

Exploring Exhaustive PCG in The Witness

Nathan R. Sturtevant



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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

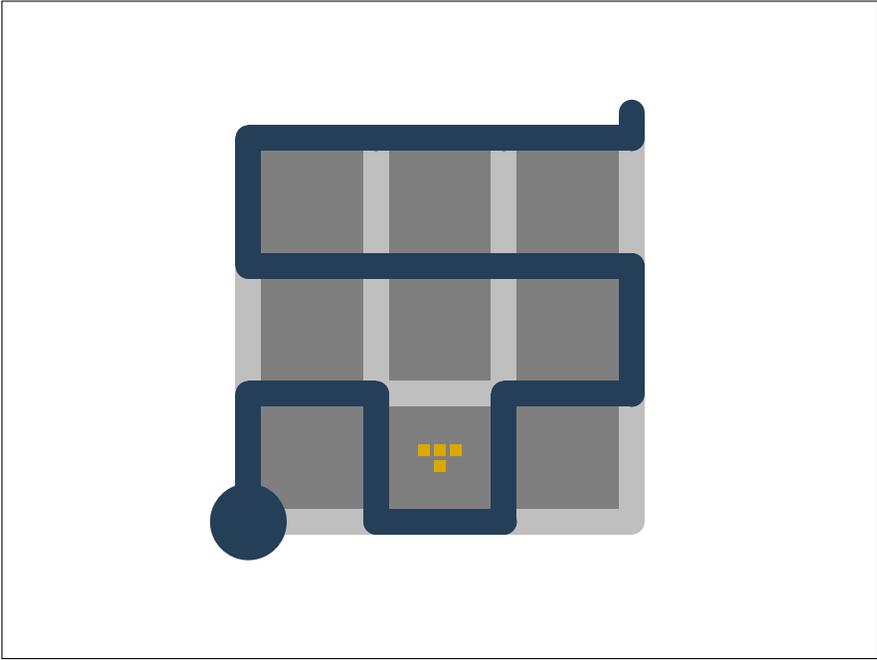
<http://the-witness.net/news/2011/11/designing-to-reveal-the-nature-of-the-universe/>



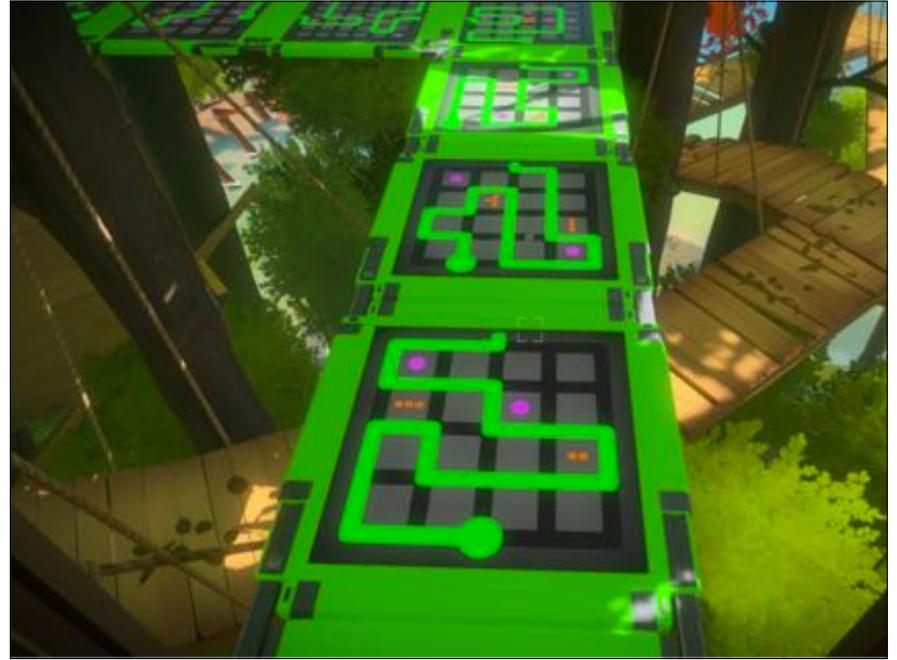
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BtB Design Aesthetic

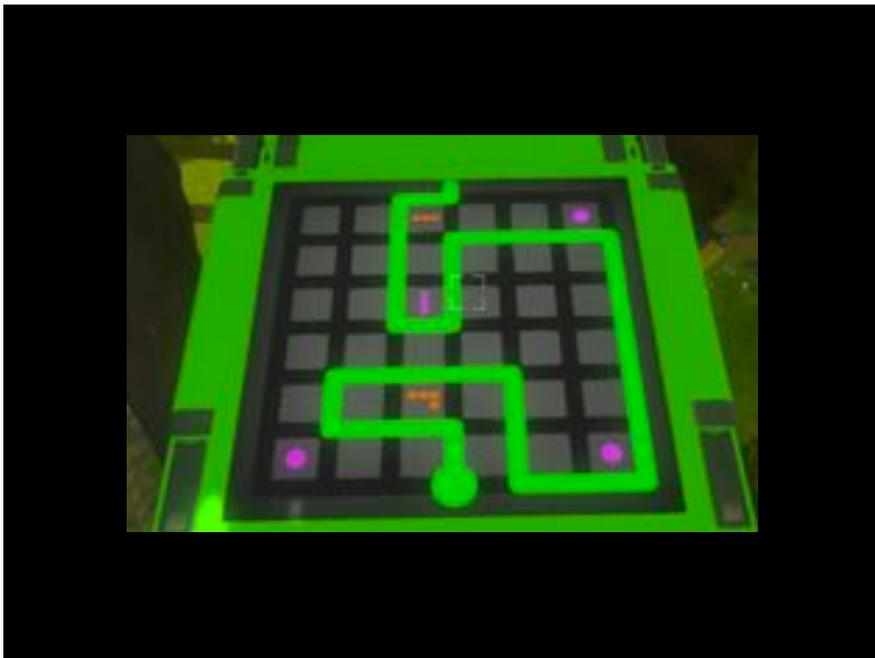
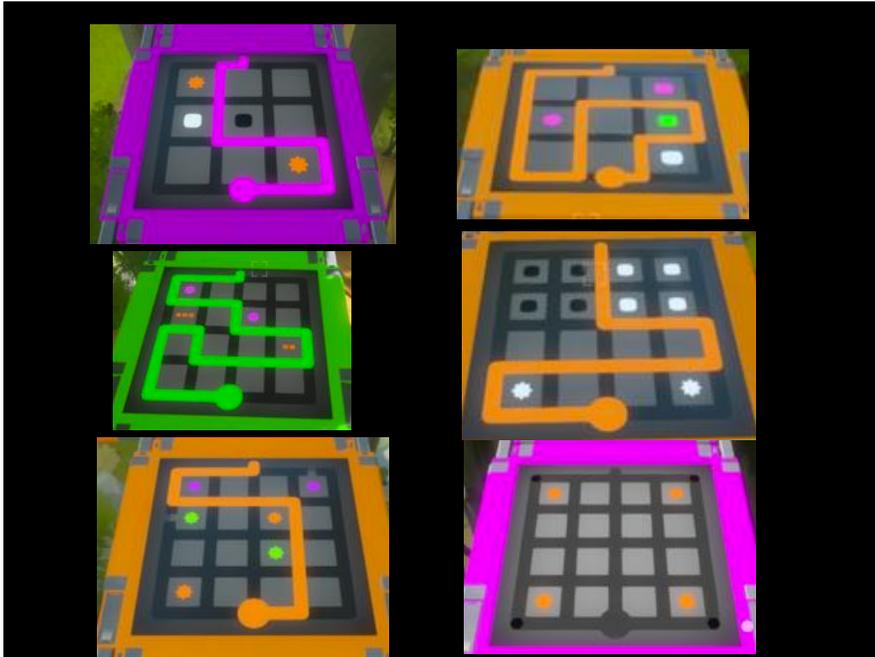
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EPCG

- 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>



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Moving Bit Lab

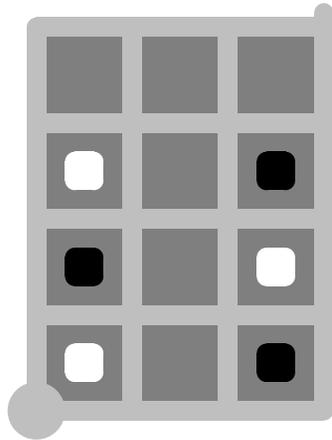
How do we find interesting puzzles?

- Look for puzzles with as few solutions as possible

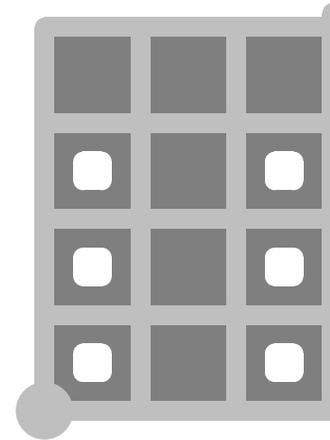
<p>One Solution Sudoku Kakuro Crossword Puzzle</p>	<p>Many Solutions Sliding Tile (Blocks) Puzzle(s) Shenzhen I/O Portal Talos Principle Bejeweled* Peg Puzzles</p>
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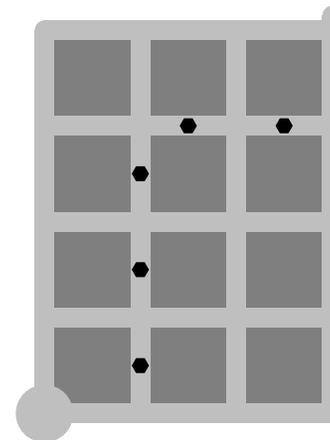
29,568 3x4 boards with 6 constraints.
16 boards with 1 solutions len 21 in 2.23s



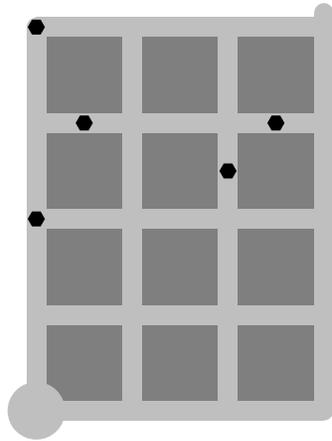
29,568 3x4 boards with 6 constraints.
924 boards with 976 solutions len 17 in 9.02s

Are all one-solution puzzles interesting?

- Longer solutions seems to be more interesting



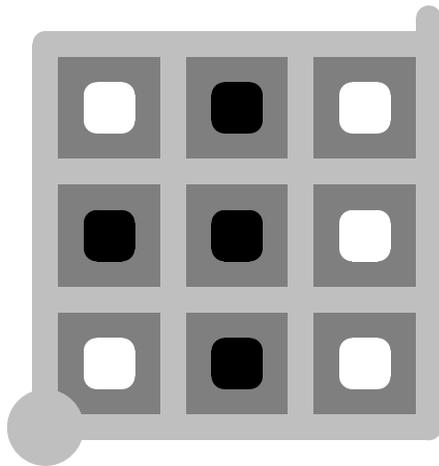
2,349,060 3x4 boards with 5 constraints
160 boards with 1 solutions len 21 in 5.20s



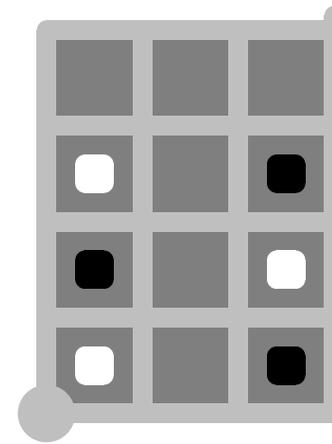
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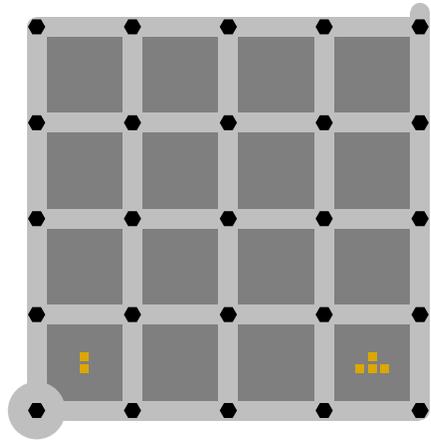
How many constraints?

- Depends on the constraint type
- Usually more constraints is more information
- Sometimes more constraints is less information



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16 boards with 1 solutions len 21 in 2.23s



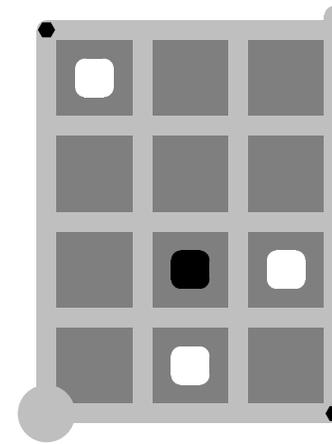


69,120 4x4 boards
7,376 boards with 1 solutions found in 2.75s

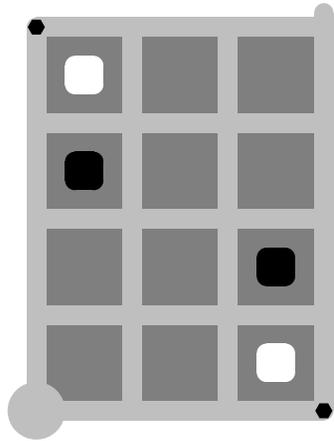


What is the impact of orthogonality?

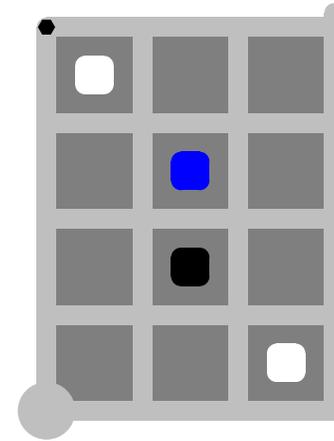
- Very easy to generate
- Levels tend to be more interesting



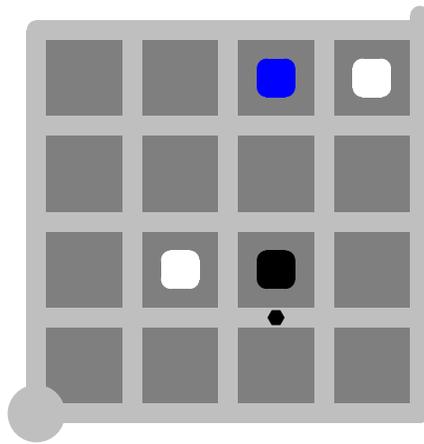
10,098,000 3x4 boards
485 boards with 1 solutions len 21 in 47.94s



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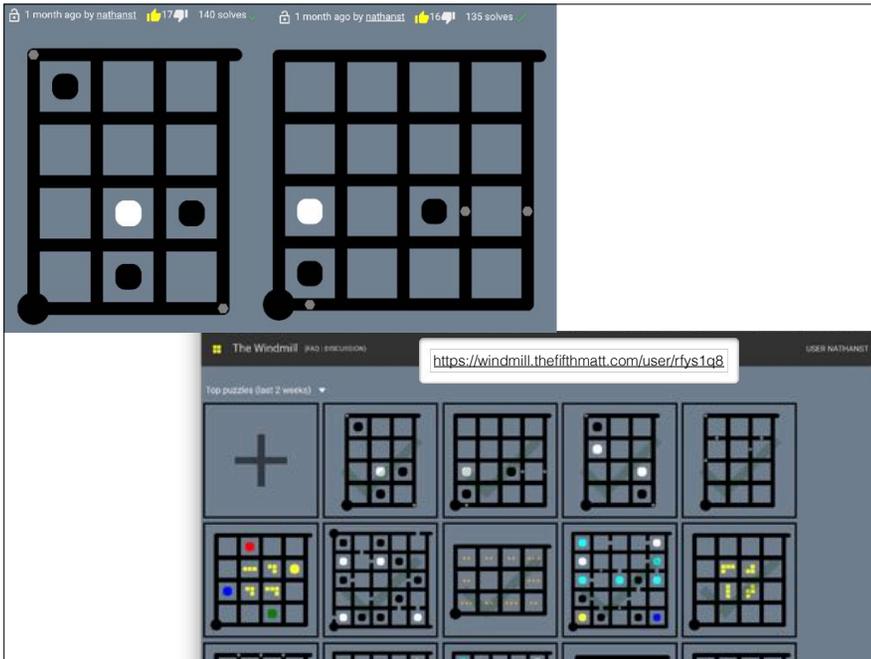


2,044,845 3x4 boards
50 boards with 1 solutions len 21 in 5.41s



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>