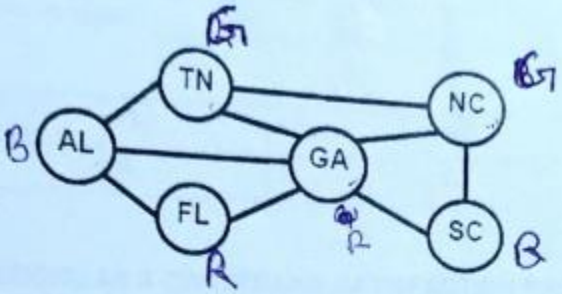
AI 2002 – Artificial Intelligence

Practice Questions (CSP)

CSP Problems:

Question No. 3 CONSTRAINT SATISFACTION PROBLEMS. (20).



You are a map-coloring robot assigned to color this Southeast USA map. Adjacent regions must be colored a different color (R=Red, B=Blue, G=Green). The constraint graph is shown.

a) (4pts) FORWARD CHECKING. Cross out all values that would be eliminated by Forward Checking, after variable GA has just been assigned value G, as shown:

AL	TN	FL	GA	NC	SC
R ~~G~~ B	R ~~G~~ B	R ~~G~~ B	G	R ~~G~~ B	R ~~G~~ B

b) (4pts) ARC CONSISTENCY. AL and FL have been assigned values, but no constraint propagation has been done. Cross out all values that would be eliminated by Arc Consistency

AL	TN	FL	GA	NC	SC
B	R ~~G B~~	R	~~R~~ G ~~B~~	~~R G~~ B	R ~~G B~~

c) (4pts) MINIMUM-REMAINING-VALUES HEURISTIC. Consider the assignment below. TN is assigned and constraint propagation has been done. List all unassigned variables that might be selected by the Minimum-Remaining-Values (MRV) Heuristic: AL, GA, NC

AL	TN	FL	GA	NC	SC
R B	G	R G B	R B	R B	R G B

d) (4pts) DEGREE HEURISTIC. Consider the assignment below. (It is the same assignment as in problem 6c above.) TN is assigned and constraint propagation has been done. List all unassigned variables that might be selected by the Degree Heuristic: GA

AL	TN	FL	GA	NC	SC
R B	G	R G B	R B	R B	R G B

e) **(4pts) MIN-CONFLICTS HEURISTIC.** Consider the complete but inconsistent assignment below. GA has just been selected to be assigned a new value during local search for a complete and consistent assignment. What new value would be chosen below for GA by the Min-Conflicts Heuristic? R

AL	TN	FL	GA	NC	SC
B	G	R	?	G	B

Question No. 4 SUDOKU AS A CONSTRAINT SATISFACTION PROBLEM (12).

A Sudoku board consists of $n \times n$ squares, some of which are initially filled with digits from 1 to n. The objective of the Sudoku puzzle is to fill in all the remaining squares such that no digit appears twice in any row, column, or $\sqrt{n} \times \sqrt{n}$ box. **Consider the case in which $n = 4$.**

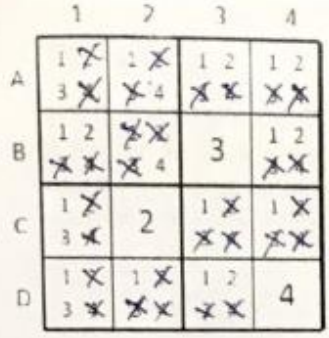
The Sudoku puzzle with $n = 4$ can be formulated as a constraint satisfaction problem with $n^2 = 16$ variables, where every variable stands for one of the 16 squares on the 4x4 Sudoku board. If we denote rows with letters A-D and columns with numbers 1-4, we end up with 16 variables: A1, A2, A3, A4, B1, B2, …, D3, D4. Each variable has domain values {1, 2, 3, 4}.

What remains to be done is to specify the constraints of the problem. We could use binary constraints for each pair of variables but might end up with a large number of constraints. A better alternative is to use global *A*llDiff constraints, where *A*llDiff ($X1, X2, \ldots, Xn$) means that all n variables, $X1, X2, \ldots, Xn$, must have different values.

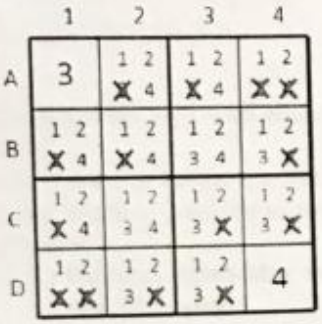
a) (2 pts) How many ***A*llDiff** constraints are required to specify that no digit may appear twice in any row, column, or **2 × 2** box? (1 per row, 1 per column, 1 per box) = 3 constraints

	1	2	3	4
A	1 2 3 4	1 2 3 4	1 2 ~~4~~	1 2 ~~4~~
B	1 2 ~~4~~	1 2 ~~4~~	(3)	1 2 ~~4~~
C	1 2 3 4	1 2 3 4	1 2 ~~4~~	1 2 3 4
D	1 2 3 4	1 2 3 4	1 2 ~~4~~	1 2 3 4

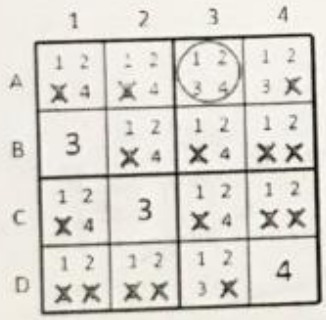
b) (2 pts) FORWARD CHECKING.
Consider the 4×4 Sudoku board on the left. Possible domain values for each variable are shown in each square. Variable B3 has just been assigned value 3 (circled).
Cross out all values from the domains of the remaining unassigned variables that now would be eliminated by Forward Checking.



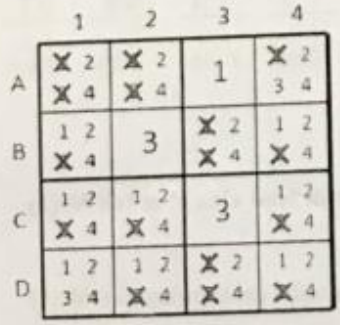
c) (2 pts) ARC CONSISTENCY.
Consider the 4×4 Sudoku board on the left. Possible domain values for each variable are shown in each square. Variables B3, C2, and D4 have been assigned values, but no constraint propagation has been done.
Cross out all values from the domains of the remaining unassigned variables that now would be eliminated by Arc Consistency



d) (2 pts) MINIMUM-REMAINING-VALUES (MRV) HEURISTIC.
Consider the 4×4 Sudoku board on the left. Possible domain values for each variable are shown in each square. Variables A1 and D4 are assigned and constraint propagation has been done.
List all unassigned variables (in any order) that now might be selected by the Minimum-Remaining-Values (MRV) Heuristic: D4, A1



e) (2 pts) LEAST-CONSTRAINING-VALUE (LCV) HEURISTIC.
Consider the 4×4 Sudoku board on the left. Possible domain values for each variable are shown in each square. Variables B1, C2, and D4 are assigned and constraint propagation has been done. A3 (circled) is chosen for assignment next.
List all values (in any order) for variable A3 (circled) that now might be selected by the Least-Constraining-Value (LCV) Heuristic: _____



f. (2 pts) DEGREE HEURISTIC (DH).
Consider the 4×4 Sudoku board on the left. Possible domain values for each variable are shown in each square. Variables A3, B2, and C3 are assigned and constraint propagation has been done.
List all unassigned variables (in any order) that now might be selected by the Degree Heuristic (ignore MRV for this problem): _____