Solving European Peg Solitaire with Constraint Programming

Plan and Context Survey

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Dissertation Outline

Abstract:

Peg solitaire is a popular, one-player board game that is played worldwide in many variations, which are stipulated by the arrangement of the pegs to form the board. One square is left empty to facilitate the opening move. Pegs are then removed by draughts style 'jumps', until no legal moves remain. The goal is to reduce the board to a single peg, or an alternate, predefined goal state. Devising a solution to the game can prove difficult, despite these simple rules. Peg solitaire has been analysed mathematically, and studied using integer programming, although there is relatively little work on the game using constraint programming techniques. Of the multitude of variations of peg solitaire, arguably the two most popular are the English variation, which has been analysed in [1], and the European variation, which will form the basis of this dissertation.

Plan of Work

The objectives for this project are as follows:

1. To devise constraint programming models of the European peg solitaire game
2. To solve the game with these models using SavileRow and Minion
3. To perform empirical evaluation of the solution, and compare different models

As such, the first stage of this dissertation is to construct a constraint satisfaction model that solves the game of European peg solitaire. Once a model is established, it will be analysed and evaluated, and any changes which can refine the model and improve the solution will be implemented to form an improved model. This will include breaking the symmetry inherent in the problem, as well as looking at different heuristics that guide the solution, and evaluating how they effect the solution.

Once a solution to European solitaire is found, and has been refined as much as possible, further analysis of alternate board arrangements may be explored, e.g. a more general n*n board; alternate goal states can be studied, e.g. Fool's Solitaire, where the goal is to fail as early as possible; additional rules can be added, e.g. a variation where an additional peg is added at one point during the sequence of moves.

Project Requirements

This project uses St Andrews' own Savile Row and Minion. Savile Row is a modelling assistant, which translates the model from the solver independent language Essence' into input language specific to Minion, which is a solver for constraint satisfaction problems.

Context Survey

Peg solitaire, in the English variation, has been studied using constraint programming in [1], which looks at integer programming and constraint programming approaches. Both approaches are analysed, and extensions to the game, such as 'Fool's Solitaire' and 'Long-hop' solitaire.

Outside constraint programming, alternate methods in computer science have been used to study the game of peg solitaire, or variations thereof: [2] looks at string rewriting systems, and applies this to peg solitaire; A.I. search techniques are used to search for solutions to different variations of peg solitaire in [3] and [4]. The peculiarities of peg solitaire even drew the attention of Alan Turing in a letter he penned in 1953, which has just recently been featured in [5].

The game of peg solitaire is mostly studied in the context of mathematics. It is given a lot of attention in Chapter 23 of [6], where different properties are analysed and many variations are considered, and occasionally features in mathematical journals as different facets of the it are studied, e.g. [7] which looks at the possibility of moving from one given position to another.

References

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