Punch Out Model Synthesis

A Stochastic Algorithm for Constraint Based Tiling Generation

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Introduction

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

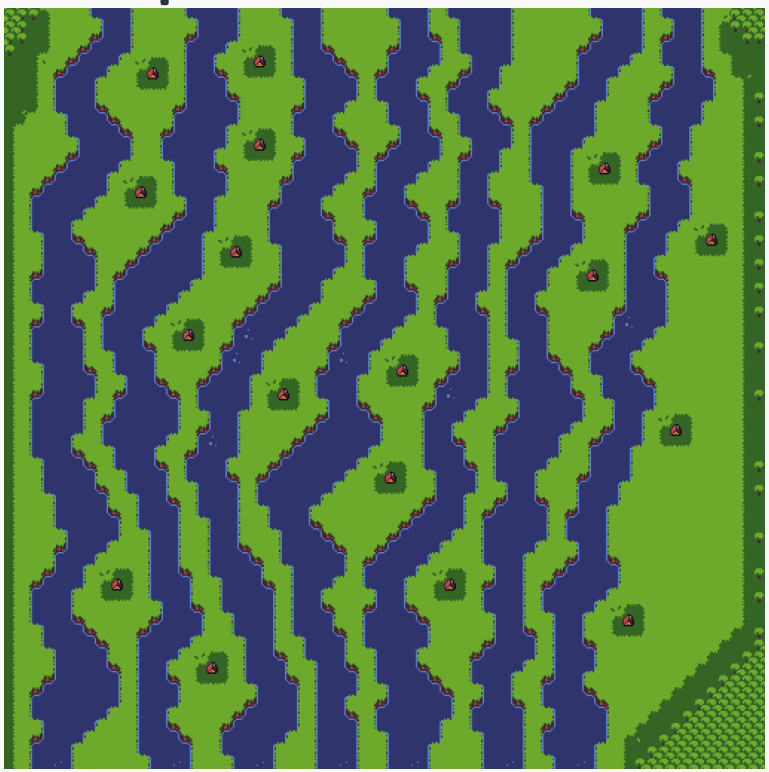
- Works on large grids
- Minimal setup requirements
- Resiliance to contradiction

Introduction

Definitions

- *Grid* composed of *cells*
- Each *cell* can hold *D tiles*
- Pairwise tile *constraints* in each dimension $(\pm X, \pm Y, \pm Z)$

Example



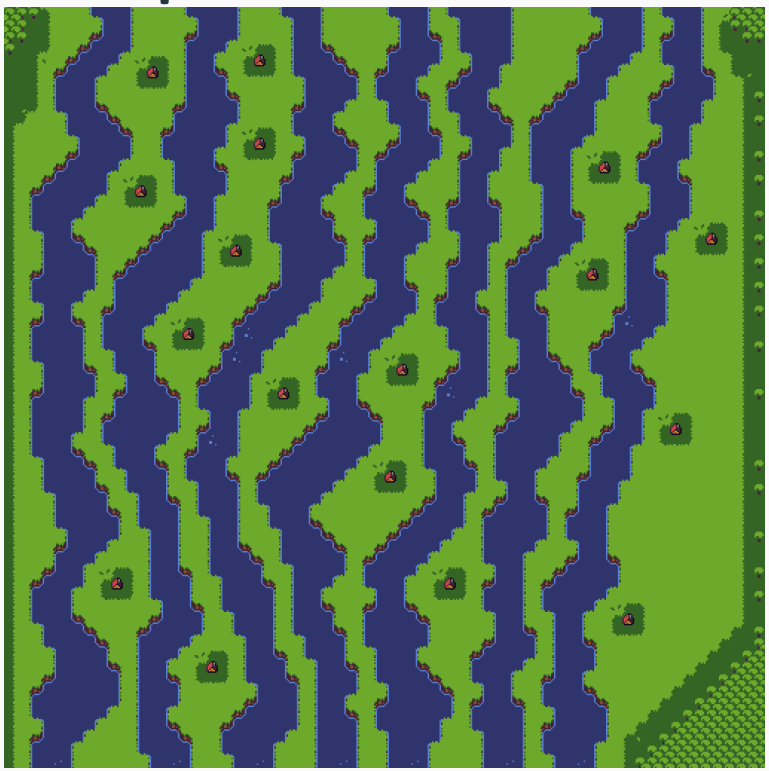
Introduction

Constraint Based Tiling Generation (*CBTG*) Problem

Find a valid grid realization

- A *realization* is a single *tile* placement at each *cell* respecting *constraints*.
- A *contradiction* if no tiles left at a cell location

Example

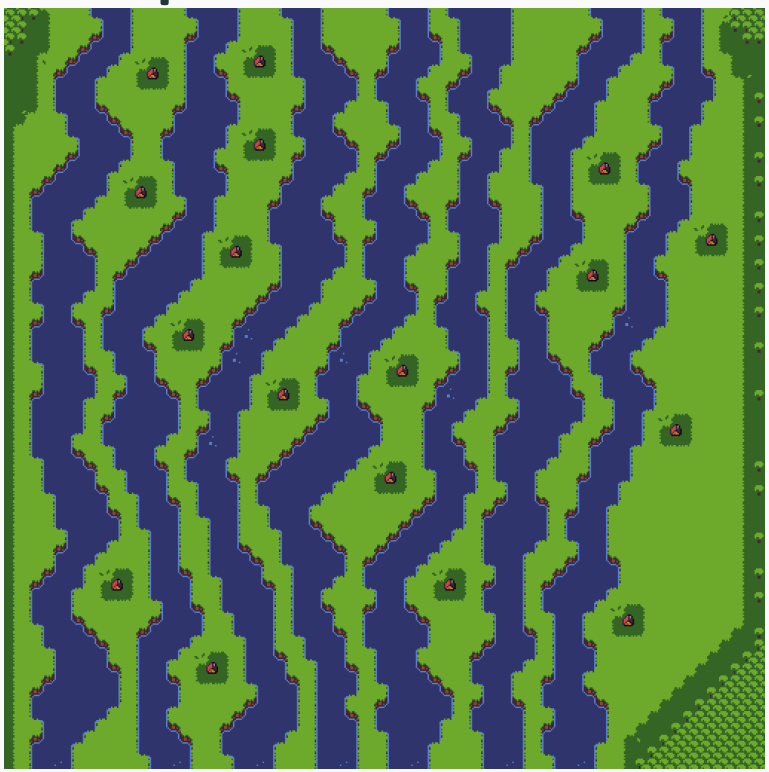


Introduction

Definitions

- A tile has *support* if there's a valid neighbor in each grid dimension direction
- A region is *Arc Consistent* if all *tiles* within the region are *supported*

Example

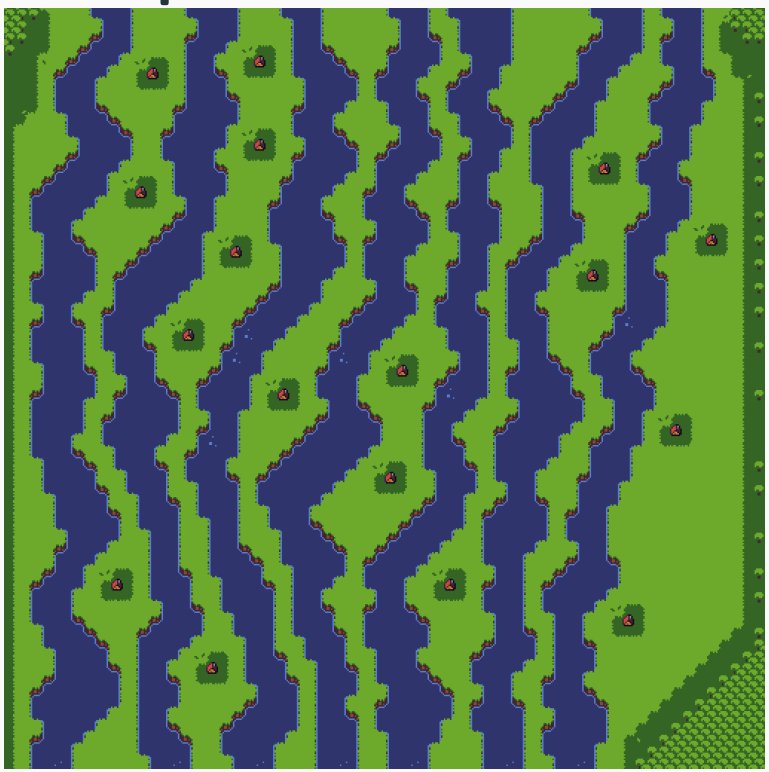


Introduction

Definitions

The basis for a *Constraint Propagation* algorithm can be made by removing *unsupported tiles* from a *cell's domain*

Example

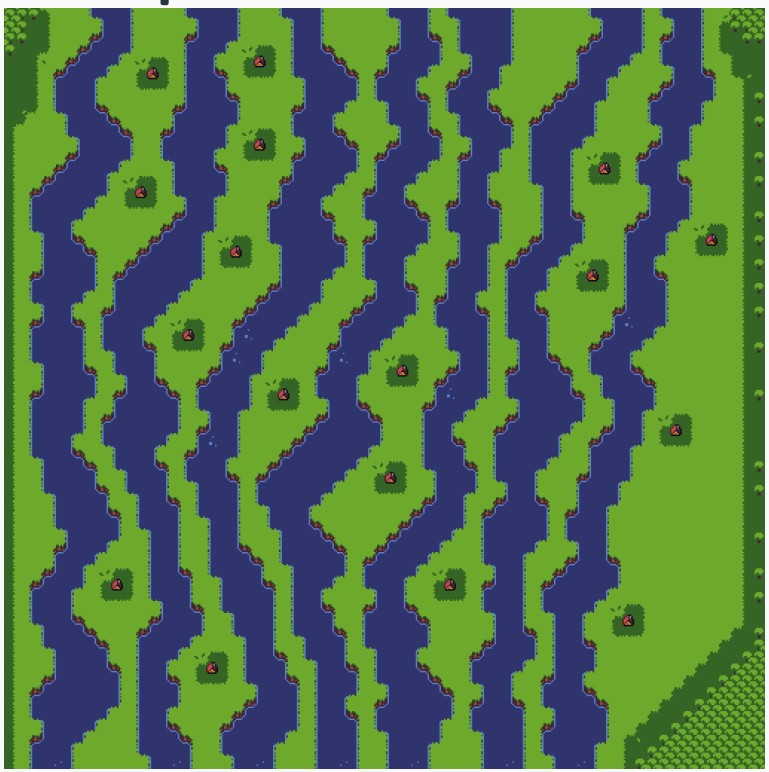


Introduction

Definitions

- *Block Level Solver*: completely maintains *Arc Consistency*
- *Grid Level Solver*: only keep summary information for the entire grid but work on *block* sub-regions

Example



Related Work

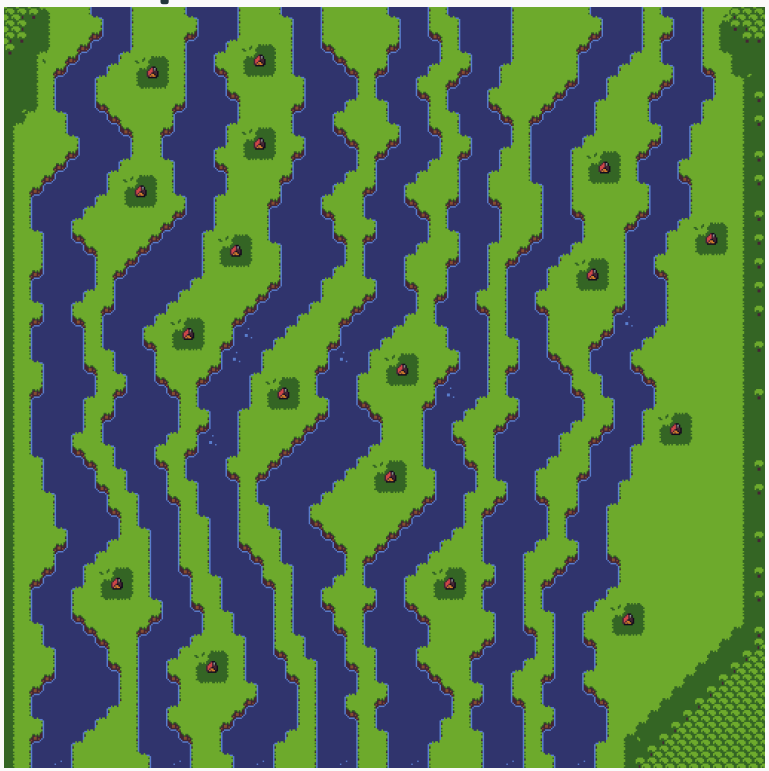
Gumin's *Wave Function Collapse* (*WFC*)

WFC

Resolve, propagate

- One-shot
- *Block Level*
- Indeterminate initial condition
- Ergodic

Example



Related Work

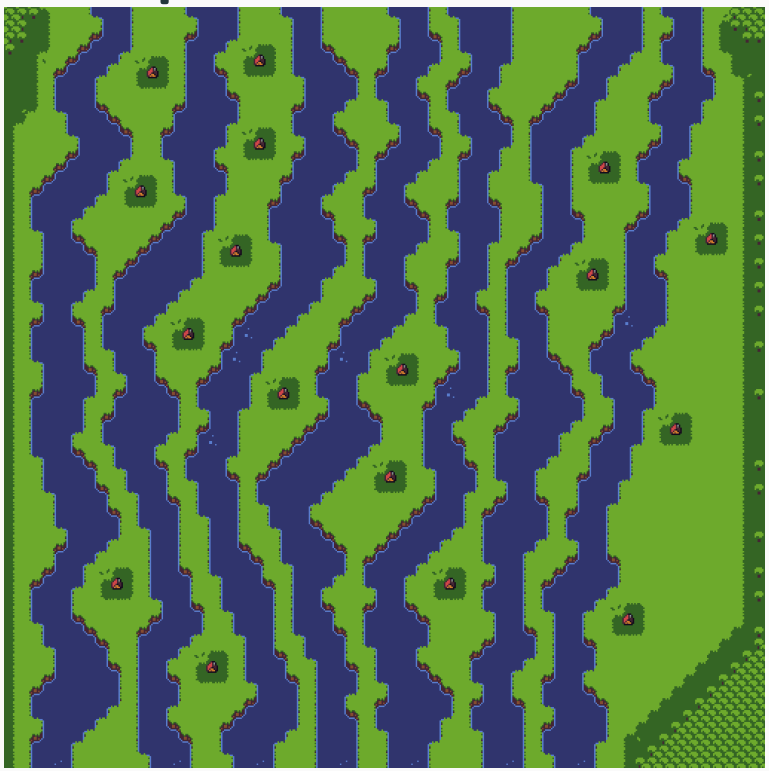
Breakout Model Synthesis (*BMS*) from Hoetzlein's *just_math*

BMS

Resolve, propagate, revert

- Stochastic backtracking
- *Block Level*
- Indeterminate initial condition
- Ergodic

Example



Related Work

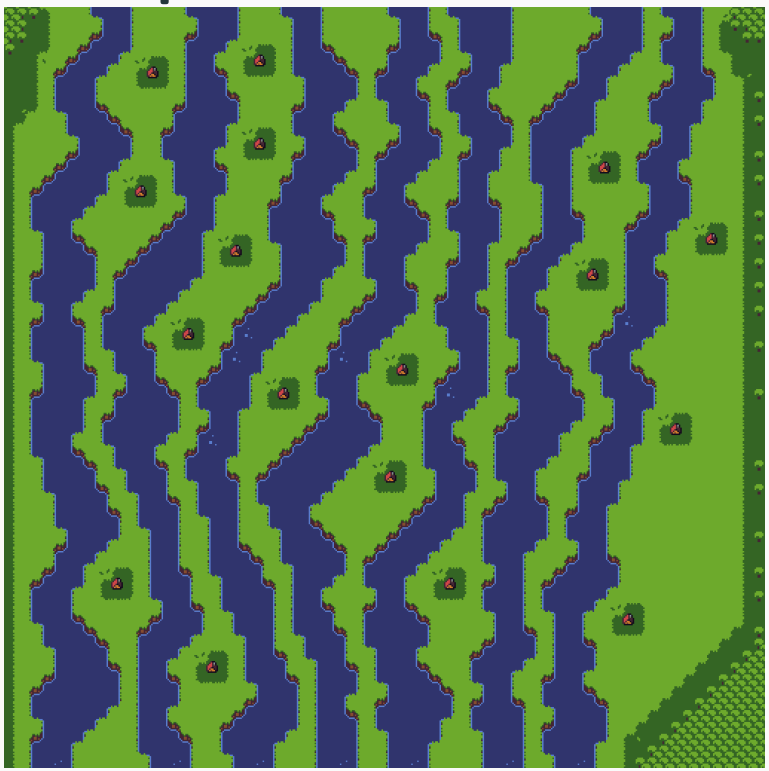
Merrell's *Modify in Blocks Model Synthesis* (*MMS*)

MMS

From resolved grid, solve block, incorporate

- Block step consistent
- *Grid Level*
- Requires bootstrap initial realization
- Non-ergodic

Example



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**

Related Work

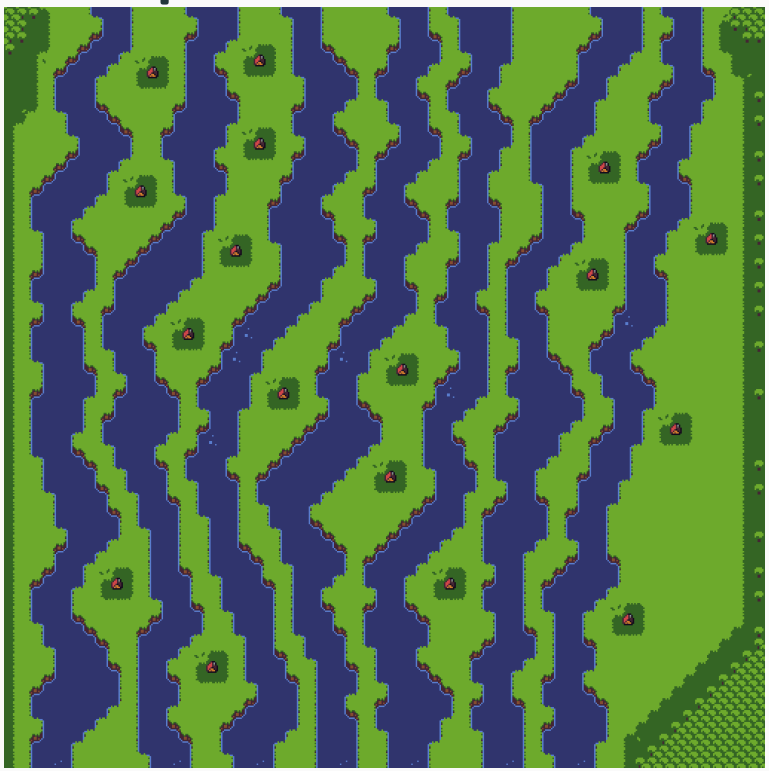
Intuition

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

Difficult to define and/or calculate

As a heuristic,
Tile Arc Consistent Correlation Length (*TACCL*) from Hoetzlein's *just_math* project

Example



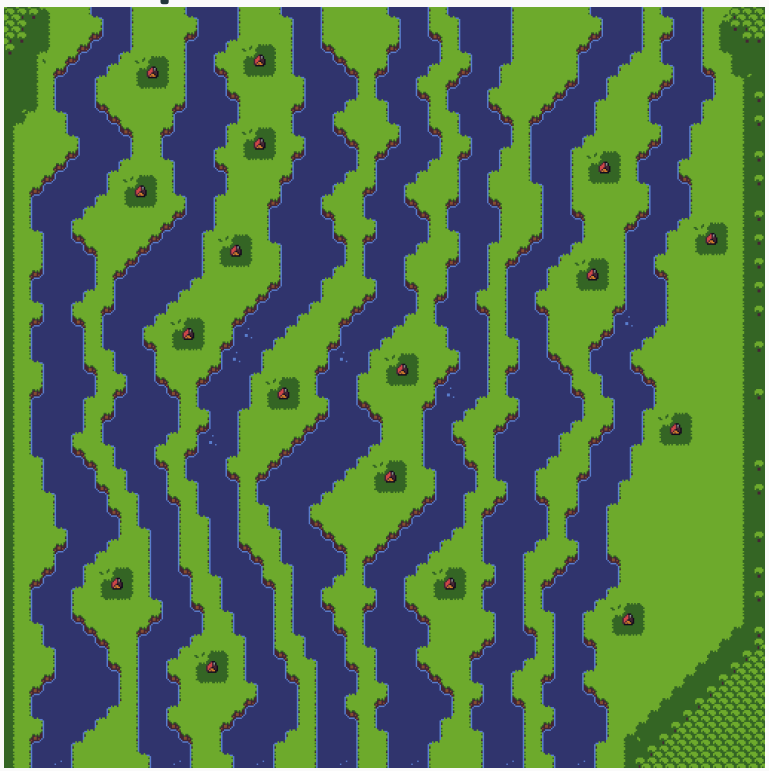
Related Work

Tile Arc Consistent Correlation Length (*TACCL*)

TACCL

- Take block in isolation

Example



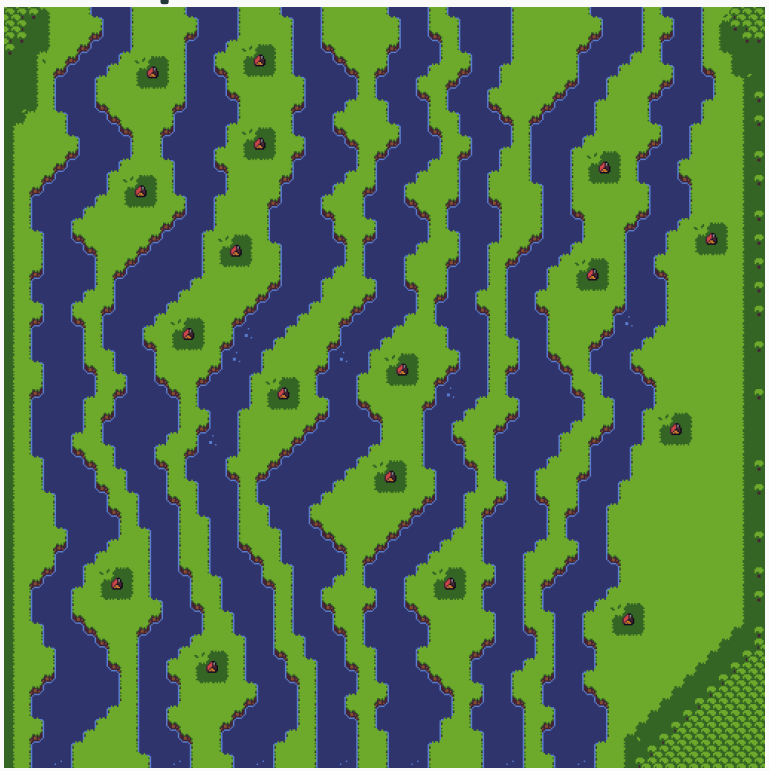
Related Work

Tile Arc Consistent Correlation Length (*TACCL*)

TACCL

- Take block in isolation
- Set block to indeterminate state

Example



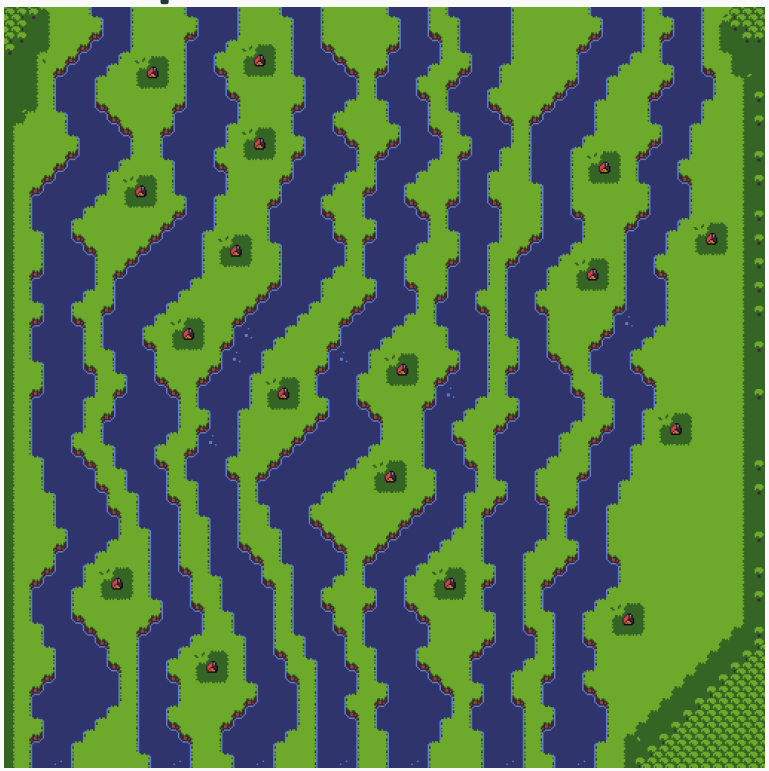
Related Work

Tile Arc Consistent Correlation Length (*TACCL*)

TACCL

- Take block in isolation
- Set block to indeterminate state
- Fix a tile at the center

Example



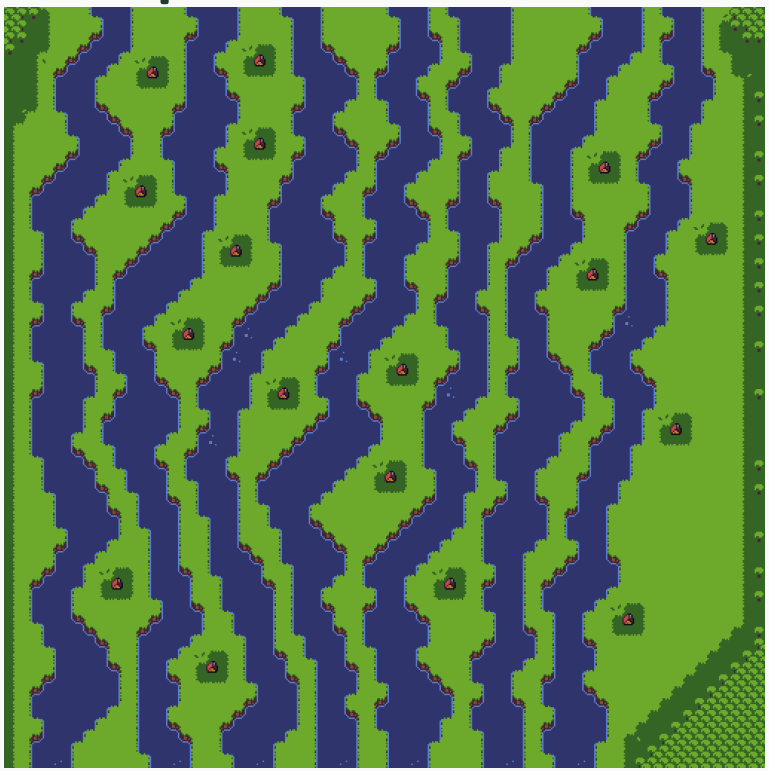
Related Work

Tile Arc Consistent Correlation Length (*TACCL*)

TACCL

- Take block in isolation
- Set block to indeterminate state
- Fix a tile at the center
- Propagate constraints

Example



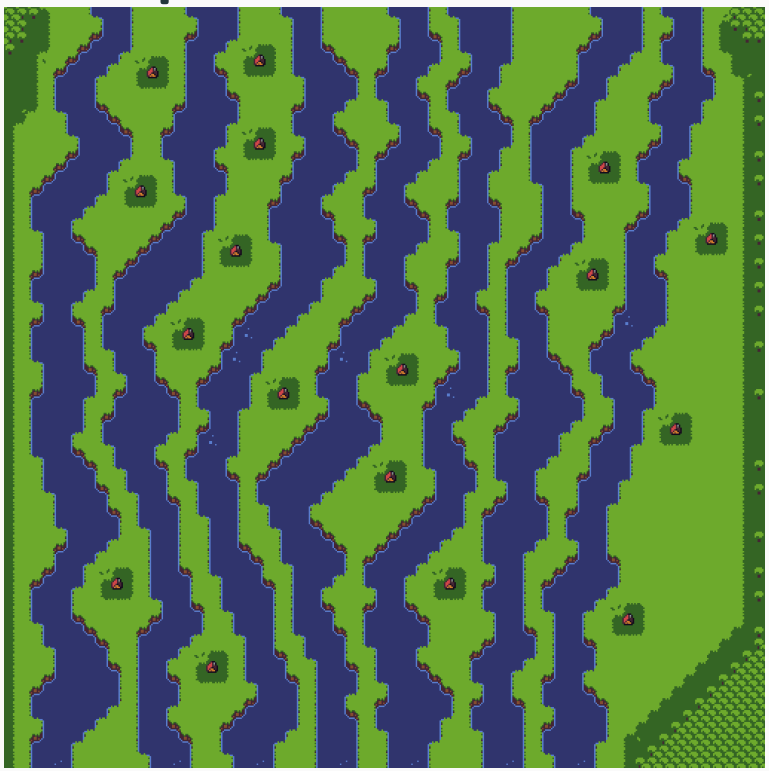
Related Work

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

Example



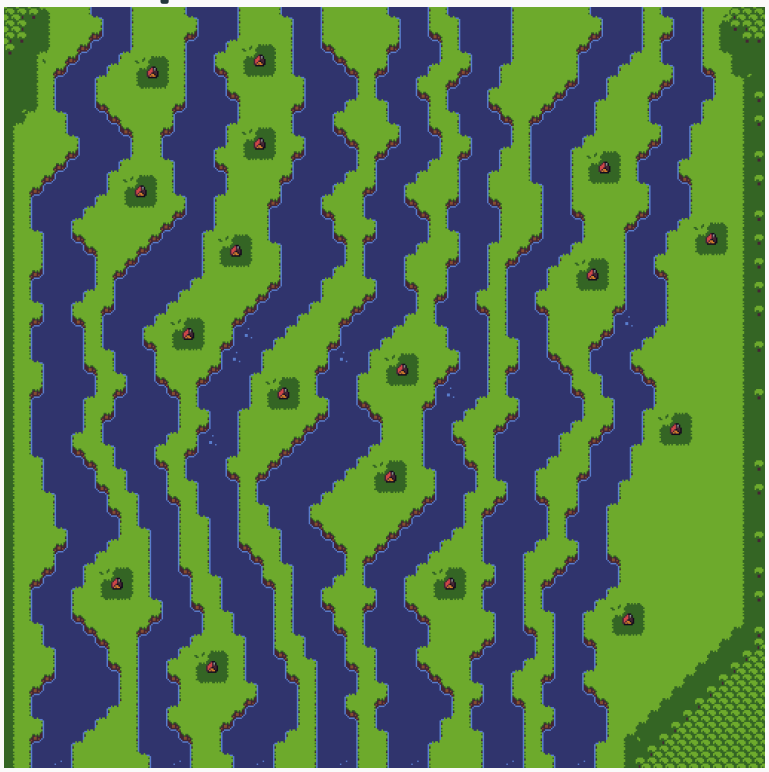
Related Work

Tile Arc Consistent Correlation Length (*TACCL*)

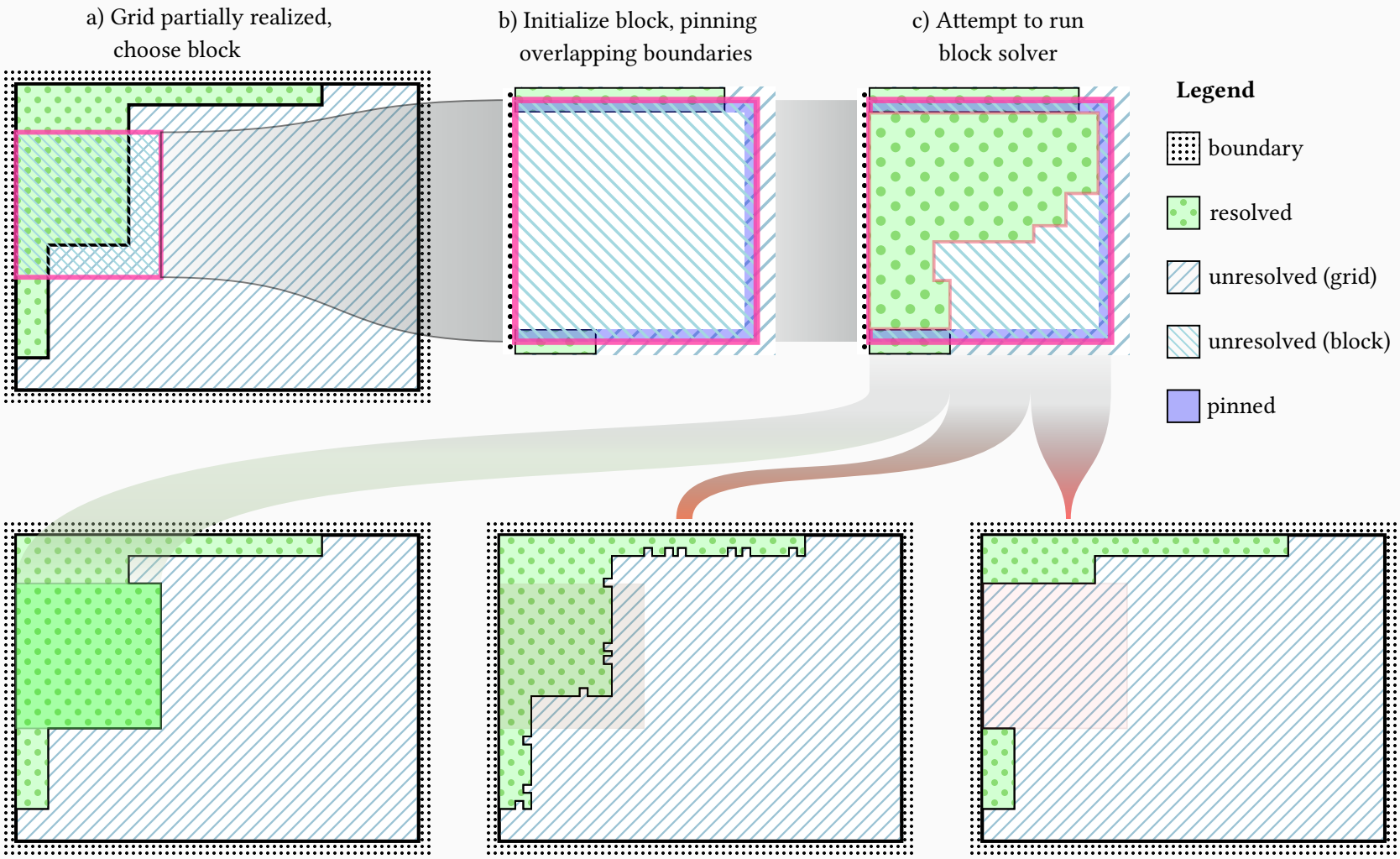
TACCL

- 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



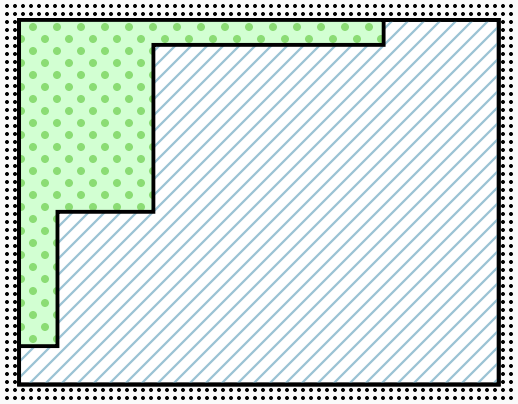
d) Success
incorporate resolved block into grid

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

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

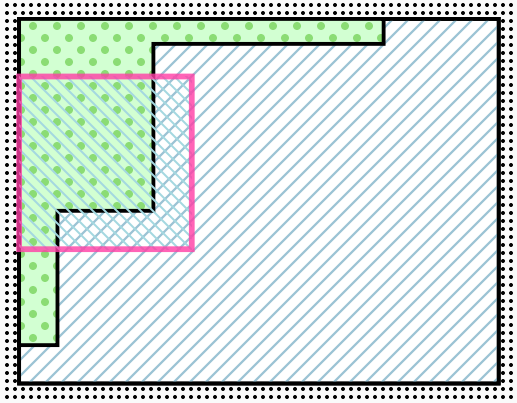
Algorithm

Grid partially realized

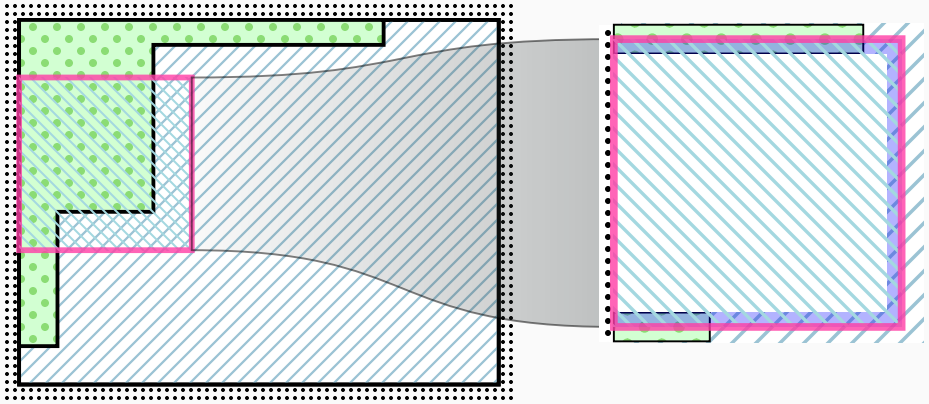


Algorithm

Choose block



Algorithm

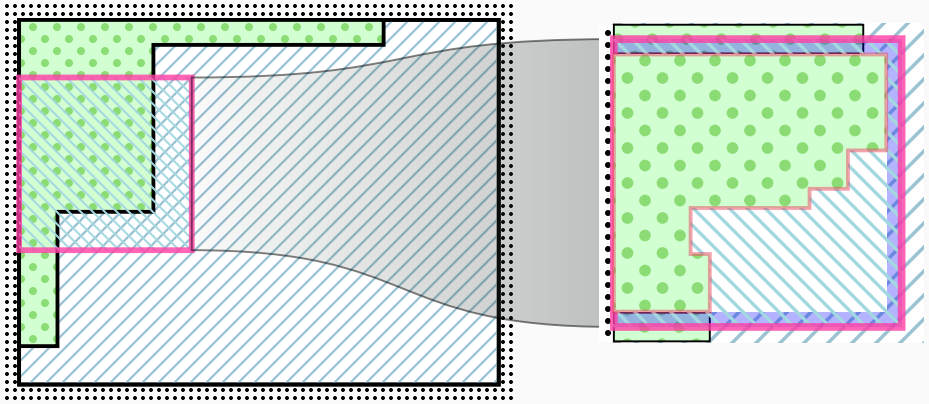


Initialize block

- Pin boundaries
- Revert interior

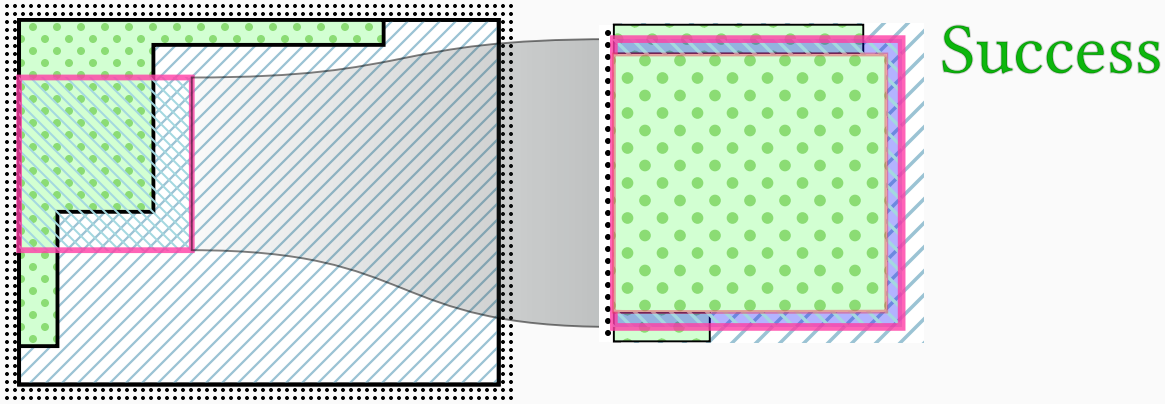
(Apply any restrictions)

Algorithm

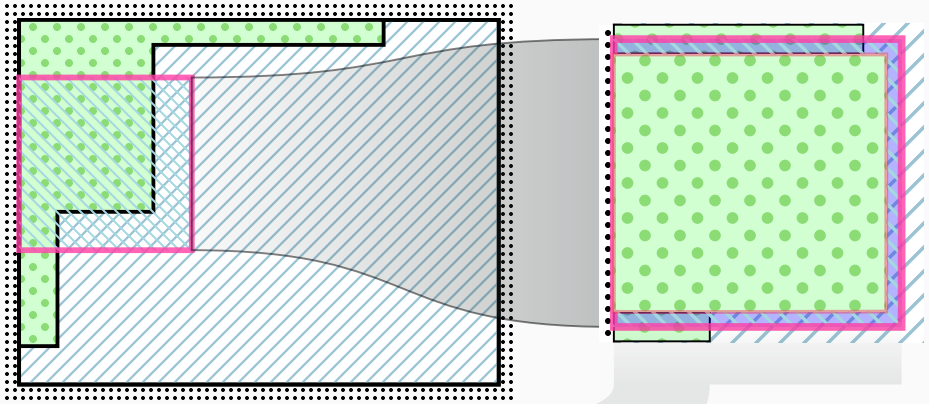


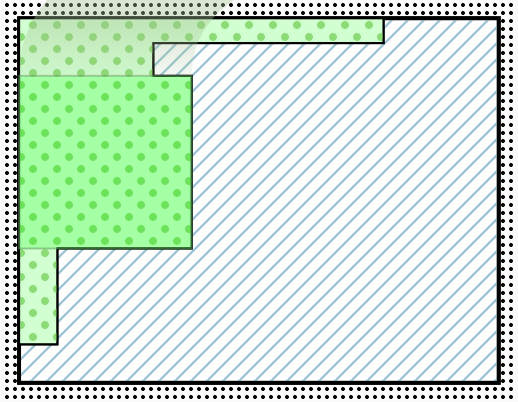
Attempt to solve

Algorithm



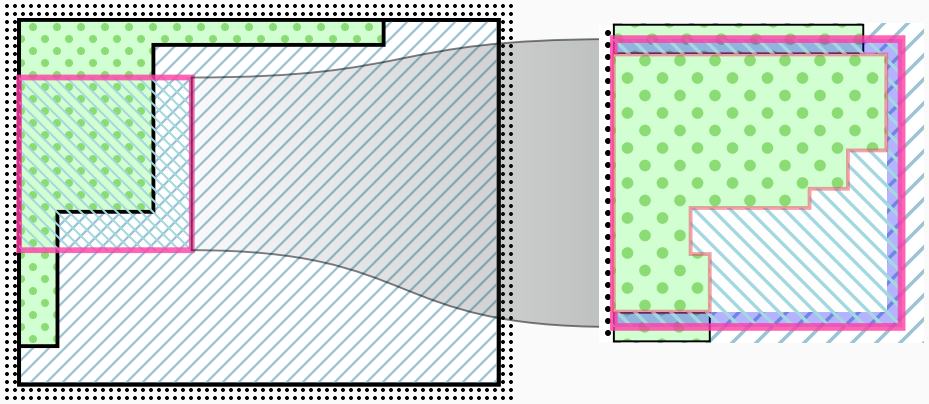
Algorithm





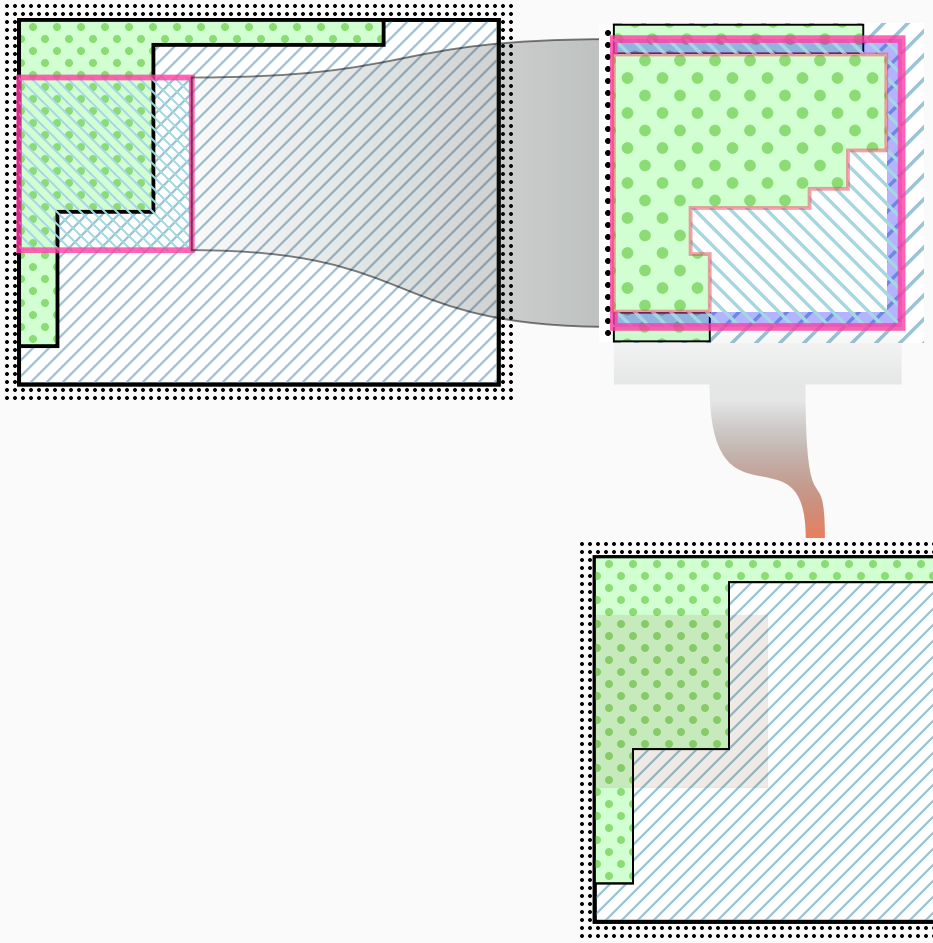
Incorporate resolved block into grid

Algorithm

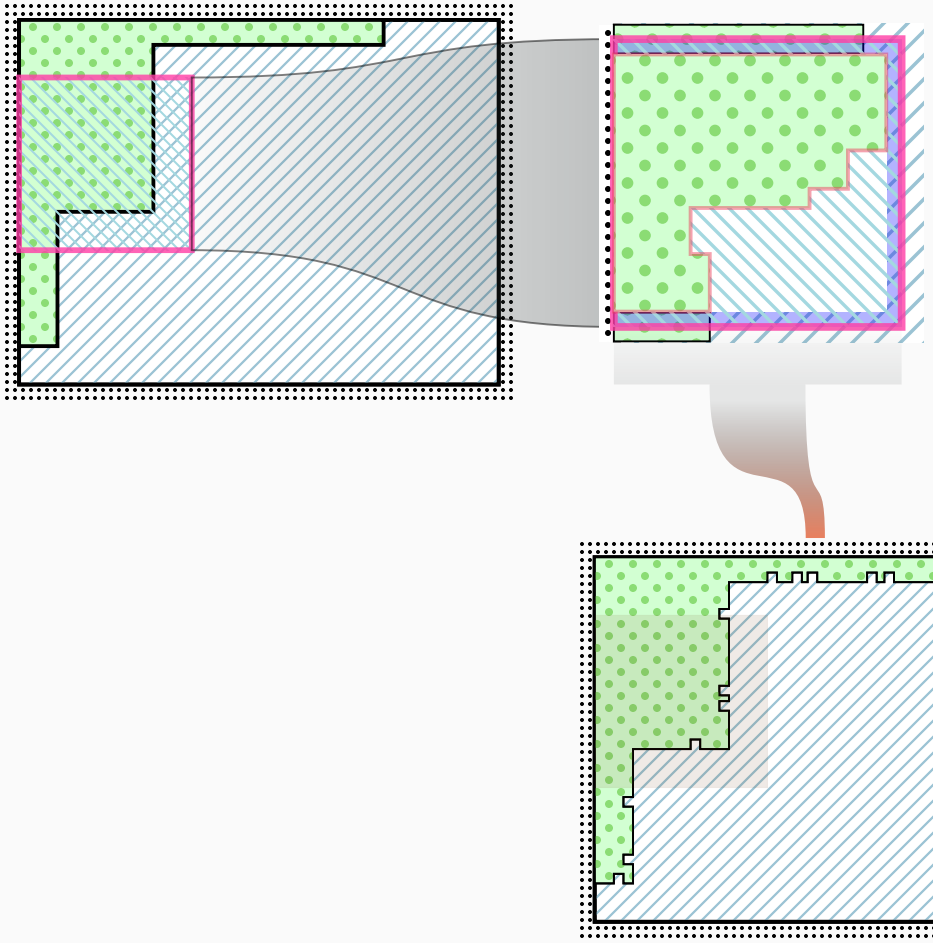


Resolution failure

Algorithm



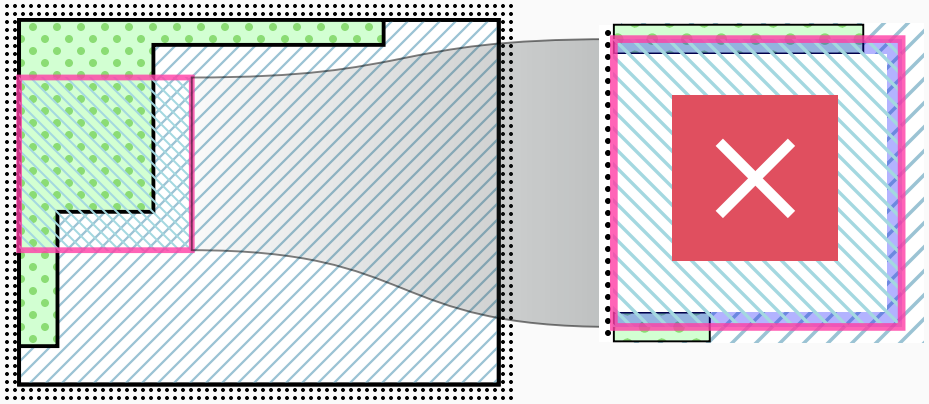
Algorithm



Resolution failure

Restore block
Erode boundary

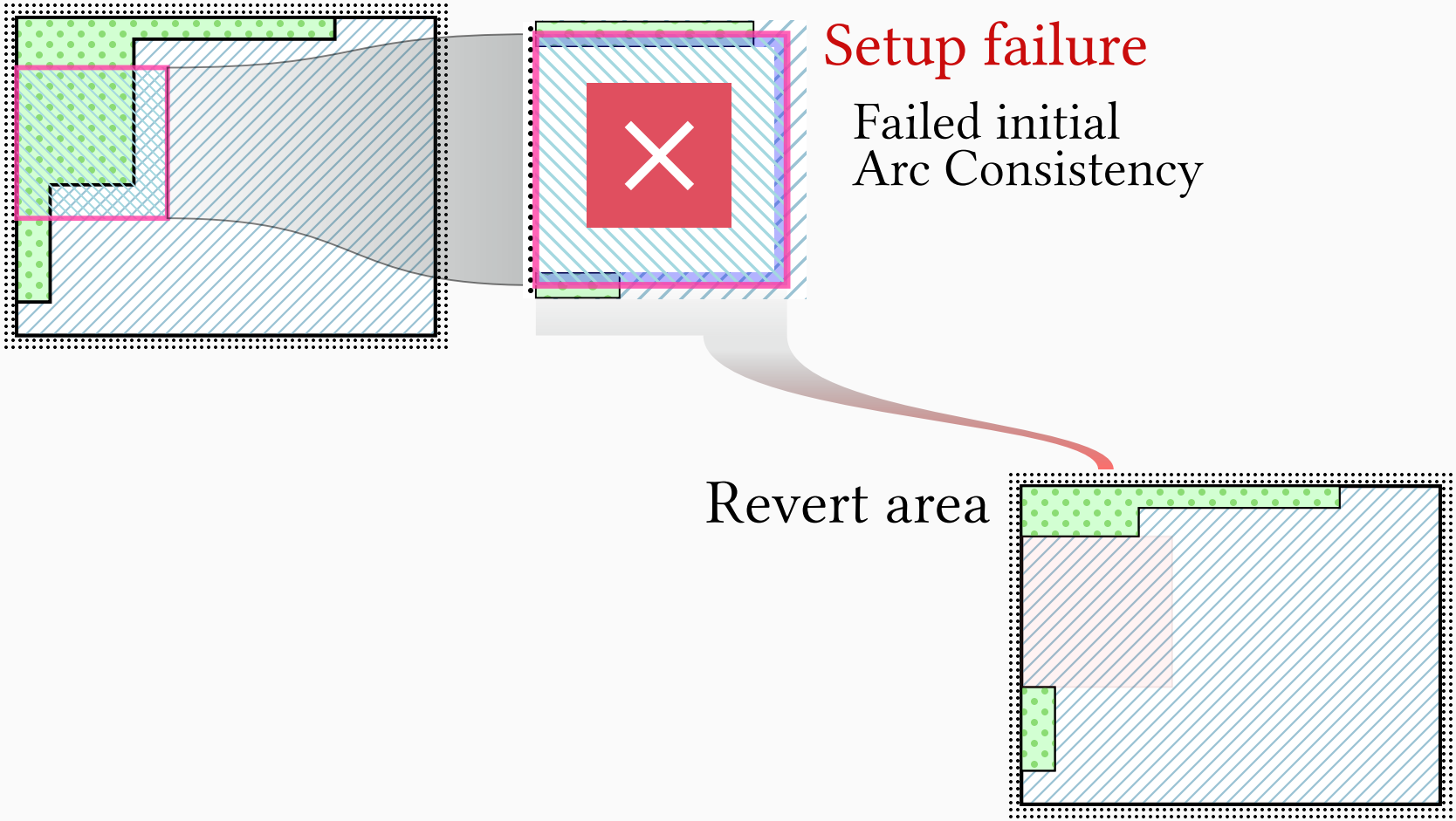
Algorithm



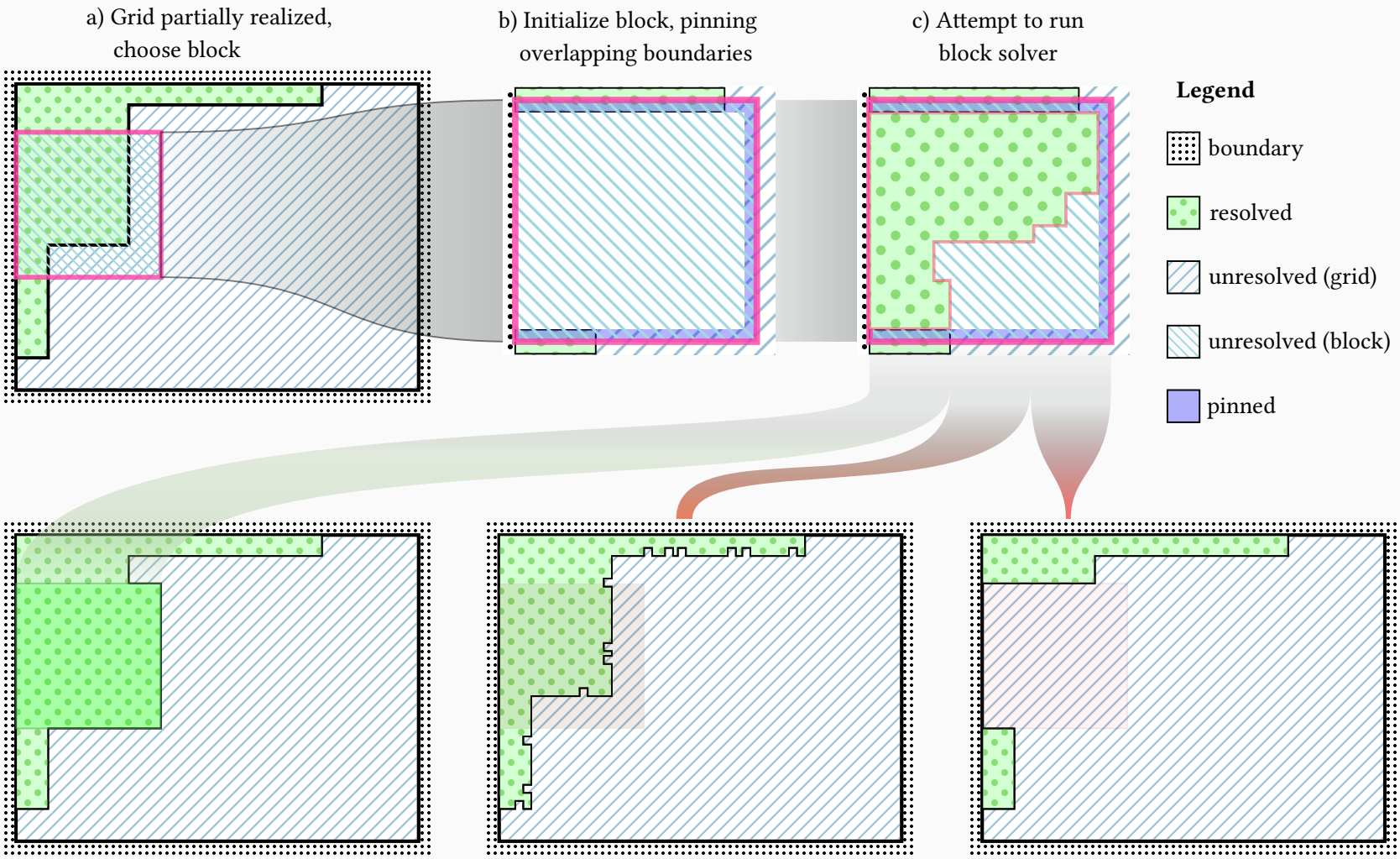
Setup failure

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

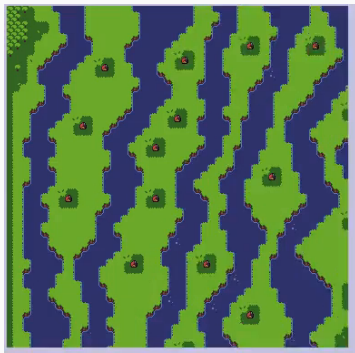
Pill Mortal Tile Set

Algorithm

ThKaspar's *Forest Micro* Tile Set

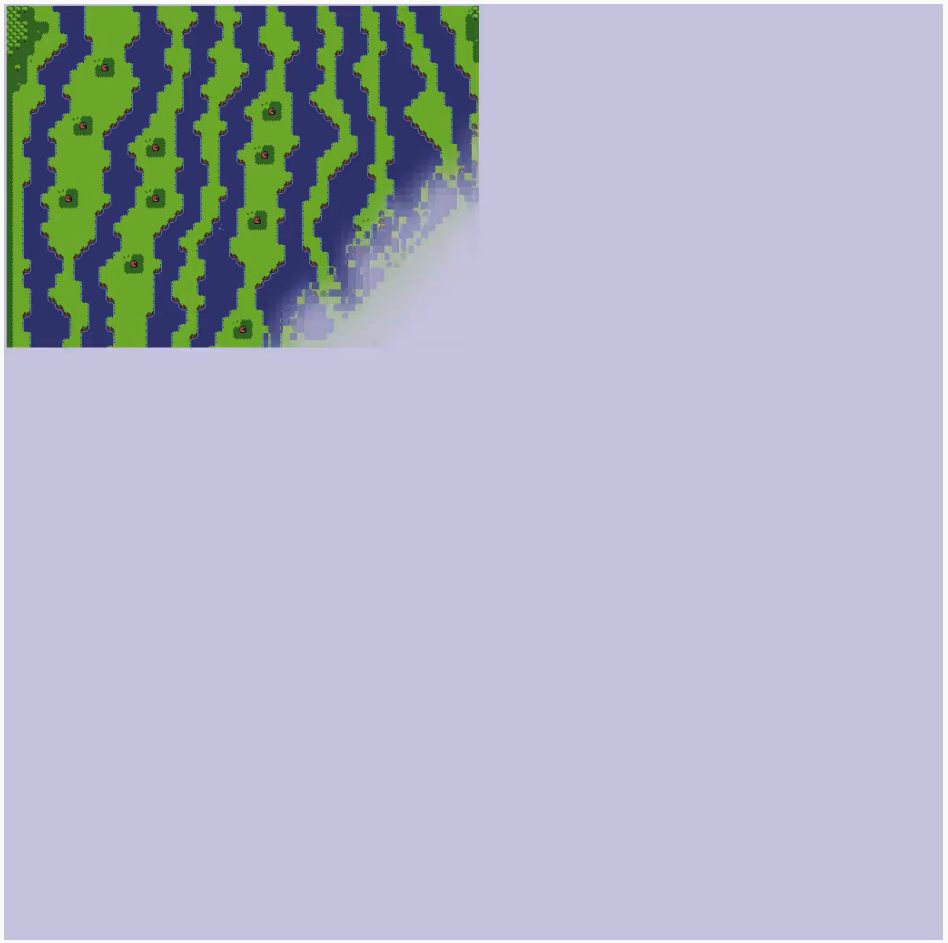
Algorithm

Choose Block



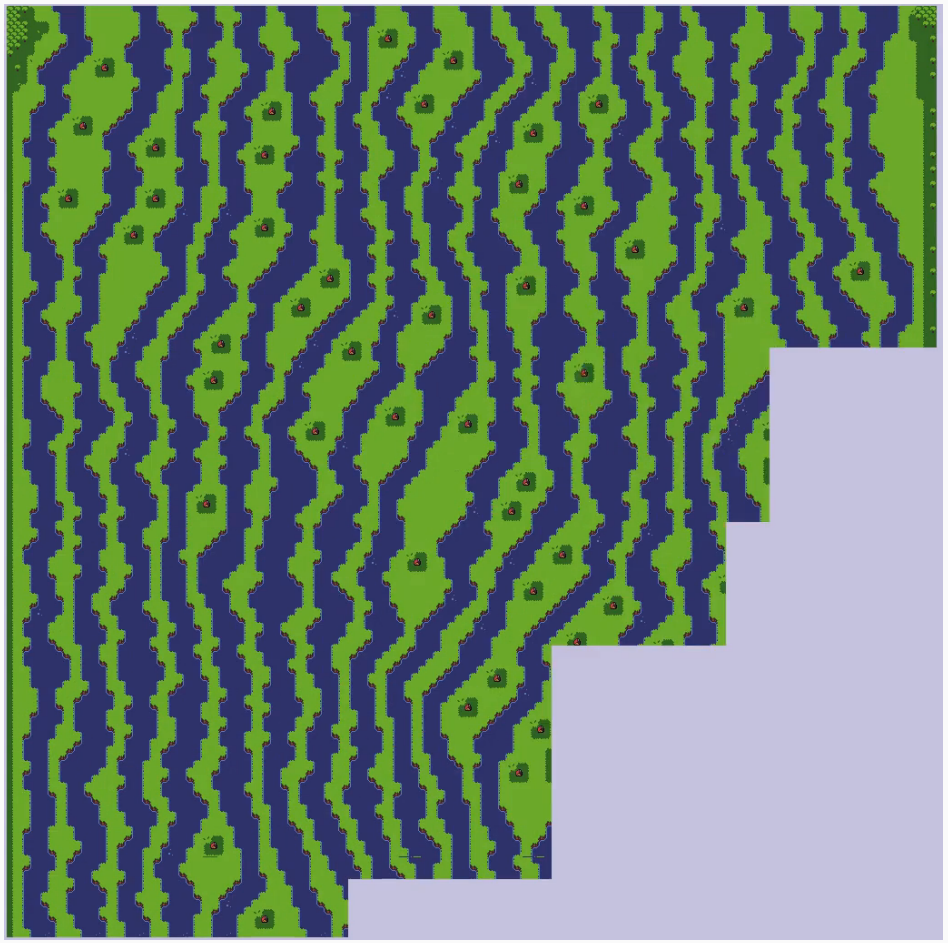
Algorithm

Choose Block



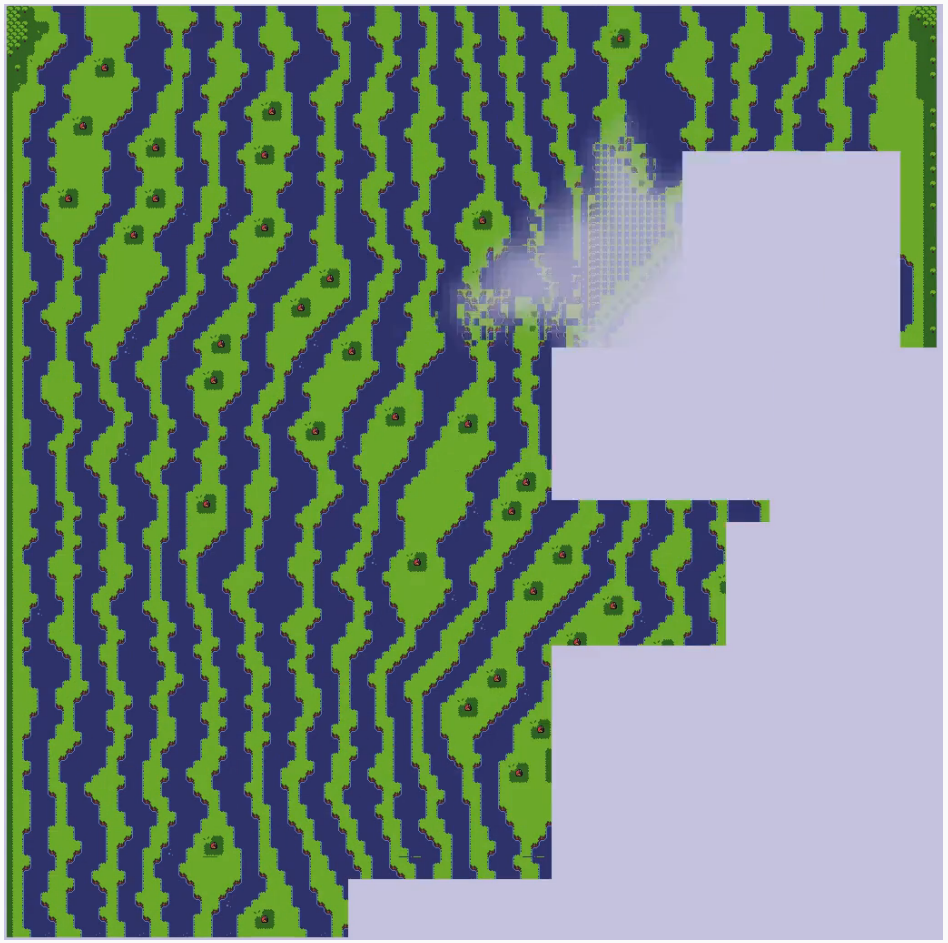
Algorithm

Revert Block



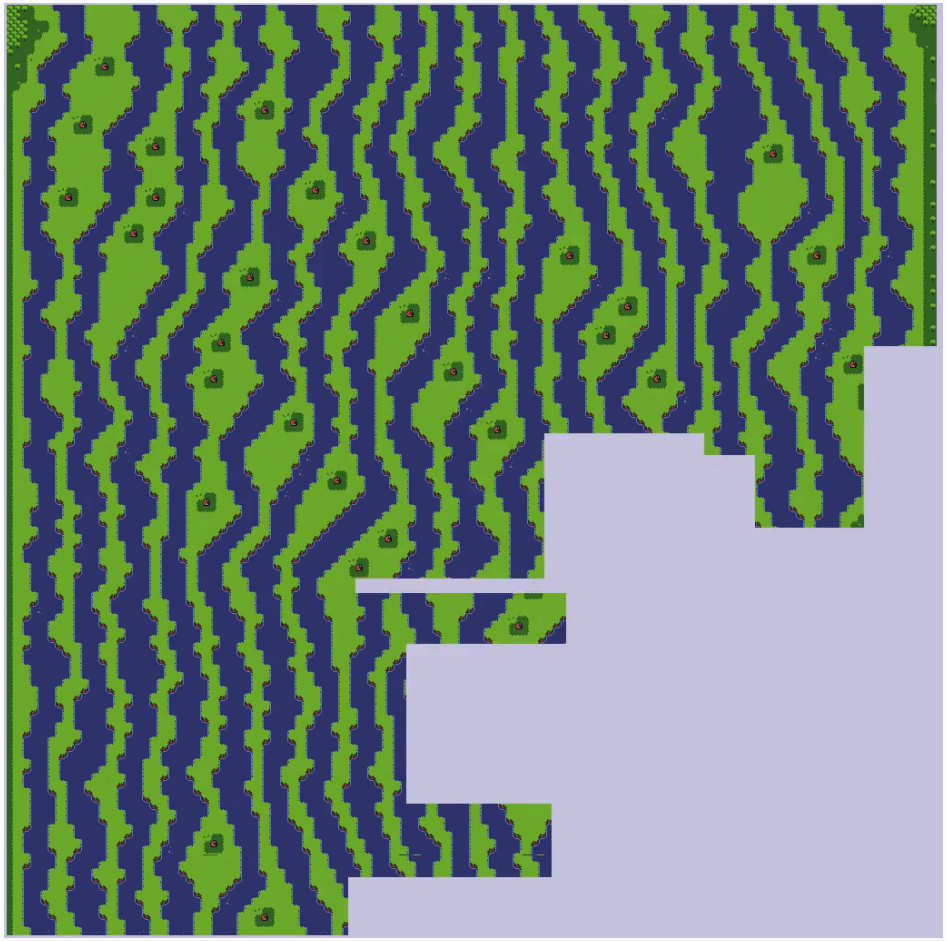
Algorithm

Revert Block



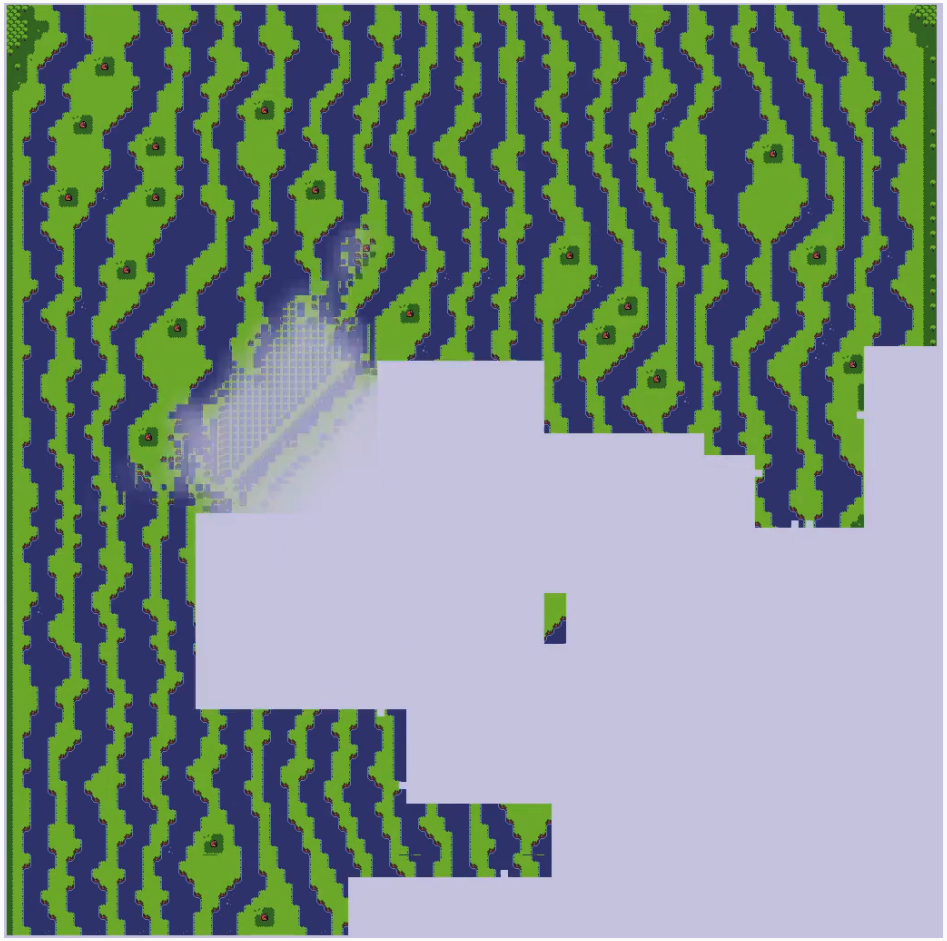
Algorithm

Erode Boundary



Algorithm

Erode Boundary



Results

Results

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Conclusion

Conclusion

https://github.com/zzyzek/PunchOutModelSynthesis