Exploring Exhaustive PCG in The Witness

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Meta Question: Could we design The Witness using EPCG?

BtB Design Aesthetic

1. Richness
2. Completeness
3. Surprise
4. Lightest Contrivance
5. Strength of Boundary
6. Compatibility of Mechanics
7. Orthogonality
8. Generosity

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Moving AI Lab

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EPCG

- Generates all possible content
  - What content does this generate?
  - What content *should* I generate?
  - How do we *select* interesting content?

Can we generate a broad range of puzzles using EPCG?

- With no parallelization and little optimization can exhaustively generate *many* interesting puzzles in less than a minute
- Although problem is hard in multiple dimensions
  - [https://www.youtube.com/watch?v=Q4gTV4r0zRs](https://www.youtube.com/watch?v=Q4gTV4r0zRs)
How do we find interesting puzzles?

• Look for puzzles with as few solutions as possible

**One Solution**
- Sudoku
- Kakuro
- Crossword Puzzle

**Many Solutions**
- Sliding Tile (Blocks) Puzzle(s)
- Shenzhen I/O
- Portal
- Talos Principle
- Bejeweled*
- Peg Puzzles
Are all one-solution puzzles interesting?

- Longer solutions seems to be more interesting
How many constraints?

- Depends on the constraint type
- Usually more constraints is more information
- Sometimes more constraints is less information
What is the impact of orthogonality?

- Very easy to generate
- Levels tend to be more interesting
10,098,000 3x4 boards
485 boards with 1 solutions len 21 in 47.94s

2,044,845 3x4 boards
50 boards with 1 solutions len 21 in 5.41s

9,582,300 4x4 boards
35 boards with 2 solutions len 24 in 160.00s

User Evaluation
(Preliminary)
Conclusions

• We can generate a broad range of interesting puzzles with EPCG
• Some guidelines for which puzzles are interesting in *The Witness*
• Repeat with additional parameters to get a full game
• Play Online
  • https://movingai.com/w1.html