Solving Sudokus with extended constraints

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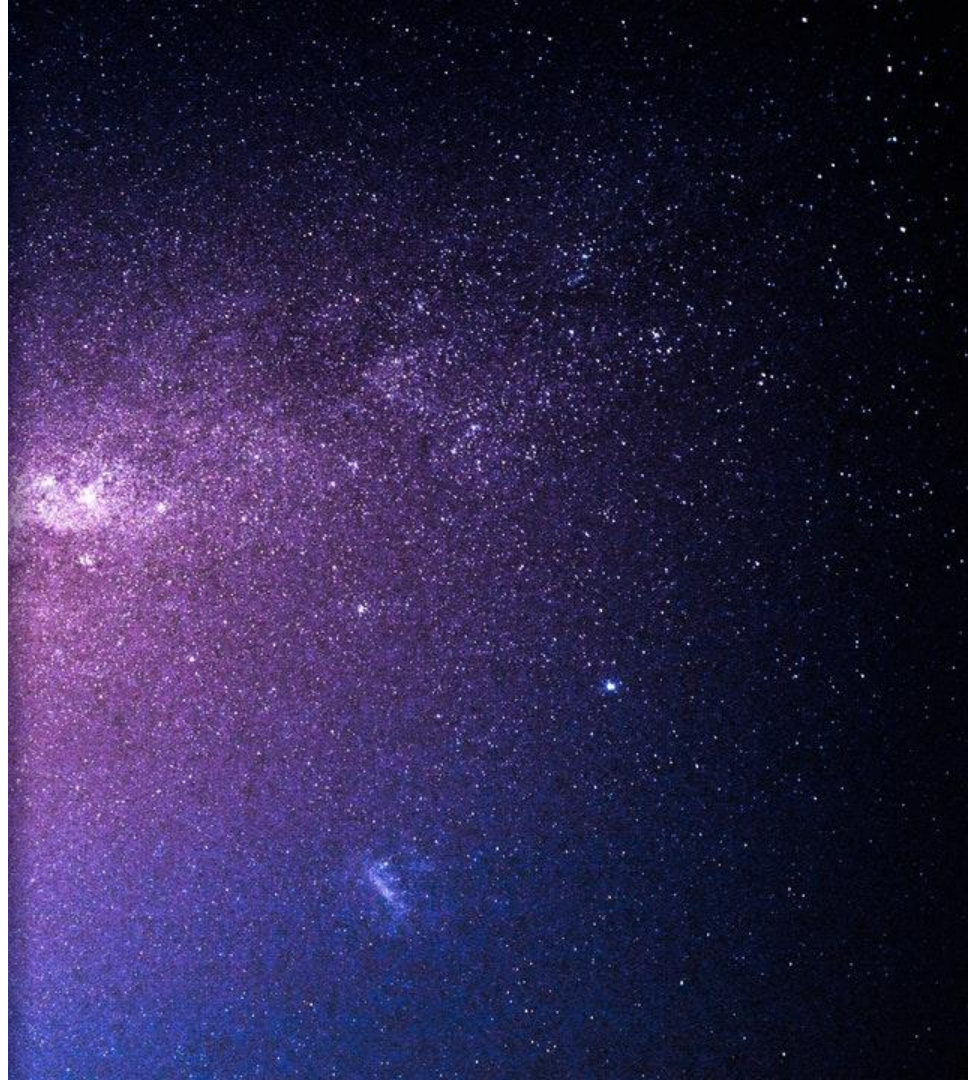Video link: https://github.com/hahamark1/KRthelastkillersamurai/raw/master/presentatie.mp4

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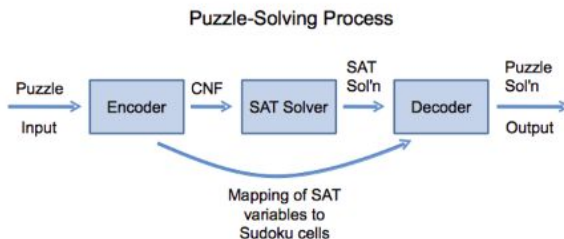
Conclusion

Introduction
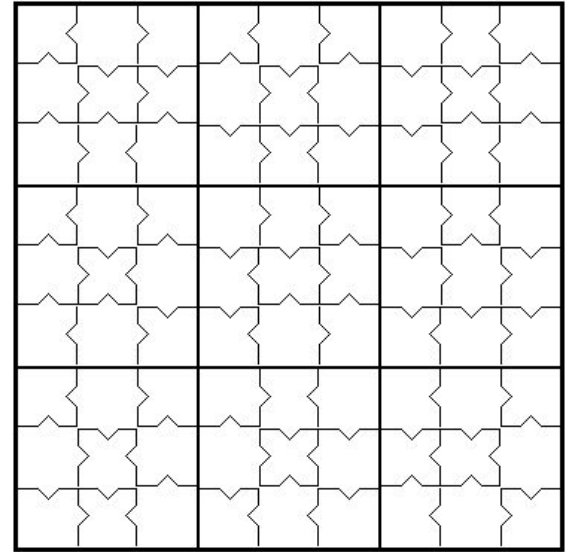
Hypothesis

Adding more constraints to the Sudoku puzzle makes the puzzle easier to solve for a SAT solver.

Encoding

- Extra set of constraints for the coloured and GT sudoku

- Coloured: add same constraints as for row/column, but now for cells of certain colour

- GT: For A>B, encode every possible value for A and all smaller values for B.

  Example: $(A9 \land (B8 \lor B7 \ldots \lor B1)) \lor (A8 \land (B7 \lor B6 \ldots \lor B1)) \lor \ldots (A2 \land B1)$

Puzzle-Solving Process

Puzzle Input → Encoder → CNF → SAT Solver → SAT Sol'n → Decoder → Puzzle Sol'n Output

Mapping of SAT variables to Sudoku cells

Experimental setup

Dataset

1800 puzzles for each type

6 different difficulty levels

Metrics

Added constraints:

- Literals per clause

Difficulty:

- Decision level, Added conflict clause & total runtime CPU

Results

GT puzzles have significantly higher difficulty level and literals per clause.

Coloured Sudoku's are also more difficult than regular Sudoku's.

	Literals per Clause	Max. dec. level	Num. of dec.	Add. confl. clauses	Total runtime
Regular	2.05	5.76	21.62	8.51	0.0001067 s
Colour	2.04	7.87	34.89	14.75	0.0004177 s
GT	2.50	36.76	1364.98	776.91	0.0228844 s

Table 3.1: Experimental results from zChaff: average statistics after solving (n=1800

Discussion

- Not generalizable for other Sudoku's

- Literals per clause as measure

- Type and encoding of added constraint

- Number of regular clauses vs added clauses

Further work

- Encode the 'standard' Sudoku with less constraints

- Work by Kwon and Jain[3] shows a reduction of the clauses by 90%

- Test similar hypothesis for bigger Sudoku's (nxn for n > 3)

Conclusion

Hypothesis rejected

- GT puzzles have significantly higher difficulty level

- Both types of Sudoku in our experiment proved to be more difficult