

PUZZLEJAR: Automated Constraint-based Generation of Puzzles of Varying Complexity

Engaging students in practicing a wide range of problems facilitates their learning. However, generating fresh problems that have specific characteristics, such as using a certain set of concepts or being of a given difficulty level, is a repetitious task for a teacher. Our goal is to develop a system to automatically generate problems in a large number of domains, including programming and math.

In this work, we present PUZZLEJAR, a system that solves a simpler task of automatically generating Sudoku and Fillomino puzzles of different complexity levels. Most previous approaches for automatically generating puzzle problems have been specific to a given puzzle and are based on a set of heuristic rules. PUZZLEJAR, on the other hand, lets one specify the puzzle definition and puzzle complexity using constraints. It then uses efficient constraint-solving to incrementally solve constraints generated from different iterations. The system first generates a solved, complete puzzle. It then introduces “holes” into the puzzle to make it an interesting problem. These holes are introduced in a fashion such that the validity constraints are still satisfied. We use the z3 SMT solver and its theory of linear arithmetic for representing and solving the constraints.

We have successfully used PUZZLEJAR to automatically generate more than 200,000 9x9 Sudoku puzzles and more than 10,000 Fillomino puzzles. The case studies with Sudoku and Fillomino puzzles show the generality of the algorithm, and our experiments confirm that PUZZLEJAR can be reasonably applied to generate larger and more complex puzzles.