Punch Out Model Synthesis

A Stochastic Algorithm for Constraint Based Tiling Generation

---

Zzyv Zzyzek

November 19th, 2024

Introduction

Punch Out Model Synthesis (*POMS*) A Constraint Based Tiling Generation (*CBTG*) algorithm:

- Works on large grids
- Minimal setup requirements
- Resilience to contradiction

Introduction

Pill Mortal Tile Set

Introduction

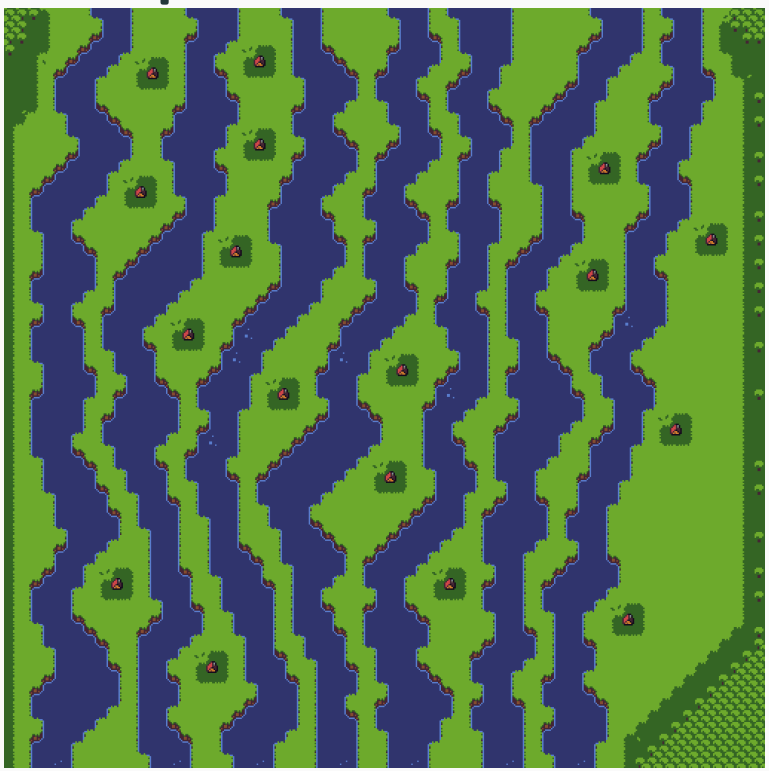
Constraint Based Tiling Generation (*CBTG*) Problem

Find a valid grid realization

A *realization* is a single *tile* placement at each *cell* respecting *constraints*.

(*Cell* can hold up to *D tiles*)

Example



Introduction

A region is *Arc Consistent* if all *tiles* in every *cell* within the region have at least one valid neighbor in each direction

The basis for a *Constraint Propagation* algorithm can be made by removing tiles without a valid neighbor

Block Level Solver: completely maintains *Arc Consistency*

Grid Level Solver: only keep minimal information for the entire grid but work on *block* sub-regions

Related Work

	WFC	*BMS*	*MMS*	*POMS*
Solver Type	Block	Block	Grid	**Grid**
Contradiction Resilience	No	Yes	Yes	**Yes**
Block Step Consistent	n/a	n/a	Yes	**No**
Indeterminate Initial State	Yes	Yes	No	**Yes**
Ergodic	Yes	Yes	No	**Yes**

WFC: Wave Function Collapse (Gumin)

BMS: Breakout Model Synthesis (Hoetzlein)

MMS: Modify in Blocks Model Synthesis (Merrell)

Related Work

Tile Arc Consistent Correlation Length (*TACCL*) (Hoetzlein)

How much influence does a tile choice have over long distances?

TACCL as a heuristic to estimate correlation length

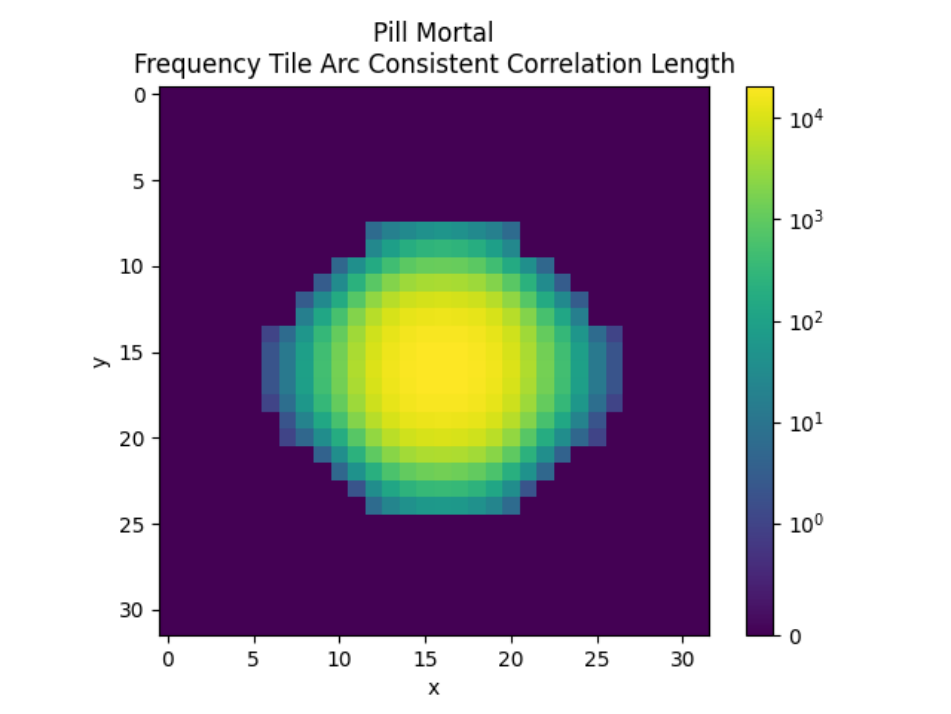
Tile Arc Consistent Correlation Length (TACCL)

TACCL

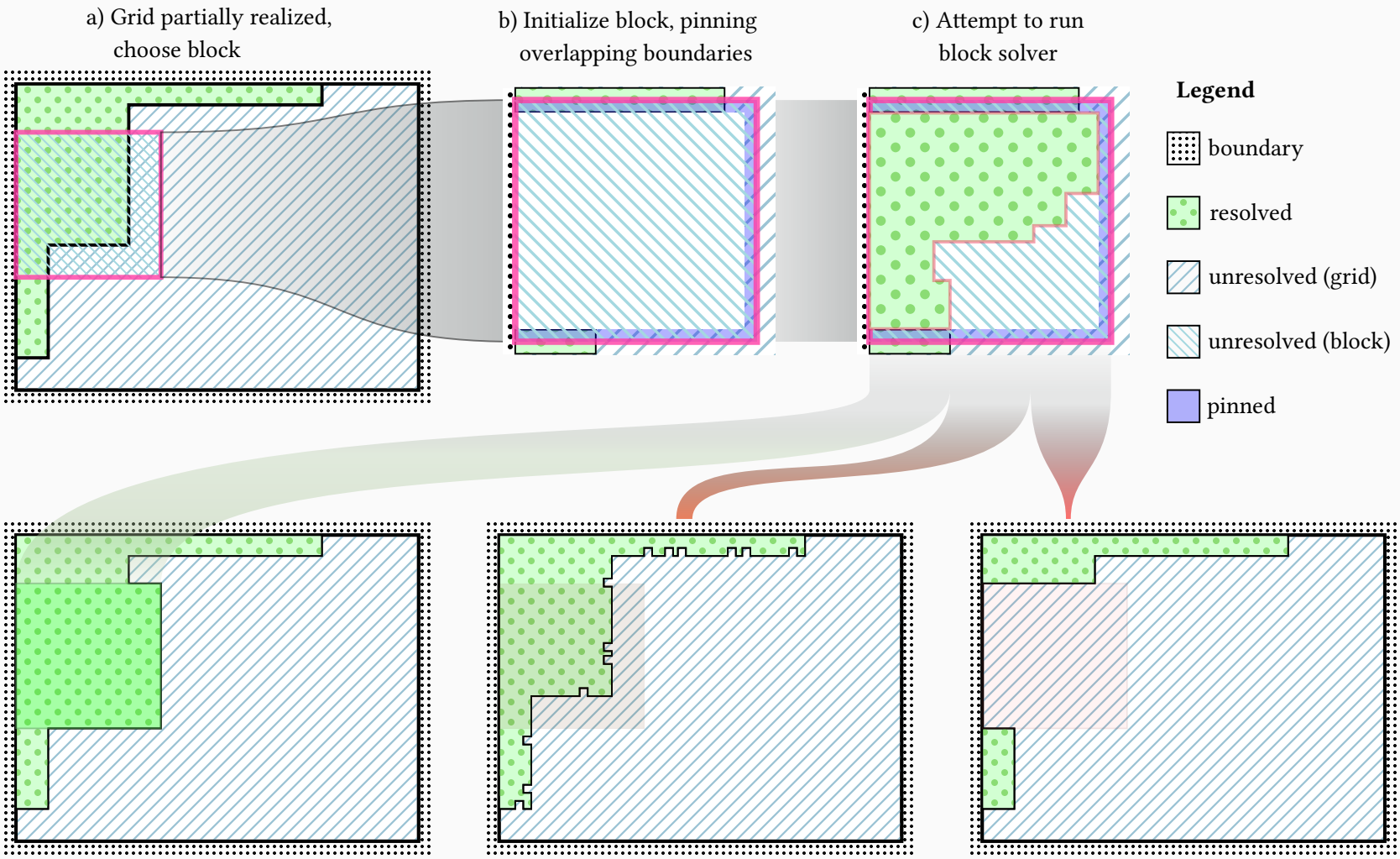
Take block in isolation

- Set block to indeterminate state
- Fix a tile at the center
- Propagate constraints
- Take minimum bounding box of altered cells
- Repeat for all tiles

Example



Algorithm: Overview



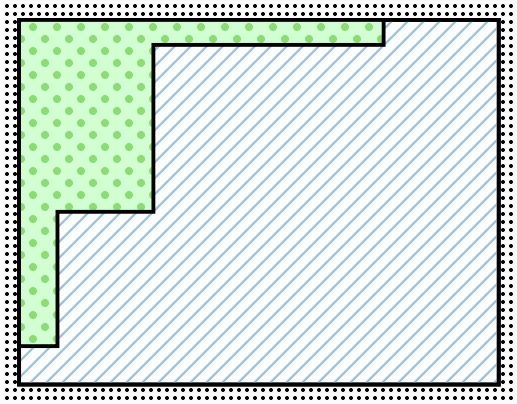
d) Success
incorporate resolved block into grid

e) Resolution failure,
restore block and erode resolved area boundaries

f) Setup failure,
revert block area in grid to unresolved

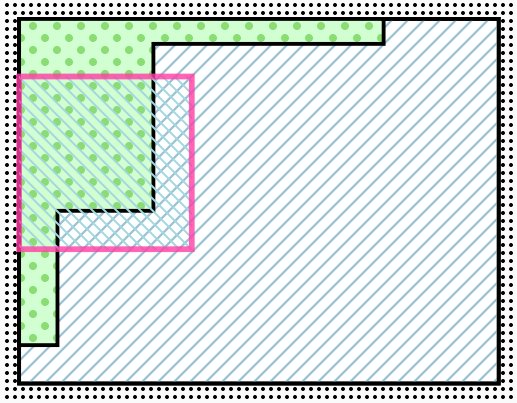
Algorithm

Grid partially realized

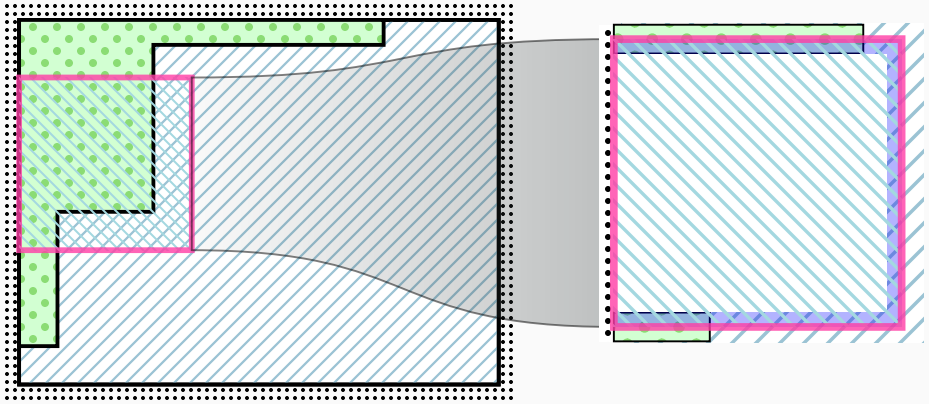


Algorithm

Choose block



Algorithm

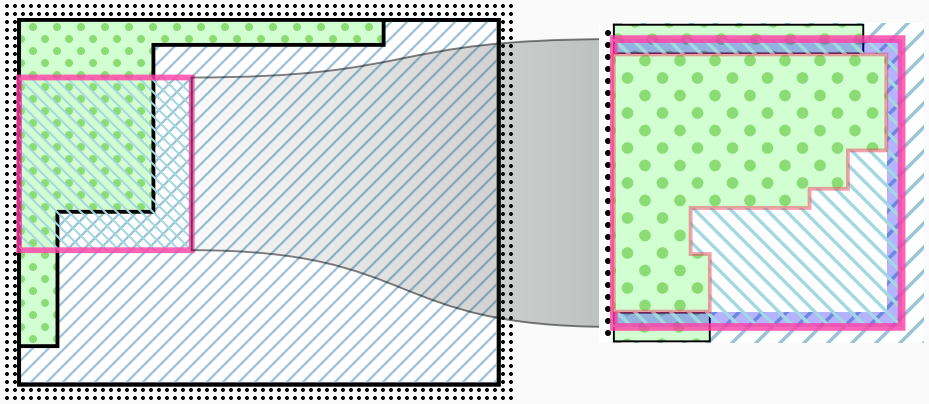


Initialize block

- Pin boundaries
- Revert interior

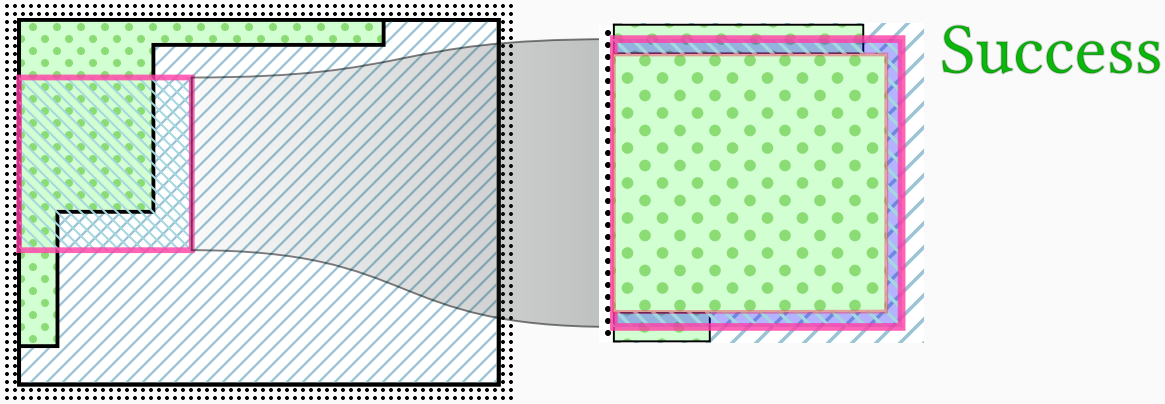
(Apply any restrictions)

Algorithm

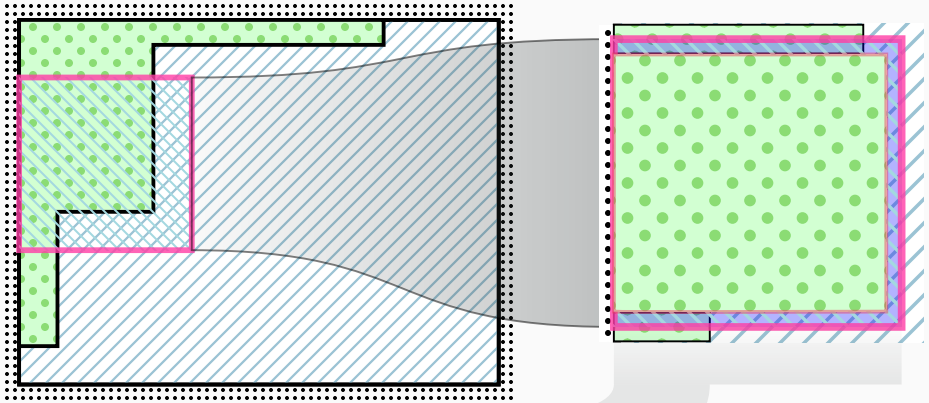


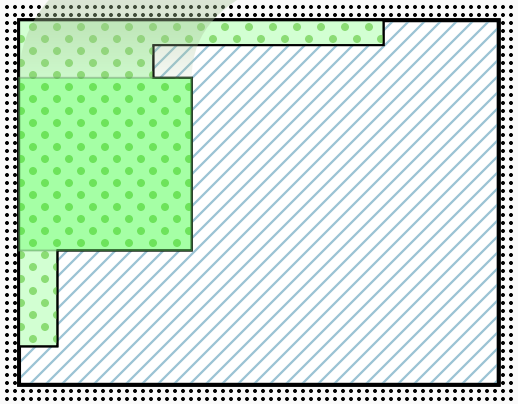
Attempt to solve

Algorithm



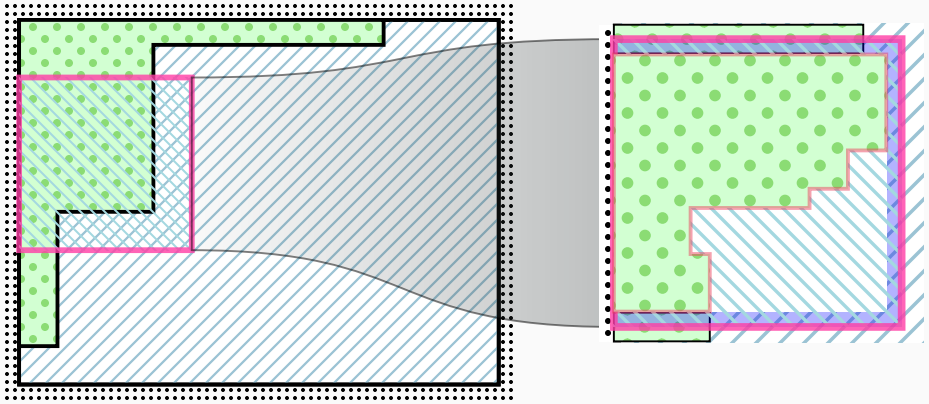
Algorithm





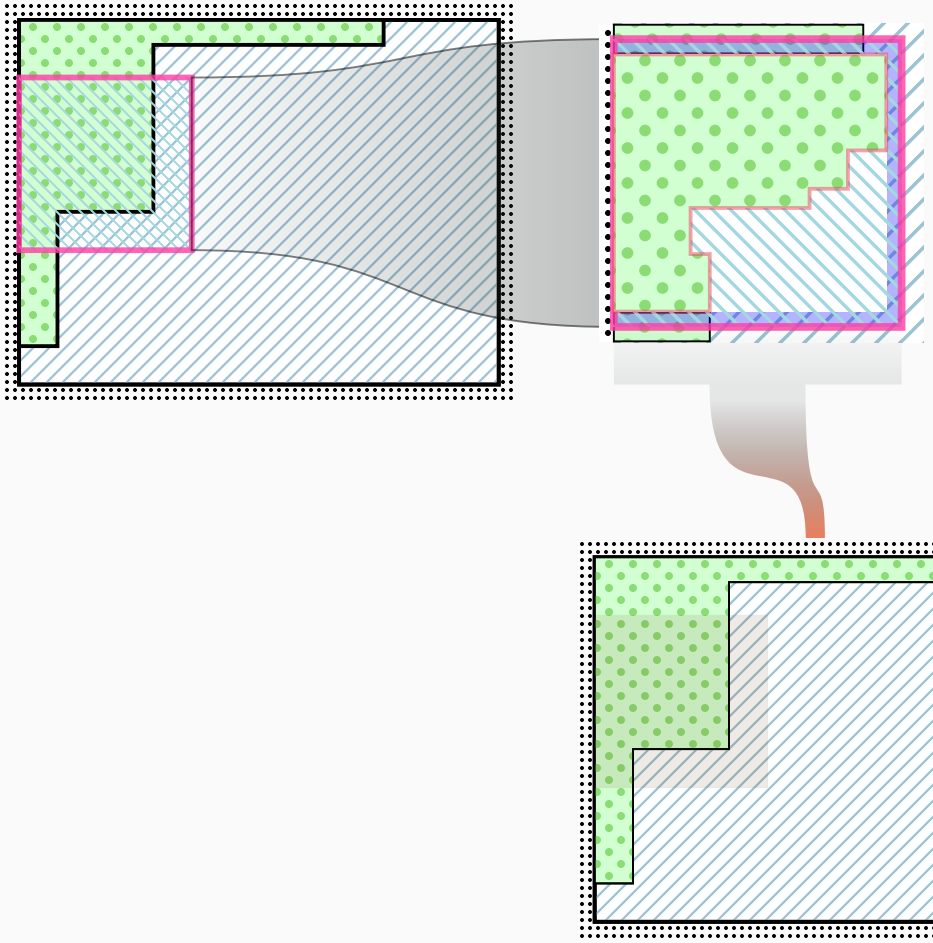
Incorporate resolved block into grid

Algorithm



Resolution failure

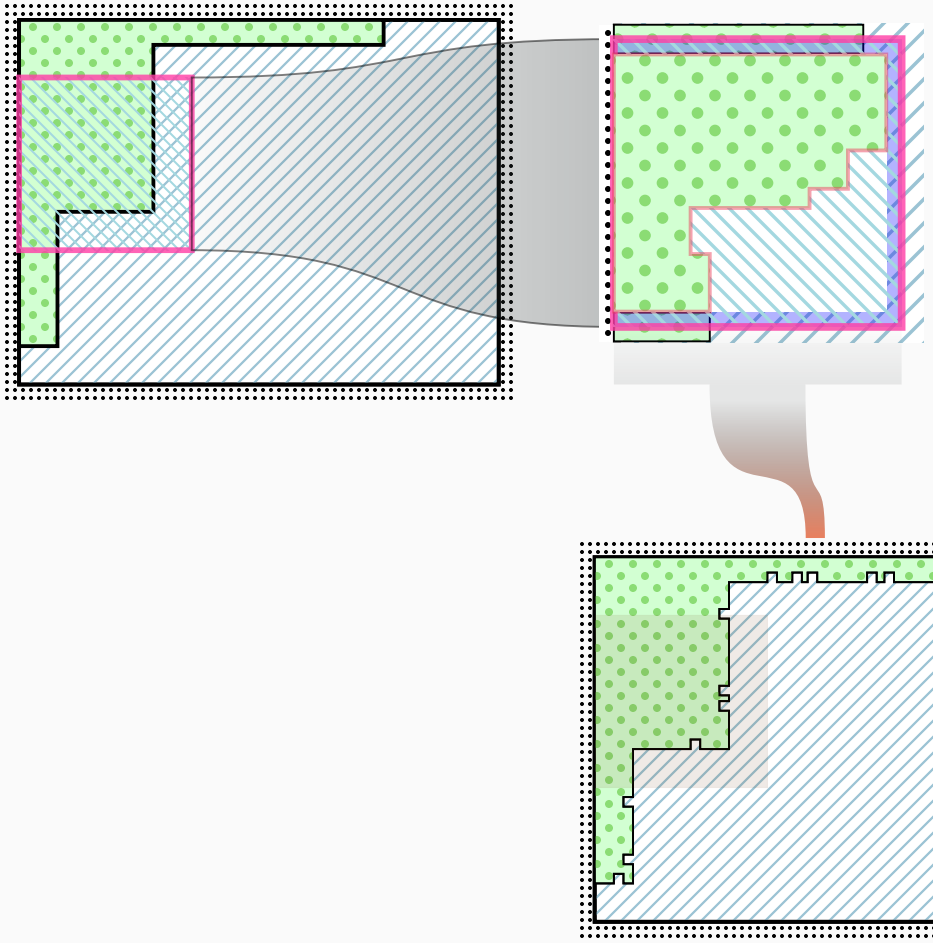
Algorithm



Resolution failure

Restore block

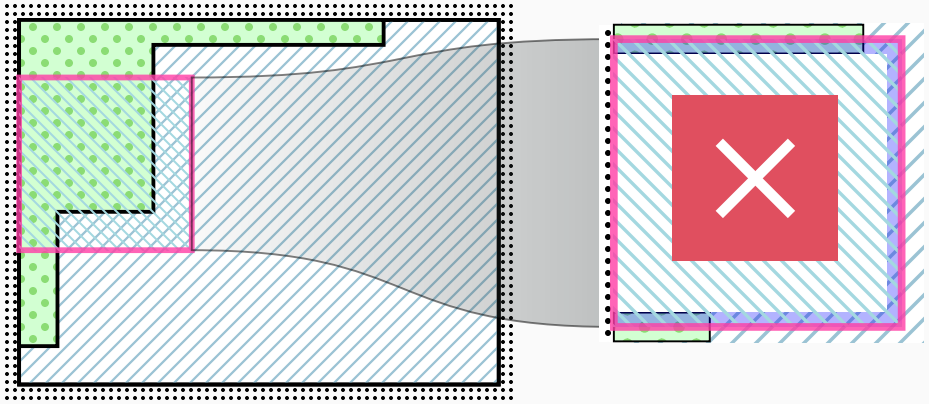
Algorithm



Resolution failure

Restore block
Erode boundary

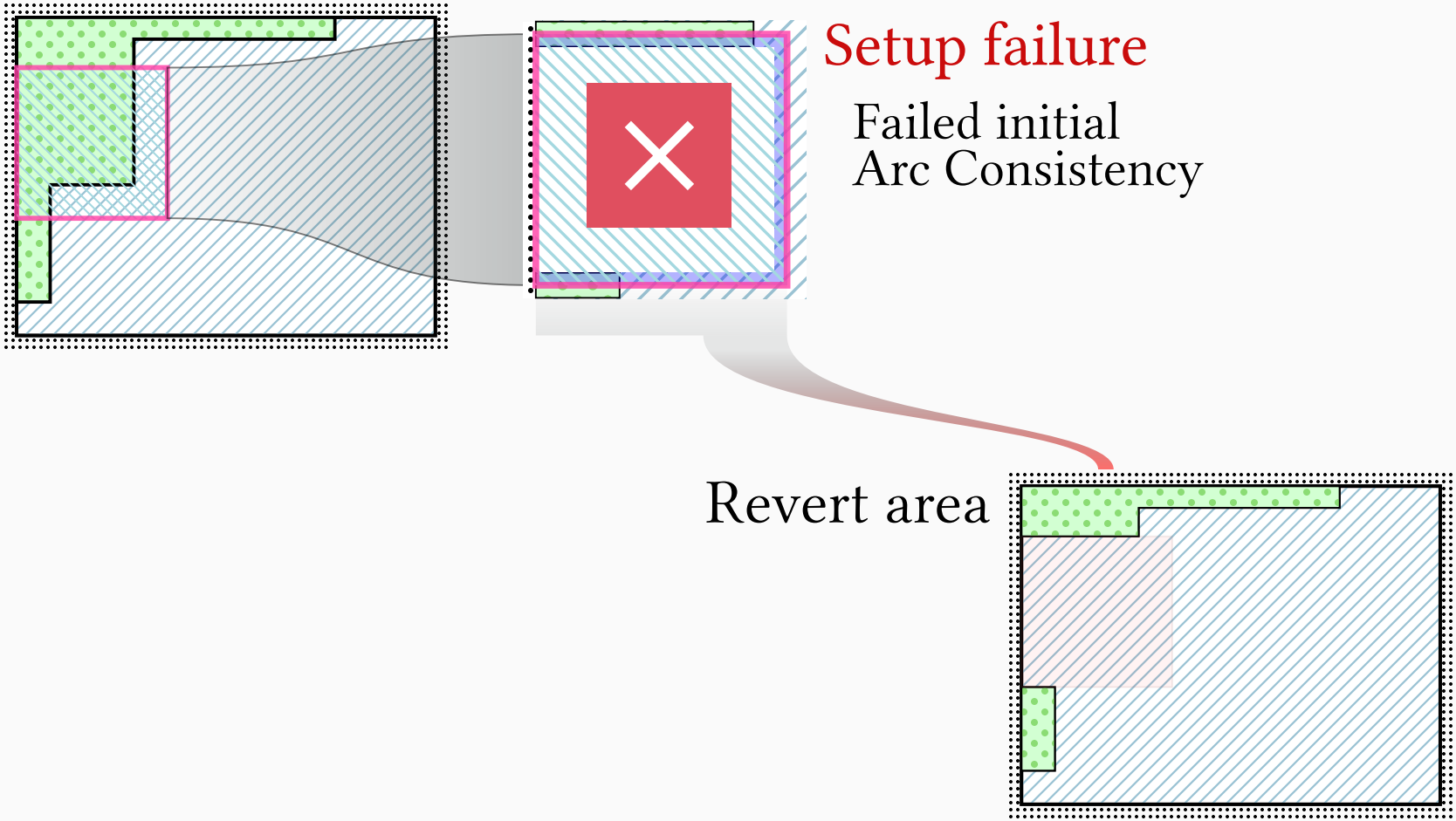
Algorithm



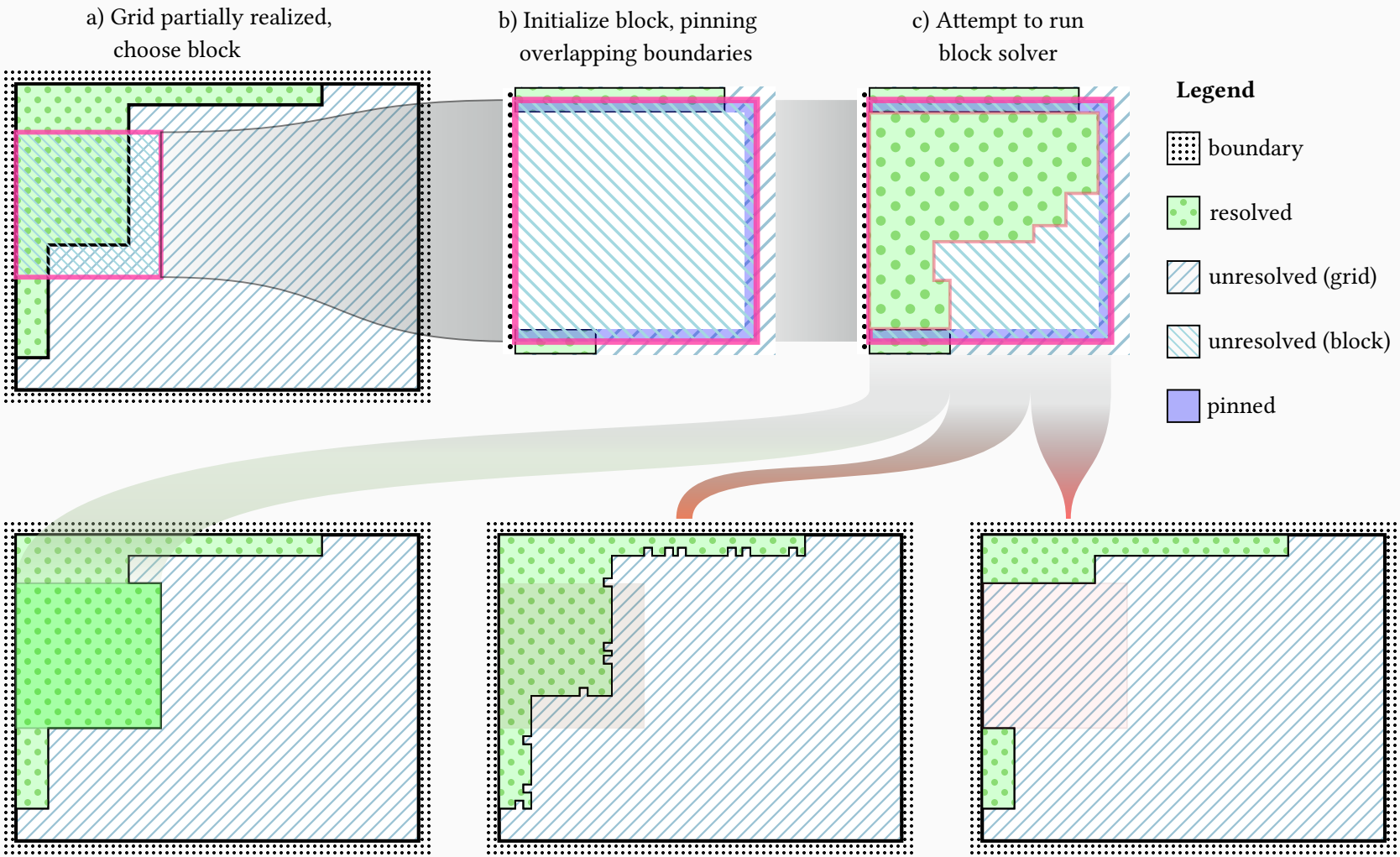
Setup failure

Failed initial
Arc Consistency

Algorithm



Algorithm



d) Success
incorporate resolved block into grid

e) Resolution failure,
restore block and erode resolved area boundaries

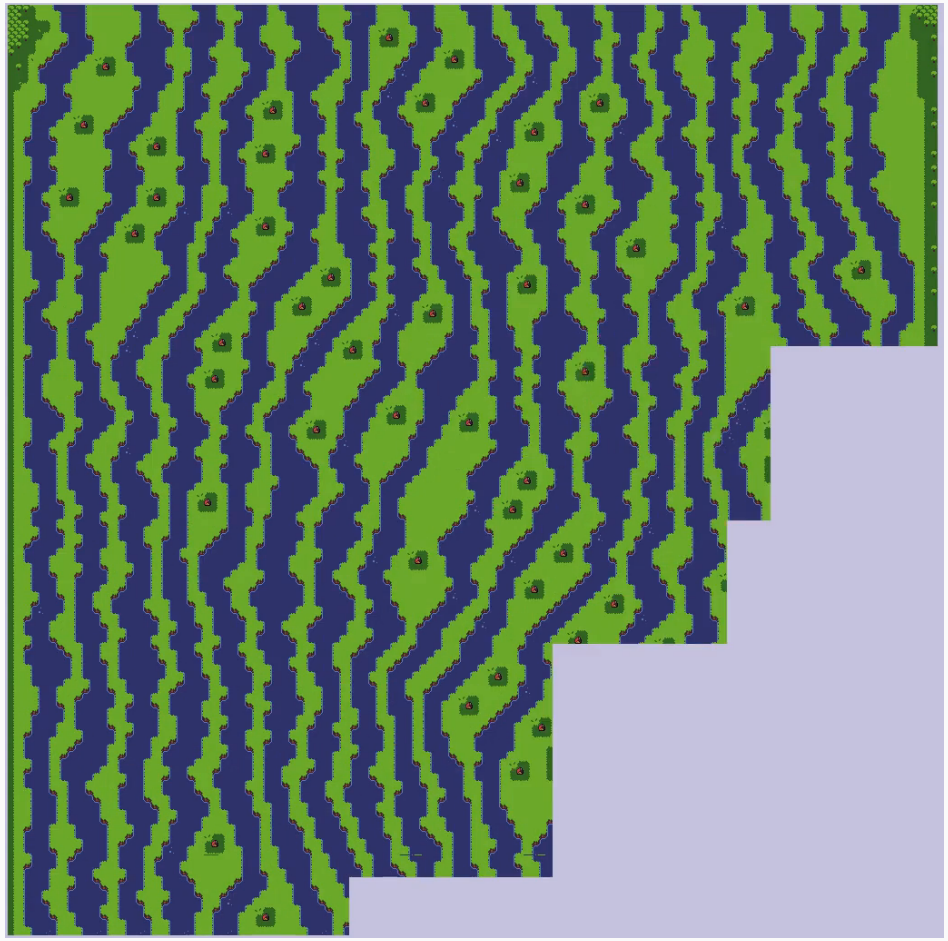
f) Setup failure,
revert block area in grid to unresolved

Algorithm

ThKaspar's *Forest Micro* Tile Set

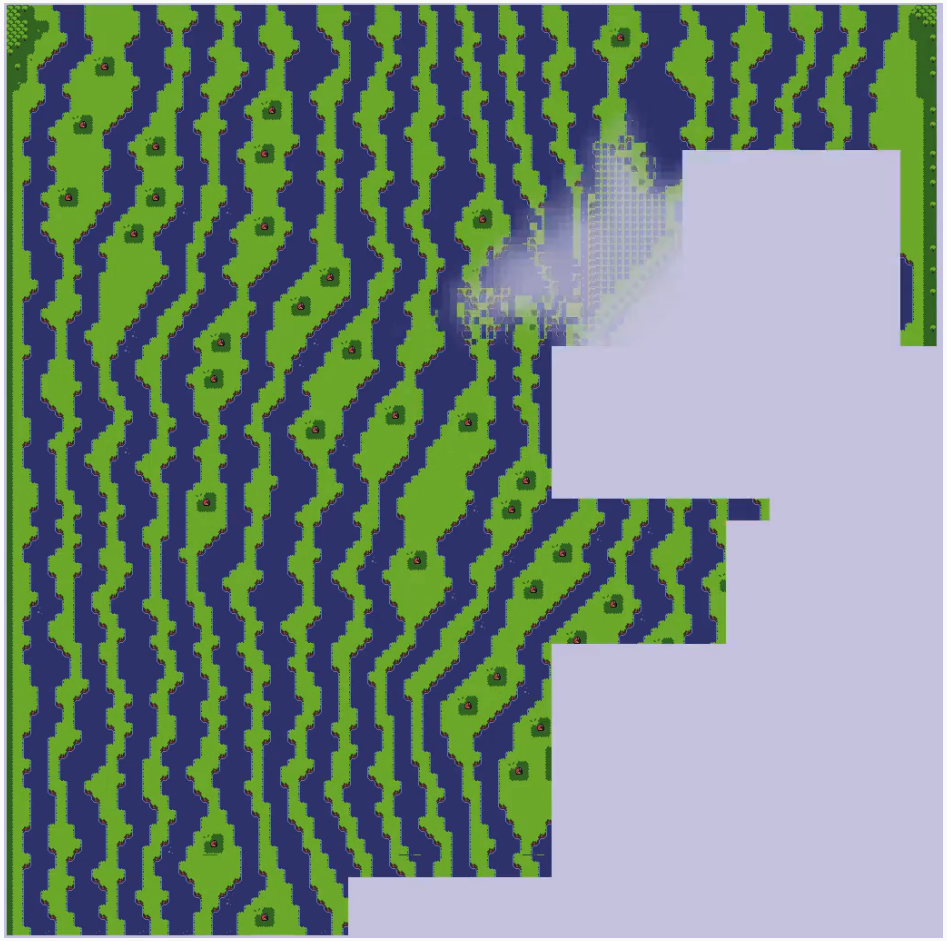
Algorithm

Revert Block



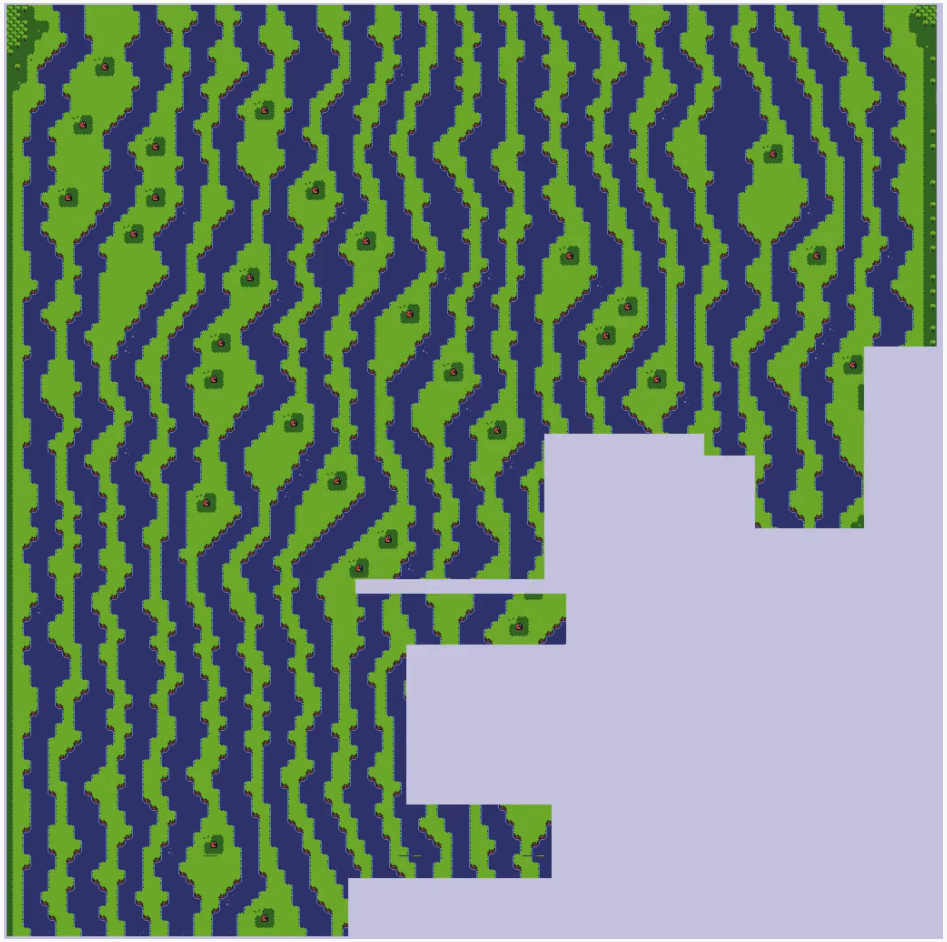
Algorithm

Revert Block



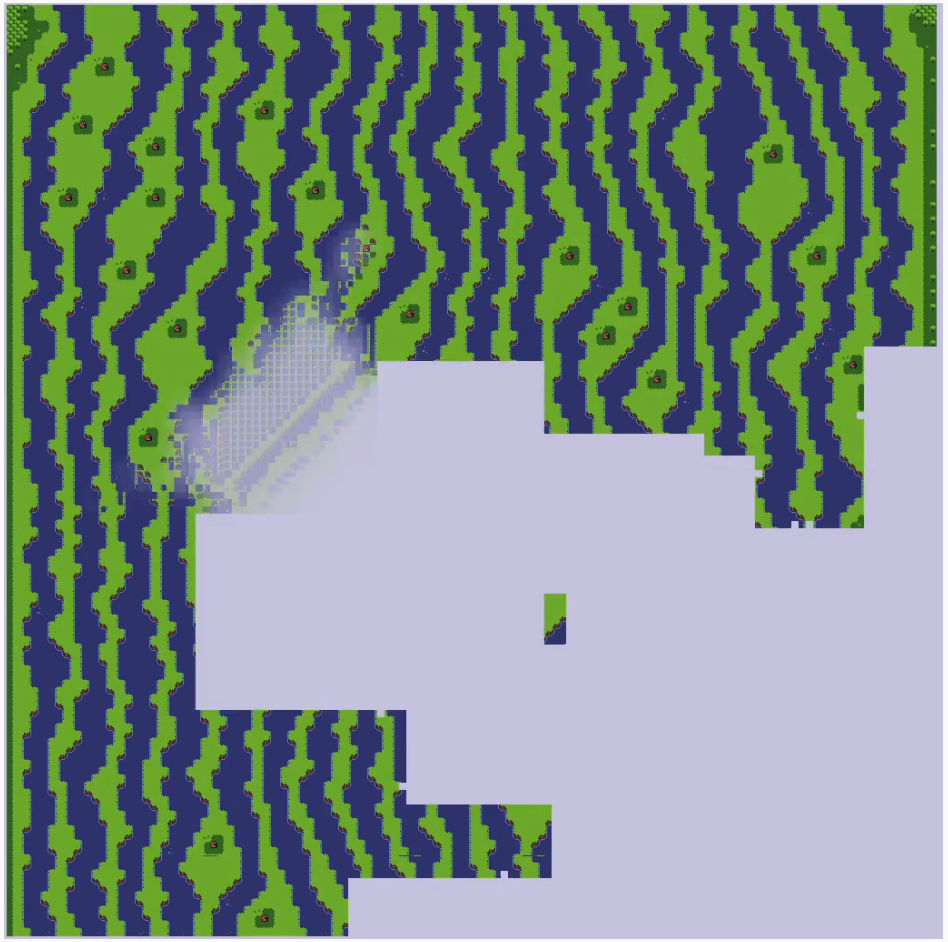
Algorithm

Erode Boundary



Algorithm

Erode Boundary



Algorithm

Pill Mortal Tile Set

Conclusion

Punch Out Model Synthesis (POMS) as an alternative when large models with minimal setup restrictions are wanted and resource limits are a concern.

Conclusion

CBTG algorithms are good at maintaining local consistency but are bad at resolving global constraints

Weak global constraints (path connections, etc.) confound POMS (and other CBTG algorithms)

fin

https://zzyzek.github.io

https://github.com/zzyzek/PunchOutModelSynthesis

https://zzyzek.github.io/PunchOutModelSynthesisWebDemo/

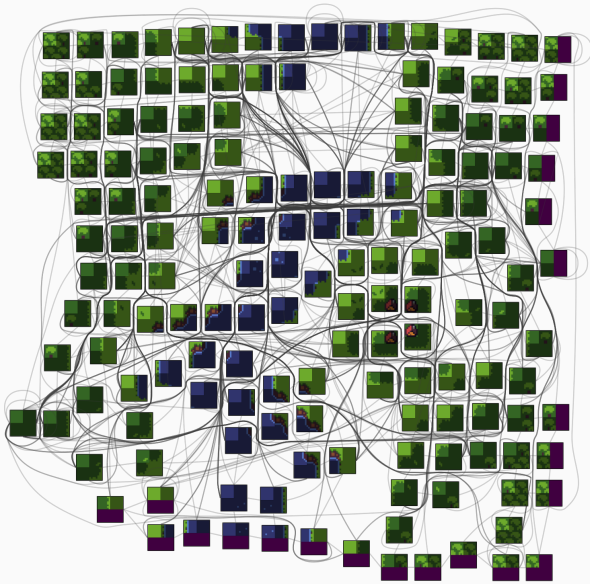
Thanks!

Auxiliary Slides

Automatic Tile Generation

`https://zzyzek.github.io/TileRuleHighlighter/`

Rule Graph (Forest Micro) **Rule Highlighter**



Highlighted Runs

LUNARSIGNAL's *Overhead Action RPG Overworld* Tile Set (x10)

Highlighted Runs

0x72's *Two Bit Micro Metroidvania* Tile Set (x10)

Highlighted Runs

Kingel's *Minirogue* Tile Set (x10)

Auxiliary Slides

- Bitter lesson includes learning *and* search
- Trade off between resources used to learn vs. resources used for run time search
- "Parables of the Power of Planning in AI" by Noam Brown (`https://www.youtube.com/watch?v=eaAonE58sLU`)

Auxiliary Slides

Other Problems

- Salad
- Oatmeal
- Global Cohesion/(weak) Global Constraints

Auxiliary Slides

Potential Future Work

- Spectral Graph Decomposition methods for automatic biome detection
- AC4 speedups via templates
- Weak global constraints