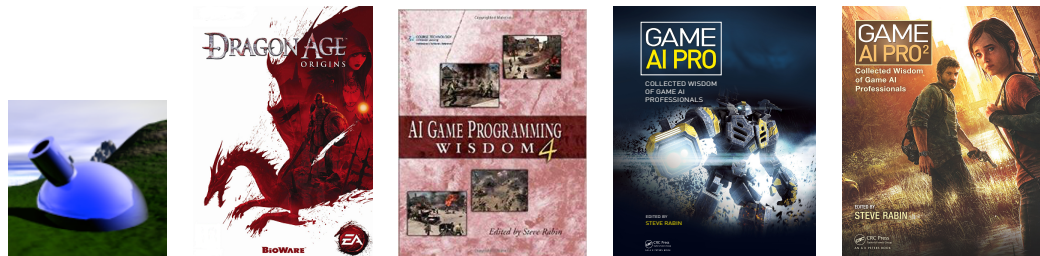




PCG, Design, and Exhaustive Search

Nathan Sturtevant

Assistant Professor
University of Denver
@nathansttt



AI ARTIFICIAL INTELLIGENCE
SUMMIT

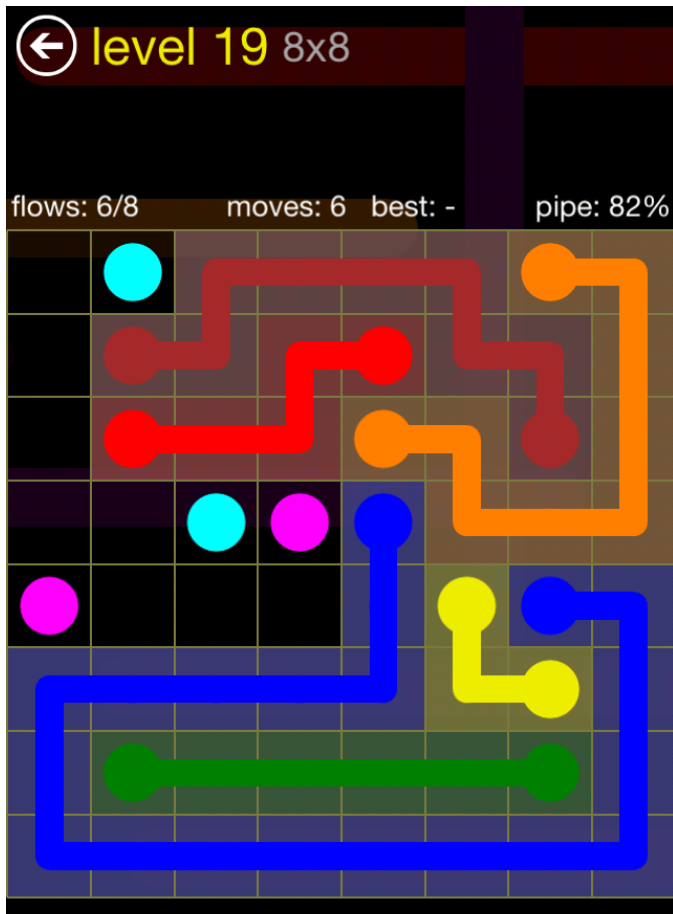
GAME DEVELOPERS CONFERENCE®
MOSCONE CENTER · SAN FRANCISCO, CA
MARCH 2-6, 2015 · EXPO: MARCH 4-6, 2015



You want to write checks you can cash, creative and technically, but you want to write the biggest checks you possibly can.

Chris Hecker
AIIDE 2010

PCG & Design





Why don't we have a virtual wind tunnel for figuring out the dynamics of the player experience?

Paul Tozour
GDC 2013 AI Summit



Aim towards the **Richest** space,
explore it **Completely**, and trace a
strong **Boundary** around it.

Jonathan Blow & Marc ten Bosch
Designing to Reveal the Nature of the Universe
IndieCade 2011

Braid - Platformer

Reverse Time

Green Items

Level
Set

Level
Set

Level
Set

Level
Set

Level
Set

Time/x-loc

Shadow

Slow-mo





Aim towards the **Richest** space,
explore it **Completely**, and trace
a strong **Boundary** around it.

Jonathan Blow & Marc ten Bosch
Designing to Reveal the Nature of the Universe
IndieCade 2011





Approach #1

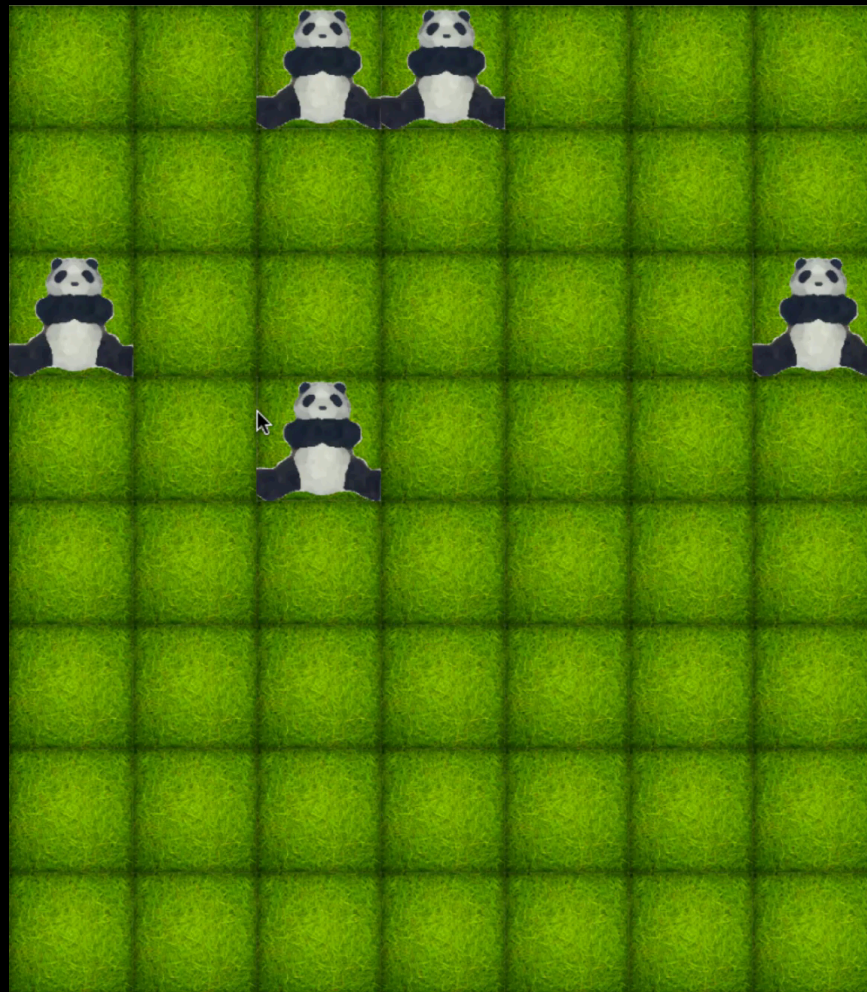
Choose height at each location
 768^{1024} possibilities

Approach #2

Choose offset at each location
 768×3^{1023} possibilities!

Approach #3

Change slope occasionally
 $768 \times 3^{256} = 10^{125}!$

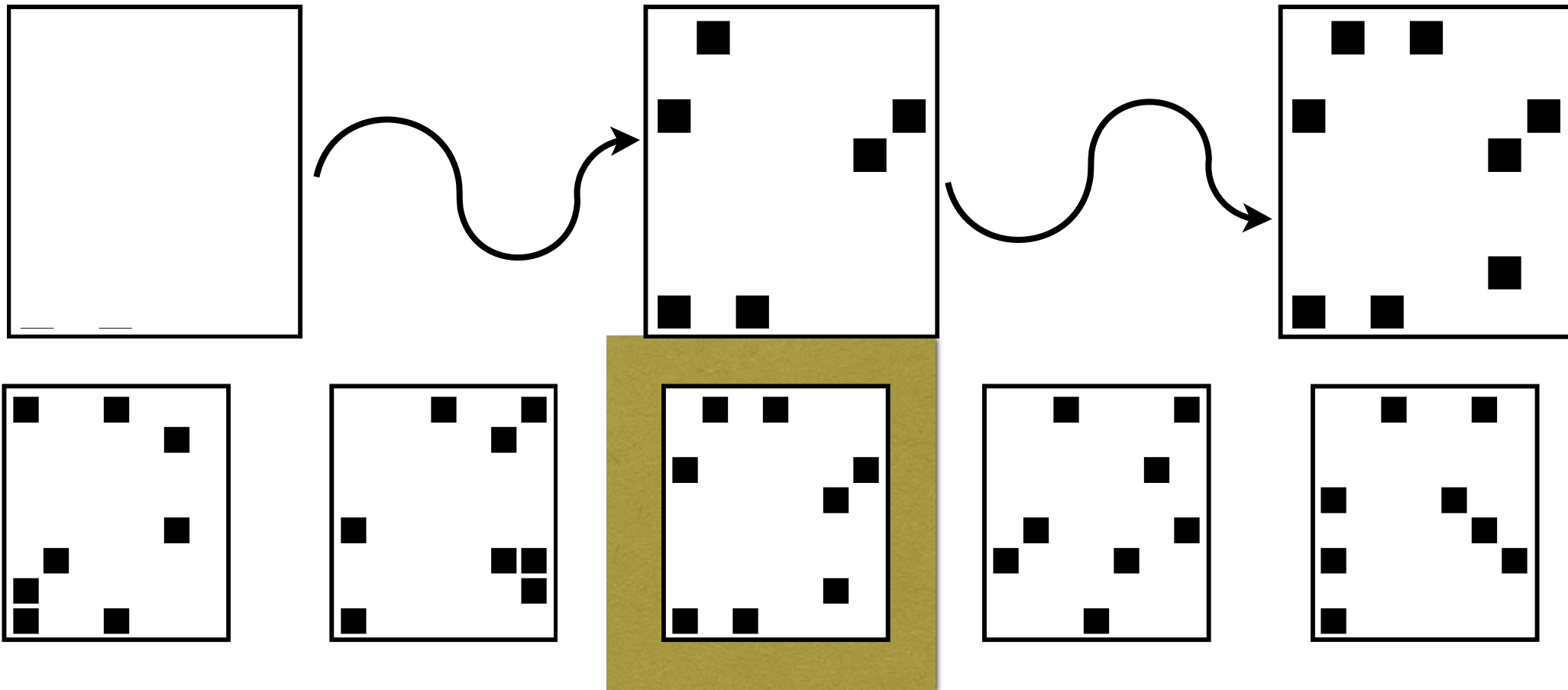


Pieces	Combinations
1	56
2	1,540
3	27,720
4	267,290 millions
5	3,819,816
6	32,468,436
7	231,917,400

Pieces	Combinations
8	1,420,494,075
9	7,575,968,400
10	35,117,951,480 billions
11	148,902,215,280
12	558,383,307,300
13	1,889,912,732,400 trillions
14	5,804,731,963,800

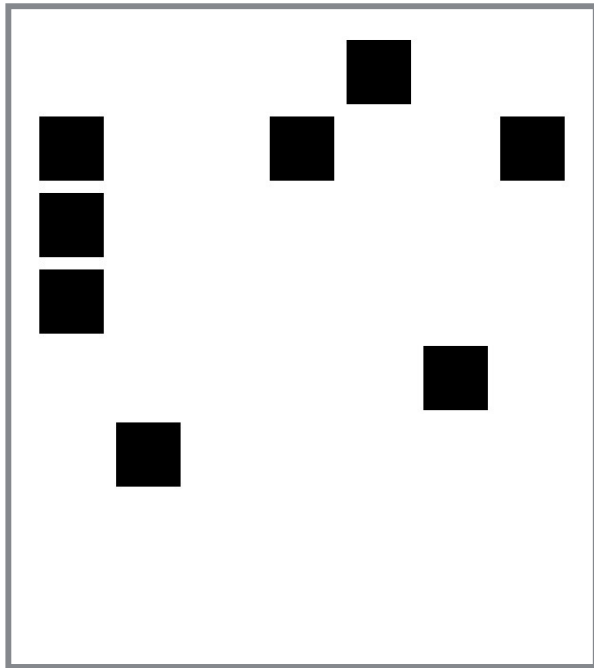


Generate vs. Filter

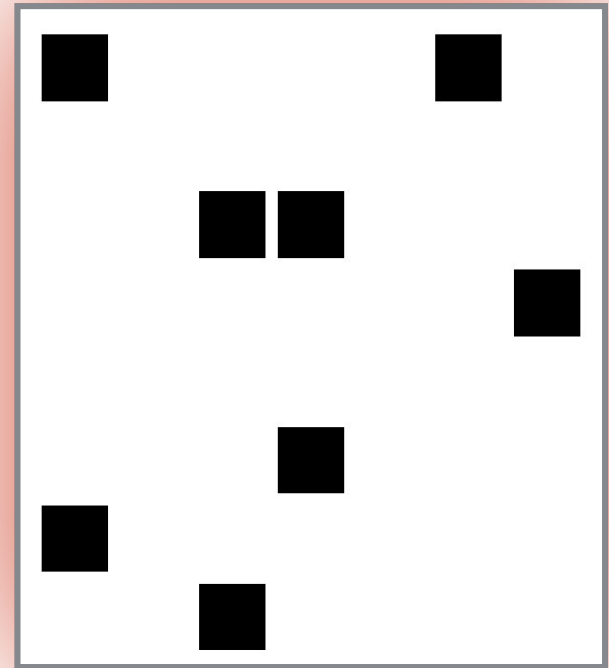




All content & select interesting



VS



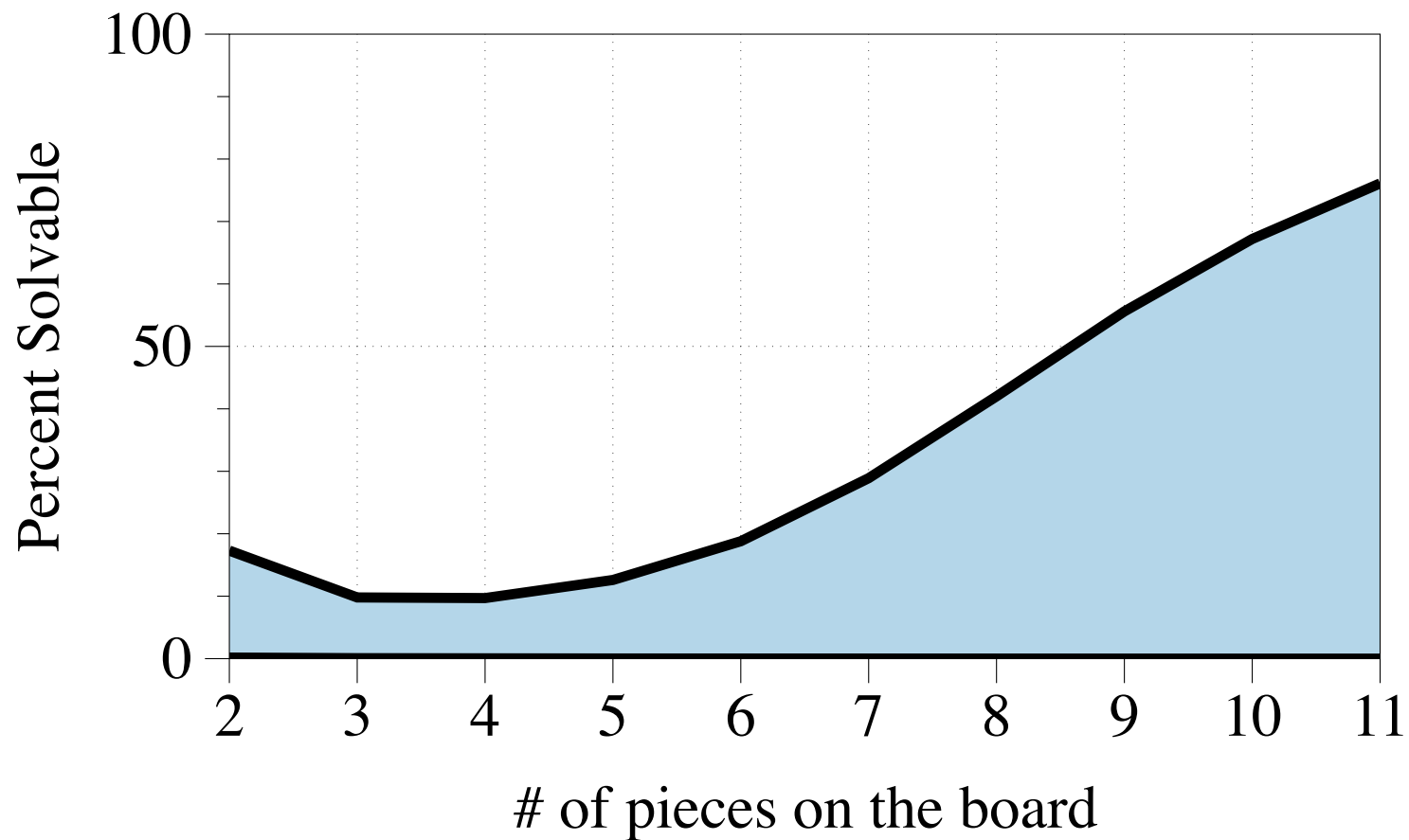


One more step towards Shigi

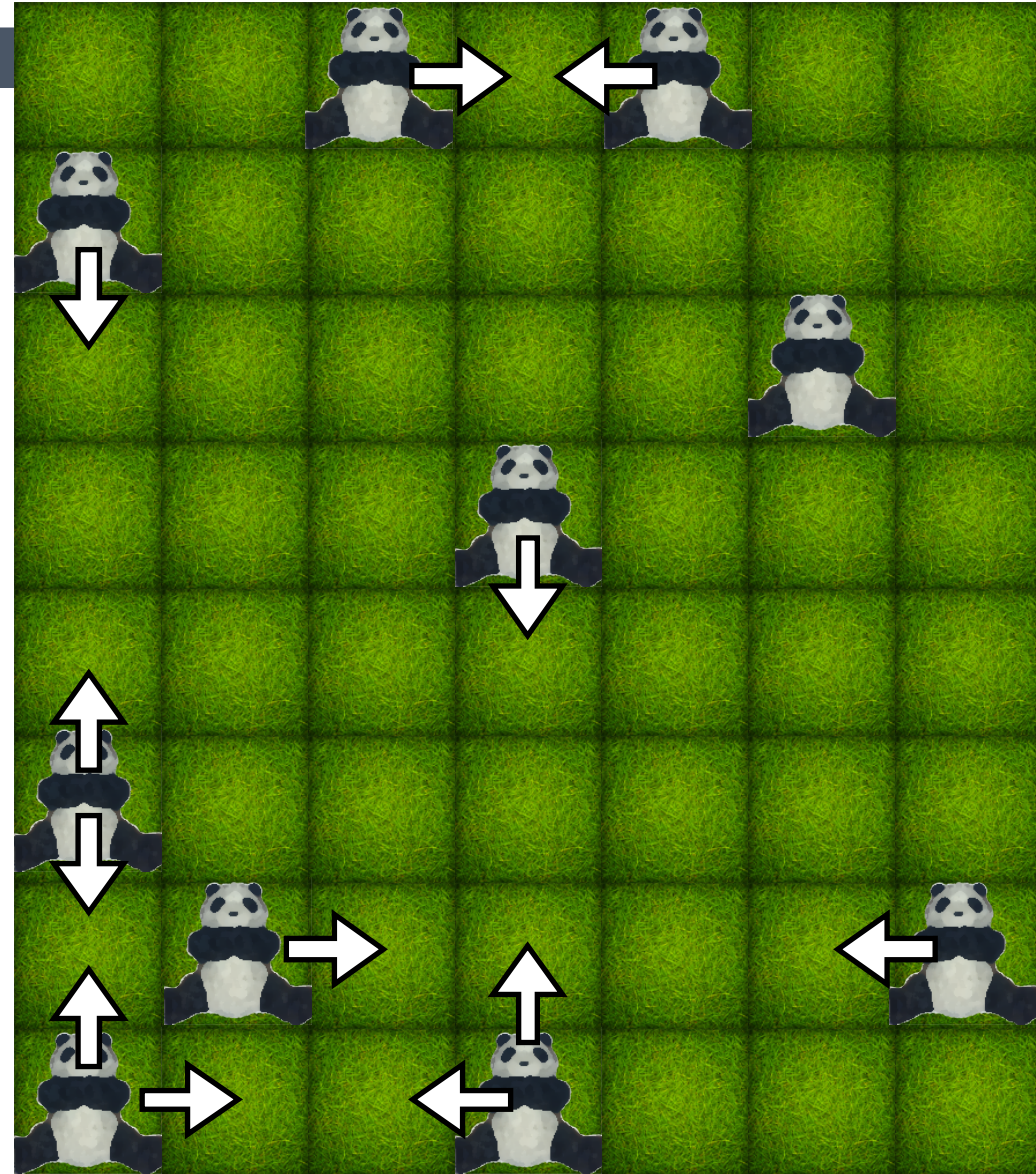
- Paul Tozour - 2013 AI Summit
 - Hypothetical design agent
 - Wind tunnel for game design
- Use our data for this purpose



What % of levels are solvable?

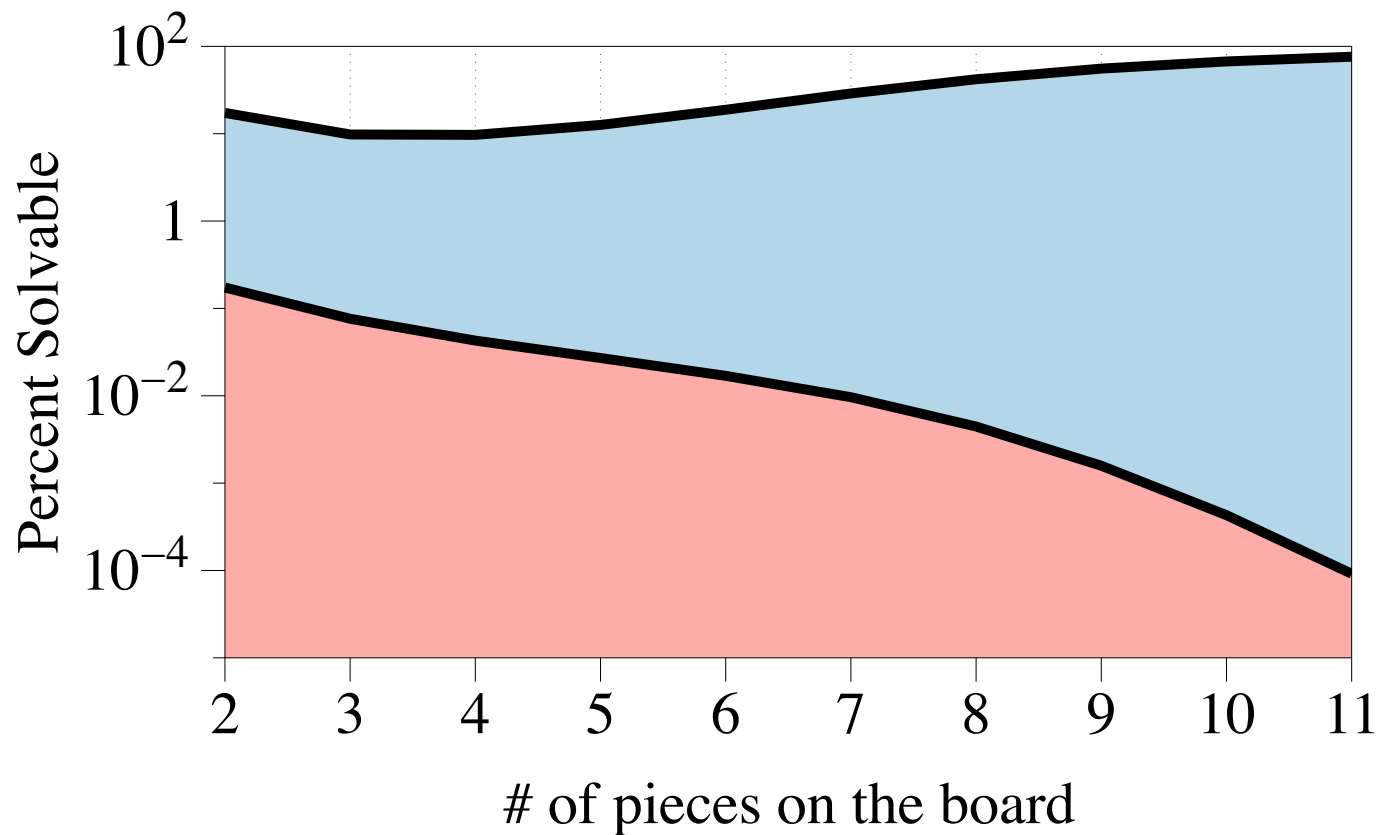


In a random level, what moves lead to a solution?





What if we constrain to a single sol'n?



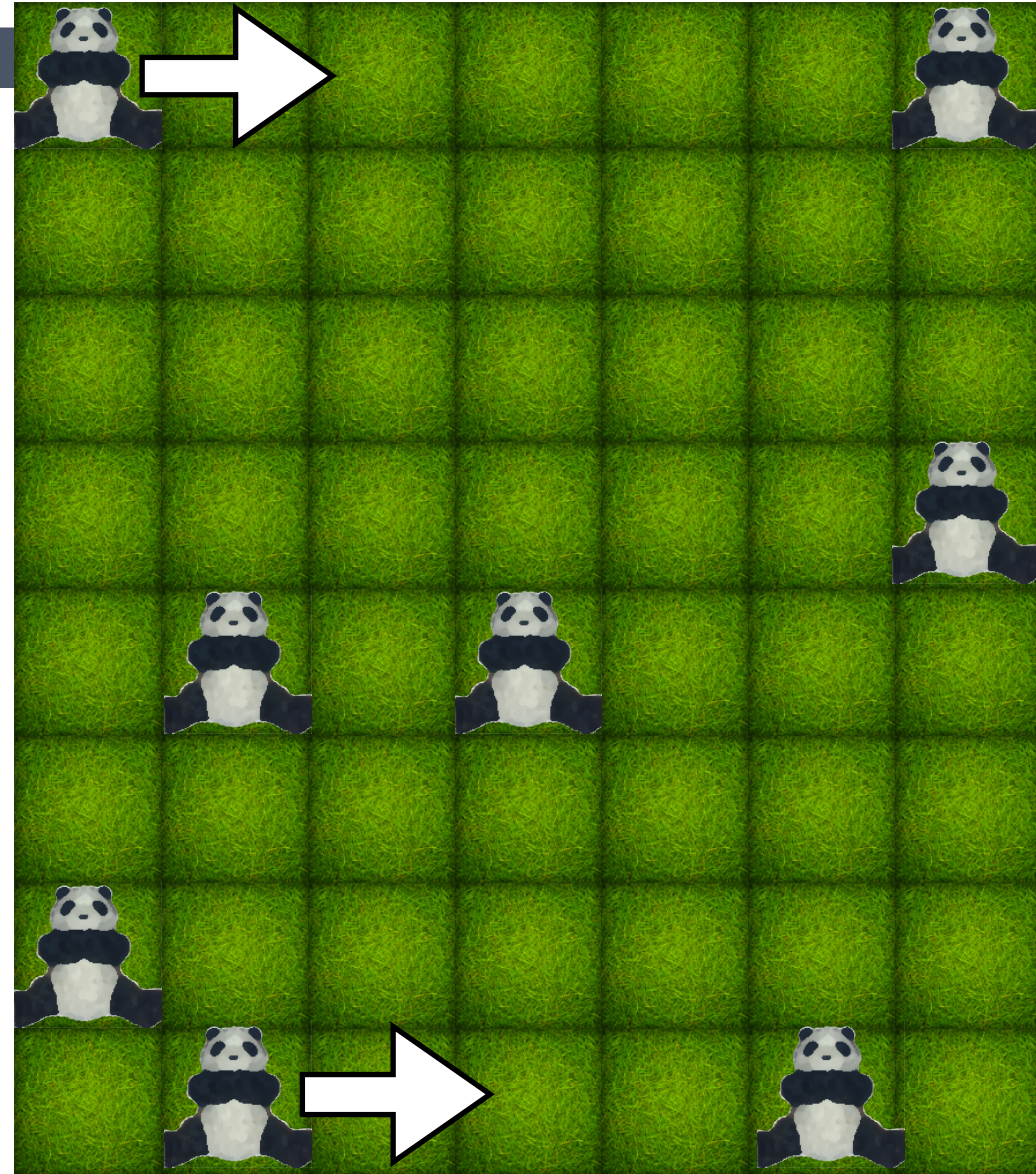


How many solvable levels with 5 pieces?

- 28,374
- How many of these are unique?
 - 17

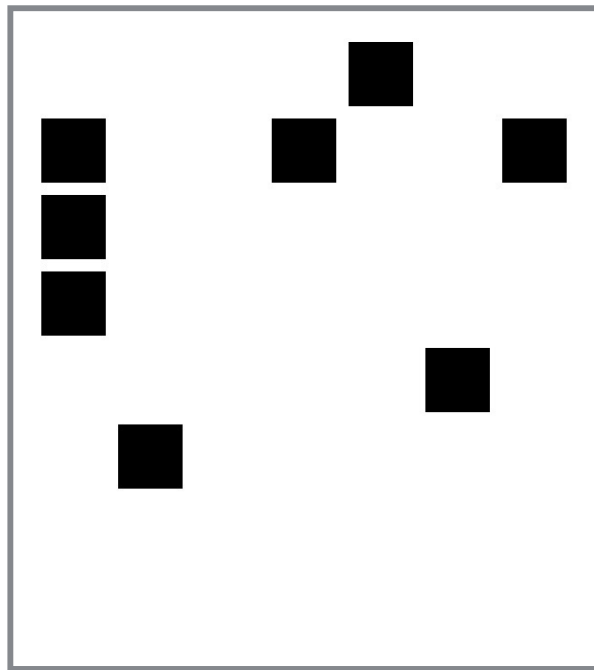
Result of
constraints:

Room for
expertise



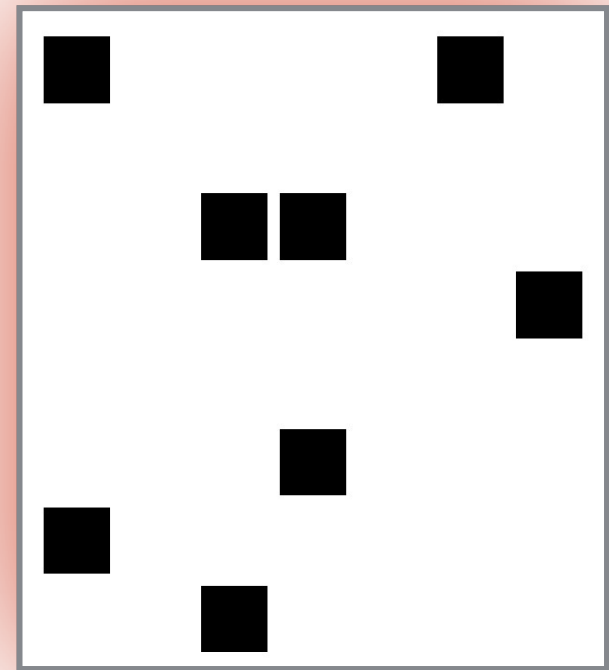


Measure Naive vs. Informed Actions



1.0

VS

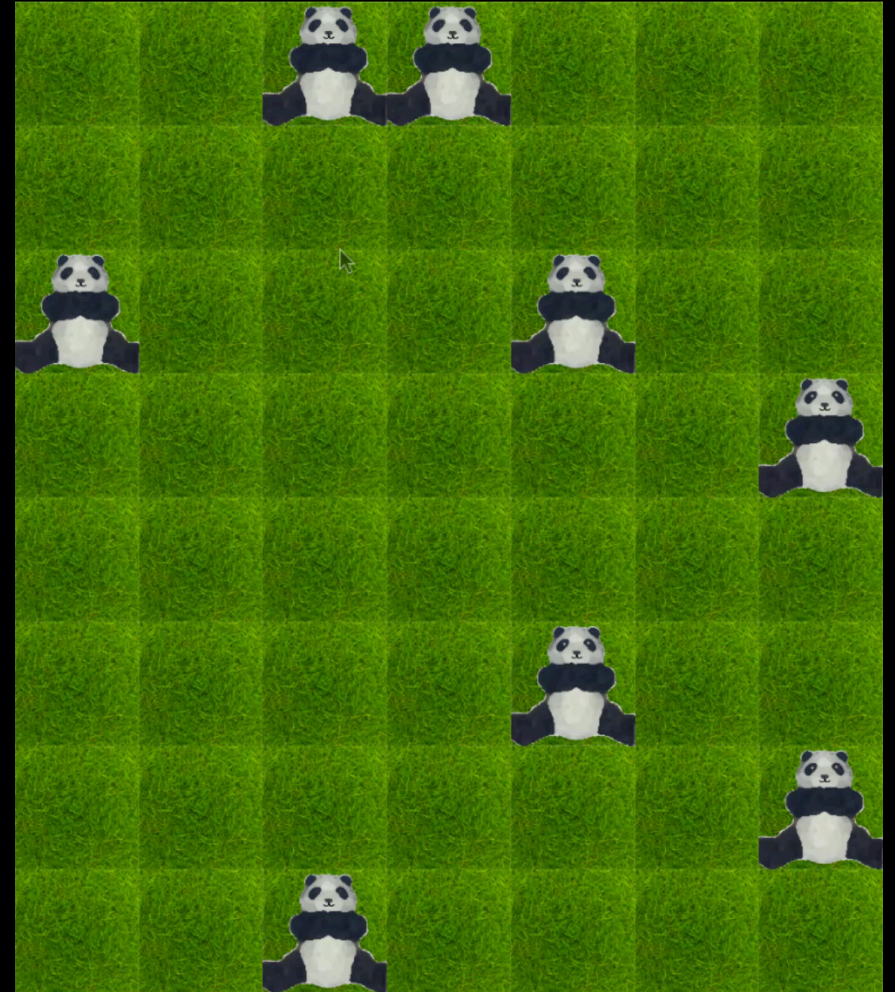


4.9

Moves Same Panda



Moves Different Panda



Panda Push - Object Puzzle

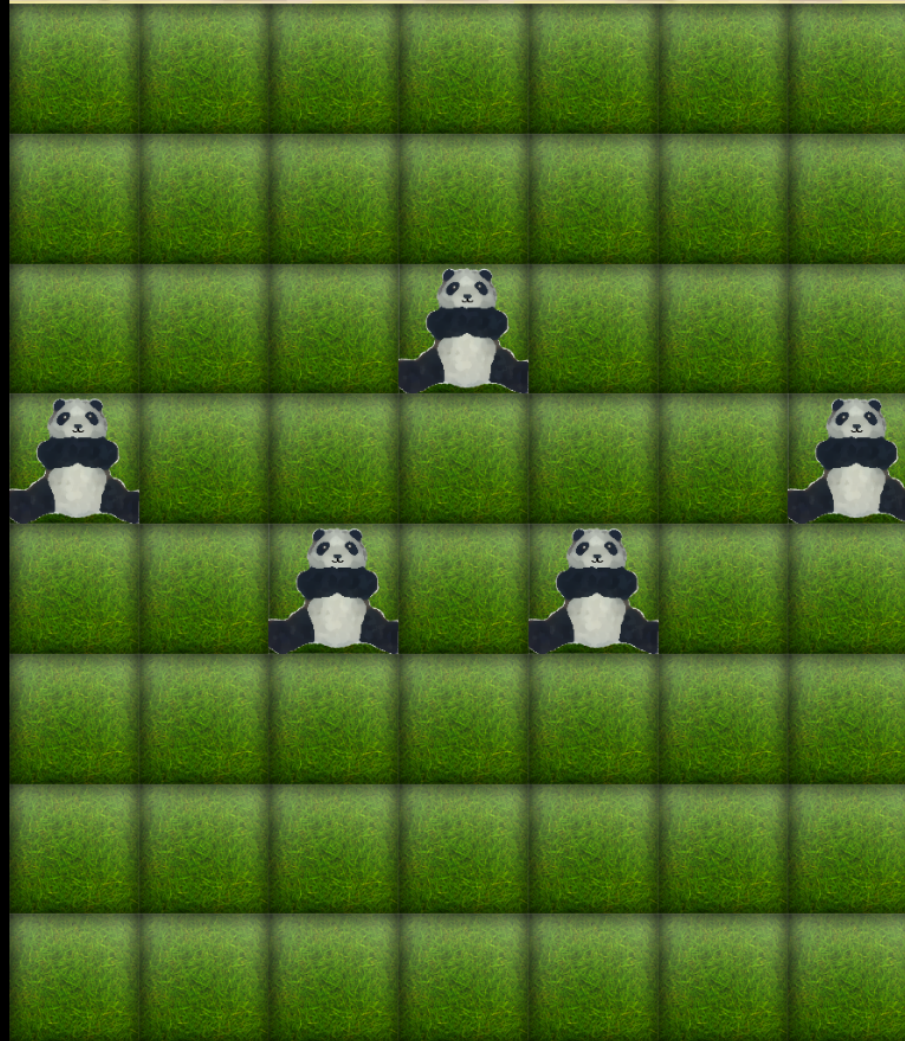
All Moves
Solution

Level
Set

Pack: 4 Level: 6

00:04

[Back](#)



Undo

Panda Push - Object Puzzle

All Moves
Solution

Level
Set

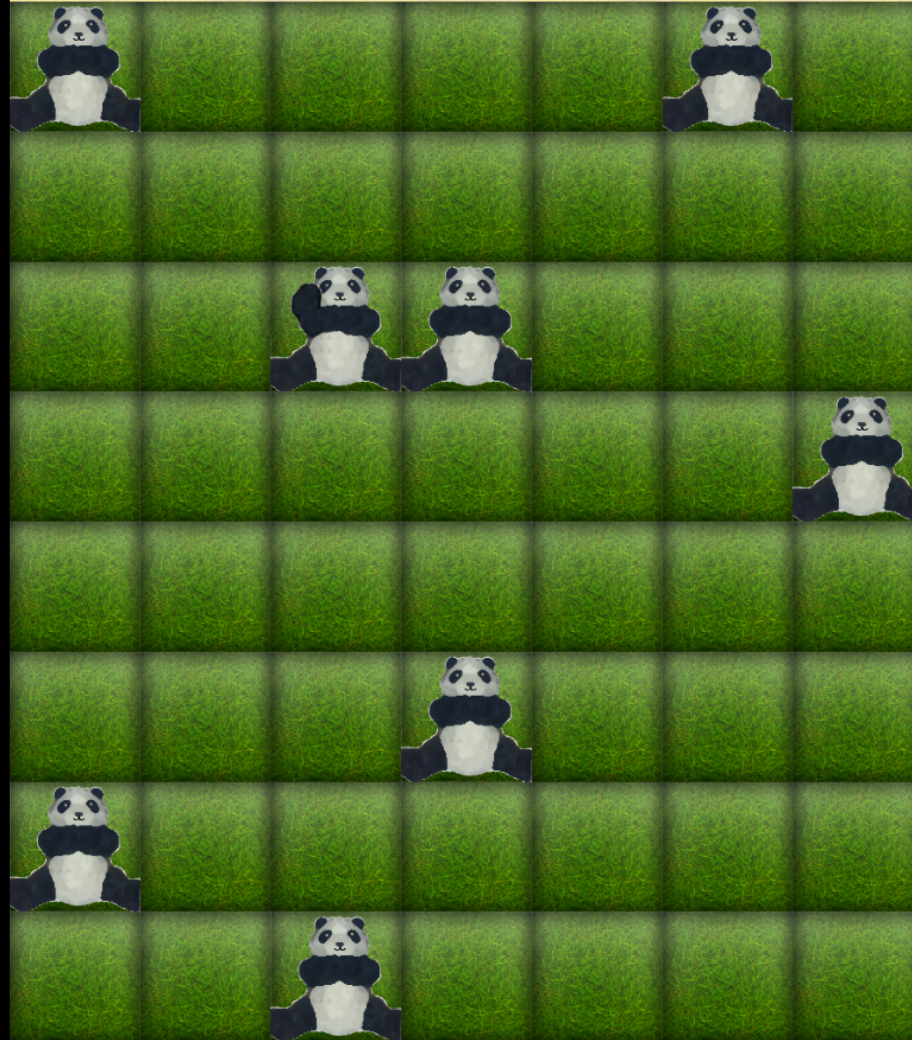
Single Solution

Level
Set

Pack: 8 Level: 1

00:04

[Back](#)



Undo

Panda Push - Object Puzzle

All Moves
Solution

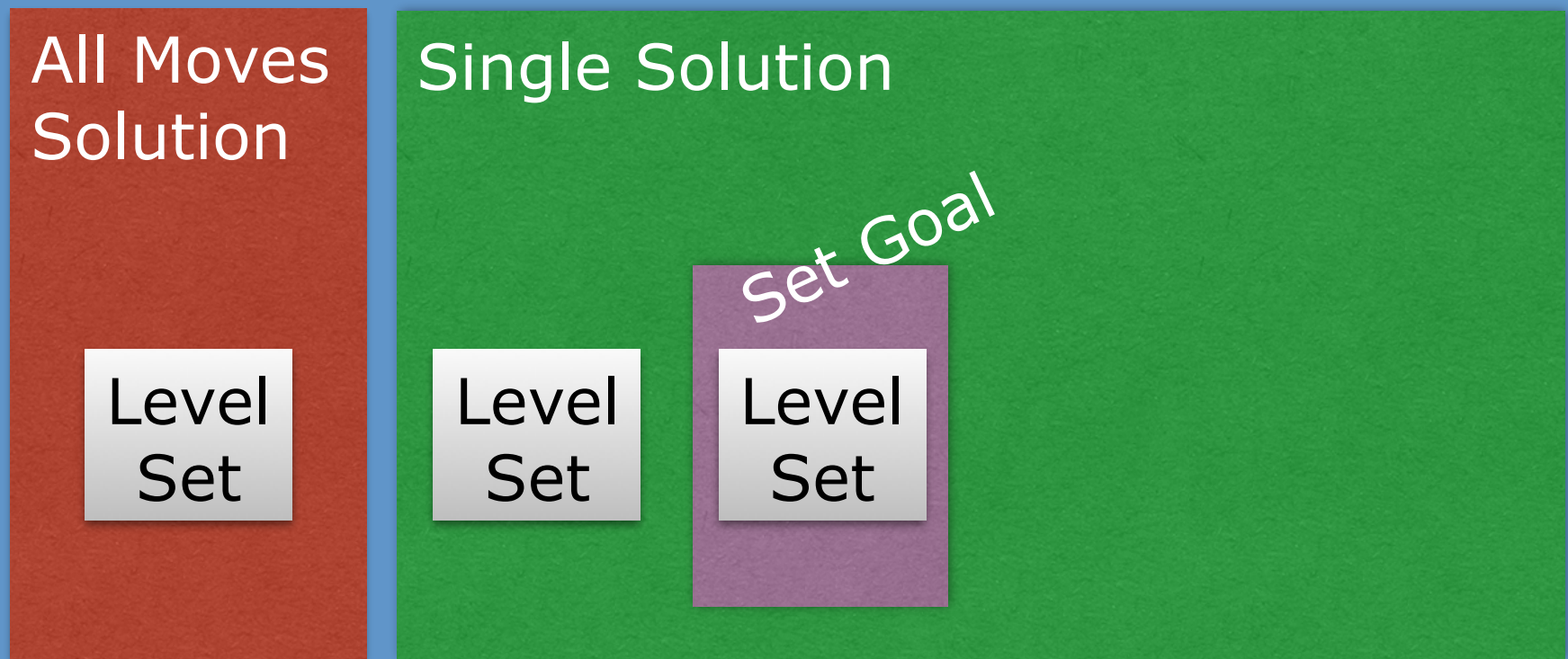
Level
Set

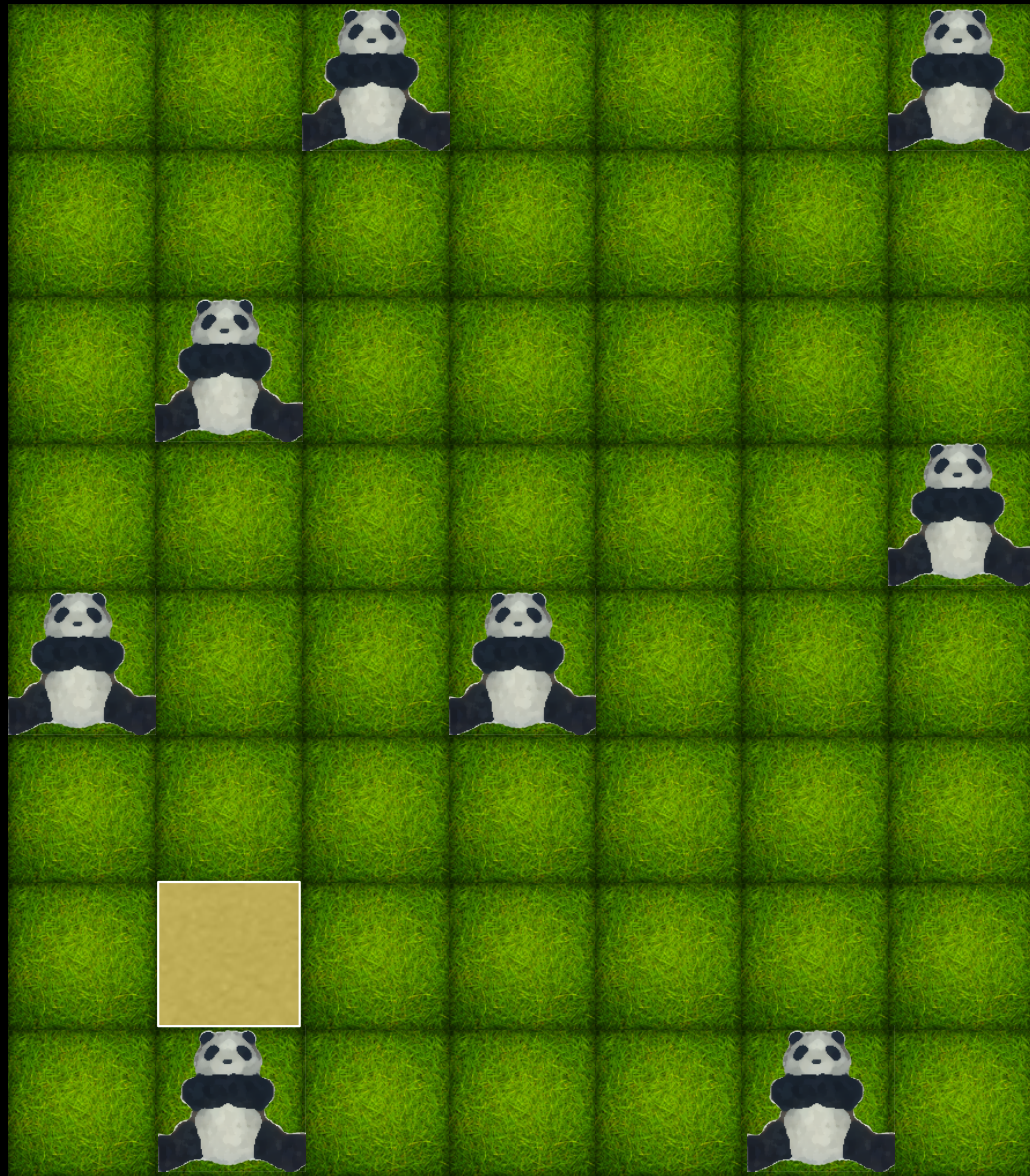
Single Solution

Level
Set

Set Goal

Level
Set





Panda Push - Object Puzzle

All Moves
Solution

Level
Set

Single Solution

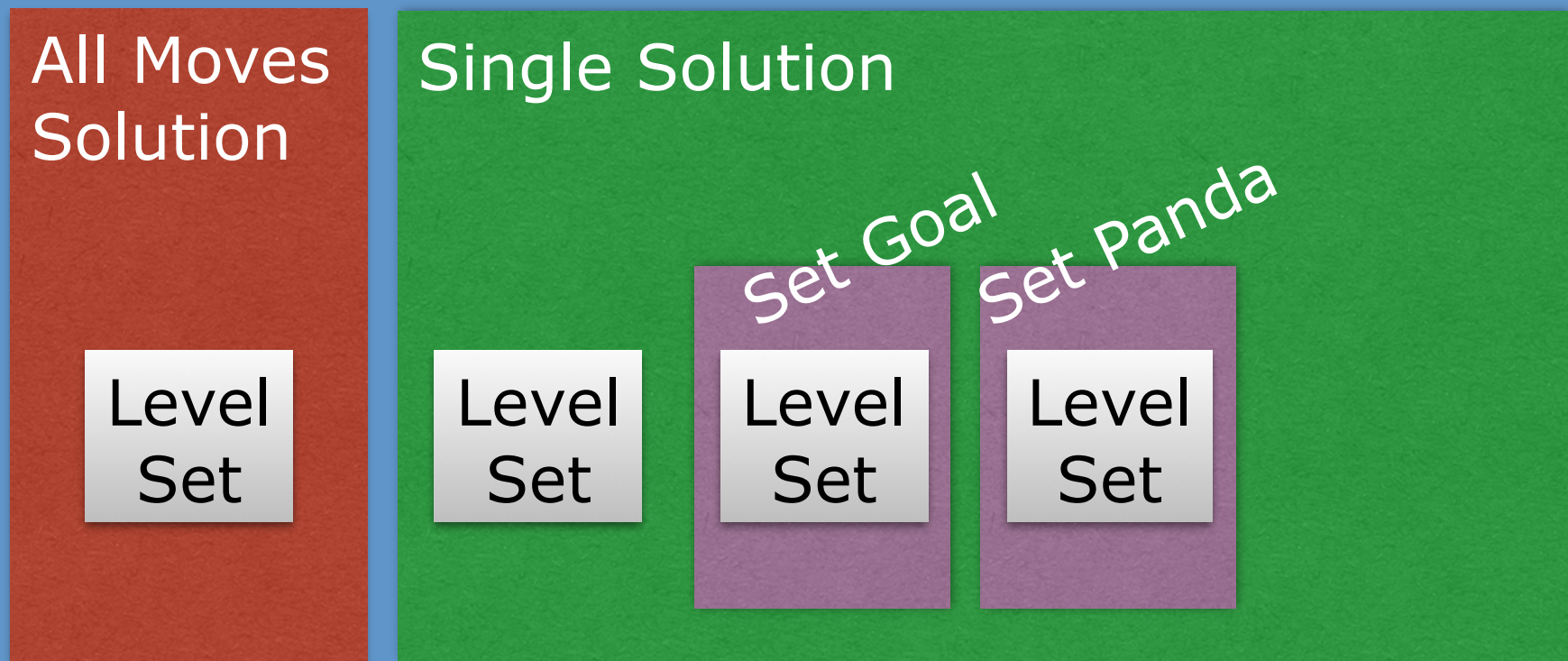
Level
Set

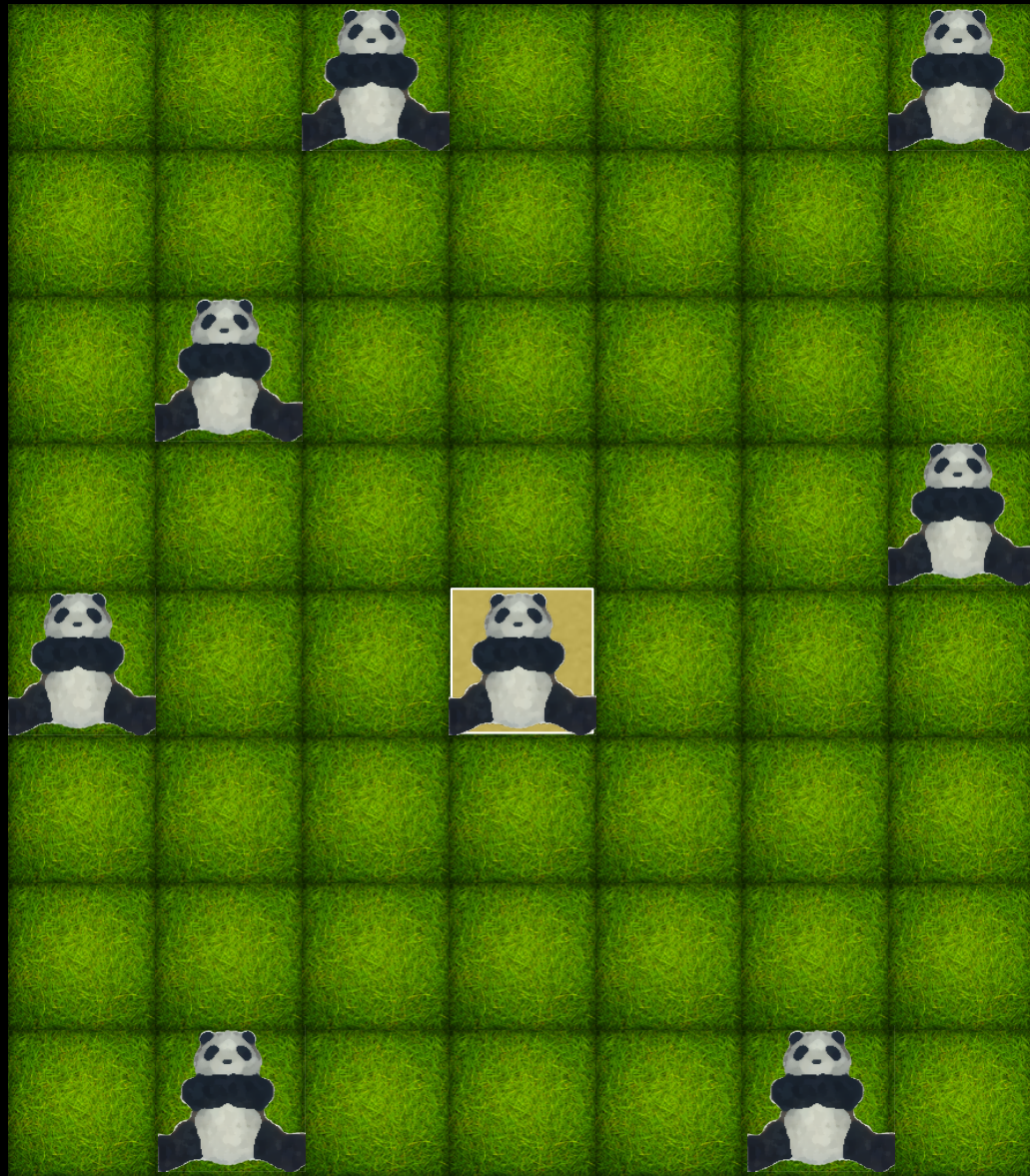
Set Goal

Level
Set

Set Panda

Level
Set





Panda Push - Object Puzzle

All Moves
Solution

Level
Set

Single Solution

Level
Set

Set Goal

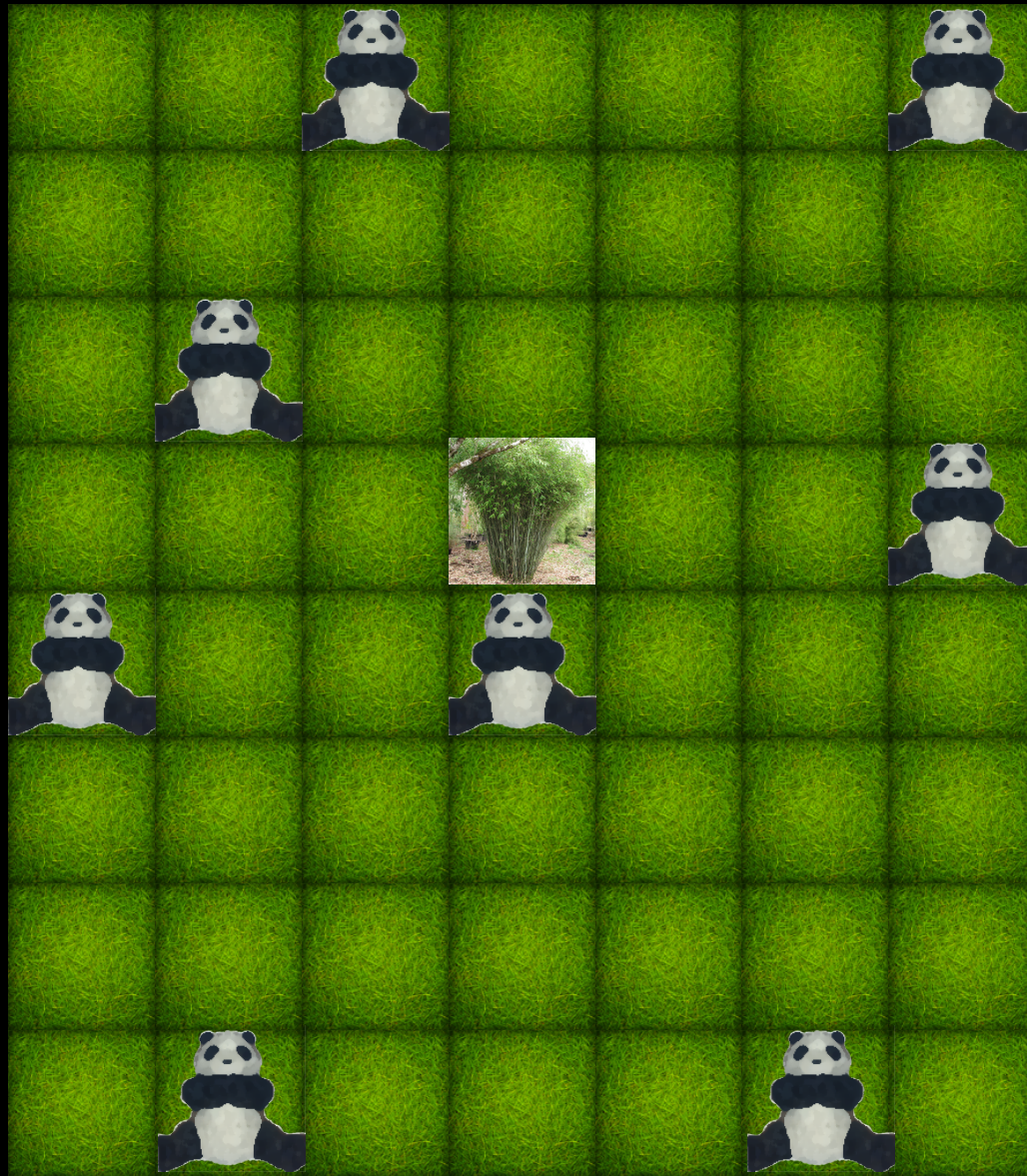
Level
Set

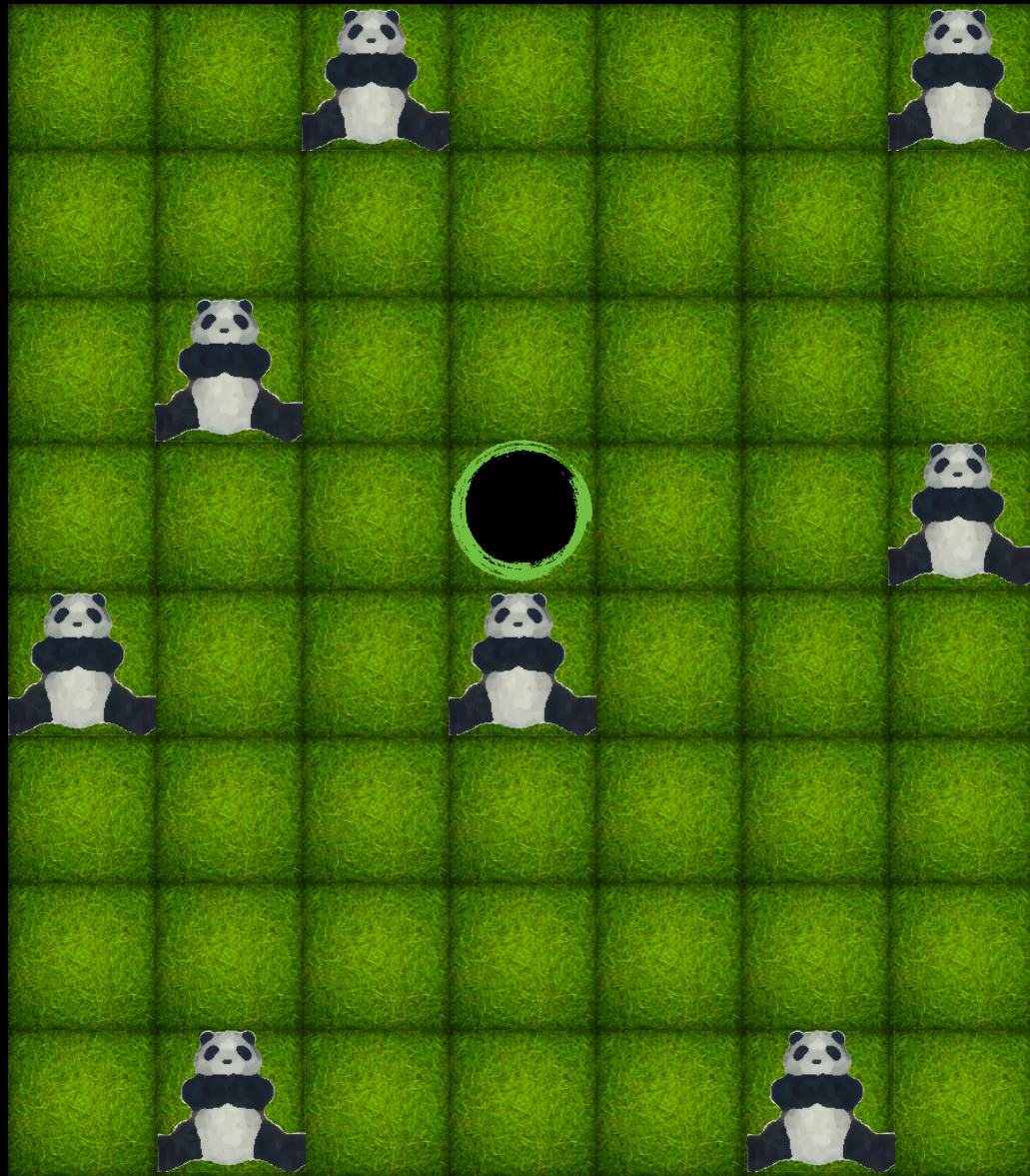
Set Panda

Level
Set

Obstacles

Level
Set







Key Idea:

Generate & Filter All Content



Key Idea:

Select Content to Reward Mastery



Key Idea:

Layer Constraints to Increase Depth



Key Idea:

Repeat the Process with New
Mechanics to Create Breadth
[Mechanic = new constraint]



Final Charge:

Use PCG to amplify your efforts.
Go make great games!