational power. Applying different strategies for solving the Sudoku puzzle by pen paper test means applying all the possibilities one by one while MATLAB allowed us to use many of the tools and built- in functions. Both the cases check all the possibilities of empty cells to be filled. GUI allowed us to generate games, solve them and verify the given solutions in a simple and quick way.

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