

Optimization Assignment

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1 Sudoku

In this tutorial we shall use `Python`. The objective is to solve the puzzle Sudoku for any size (order), using integer programming.

1.1 Formulation

To formulate the problem, propose answers to the following questions :

- Using only binary variables, how can we specify that a given number k is located in position (i, j) in the grid ?
- What variables should we use ?
- How do we express the line, column and square constraints ?
- How do we express the fact that only a single number can be located at any location (i, j) ?
- How do we express the known numbers as constraints ?

1.2 Resolution using `Python`

- One of the best toolbox for optimisation in `Python` is `cvxopt`
- In particular, `cvxopt.glpk` has an integer programming solver :

```
import numpy as np
import cvxopt
import cvxopt.glpk
```

To use the help on `cvxopt.glpk.ilp`, which is the integer linear programming solver, use :

```
cvxopt.glpk.ilp?
```

- you have to use the `cvxopt` “matrix” object

```
from cvxopt import matrix
b = matrix(np.ones(...))
```

To help, a python notebook is available.

	2	4	
			2
3			
	1	3	

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1.3 Test

Solve the following sudokus.

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

(simple)

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

(Very hard)

8	F	C					A				6
		A			F			B	7	4	D
B		4			D	6	7		0		5
1					0	3		9	2		
				1	F	D		3	0		E
	1	6			C		B		A		3
	C	D			6	3	5		9	2	
9		3	4	E	2			7	D		
				5	7			8	C	3	0
		E	2		4		7	1		F	6
	5	3			8		9			E	C
7	0	6			C	9		D	E	3	
				D	E		4	0			2
	7	8			C		4	2		B	5
	2	9	E	B			5			4	
6					7					1	8
											3

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hard

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