Occupancy-Regulated Extension

Using Chunks to Build Levels

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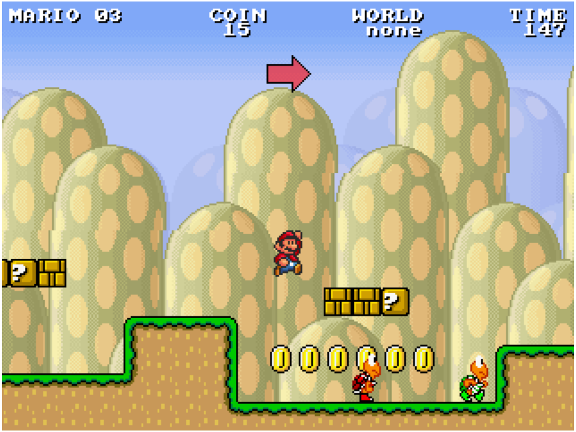
August 25, 2010

Motivation

- Existing generators impose constraints in pursuit of a goal.

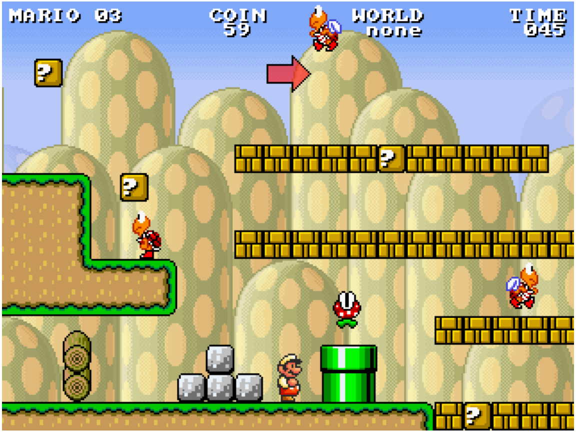


Motivation

- But human designers often create surprising levels.

Motivation

- The goal: create levels that can routinely surprise their creator.



Insight

- Randomly placed components would be surprising, but not interesting.
- Placing groups of components reduces entropy, and can exploit human authoring.
- Occupancy can be used to constrain assembly of chunks.
- Thus Occupancy-Regulated Extension.

The ORE Algorithm

1. Select a context.
2. Pick a chunk to insert:
   (i) Filter available chunks.
   (ii) Select among compatible chunks.
3. Integrate the selected chunk into the level.

Occupancy in ORE

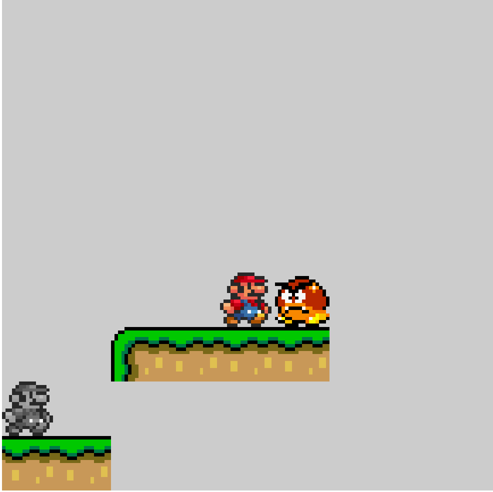
- Occupancy is expressed as concrete anchor points.
- Each chunk defines its own anchor points.
- These anchors determine how pieces can fit together.

Context Selection

- Picks a random anchor at which to add a chunk.
- Keeps track of used and unused anchors.
- Handles edge cases: might reset the list of used anchors, or even improvise a new anchor.

Example

- The initial context:

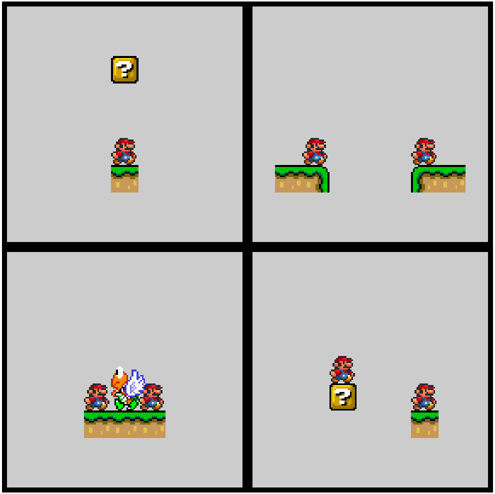


Chunk Filtering

- Uses a notion of spatial compatibility to exclude things that don't fit.
- Determines type compatibility for overlapping components.
- Filters out chunks that would extend outside of the bounding box of the level.
- Considers each chunk in the library at each of its anchors, so the algorithm isn't directional.

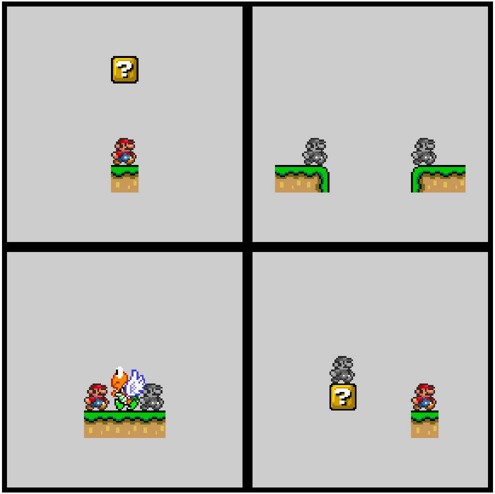
Example

- An example library:



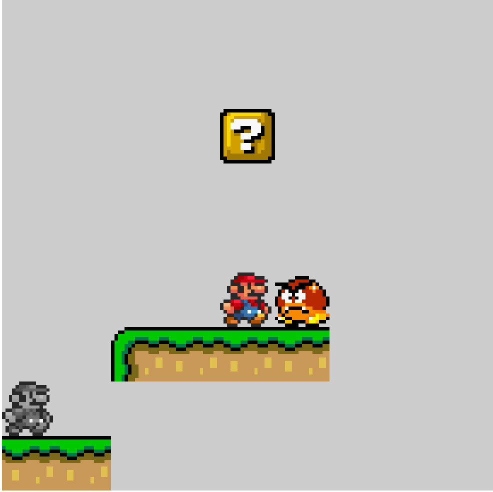
Example

- The matching anchors:



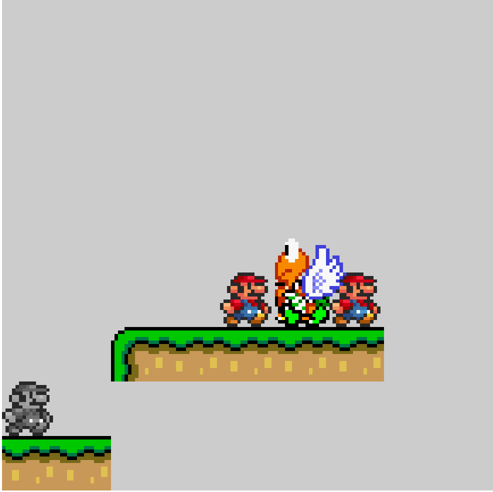
Example

- The first match:



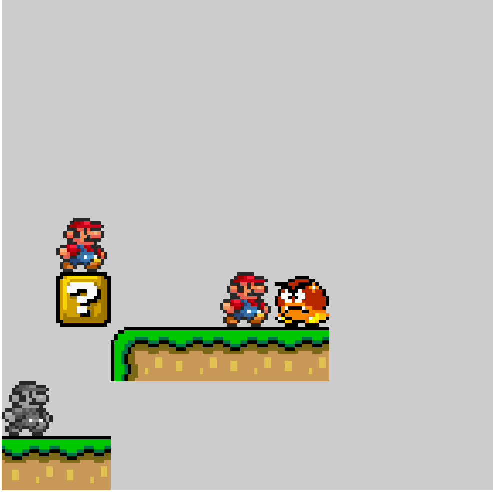
Example

- The second match:



Example

- The third match:

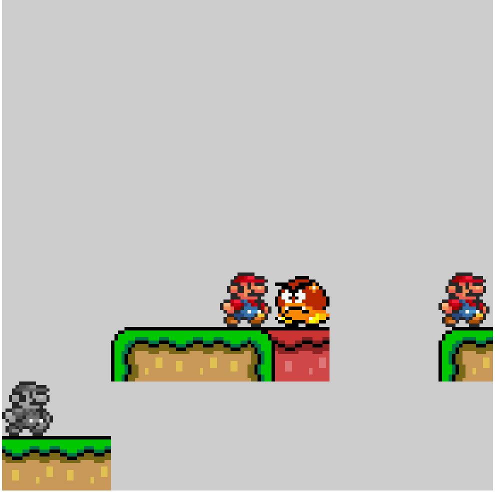


Example

- One of the non-matches:

Example

- Another non-match:



Chunk Selection

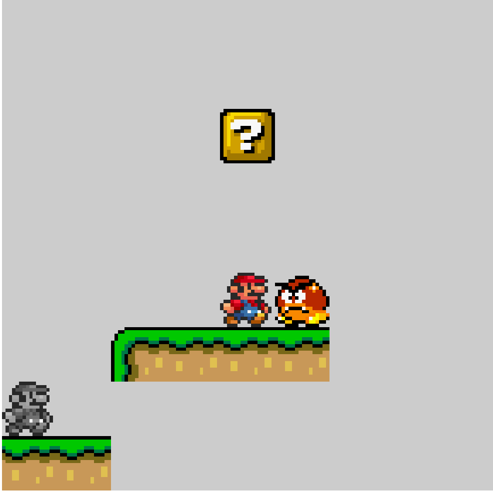
- Considers only the first several (currently 17) filtered chunks.
- Computes chunk metrics:
  - f: Chunk default frequency, as defined in the library.
  - b: Chunk boredom value: number of times the chunk has been used so far.
  - p: Chunk precision bias: 0.2 if the chunk is labeled as "precise"; 1 otherwise.
- Calculates a weight for each chunk being considered:
  - $w = f * 0.7^b * p$

Chunk Selection

- Uses weighted random selection with the computed weights to choose a chunk to insert.
- Default chunk frequencies prevent complex chunks from dominating the output.
- The boredom value helps ensure variety in chunk selection.
- The precision value is an example of a level design choice encoded in the chunk selection policy.

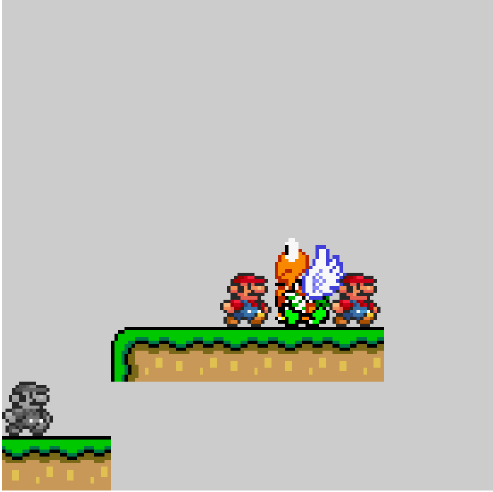
Example

- The weight for the first match might be:
  $w = 0.75 * 0.7^0 * 1 = 0.75$



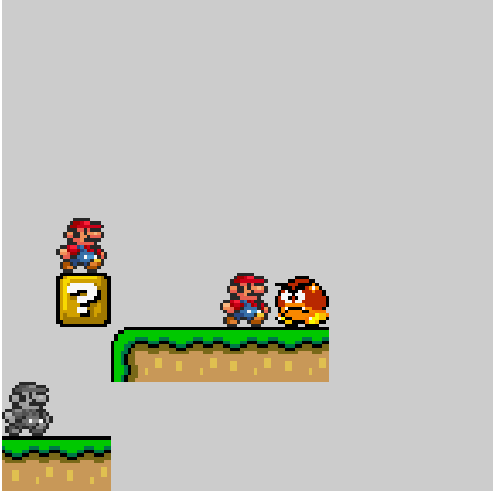
Example

- The weight for the second match might be: $w = 1 * 0.7^0 * 1 = 1$



Example

- The weight for the third match might be: $w = 0.5 * 0.7^0 * 0.2 = 0.1$

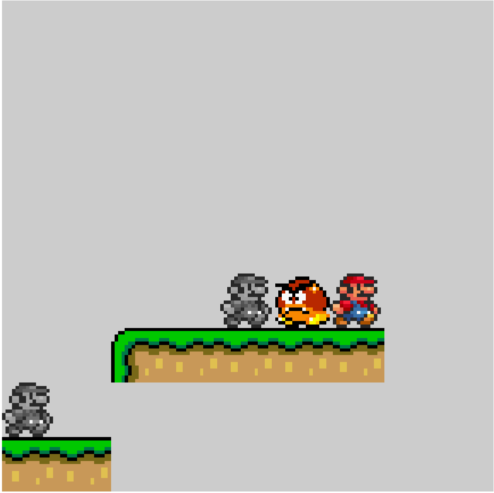


Chunk Integration

- Removes any overlapping components from the incoming chunk.
- Adds remaining components to the level under construction.
- This step could be used to enforce some global constraints.

Example

- The result of integration, assuming the second match is selected:

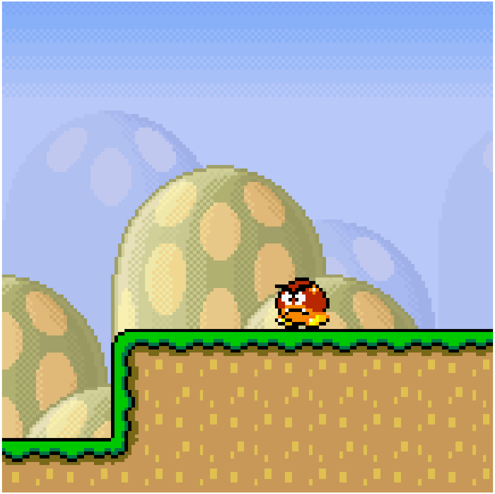


Post-Processing

- Specifies and expands terrain sprites.
- Implements global constraints on the distribution of enemies and powerups by removing some.
- Tries to patch up sprite inconsistencies.

Example

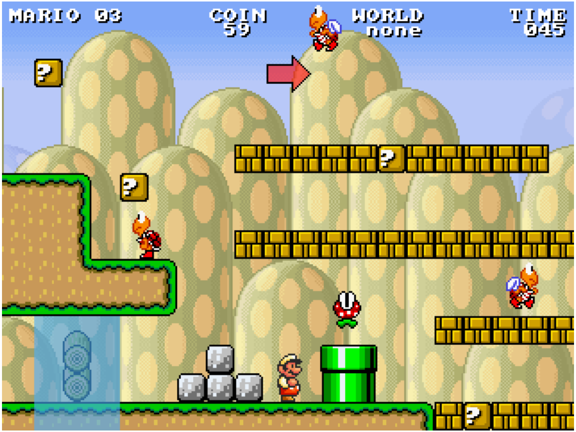
- The level after post-processing:



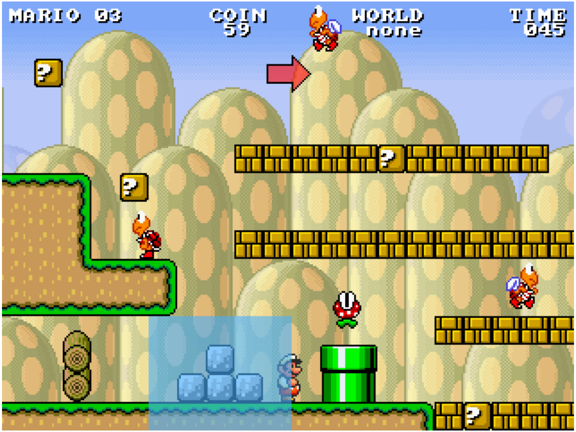
The Chunk Library

- A total of 42 chunks.
- Ranges from 3x2 to 10x10 tiles in size.
- Hand-crafted chunks, some with authored complexity.

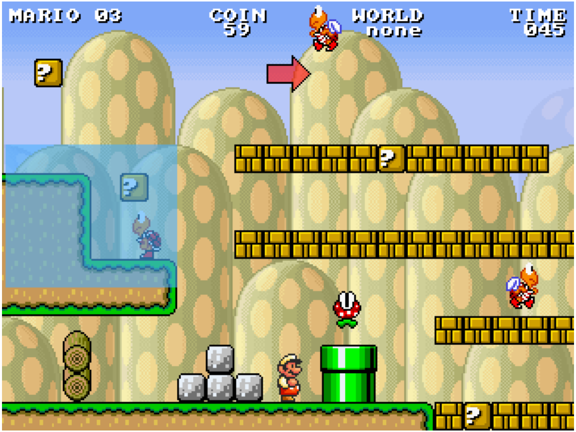
Example Chunks



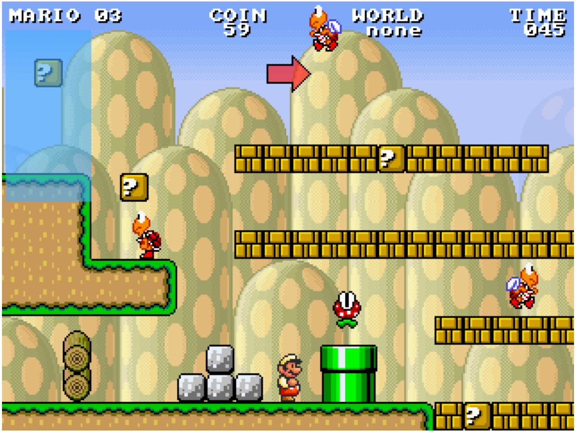
Example Chunks



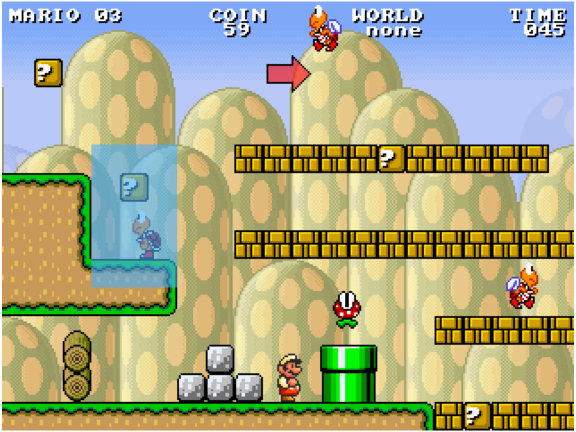
Example Chunks



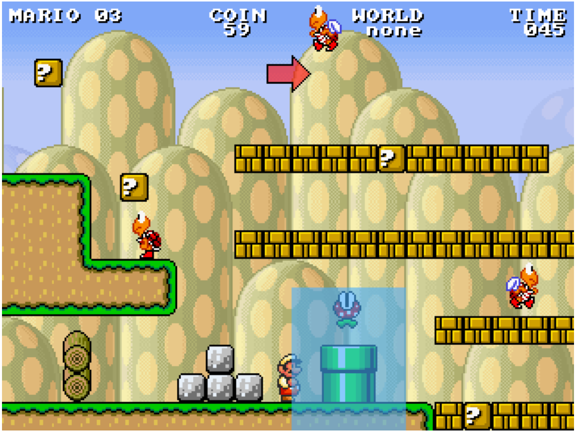
Example Chunks



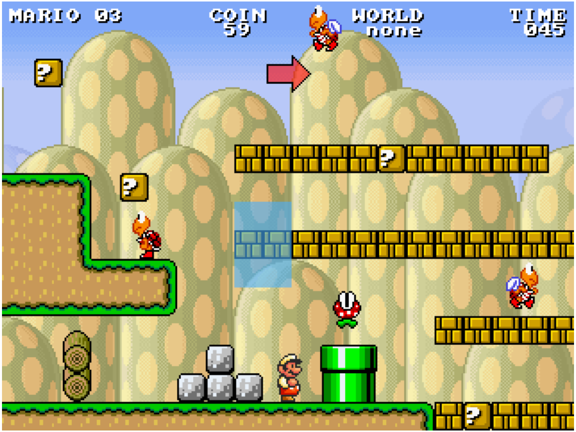
Example Chunks



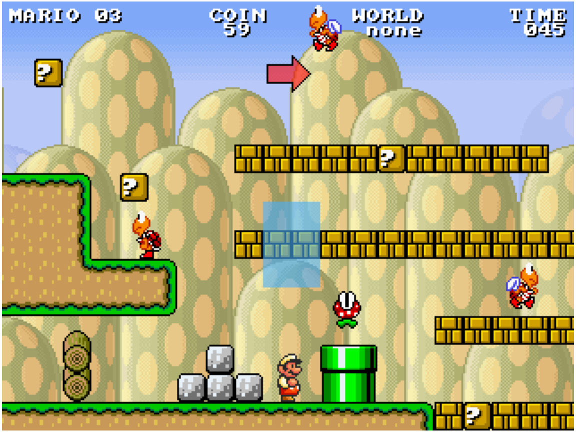
Example Chunks



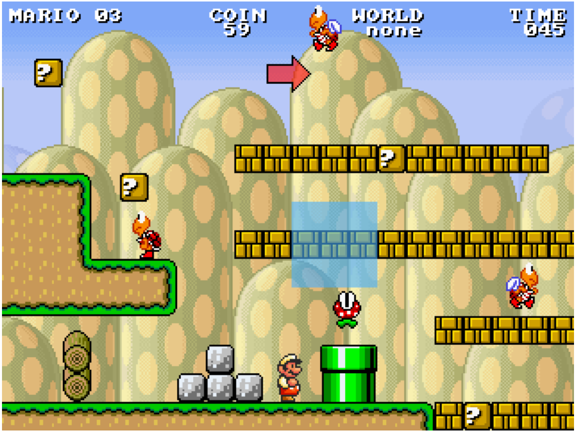
Example Chunks



Example Chunks



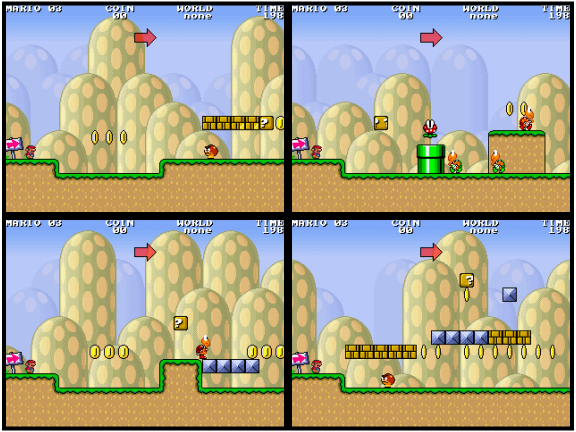
Example Chunks



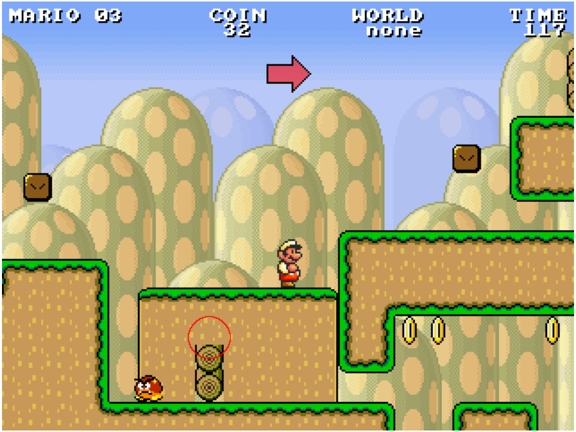
Summary

- Using human-authored chunks, ORE assembles a level by adding chunks one-at-a-time.
- The main constraint imposed is that added chunks are anchored via potential positions.
- The algorithm is highly customizable, and higher-level constraints can be imposed on it.

Results



Failures



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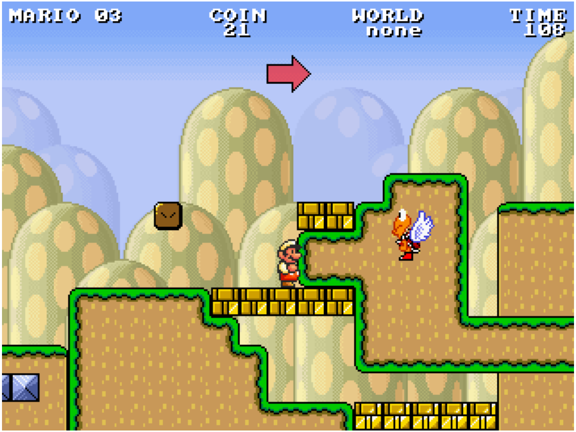

Future Work

- On-line generation for dynamic difficulty adjustment.
- An interface for mixed-initiative design.
- Automatic chunk library extraction.
- Application to other domains.