Jigsaw-Puzzle Technique for Staged Model of Self-Assembly

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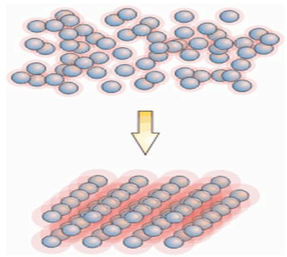
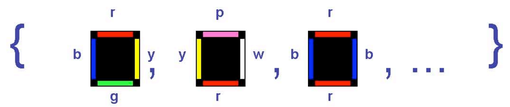
Self Assembly

Self assembly is the process in which simple parts "self-organize" into larger structures.



Tile Model of Self Assembly

Tile system consists of four pieces:
tile set (Wang tiles), seed tile, glue matrix and temperature threshold.



	r	g	b	y	p	w
r	5	1	2	4	3	1
g	1	4	1	0	0	2
b	2	1	7	0	2	0
y	4	0	0	6	1	1
p	3	0	2	1	4	0
w	1	2	0	1	0	7

Staged Model of Self Assembly

To create a specific structure, we can create a set of tiles such that mixing these tiles in the solution results in that structure and no other. The size of tileset is called tile complexity.

It is possible to reduce the tile complexity of the self-assembly process by introducing the tiles in the solution in stages, using a different set of tiles for each stage. This is called the staged model of self-assembly.

Performance Measures for the Model

1. Tile Complexity: number of distinct tile types.
2. Bin Complexity: number of distinct contains used to store intermediate structures.
3. Stage Complexity: number of stages.
4. Temperature Sensitivity: the values of temperature threshold.

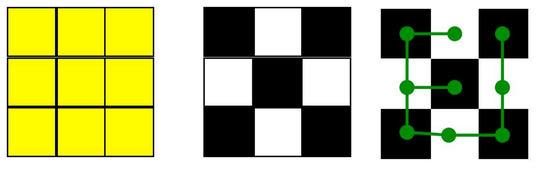
Quality Measures for the Model

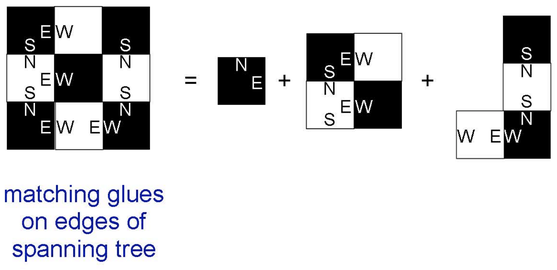
1. Planarity: tiles can be moved into position without intersecting each other.
2. Connectivity: every pair of adjacent tiles should be connected.
3. Scale factor.

Spanning-Tree Technique

Spanning tree method can create any shape.

1. Tile Complexity: O(1).
2. Bin Complexity: O(number of tiles).
3. Stage Complexity: O(depth of spanning tree).
4. Temperature Sensitivity: 1.
5. Planar: yes.
6. *Not fully connected.*



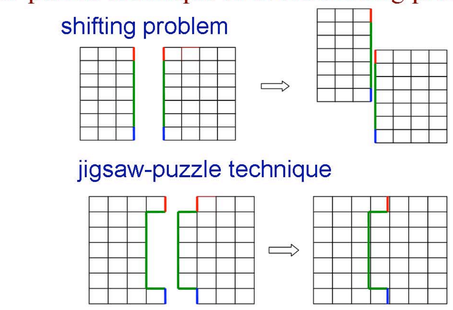


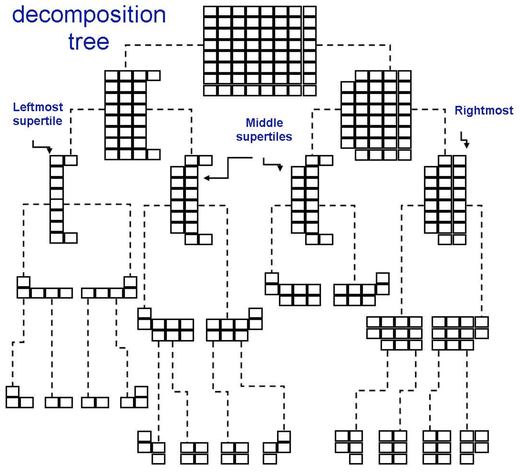
Jigsaw-Puzzle Technique

Jigsaw-puzzle technique create shapes that are fully connected but right now it can only be used to create NxN squares.

1. Tile Complexity: O(1).
2. Bin Complexity: O(1).
3. Stage Complexity: O(logN).
4. Temperature Sensitivity: 1.
5. Planar: yes.
6. Fully connected.

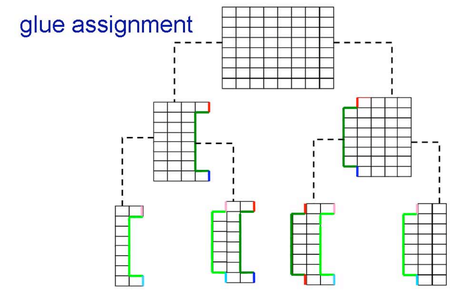
The idea behind jigsaw-puzzle technique is to build structures by combining supertiles. But combining supertiles while using only constant number of glues results in shifting problem. We use jigsaw-puzzle technique to avoid shifting problem.





We use jigsaw-puzzle technique recursively to get the decomposition tree for the NxN square. The height of the tree corresponds to stage complexity while the number of distinct supertiles at each level represents bin complexity.

We assign glue types along the boundary of decomposition—using 3 glue types per decomposition. We alternate glue types between successive decompositions.



Future Work

The next step is to extend jigsaw-puzzle technique to create any general shape. We also plan to investigate methods for creating 3-D structures.

References

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