Sudoku Puzzle Solver using Backtracking Algorithm

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Python Assignment from CS-140 Lecture notes

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What is Sudoku ?

- Sudoku requires no calculation or arithmetic skills.
- It is essentially a game of placing numbers in squares.
- It uses very simple rules of logic and deduction.
- It can be played by children and adults and the rules are simple to learn.
- Objective of game is to fill all the blank squares in a game with the correct numbers.

	a	b	c	d	e	f	g	h	i
A			8			6		4	7
B	4					1		3	8
C					7			6	5
D	6		3			7	5		
E	7		1				6		3
F							7		4
G	8				9		3		
H	5	3		2			8		9
I				7			4		

Simple Rules of Sudoku Solving

There are three very simple constraints to follow:

- ✓ Every row of 9 numbers must include all digits 1 through 9 in any order
- ✓ Every column of 9 numbers must include all digits 1 through 9 in any order
- ✓ Every 3 by 3 subsection of the 9 by 9 square must include all digits 1 through 9

Online Material of Sudoku Puzzle

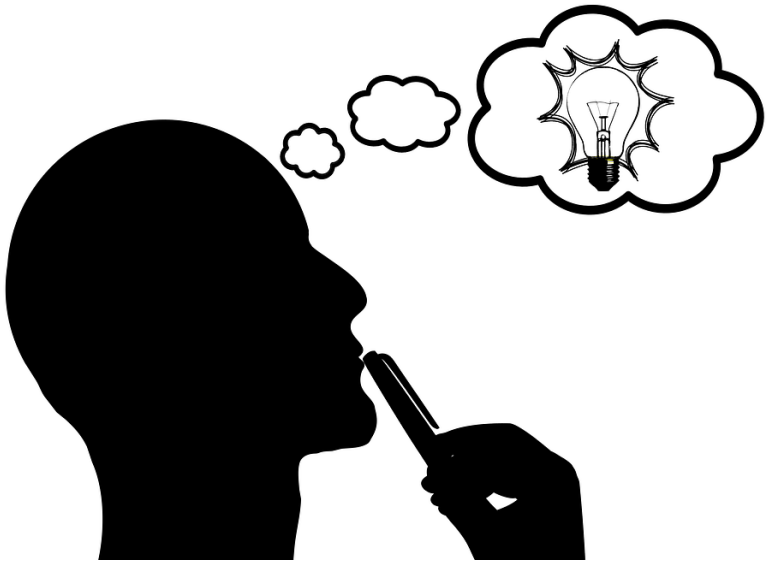
Here are a few Sudoku Websites that you can practice some more:

- https://www.thesudoku.com/
- www.sudokufun.com
- www.dailymail.co.uk/coffeebreak/puzzles/sudoku.html

Manual Solution of Sudoku Puzzle

First of all, we will solve sudoku puzzle manually using backtracking algorithm.

Let’s start with the worksheet provided to individual students



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

Python Solution of Sudoku Puzzle (Step # 1)

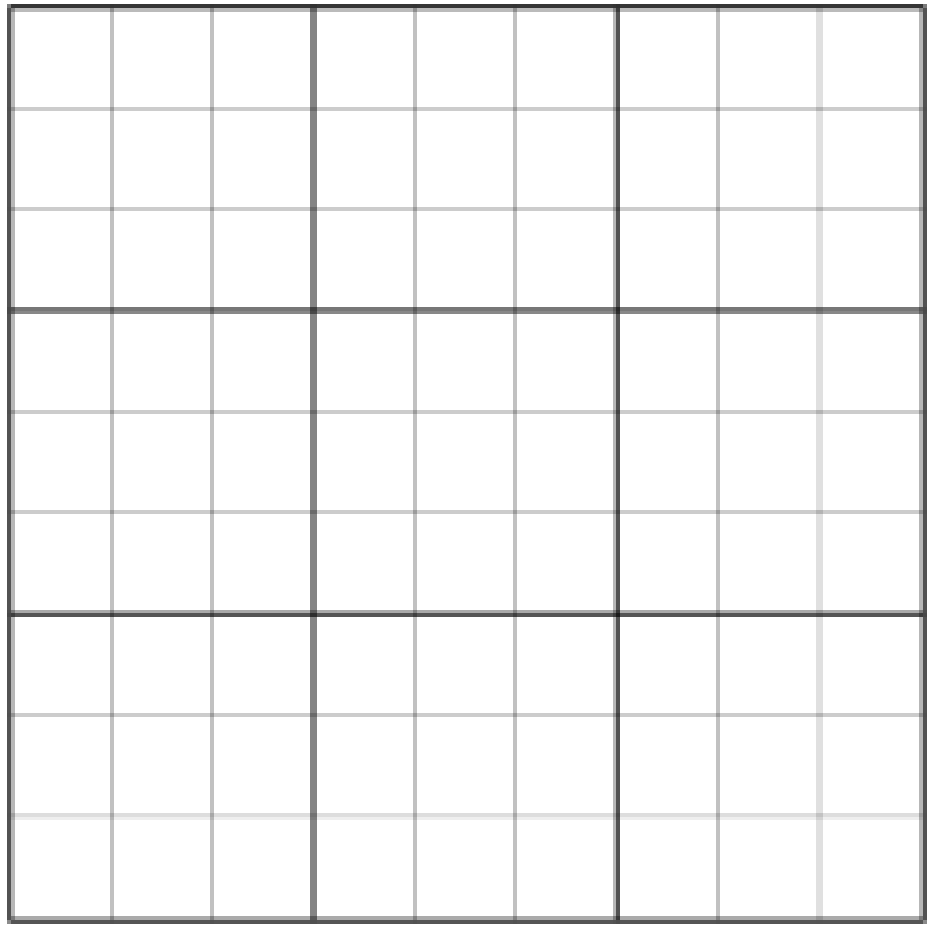
<u>The first step is to put the manual sudoku in Python lists, For empty spaces write zero</u>

```
# This is the Sudoku Puzzle It consists of 9 lists inside
# Always Remember the
#"ONE COMPLETE LIST [] IS ONE ELEMENT"
# So there are 9 elements in total, IF you consider only one list
# THERE are also 9 elements

board = [
    [7,8,0,4,0,0,1,2,0],
    [6,0,0,0,7,5,0,0,9],
    [0,0,0,6,0,1,0,7,8],
    [0,0,7,0,4,0,2,6,0],
    [0,0,1,0,5,0,9,3,0],
    [9,0,4,0,6,0,0,0,5],
    [0,7,0,3,0,0,0,1,2],
    [1,2,0,0,0,7,4,0,0],
    [0,4,9,2,0,6,0,0,7]
]
```

Python Solution of Sudoku Puzzle (Step # 2a)

<u>The second step is to make function for printing board “like this below” with lines seperating each BOX, ROW and COLUMNS</u>



```
7 8 0 | 4 0 0 | 1 2 0
6 0 0 | 0 7 5 | 0 0 9
0 0 0 | 6 0 1 | 0 7 8
- - - - - - - - - - -
0 0 7 | 0 4 0 | 2 6 0
0 0 1 | 0 5 0 | 9 3 0
9 0 4 | 0 6 0 | 0 0 5
- - - - - - - - - - -
0 7 0 | 3 0 0 | 0 1 2
1 2 0 | 0 0 7 | 4 0 0
0 4 9 | 2 0 6 | 0 0 7
```

Python Solution of Sudoku Puzzle (Step # 2b)

```
def print_board(bo):  #FUNCTION

# Each list (one square bracket) count the row number
# That's why used "len(bo)"

    for i in range(len(bo)):   ##Because see the ROW number

        if i%3==0 and i!=0:
            print("- - - - - - - - - - - -")

# But in J we used len(bo[0])
# means that we are using column , See column marks inside the list 1st Element

        for j in range(len(bo[0])):
            if j%3==0 and j!=0:
                print("| ", end="")

# Change line after 8 elements

            if j==8:
                print(bo[i][j])

#Print space after each element, if not on last entry
#Don't spare the line

            else:
                print(str(bo[i][j])+" ",end="")
```

Python Solution of Sudoku Puzzle (Step # 3)

<u>The third step is to make function for finding positions of empty values in ROW and COLUMNS</u>

```
def find_empty(bo):
    for i in range(len(bo)):  # Same we write for ROW number
        for j in range(len(bo[0])):   # Same we write for column number
            if bo[i][j]==0:
                return(i,j)
    return None
```

```
7 8 0 | 4 0 0 | 1 2 0
6 0 0 | 0 7 5 | 0 0 9
0 0 0 | 6 0 1 | 0 7 8
- - - - - - - - - - -
0 0 7 | 0 4 0 | 2 6 0
0 0 1 | 0 5 0 | 9 3 0
9 0 4 | 0 6 0 | 0 0 5
- - - - - - - - - - -
0 7 0 | 3 0 0 | 0 1 2
1 2 0 | 0 0 7 | 4 0 0
0 4 9 | 2 0 6 | 0 0 7
```

(3,0)
Tuple

(5,6)
Tuple

(7,2)
Tuple

These all will be later passed to a function
Having a parameter names **"pos"**

FIND_EMPTY FUNCTION

***All Locations of Empty Boxes**

(0 , 2) (0 , 4) (0 , 5) (0 , 8)

(1 , 1) (1 , 2) (1 , 3) (1 , 6) (1 , 7)

(2 , 0) (2 , 1) (2 , 2) (2 , 4) (2 , 6)

(3 , 0) (3 , 1) (3 , 3) (3 , 5) (3 , 8)

(4 , 0) (4 , 1) (4 , 3) (4 , 5) (4 , 8)

(5 , 1) (5 , 3) (5 , 5) (5 , 6) (5 , 7)

(6 , 0) (6 , 2) (6 , 4) (6 , 5) (6 , 6)

(7 , 2) (7 , 3) (7 , 4) (7 , 7) (7 , 8)

(8 , 0) (8 , 4) (8 , 6) (8 , 7)

Python Solution of Sudoku Puzzle (Step # 4a)

The fourth (a) step is to make function "valid" with 3 arguments for checking valid entries

Before starting the work, first learn what are these "THREE" arguments

```
def valid(bo,num,pos):
```

This is nothing but only the "Print Board Function" passed

This is simple numbers list "Passed from 1 to 9" in next step

This is tuple returned from "find_empty" function

Python Solution of Sudoku Puzzle (Step # 4b)

<u>The fourth (b) step is to checking entries by row and column (One by One)</u>
<u>Also, we are making sure that it is not the same checked before !</u>

```
def valid(bo,num,pos):

# CHECK ROW AND COLUMN IN 2 FOR LOOPS

    for i in range(len(bo)):
        if bo[pos[0]][i]==num:
            return False

    for i in range(len(bo[0])):
        if bo[i][pos[1]]==num:
            return False

    # CHECK BOX
    box_x = pos[0]//3
    box_y = pos[1]//3

    for i in range(box_x*3, box_x*3 + 3):
        for j in range(box_y*3, box_y*3 + 3):
            if bo[i][j]==num:
                return False

    return True
```

Python Solution of Sudoku Puzzle (Step # 4c)

<u>The fourth (c) step is to move technically find the "box number and box term" Using the "FLOOR DIVISION (//) and MULTIPLICATION TECHNIQUE"</u>

```python
def valid(bo,num,pos):

# CHECK ROW AND COLUMN IN 2 FOR LOOPS

    for i in range(len(bo)):
        if bo[pos[0]][i]==num:
            return False

    for i in range(len(bo[0])):
        if bo[i][pos[1]]==num:
            return False

    # CHECK BOX
    box_x = pos[0]//3
    box_y = pos[1]//3

    for i in range(box_x*3, box_x*3 + 3):
        for j in range(box_y*3, box_y*3 + 3):
            if bo[i][j]==num:
                return False

    return True
```

Box No (0,0)

Box No(0,2)

7	8	0	4	0	0	1	2	0
6	0	0	0	7	5	0	0	9
0	0	0	6	0	1	0	7	8
0	0	7	0	4	0	2	6	0
0	0	1	0	5	0	9	3	0
9	0	4	0	6	0	0	0	5
0	7	0	3	0	0	0	1	2
1	2	0	0	0	7	4	0	0
0	4	9	2	0	6	0	0	7

Box No (2,1)

box_x = pos[0] // 3	box_y = pos[1] // 3	
0 // 3 = 0	2 // 3 = 0	→ Box No (0,0)
1 // 3 = 0	4 // 3 = 1	
2 // 3 = 0	5 // 3 = 1	
3 // 3 = 1	8 // 3 = 2	→ Box No (1,2)
4 // 3 = 1	1 // 3 = 0	
5 // 3 = 1	3 // 3 = 1	
6 // 3 = 2	6 // 3 = 2	
7 // 3 = 2	7 // 3 = 2	
8 // 3 = 2	0 // 3 = 0	→ Box No (2,0)

(0 , 2) (0 , 4) (0 , 5) (0 , 8)

(1 , 1) (1 , 2) (1 , 3) (1 , 6) (1 , 7)

(2 , 0) (2 , 1) (2 , 2) (2 , 4) (2 , 6)

(3 , 0) (3 , 1) (3 , 3) (3 , 5) (3 , 8)

(4 , 0) (4 , 1) (4 , 3) (4 , 5) (4 , 8)

(5 , 1) (5 , 3) (5 , 5) (5 , 6) (5 , 7)

(6 , 0) (6 , 2) (6 , 4) (6 , 5) (6 , 6)

(7 , 2) (7 , 3) (7 , 4) (7 , 7) (7 , 8)

(8 , 0) (8 , 4) (8 , 6) (8 , 7)

Pos[0] is the “x” element

Pos[1] is the “y” element

Python Solution of Sudoku Puzzle (Step # 5)

<u>The final step is to just use the solve function managing all the backtracking Tasks with the recursive function</u>

```
def solve(bo):

    find = find_empty(bo)

    if not find:
        return True
    else:
        row,col = find


    for i in range(1,10):
        if valid(bo,i,(row,col)):
            bo[row][col]=i

            if solve(bo):
                return True

            bo[row][col] = 0

    return False
```