A Review of “Solving Peg Solitaire with Bidirectional BFIDA*”

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Synopsis

The work contributes towards the previous solution of the problem in three aspects:-

- Improves the heuristic previously used to solve the peg soliatire problem.
- Makes detection of duplicate states easier
- Decreases the time taken by previous state-of-art solver in the last iteration.Thus it significantly decreases overall time taken (by a order of magnitude 2) as last iteration takes most amount of time.

Introduction

A peg solitaire , known as Brainvita in India is a game for single person where the objective is to change the state of board from initial state B1 to a goal state B2 through consecutive jumps of pegs in the “jumped over” peg is removed from board.It is played on variety of boards.Some are depicted in figure 1.

The most common start state and end state are depicted in Figure 2 .At the start only central hole is empty and at end only central hole holds a peg.

Contributions

- **Improved Heuristics**
  They must be admissiable and consistant to find optimal solution to problem.In this problem we are trying to find the least numbers of moves(consecutive jumps of same peg count as one move).The heuristic used in the paper are:-

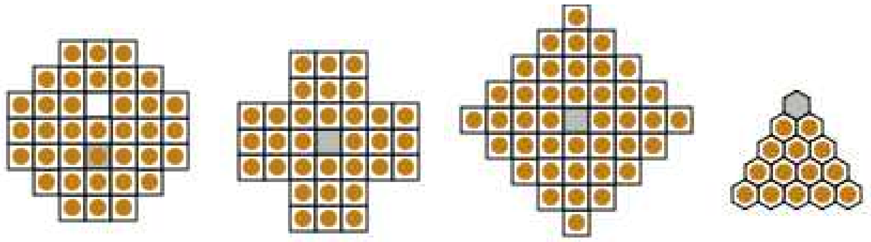

Figure 1: French,English,Diamond and Triangle Boards

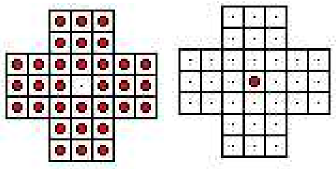

Figure 2: Start and End state

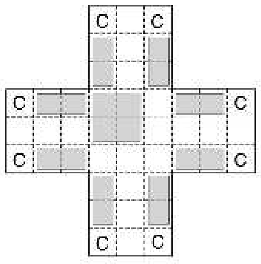

Figure 3: Corner and merson regions on English Board

1. *Number of Pegs at corners* $(h_c(n))$
   The pegs at corners marked by C in Figure 3 cannot be jumped over.So a move must initiate at these pegs.Hence atleast moves equal to number of corner pegs must be made to reach Final state.This heuristic will never overestimate the number of moves which makes it admissiable.But to have a more tighter bound authors have defined two more heuristics.

2. *Maximum moves required to remove excess pegs of each type* $(h_t(n))$
   Figure 4 shows the peg types.The blue ones are the corner pegs.The final state B2 requires us to remove pegs from all position but leave one at red.So at no point red pegs can be removed completely.For the independence of this heuristic from the former one,authors have neglected the pegs which are captured(jumped over) by the moves starting at corners.

3. *Number of occupied Merson Regions* $(h_m(n))$
   A merson region is a subsection on board which when filled with pegs completely,has no way to remove a peg by a move that does not originate inside that region.Here authors count a **static set** of merson regions except corner which is taken care off by the first heuristic.

The final heuristic that author uses is:-

$$h(n) = h_c(n) + max(h_t(n), h_m(n))$$

- **Detection of Duplicate States**

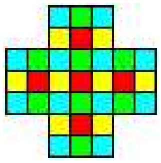

Figure 4: Different types of regions shown by different colors

In the previous algorithm by Bell[1],nodes which are arrived by same number of **moves,not jumps** are at same level of pegs. This makes it difficult to find and prune duplicate(can be two states which have same number of pegs but one state is exactly same as other after rotating the board) states as we have to store multiple level of BFIDA* tree.

Barker et al in this paper have made a tree level such that it cointaines same number of jumps.Thus duplicates can be detected at that particluar level and pruned to avoid redundant calculations.

- **Avoiding the last iteration**

Insted of using a traditional BFIDA*(Bredth first Iterative Deepening A)*,authors have used bidirectional search[2] varient of it.Increasing cutoff and choosing the direction,forward or backward, based on the least number of nodes passed on from previous iteration in that direction.The intersection of search would give a candidate optimal solution.

This avoids the time taken by unidirectional BFIDA* in the last iteration which lessesns the overall time of solving the board.

References

[1] Bell, G. I. 2007. "Diagonal peg solitaire". Integers: Electronic Journal Of Combinatorial Number Theory 7(G1):20.

[2] Pohl, I. 1971. "Bi-directional search". Machine Intelligence 6:127–140

[3] Peg Soliatire,Wikipedia,https://en.wikipedia.org/wiki/Peg_solitaire

[4] Jurgen Coller on Peg Soliatire,http://www.mathematische-basteleien.de/solitaire.htm

[5] Barker, Joseph K., and Richard E. Korf. "Solving Peg Solitaire with Bidirectional BFIDA." (2012).

Figure References

Figure 1 has been taken from wikipedia.Figure 2 and 4 from [4].Figure 3 from [5] itself.