

# Artificial Intelligence

## Lab3 Report

### CSP to solve Sudoku

#### **Names & Ids :**

Pola Qulta 7685

Peter Mina 7357

Nour Mohamed Mahmoud 7591

# 1 Game Description

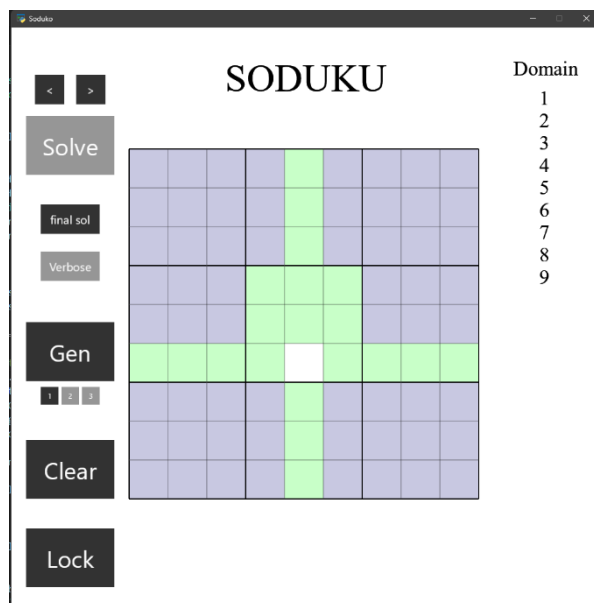
Sudoku is a logic-based number-placement game that challenges players to fill a 9x9 grid with digits from 1 to 9. The objective is to complete the grid in such a way that each row, each column, and each of the nine 3x3 subgrids (also known as regions or boxes) contains all of the digits from 1 to 9 without repetition.

## 2- Sample runs :

### - Before generation :

We can generate sudoku board with different difficulties , clear , lock and solve buttons , step by step solving .

. make user fill board and check if input correct or violate constraints for each number.



## a- Easy :

SODUKU Domain

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Solve

final sol

Verbose

Gen

1 2 3

Clear

Lock

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

SODUKU Domain

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Solve

final sol

Verbose

Gen

1 2 3

Clear

Lock

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

SOLVED

## b-Medium

SODUKU Domain

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Solve

final sol

Verbose

Gen

1 2 3

Clear

Lock

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

SODUKU Domain

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Solve

final sol

Verbose

Gen

1 2 3

Clear

Lock

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

SOLVED

## c- Hard

SODUKU

Domain

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Solve

final sol

Verbose

Gen

1 2 3

Clear

Lock

							2
		8		3			
	1						
6						1	
							4
		6					
7				6	1		
	2						
4			2				

SODUKU

Domain

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Solve

final sol

Verbose

Gen

1 2 3

Clear

Lock

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

SOLVED

## d-Unsolvable :

SODUKU

Domain  
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Solve

final sol

Verbose

Gen

1 2 3

Clear

Lock

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

UNSAT

## Comparison between difficulties :

- The initial puzzle generated for Easy difficulty tends to have a higher number of prefilled cells compared to higher difficulty levels.
- The puzzles are designed to be relatively straightforward, with more obvious patterns and fewer empty cells to fill.

Easy : 38 out of 81 initial hints.

Medium : 32 out of 81 initial hints.

Hard : 14 out of 81 initial hints.

### - Time comparison :

Easy :

```
000ku_solver/01.py  
elapsed time: 0.026424  
elapsed time: 0.011799  
elapsed time: 0.012909  
█
```

Medium :

```
000ku_solver/01.py  
elapsed time: 0.026031  
elapsed time: 0.005339  
elapsed time: 0.015454
```

Hard :

```
elapsed time: 0.021900  
elapsed time: 0.019056  
elapsed time: 0.020028  
█
```

## 3- Data structure , algorithms and assumption used:

### **GridVariable Class:**

Data Structure: Each cell in the Sudoku grid is represented by an instance of the GridVariable class, which encapsulates attributes such as position, domain (possible values), current value, and read-only status.

**Algorithms:**

Methods in this class implement algorithms for updating domain, locking variables, resetting variables, and finding inconsistencies.

**Board Class:**

Data Structure: The Sudoku grid itself is represented as a 9x9 grid of GridVariable objects.

**Algorithms:**

This class implements various algorithms for solving Sudoku puzzles, including backtracking, enforcing consistency, finding unsatisfiable variables, applying constraints, and generating Sudoku puzzles.