Solver Algorithms and Tractable Subproblem Analysis of Suguru Puzzles

Butrahandisya[1], Muhammad Arzaki[2], Gia Septiana Wulandari[3]

[1,2,3]School of Computing, Telkom University, Bandung
[1]andyyy@student.telkomuniversity.ac.id, [2]arzaki@telkomuniversity.ac.id,
[3]giaseptiana@telkomuniversity.ac.id

Abstract

This paper explores algorithmic and mathematical aspects of Suguru puzzles, a single-player pencil-and-paper puzzle introduced in 2001 and proven NP-complete in 2022. Two algorithmic approaches are presented for solving Suguru puzzles: the backtracking approach and the SAT-based approach. The backtracking approach demonstrates an asymptotic running time of $O(R \cdot (mn - H + 2)!)$ for solving a Suguru puzzle of size $m \times n$, R regions, and H hint cells. Furthermore, a SAT encoding of the puzzle rules into propositional formulas is proposed, where the number of variables and clauses are bounded above by $O(m^3 n^3)$ for an $m \times n$ Suguru instance. In addition, it is proven that any Suguru puzzle of size $m \times n$ with either $m = 1$ or $n = 1$ can be solved in linear time in terms of the puzzle size. Experimental results show that the backtracking approach is faster for solving Suguru puzzles of sizes 10×10 or smaller, while the SAT-based technique is superior for solving larger puzzles.

Keywords: asymptotic complexity, backtracking, SAT encodings, Suguru puzzles, tractable subproblems