

Discrete Mathematics

Homework I

One More Puzzle with SMT Solver

but not with your team members this time

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Assignment Overview

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- Write a C program that finds a solution of a given game of the **Number Cross** puzzle using the Z3 SMT solver
- Submission
 - deadline: **9 Oct (Wed), 11:59 PM**
 - deliverables
 - program (C source code files, build script, README)
 - write up (1 page)
- You are not allowed to collaborate with any one in or out of the class in doing this homework
 - it is allowed to reuse the PA 1 results of your team

Number Cross

- Number Cross consists of a $M \times N$ grid where every square, every row, and every column and is labeled with a positive integer
- The goal of the game is to determine the color of each square as either Black or White, such that
 - the label (number) of each column is the same as the sum of the numbers in the Black squares of the column
 - the label of each row is the same as the sum of the numbers in the White squares of the column
 - the number of a square label is greater than or equal to 1, and not greater than 9
 - initially, no information on the coloring is given

20	23	30	29	34	6	9	21	19	
8	2	1	8	1	3	5	7	6	18
9	1	4	2	5	6	3	1	7	28
3	5	1	4	9	1	3	9	1	8
8	6	6	3	5	1	1	4	1	4
8	6	6	2	6	8	3	3	9	31
8	7	8	8	4	5	2	1	1	18
4	8	3	5	5	2	1	2	8	24
1	2	8	8	8	3	7	2	7	22
8	3	9	5	9	2	1	4	9	35

20	23	30	29	34	6	9	21	19	
8	2	1	8	1	3	5	7	6	18
9	1	4	2	5	6	3	1	7	28
3	5	1	4	9	1	3	9	1	8
8	6	6	3	5	1	1	4	1	4
8	6	6	2	6	8	3	3	9	31
8	7	8	8	4	5	2	1	1	18
4	8	3	5	5	2	1	2	8	24
1	2	8	8	8	3	7	2	7	22
8	3	9	5	9	2	1	4	9	35

Requirements

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- Your program must use the Quantifier-free LIA logic to model this game (not propositional logic)
- Input
 - input is given via the standard input
 - the first line consists of N tokens which are a sequence of the column labels
 - each of the following M lines has $N + 1$ tokens; first N tokens are a sequence of the square labels in the row, and the last label for the row label
 - M is not greater than 50, and so is N .
- Output
 - print the coloring of the grid to the standard output
 - 1 : Black
 - 0 : White
 - print “No solution” if there’s no solution

20	23	30	29	34	6	9	21	19
8	2	1	8	1	3	5	7	6
9	1	4	2	5	6	3	1	7
3	5	1	4	9	1	3	9	1
8	6	6	3	5	1	1	4	1
8	6	6	2	6	8	3	3	9
8	7	8	8	4	5	2	1	1
4	8	3	5	5	2	1	2	8
1	2	8	8	8	3	7	2	7
8	3	9	5	9	2	1	4	9

<Input example>

1	1	0	1	0	0	1	0	0
0	1	1	0	1	0	0	0	0
1	1	1	0	1	0	0	1	1
1	1	1	1	1	1	1	0	1
0	0	0	1	1	0	0	1	1
0	1	1	1	0	0	1	1	0
0	0	1	0	0	0	1	1	1
1	1	1	1	0	1	0	1	0
0	0	0	0	1	1	0	1	0

<Output example>

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Program Structure

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- Write a C program running on UNIX/LINUX
 - Each program receives input from the standard input and produces the output to the standard output
 - Tests will be conducted on Peace
- The program must be built as a single executable
 - Programs can execute Z3 in a middle of execution through `popen` (see an example of `nqueen-LIA.c`)
- You must submit a build script and README together with source code files
 - build script: Bash script, Makefile, Ant, Maven, etc.
 - README: instruction/manual on how to build and run your program

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Submission

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- Deadline: 9 Oct (Wed), 11:59 PM
 - no late submission will be accepted
- Submit the program and one write-up (report)
 - Program: source code files, build script and README
 - Write up: must not exceed 1 page (in A4; either in single or double column)
- Submit all deliverables via Hisnet homework submission repository
- Your submissions may be open to the class and public

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Evaluation Criteria

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- Write up (60 points)
 - Description (50 points)
 - check whether you found all constraints of a solution
 - check whether each constraint is correctly represented as a logic formula
 - check whether you demonstrate the correctness of your programs in a convincing way (e.g., by tests)
 - check whether all descriptions are clear and consistent
 - Discussion (10 points)
 - detailed analysis of results, interesting observations, lessons learned, suggestions, new ideas, etc.
- Tests (40 points)
 - Run each program with several inputs to see whether the results are correct
 - Note that tests will be conducted on the Peace server