Layout problems and generative design for shape modeling in computational fabrication

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Loria – MFX team

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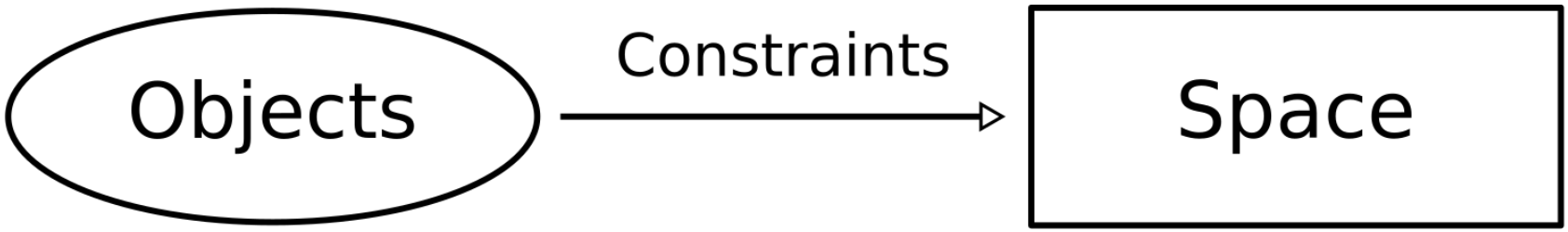
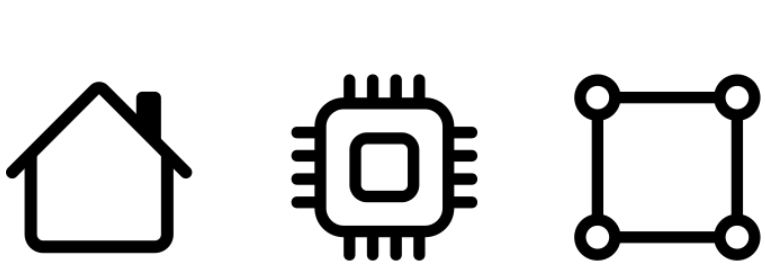
Supervised by *Sylvain Lefebvre* and *Samuel Hornus*

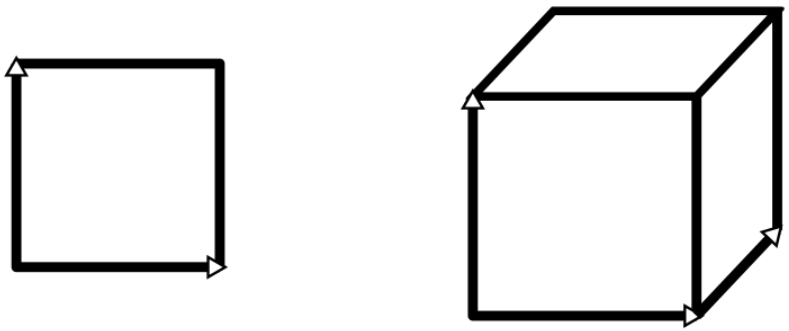
1. Layout problems
   - Definition
   - Example: electronic circuit layout

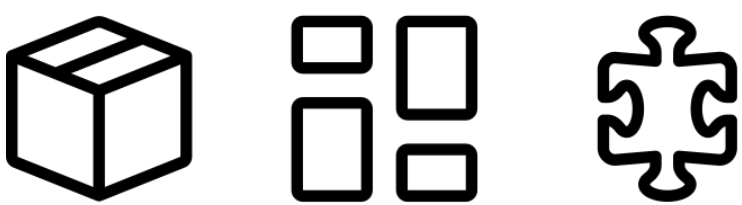
2. 3D printing support generation
   - Introduction
   - Layout problem?
   - Solution space
   - Solver
   - Results

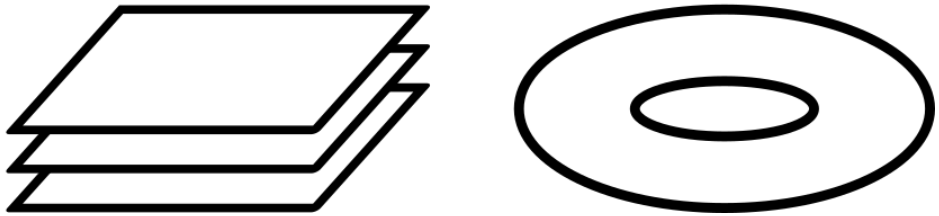
Definition







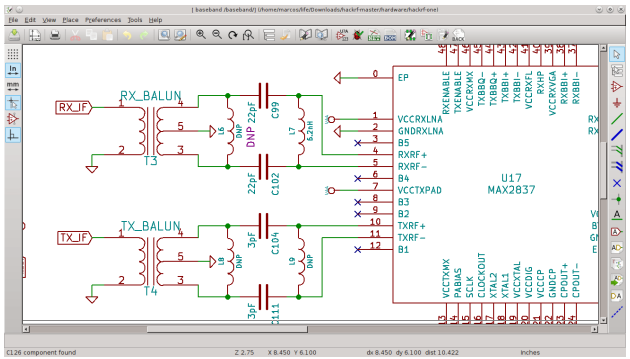


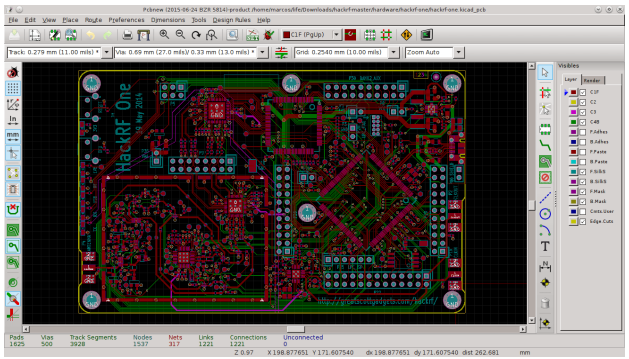


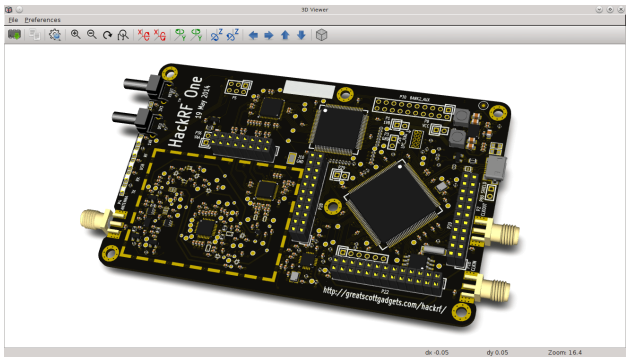
Electronic design automation

EDA

Tools automating the process and alleviating the complexity of designing electronic systems







Open source EDA suite: KiCad EDA

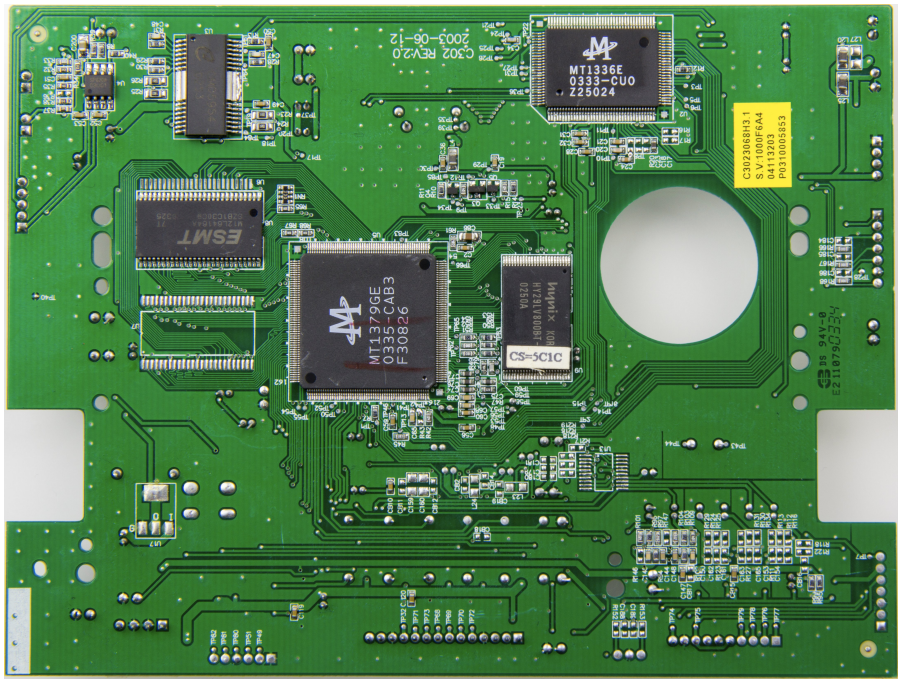
Definition

Layout problem

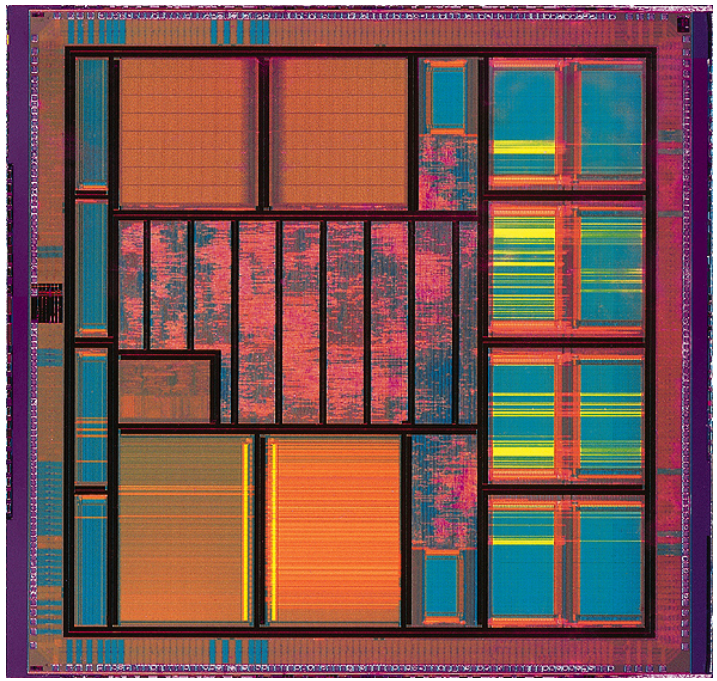
Space Multi-layered board/substrate

Objects Electronic components and interconnects

Constraints Connectivity, wire length and density, signal delay ...



PCB



VLSI

Future projects

Re-layout of existing PCBs

Change the layout of an already existing circuit to fit a new space or a new set of constraints

Routing of arbitrary LED distributions

Find a way to route an arbitrary distribution of LEDs on a surface

1 Layout problems
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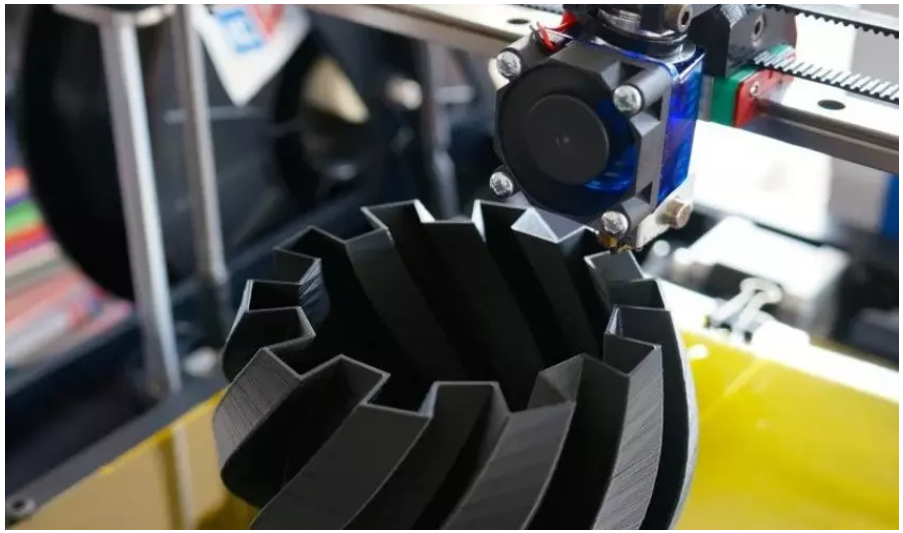
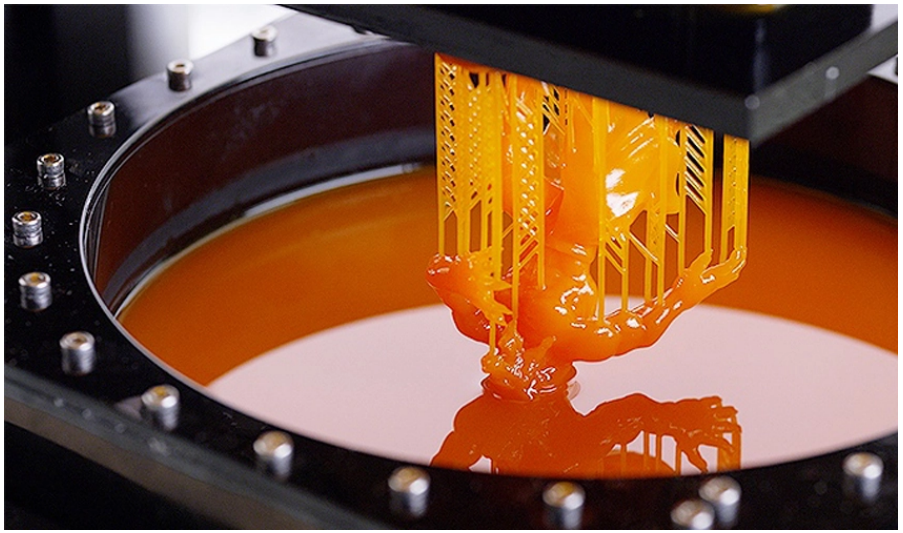
3D Printing

Principle

Construction of a 3D object from a digital 3D model typically by stacking many thin layers of a material



Filament deposition modelling (FDM)

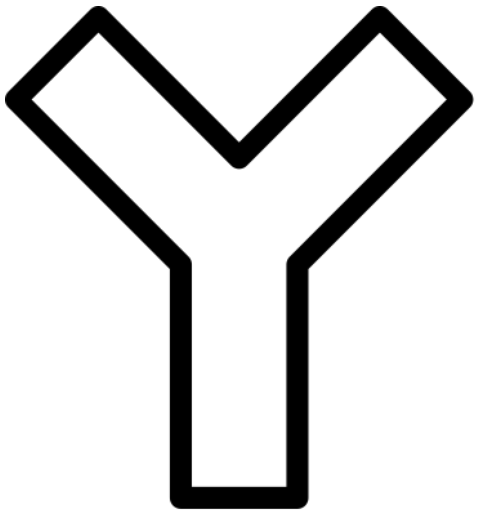


Stereolithography (SLA)

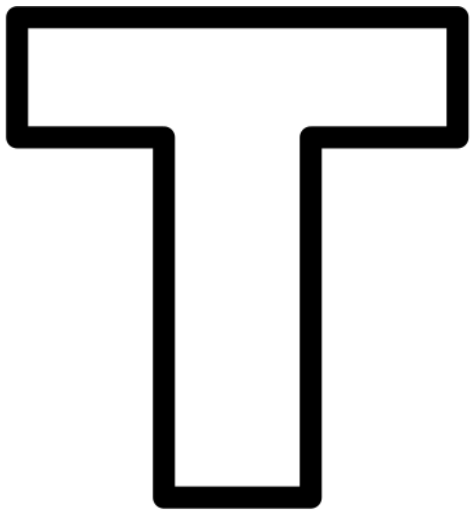
Why supports?

Printability

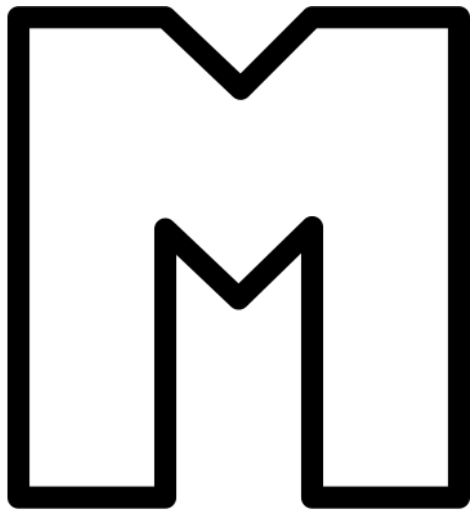
Some structures cannot be printed directly by a 3D printer



Overhang
< 45°

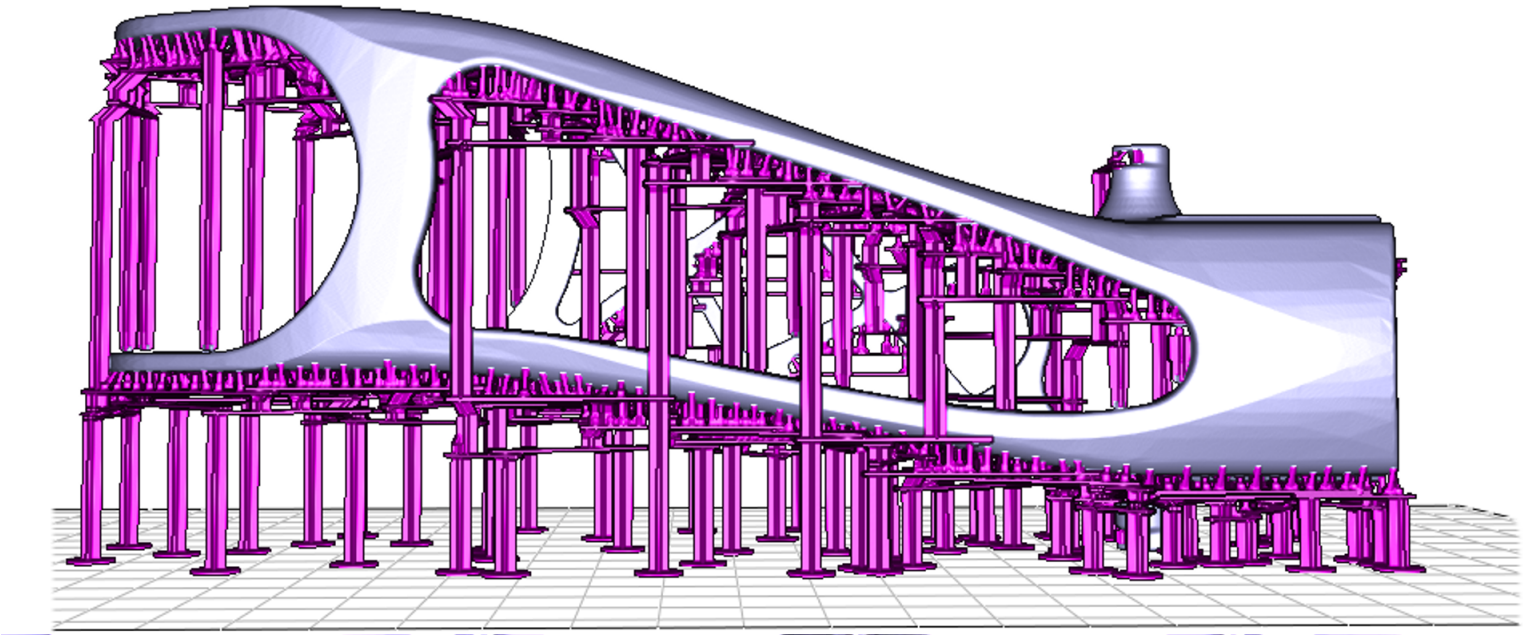


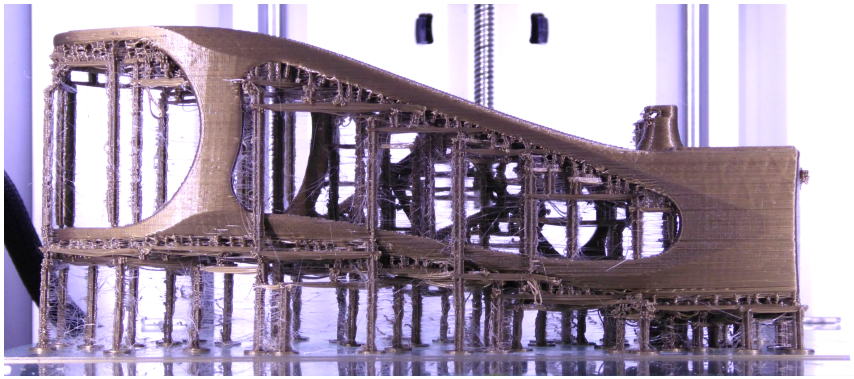
Overhang
> 45°

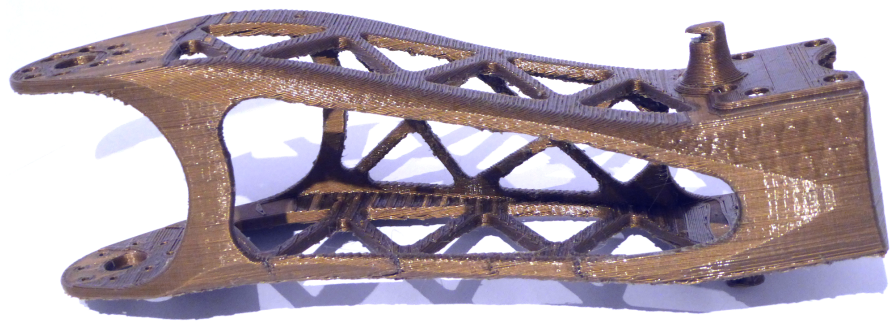


Local
minima

Bridging the gap







Bridging the Gap: Automated Steady Scaffoldings for 3D Printing, J. Dumas et al. 2014

Objectives

Goals

Printability Reliable support structure

Removal Minimize contact with piece

Speed Minimize material use

Priorities

1. Generate supports that *avoid* the piece
2. Generate supports *quickly*
3. Generate supports that are *efficient*

Approach it as a *layout problem*!

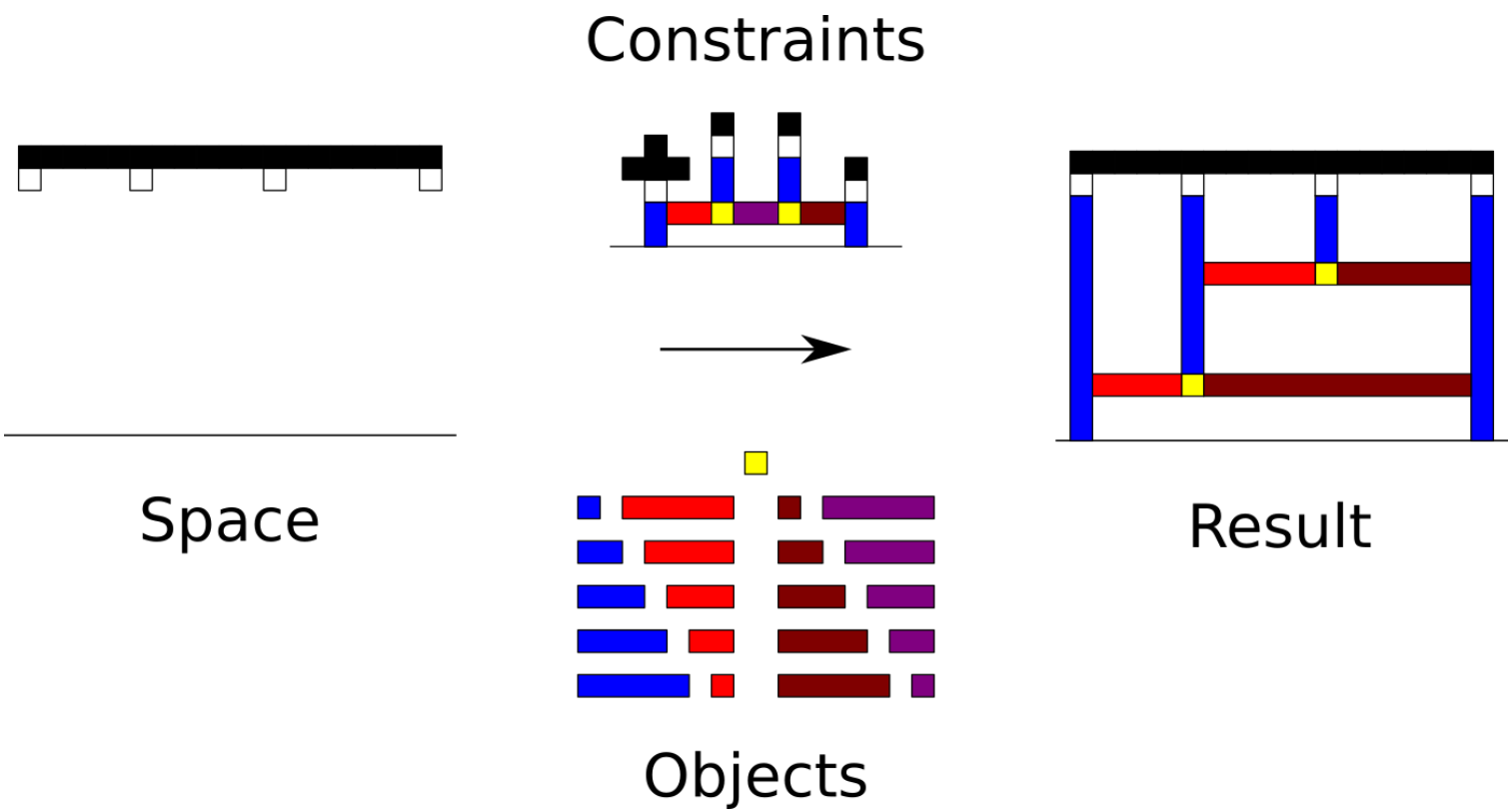
Layout problem

Summary

Space Voxel grid containing the object to print

Objects Different types of voxels

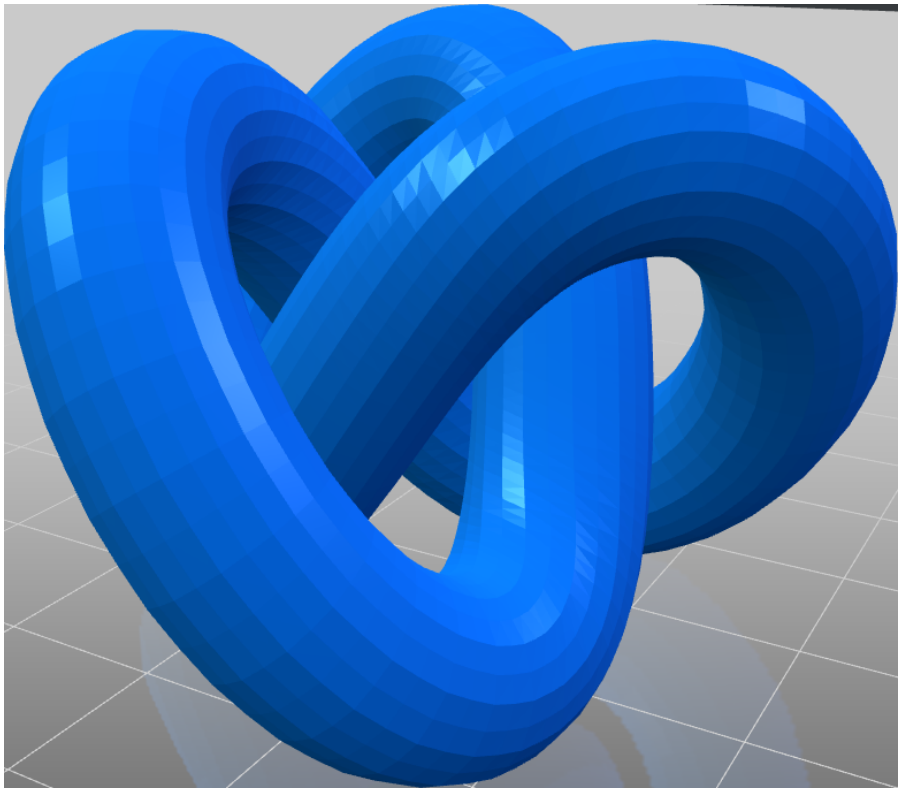
Constraints Adjacency constraints between types of voxels

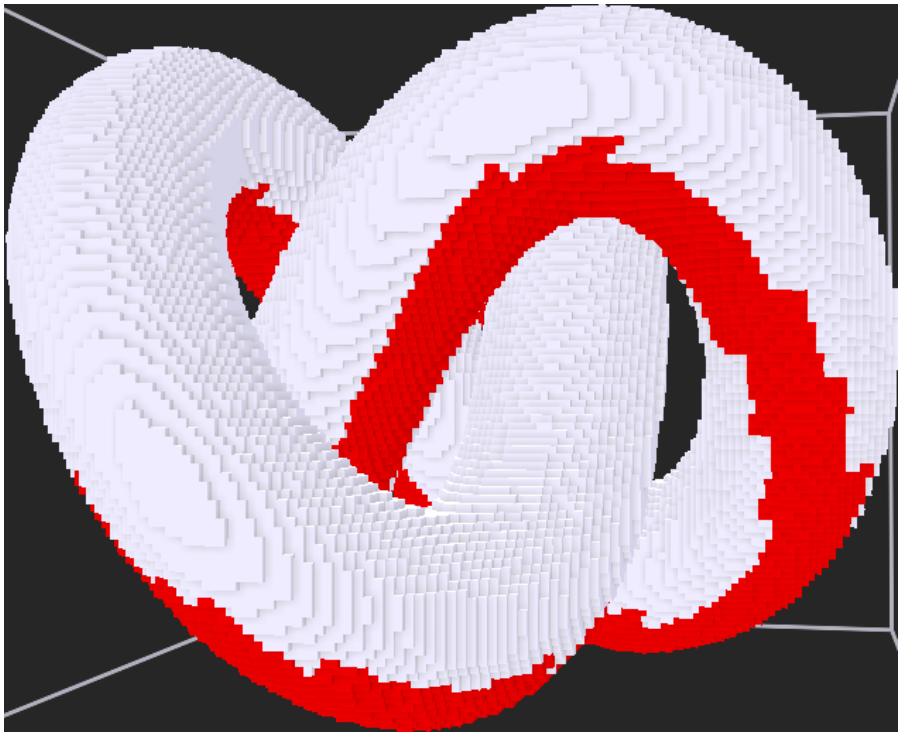


Space

Input

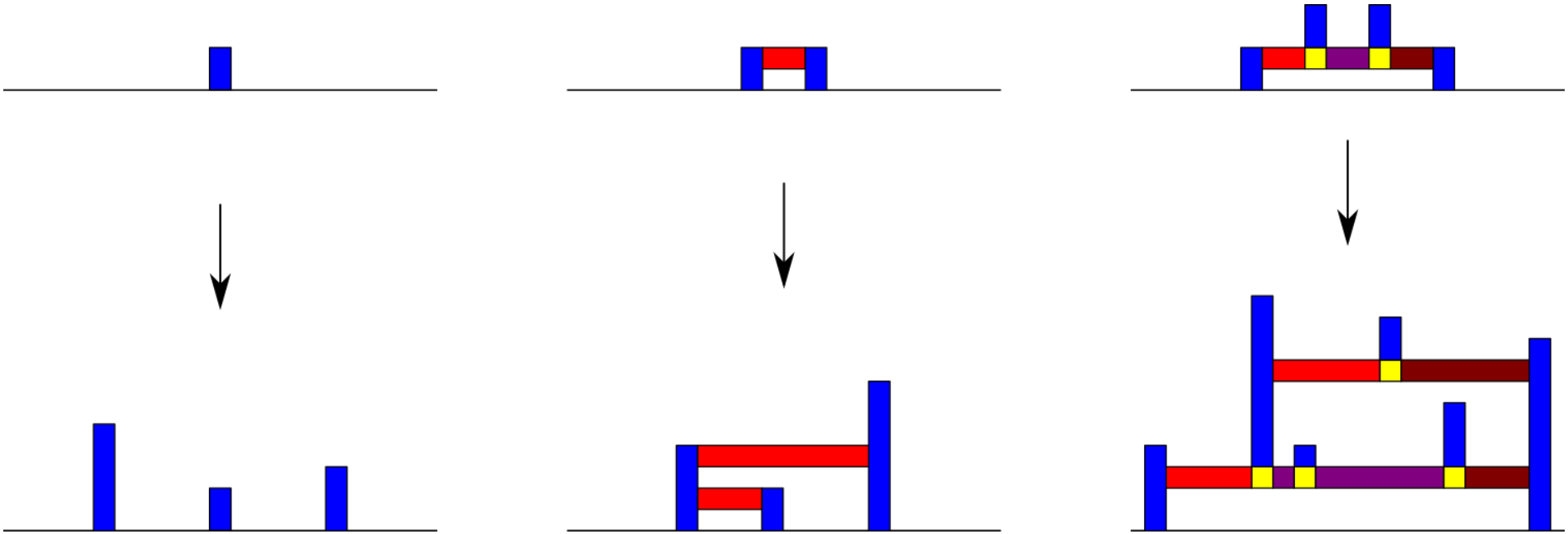
Voxelize the 3D object and find zones that need support





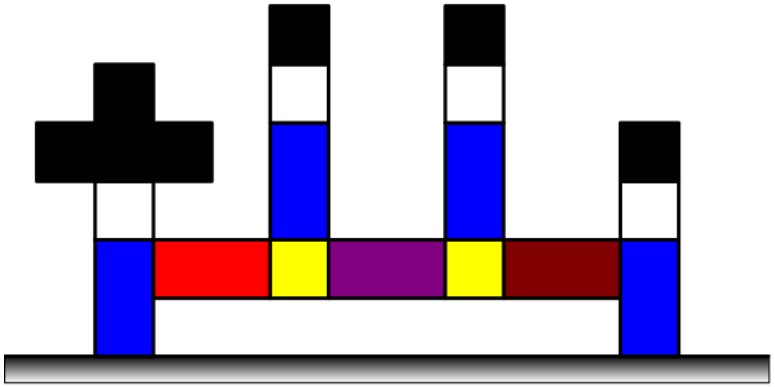
Exemplar

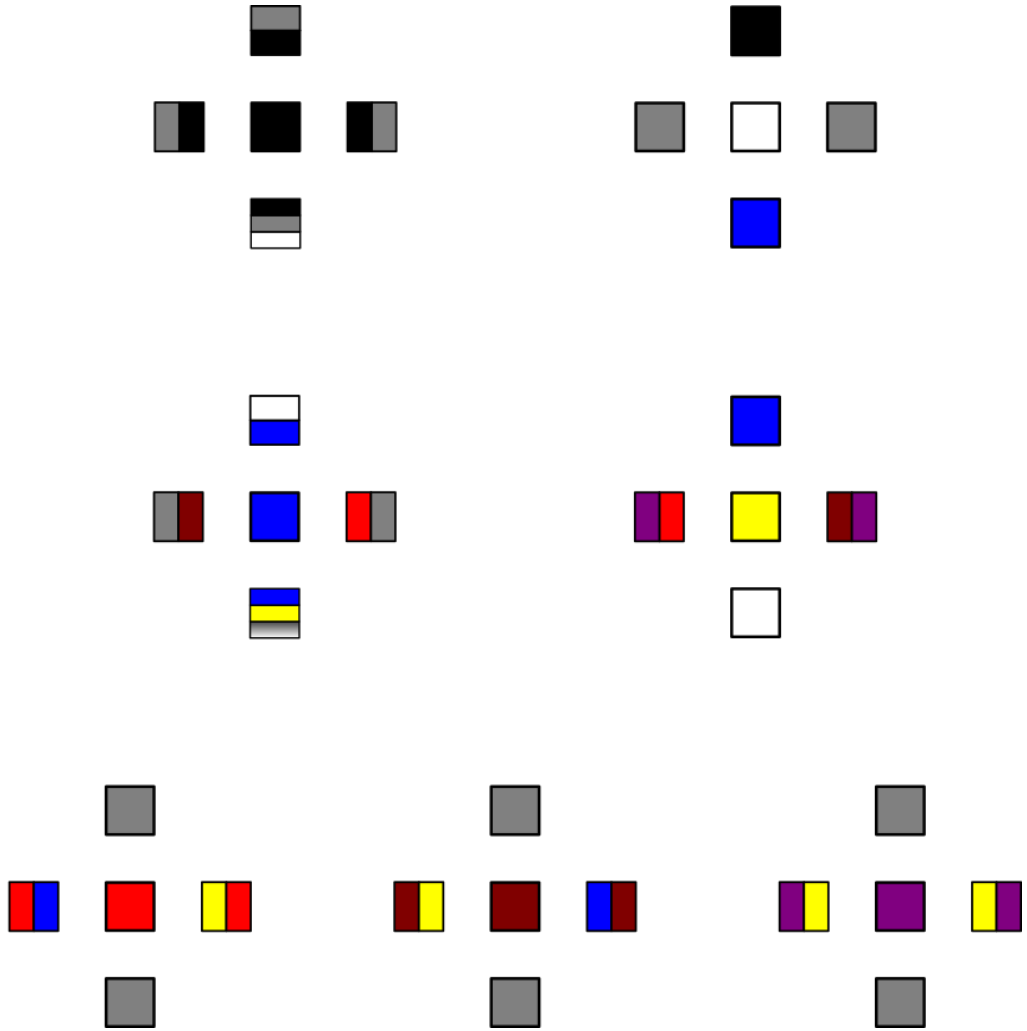
Exemplars



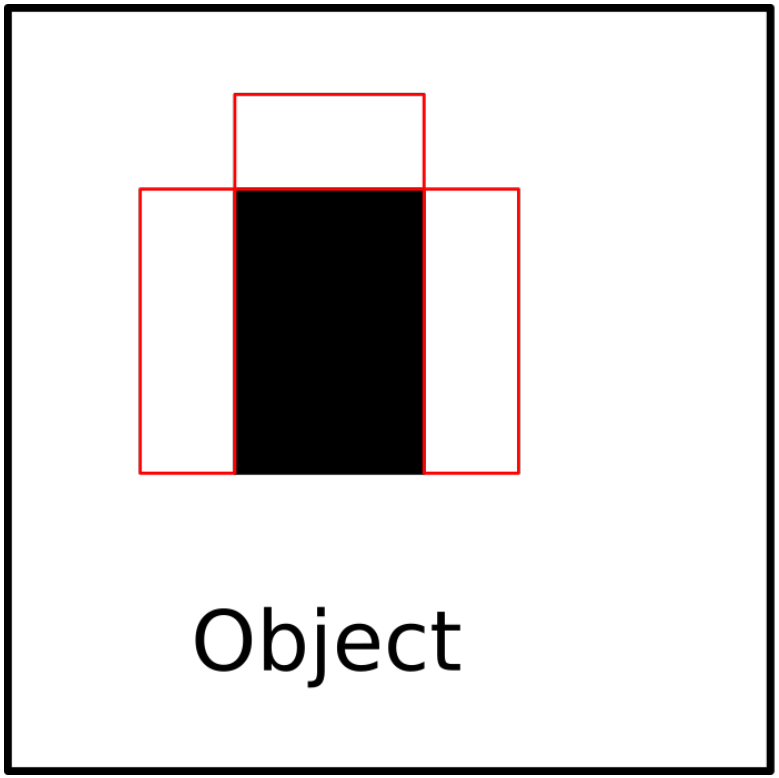
Results

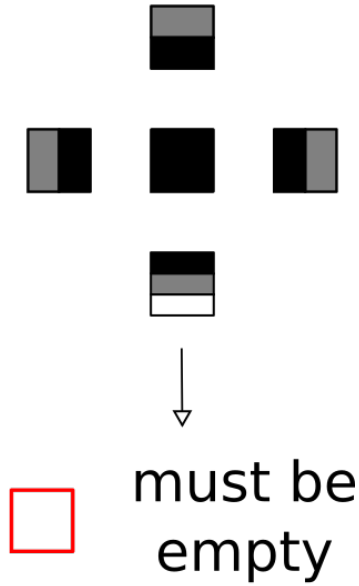
Adjacency constraints



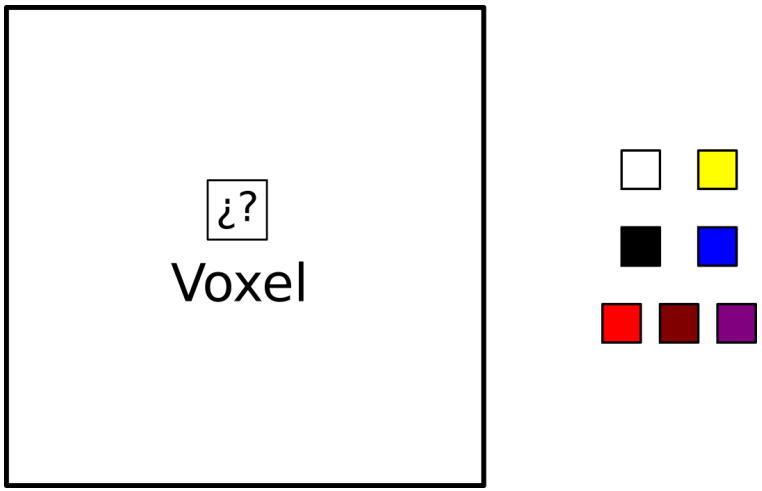


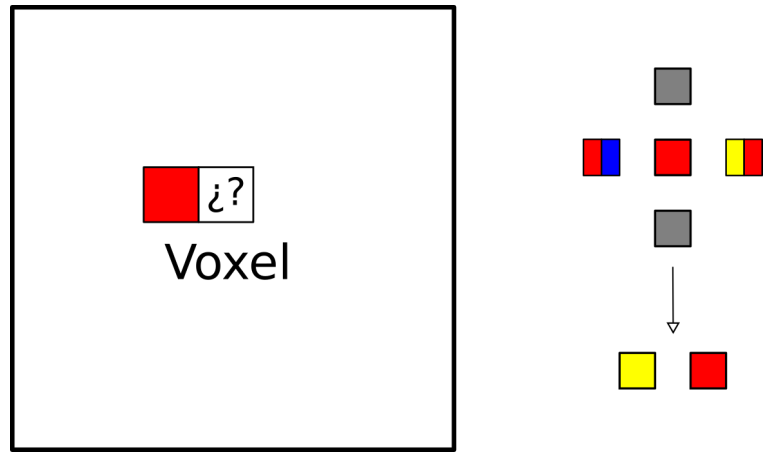
Object avoidance



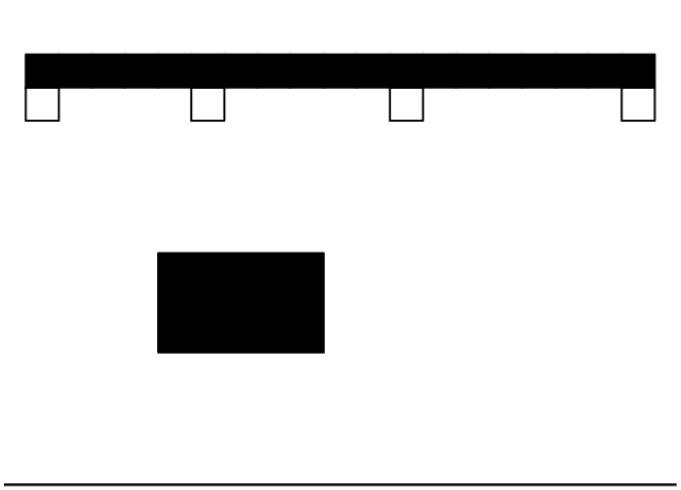


Possibility sets

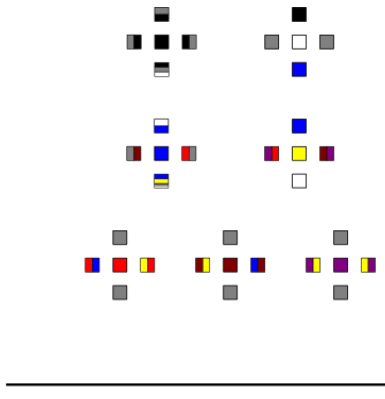




Solution space



Initial scene



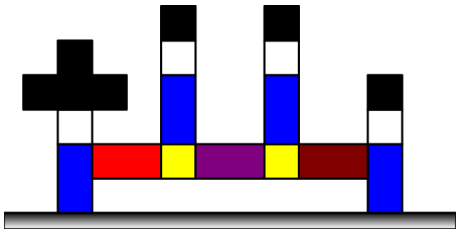
Constraint propagation

$$\pi(\square) \subseteq \left\{ \begin{array}{cc} \square & \square \\ \square & \square \\ \square & \square \end{array} \right\}$$

$$\square \in [1, N]^2$$

Solution space

Solver principle



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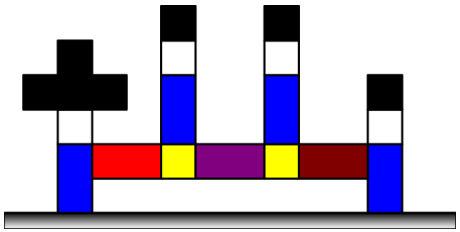
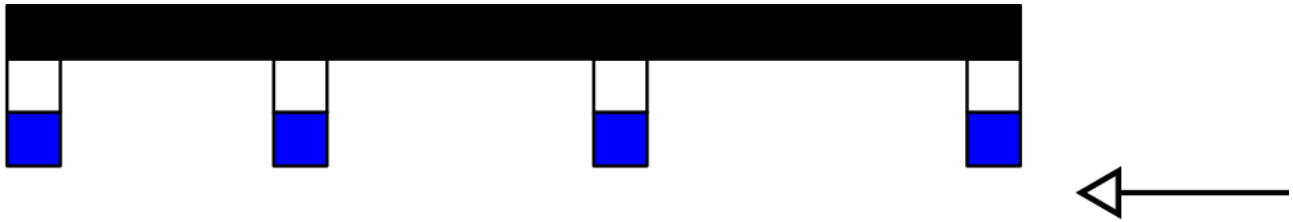
Solver principle





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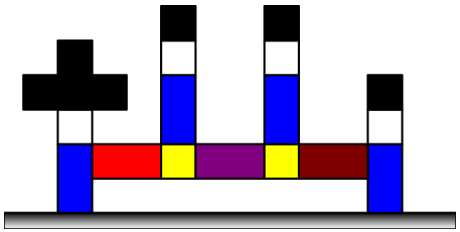

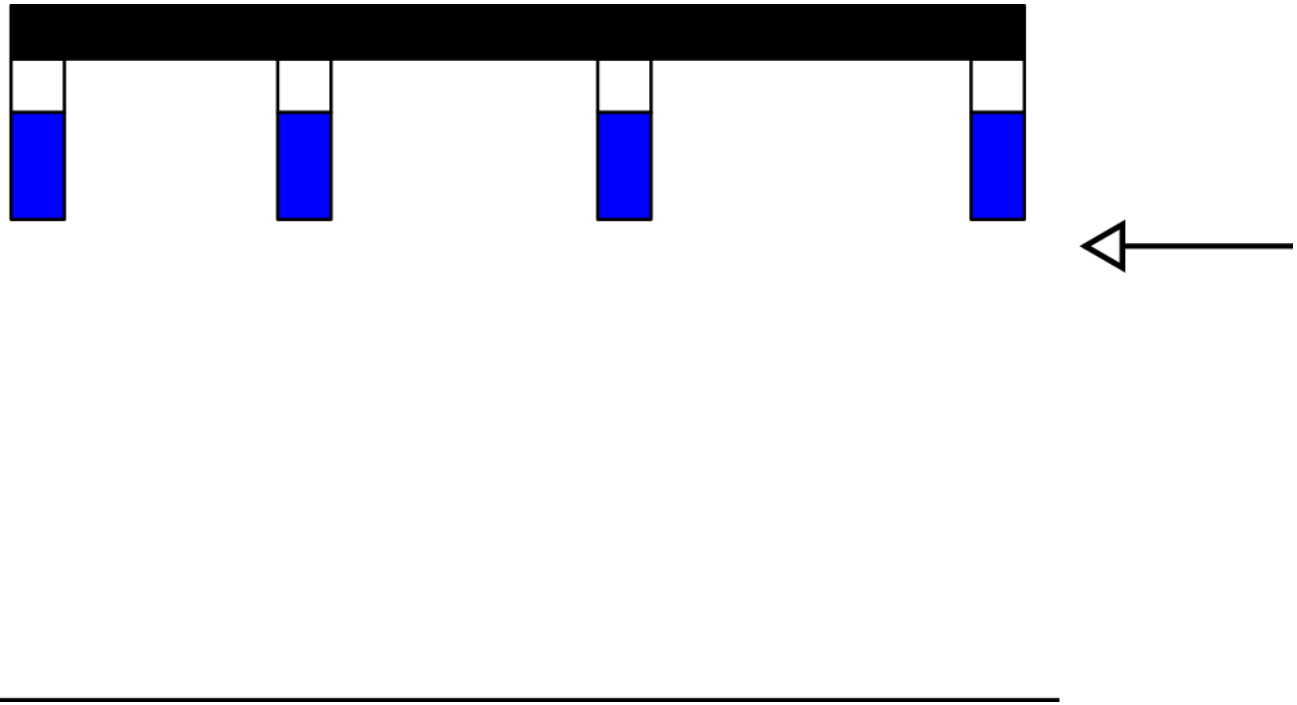

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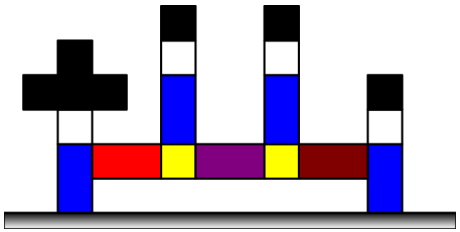

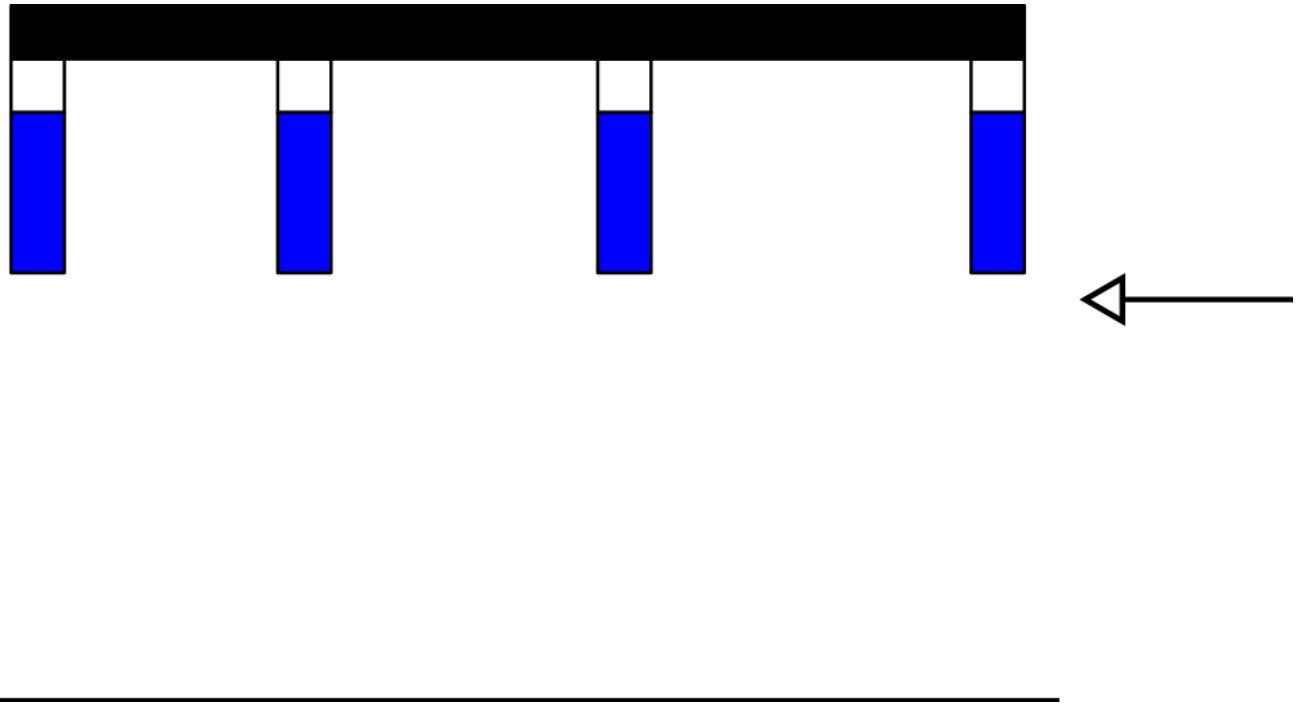

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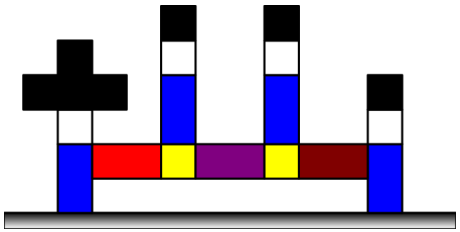

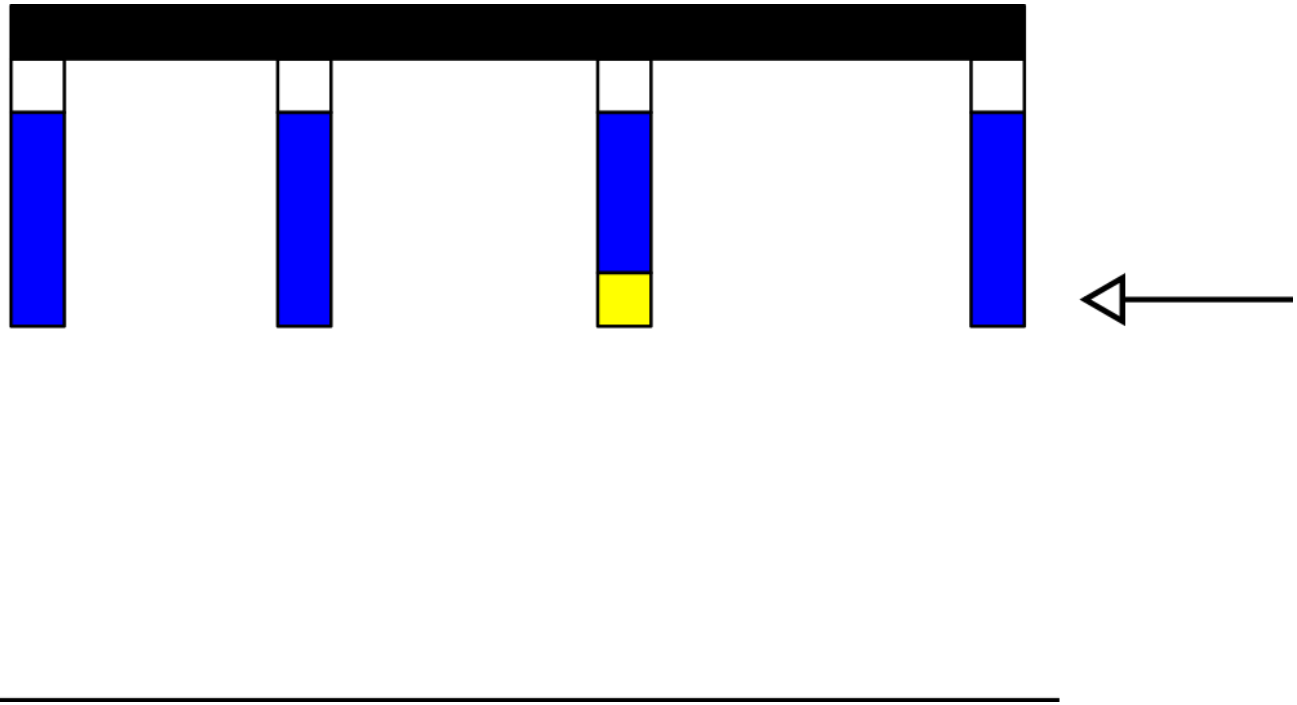

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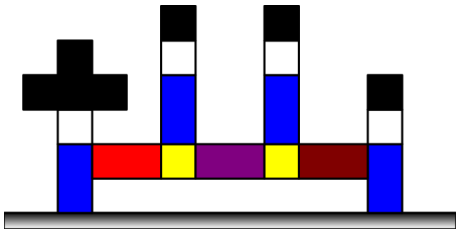

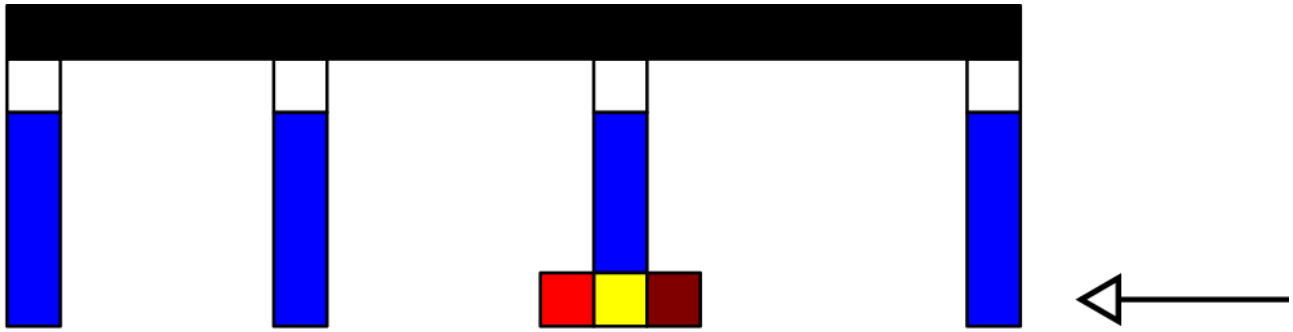

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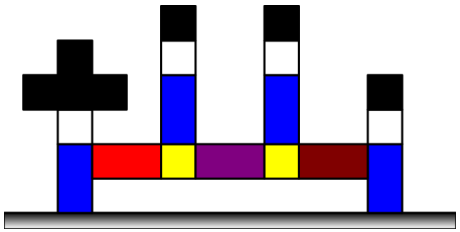

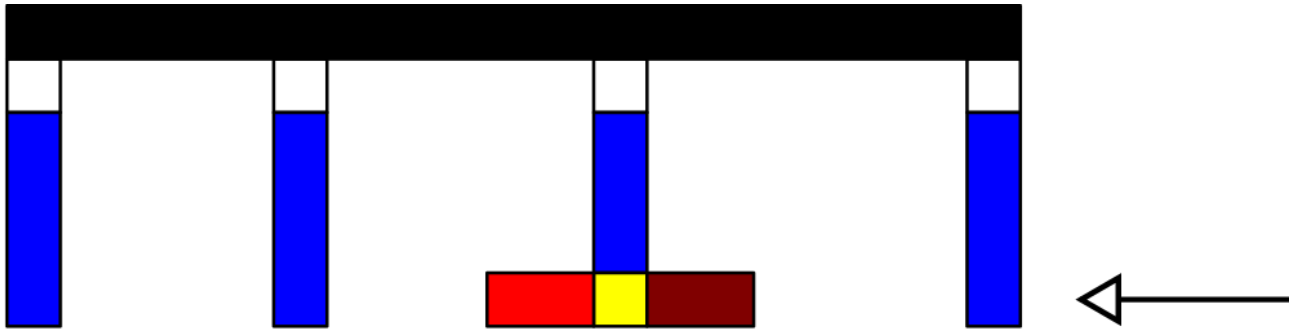

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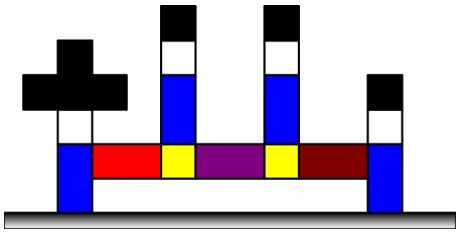

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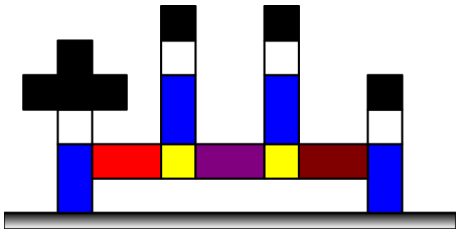

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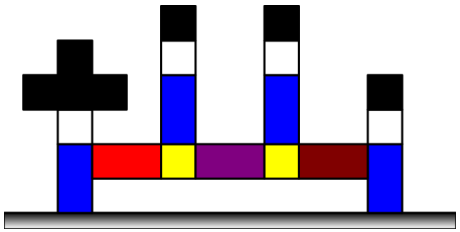

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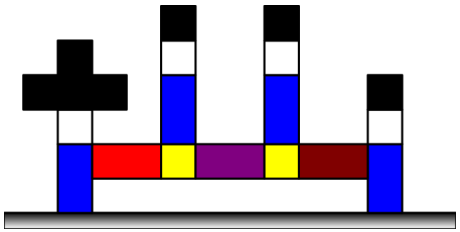

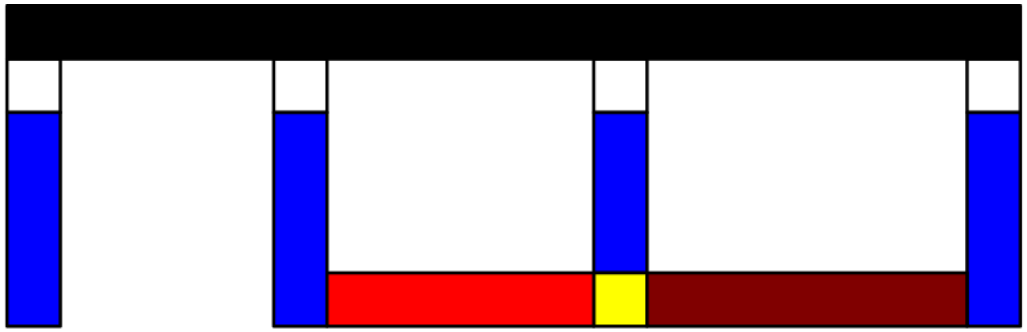

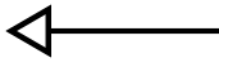

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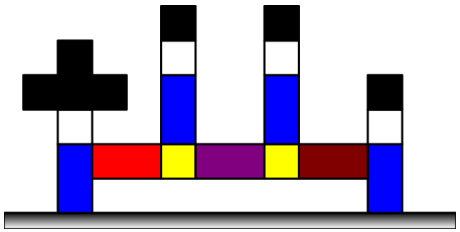

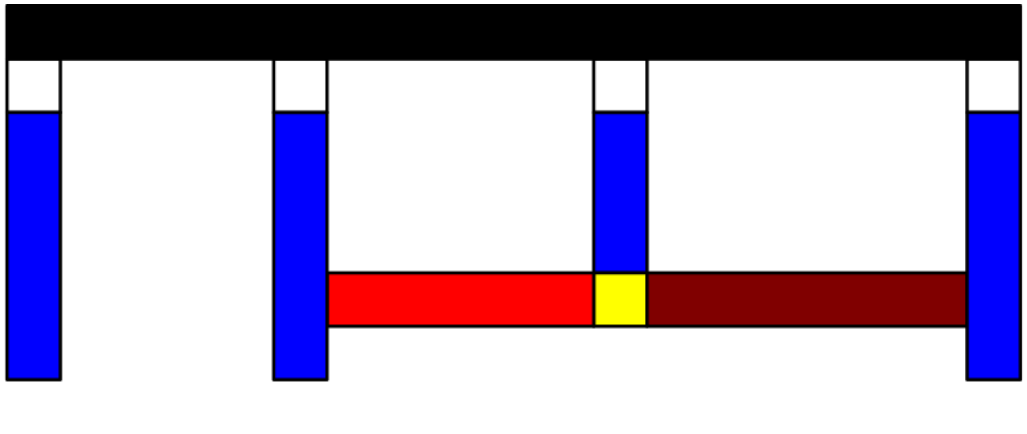

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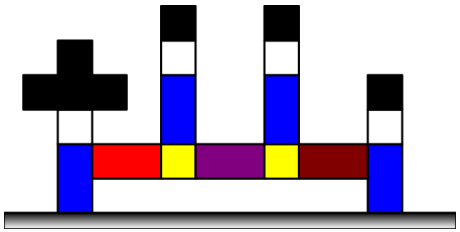
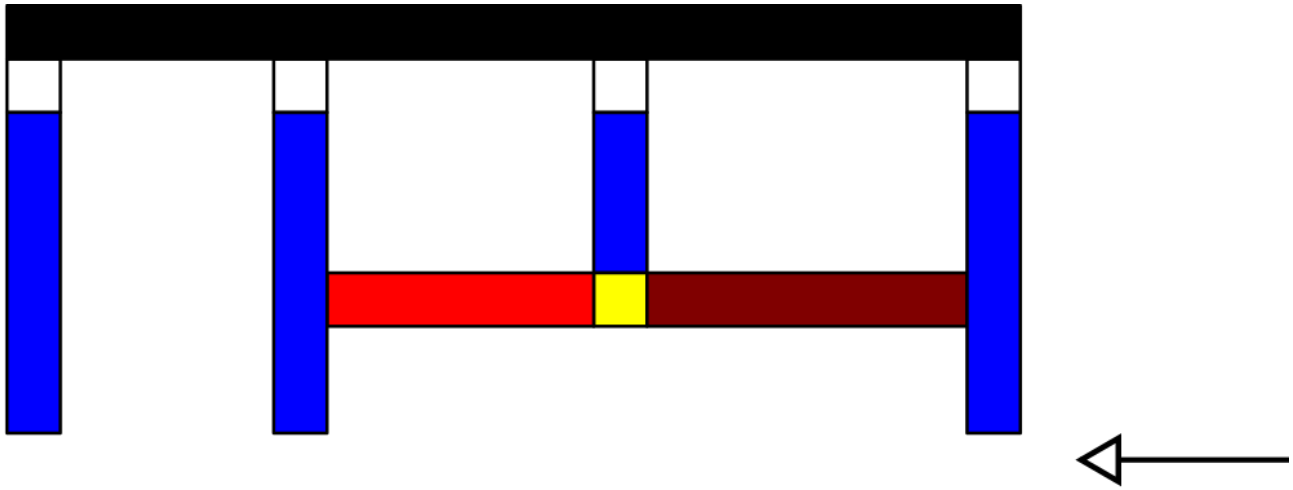
Solver principle





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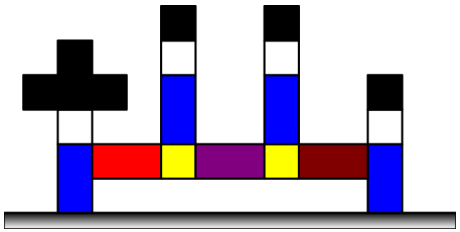
Solver principle



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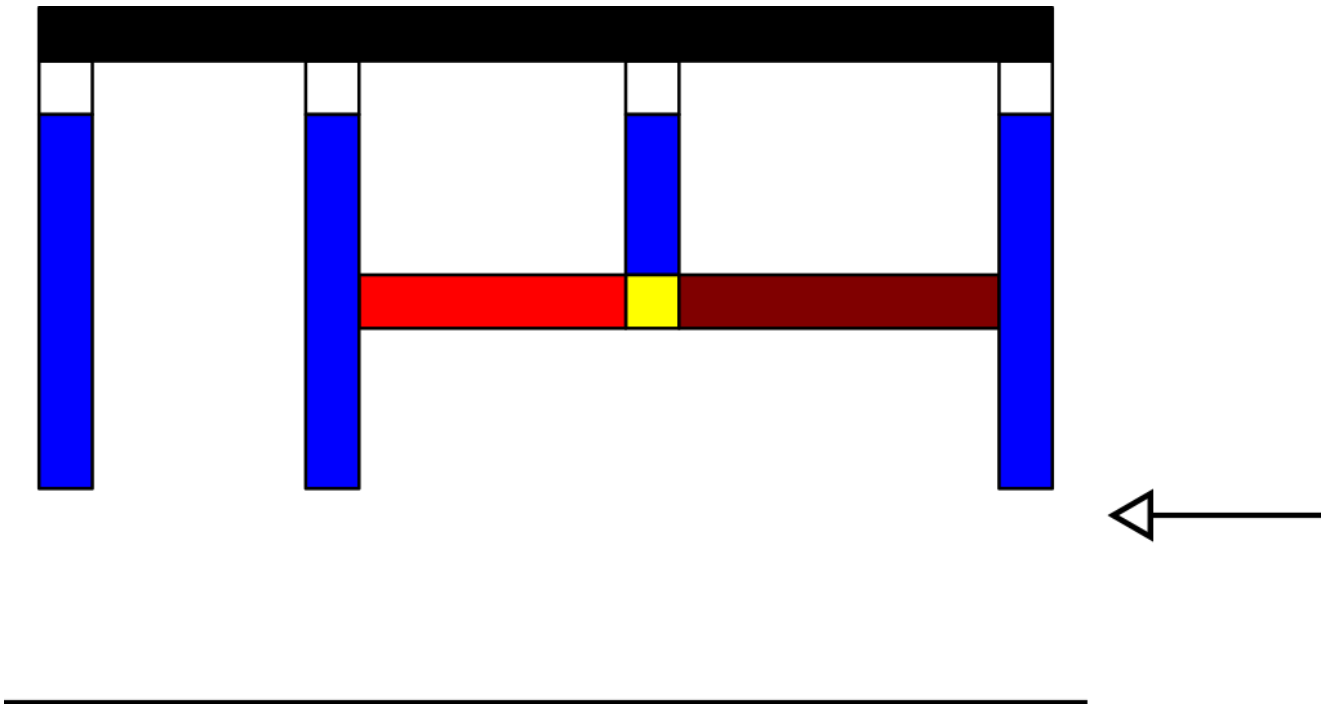

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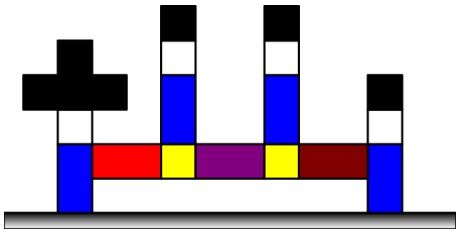

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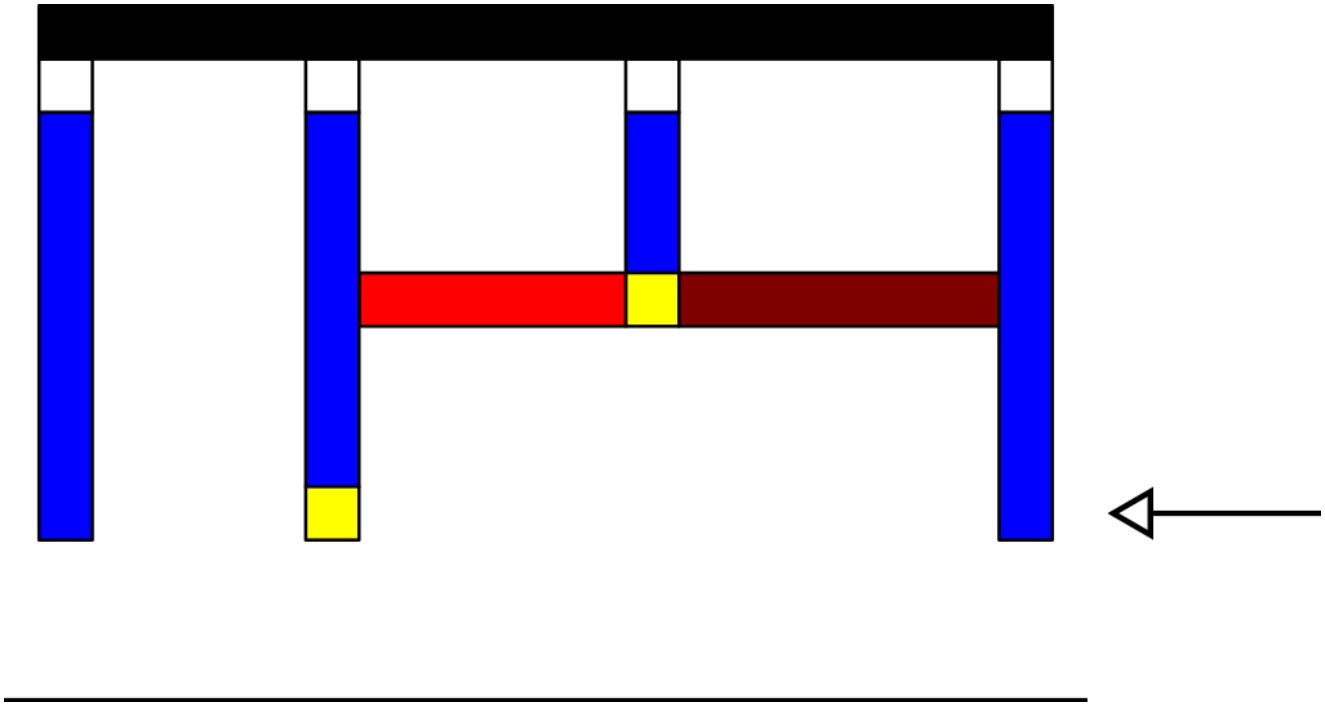

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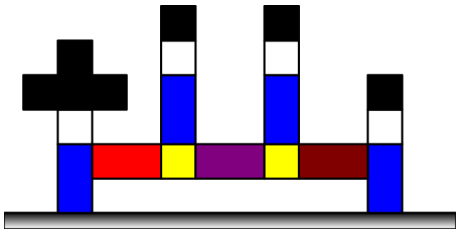

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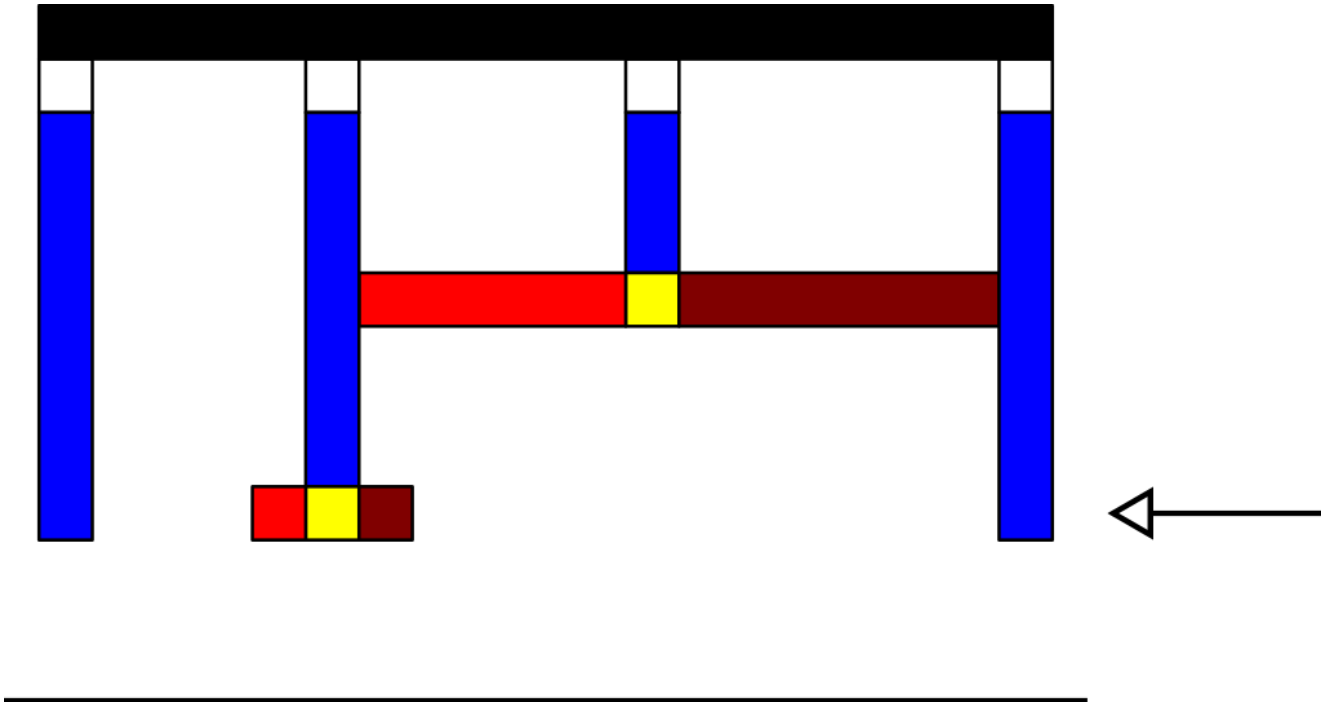

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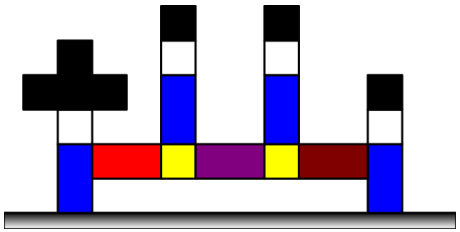

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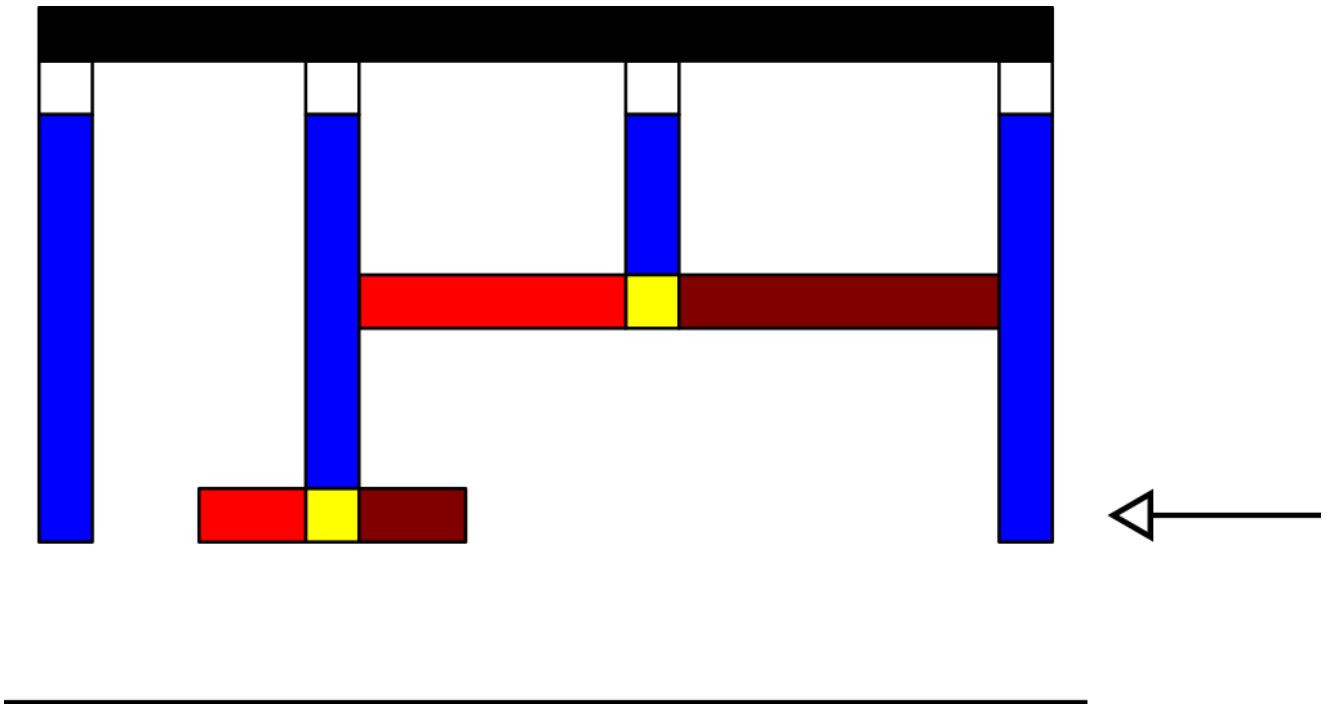

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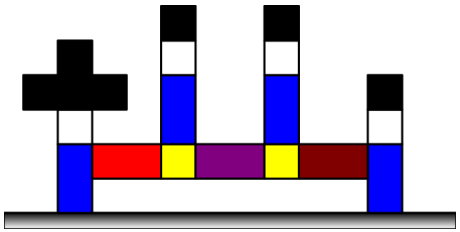

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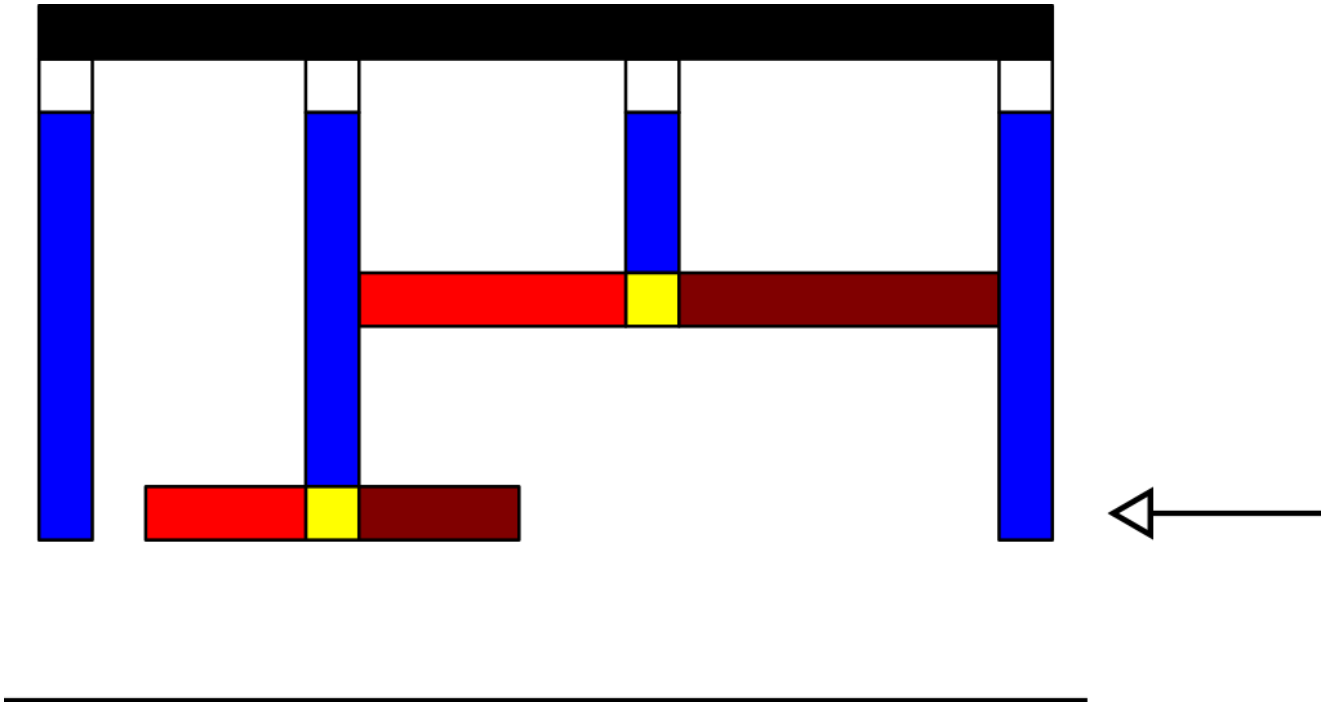

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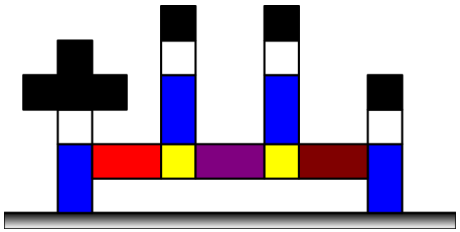

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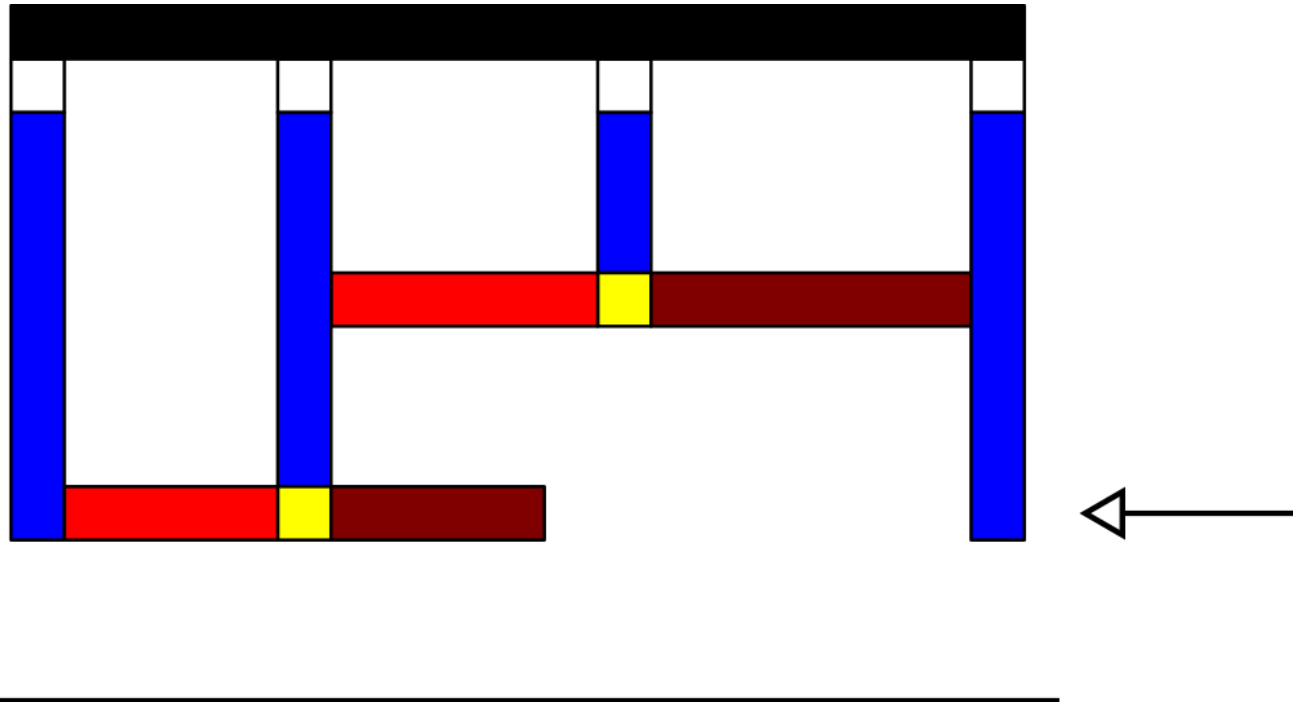

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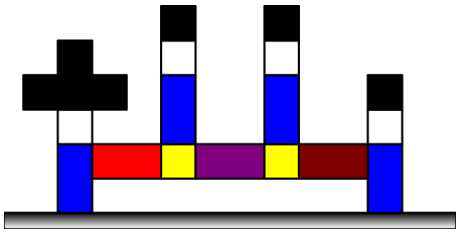

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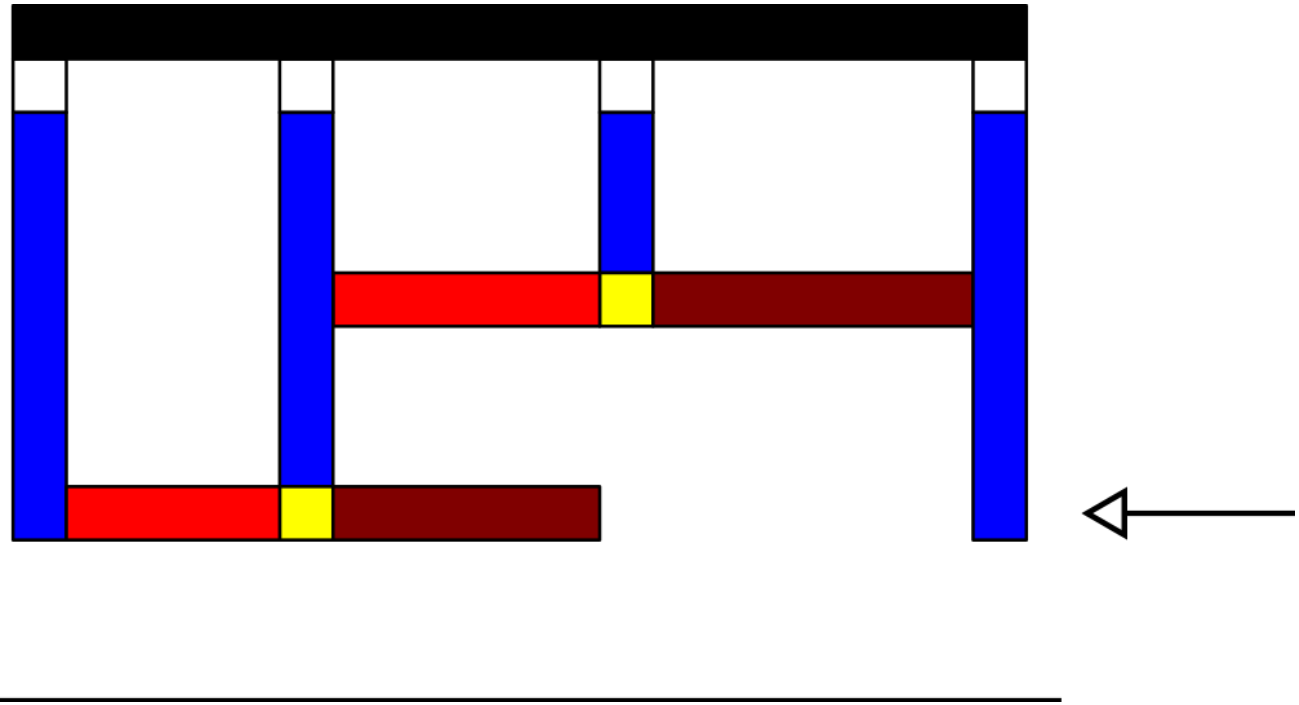

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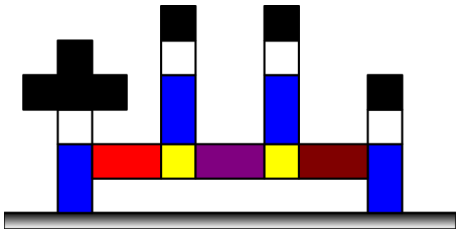

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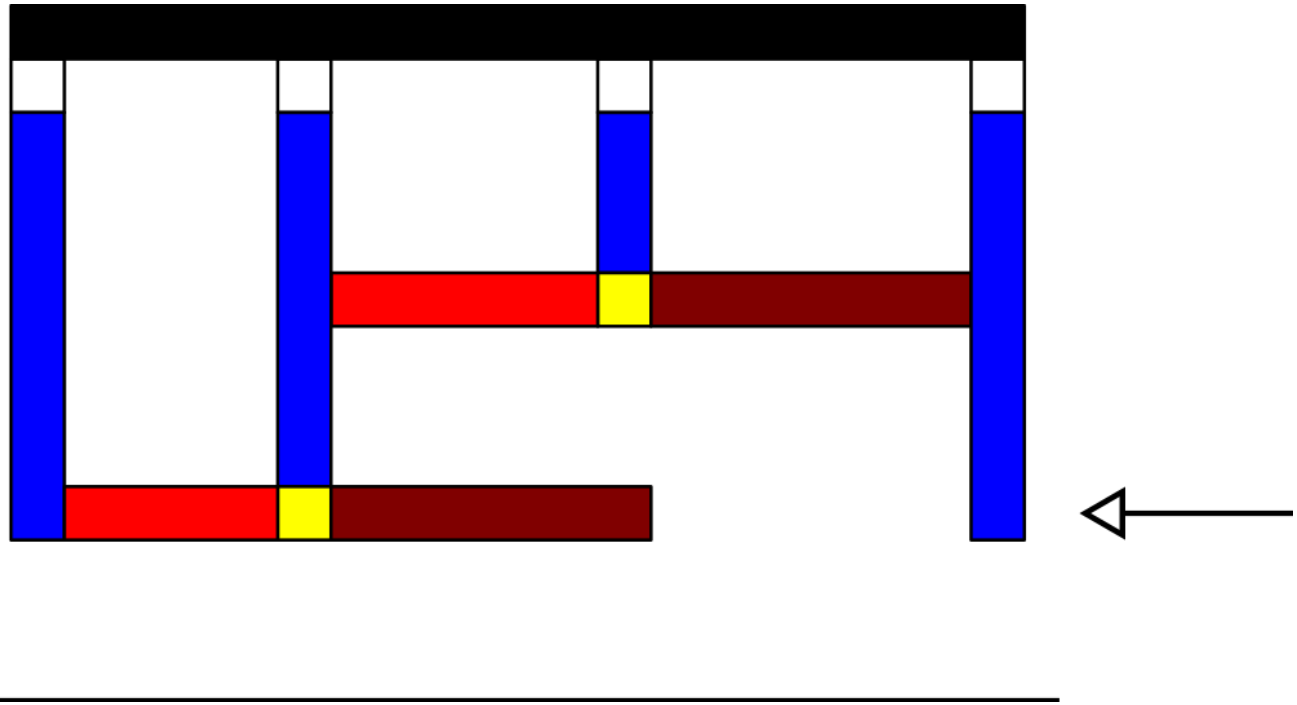

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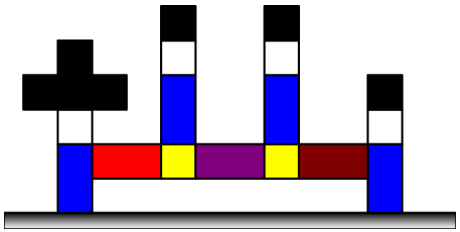

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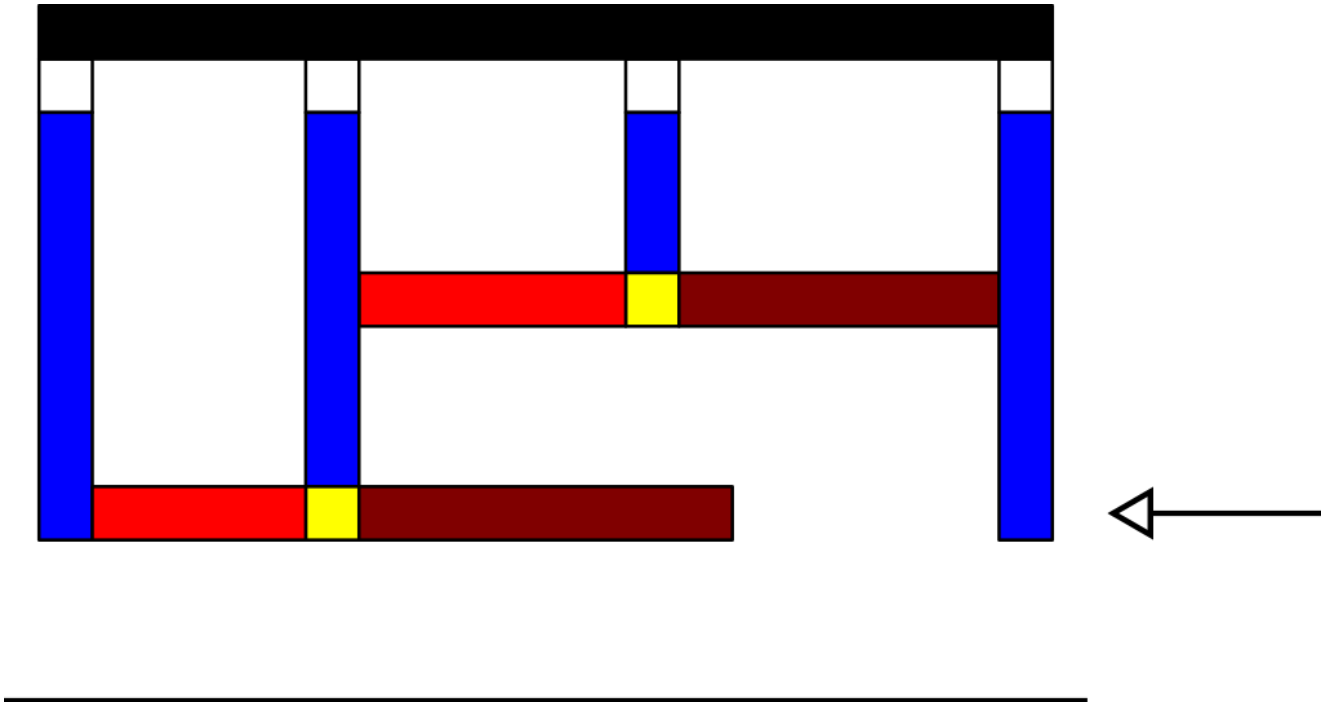

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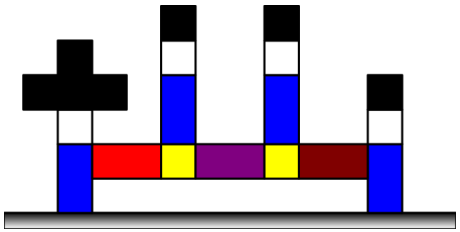

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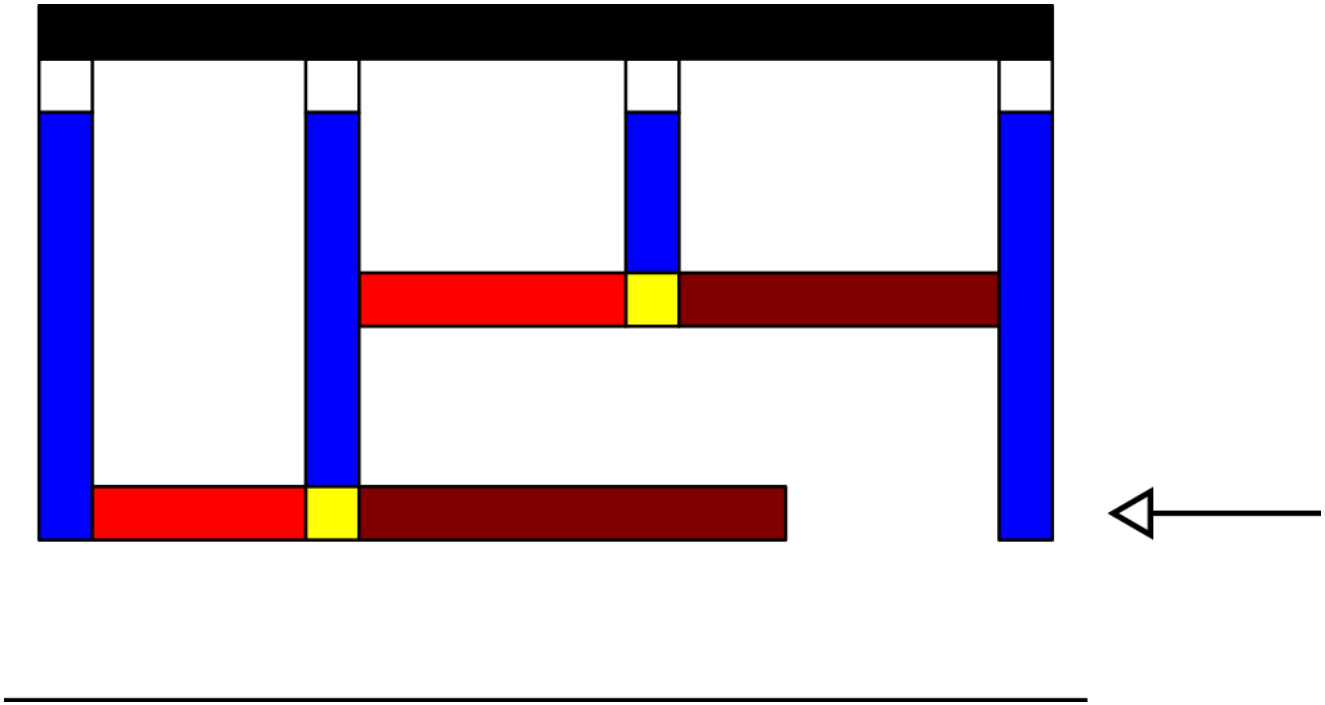

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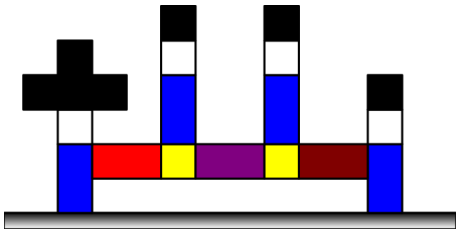

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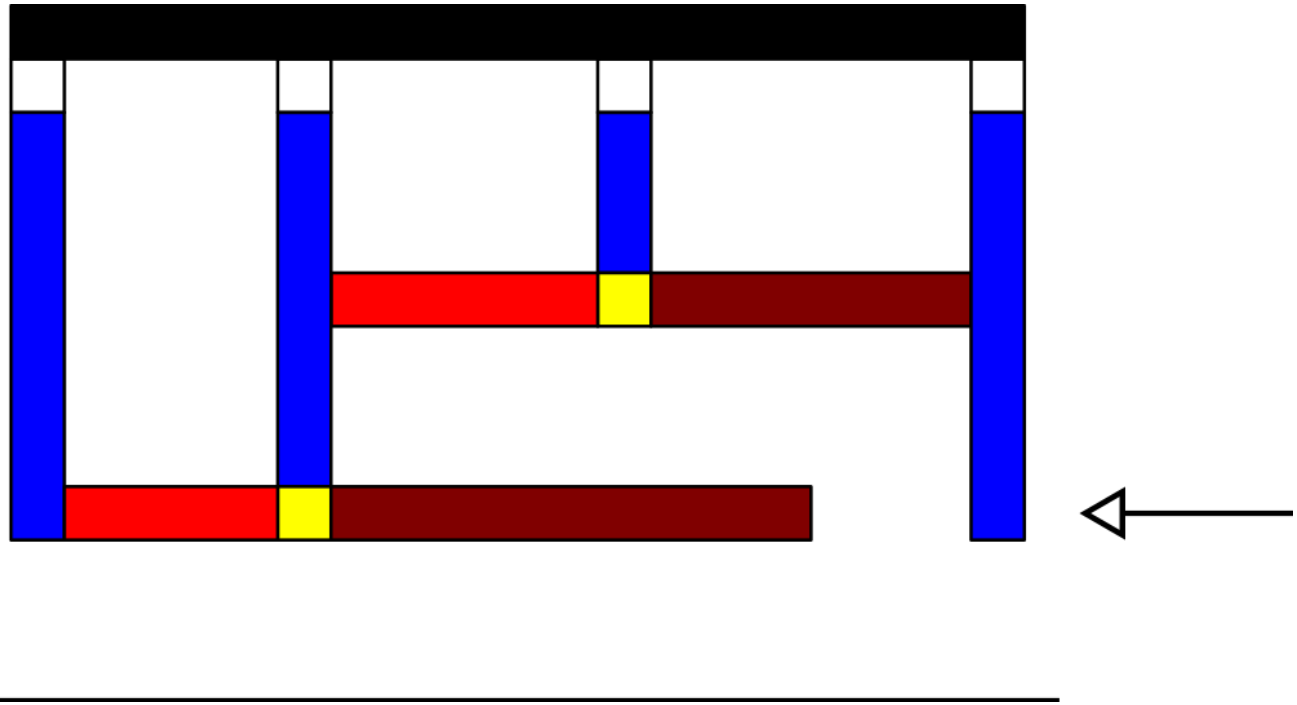

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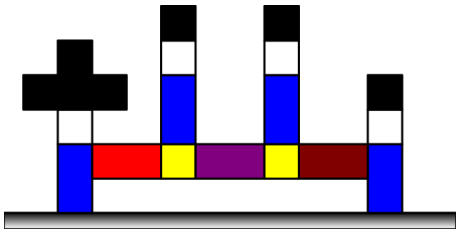

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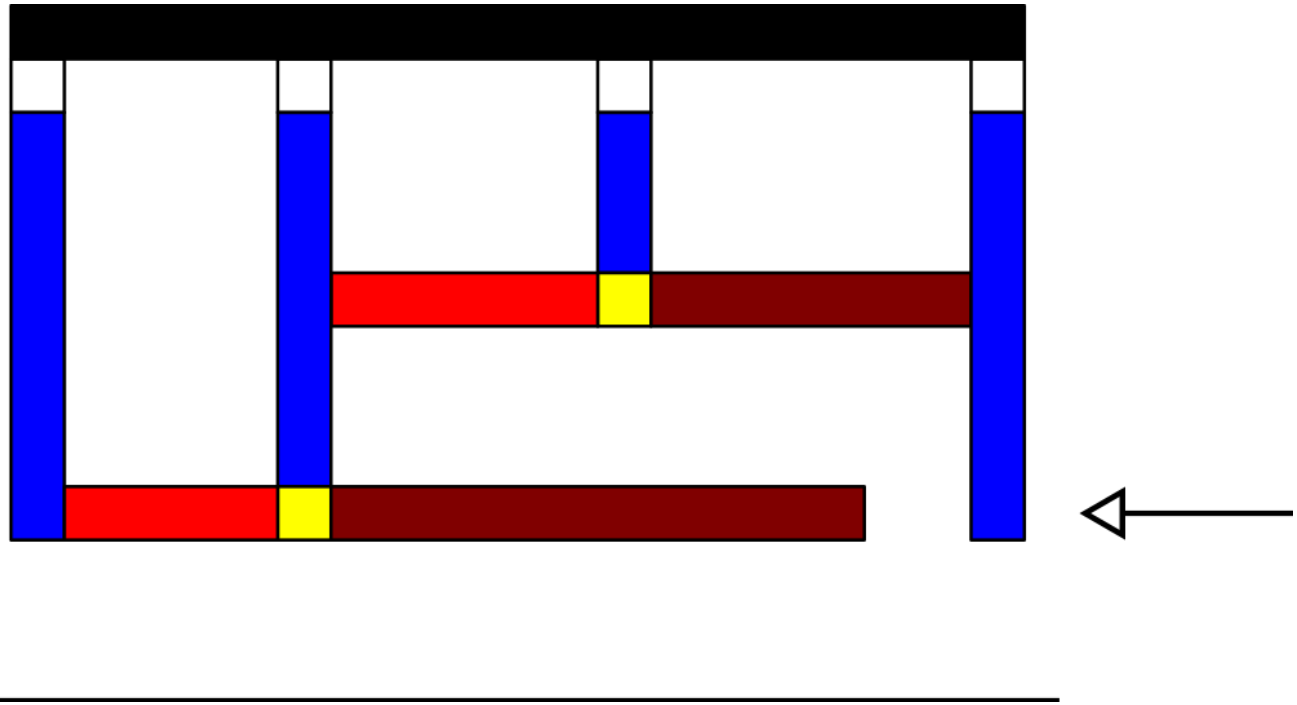

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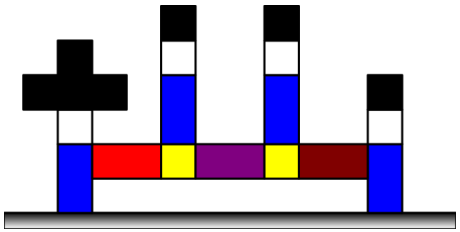

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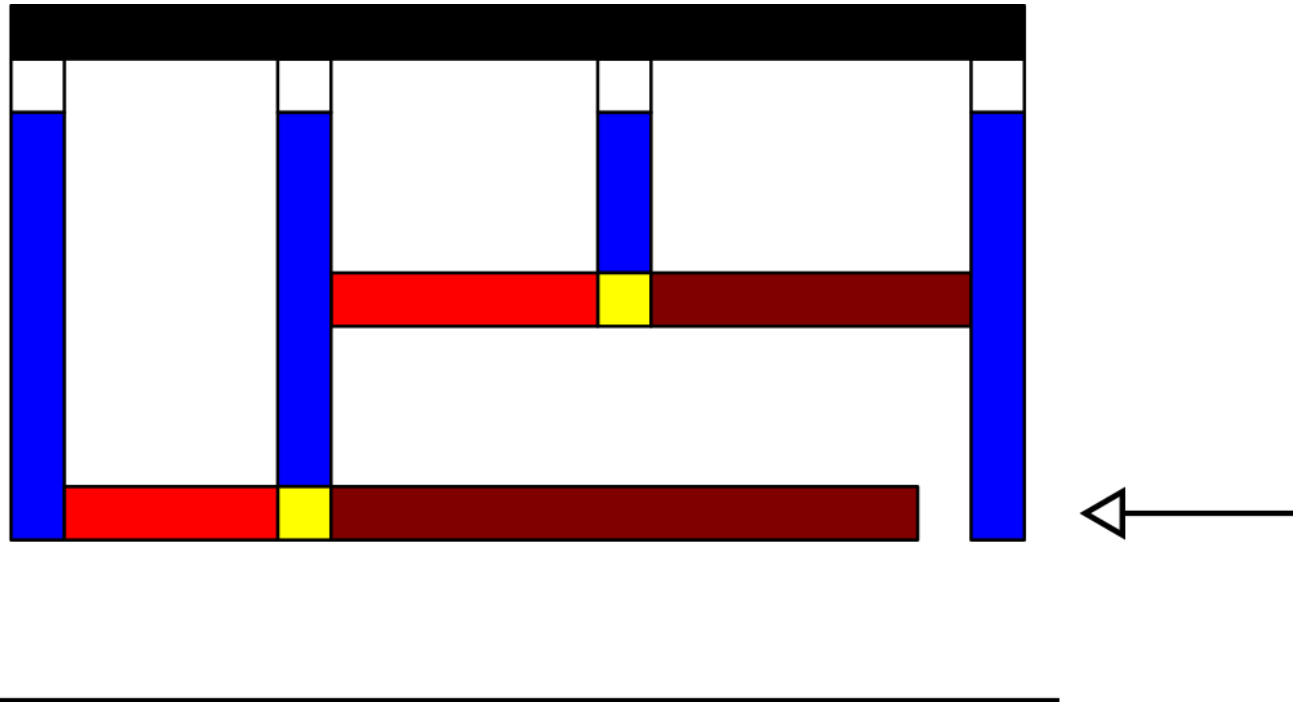

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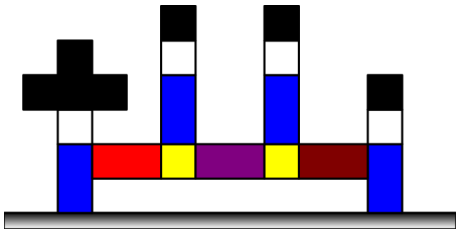

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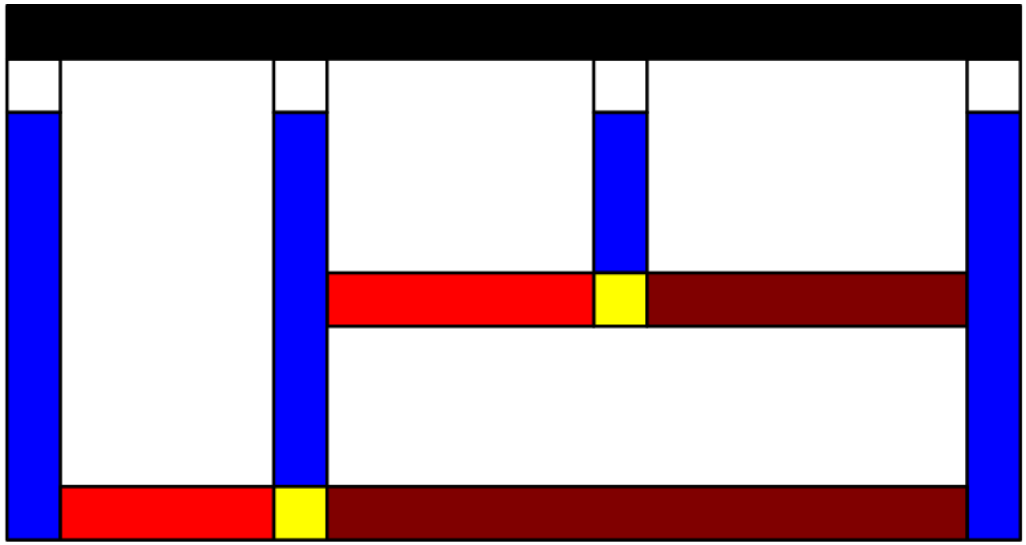

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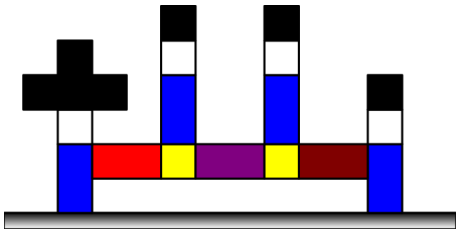

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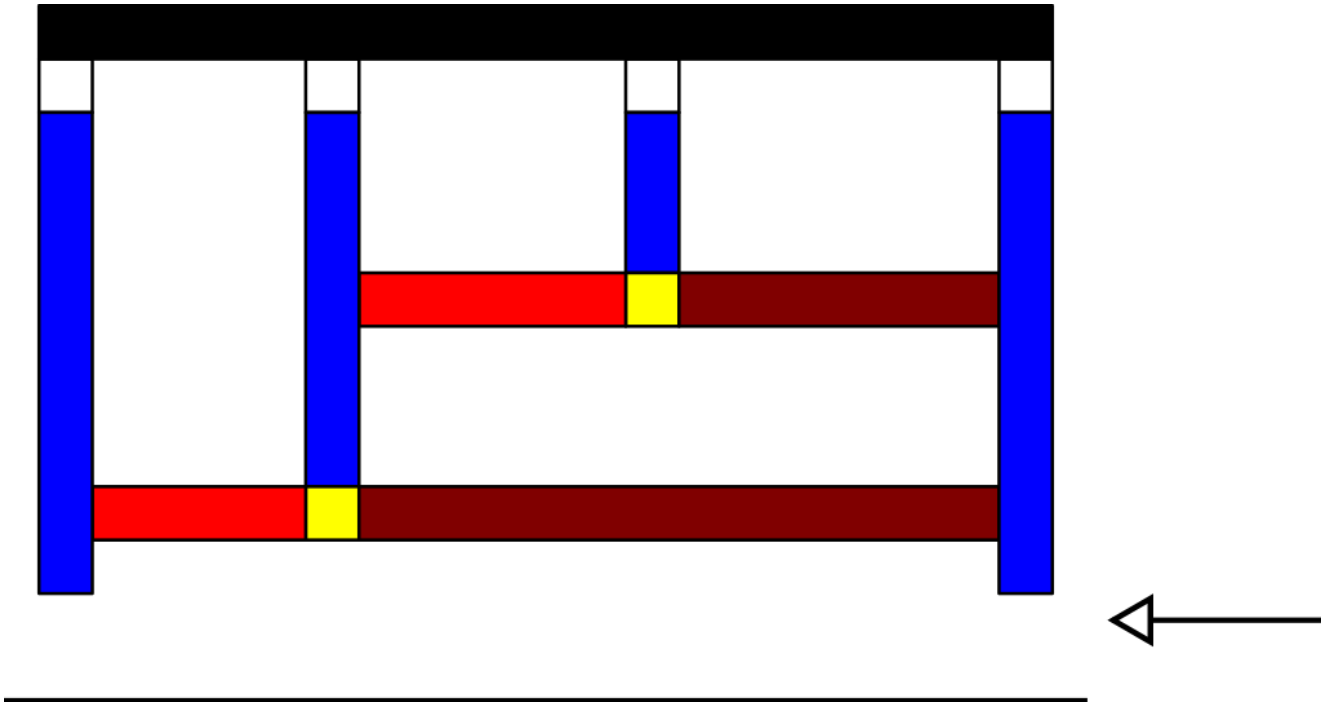

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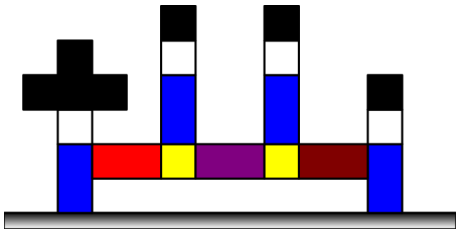

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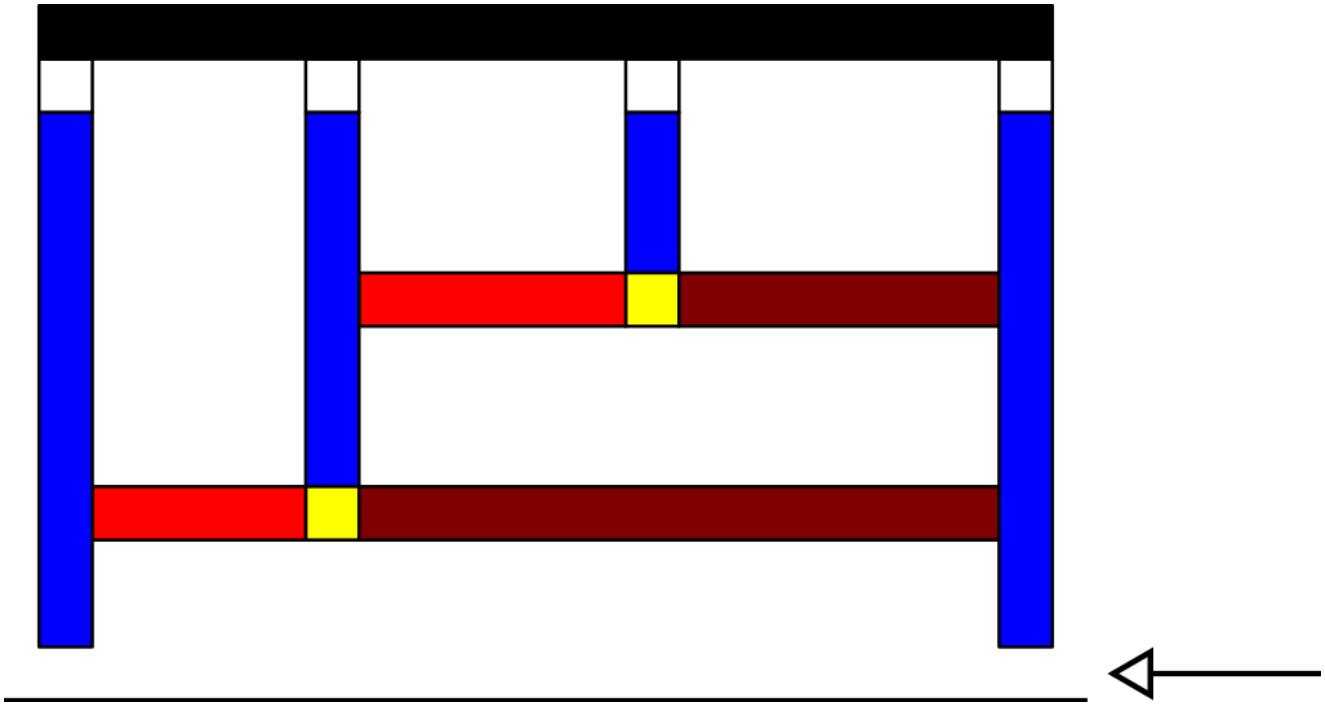

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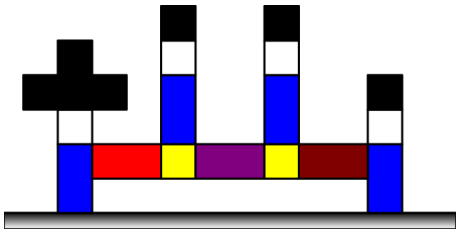

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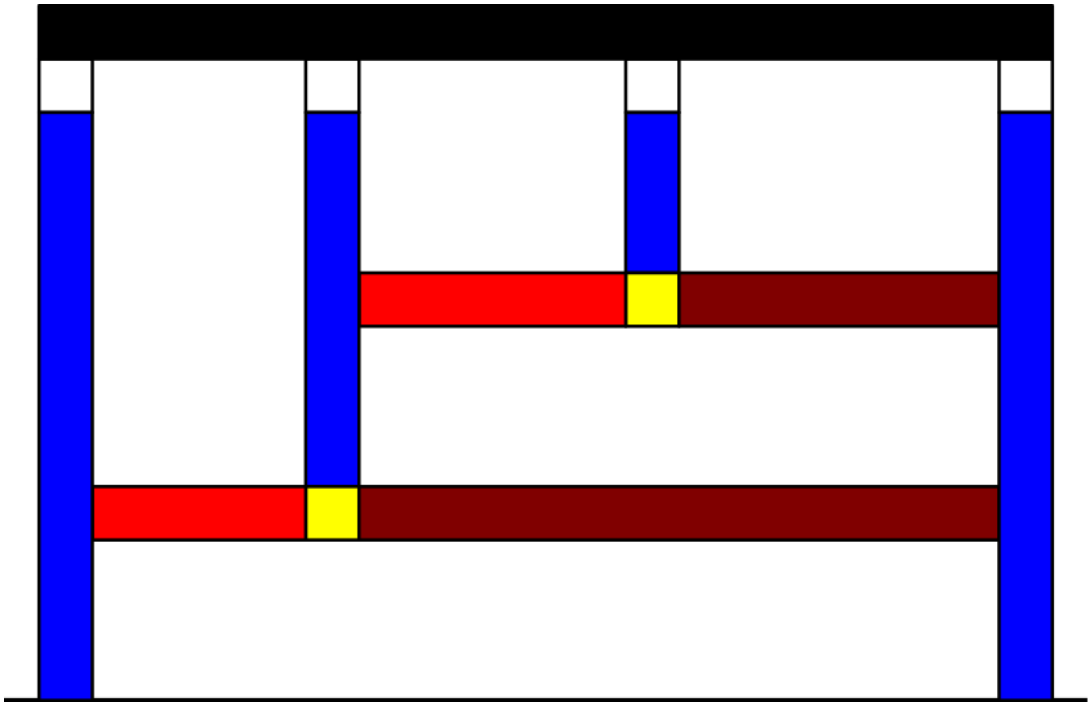
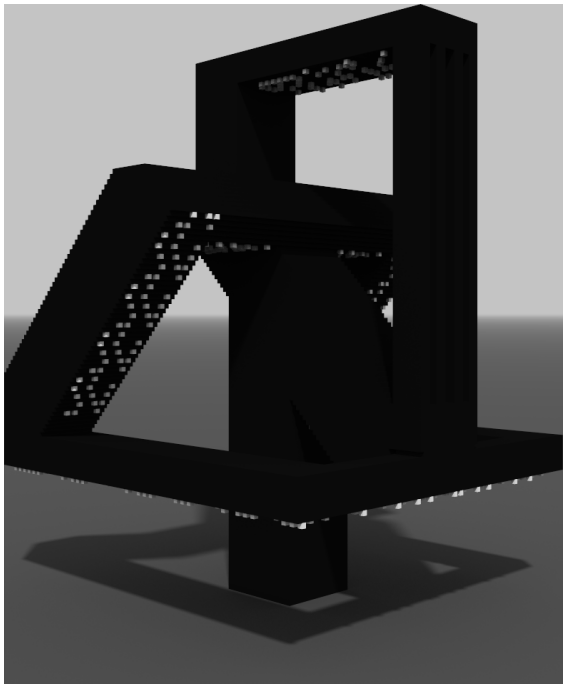
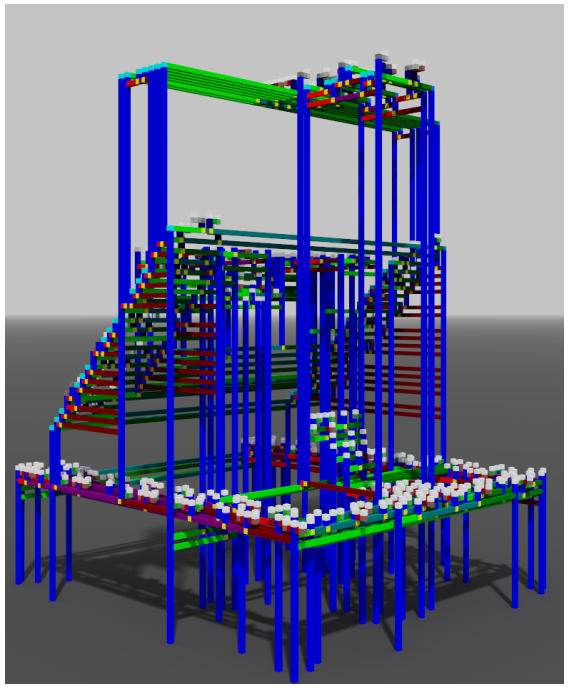
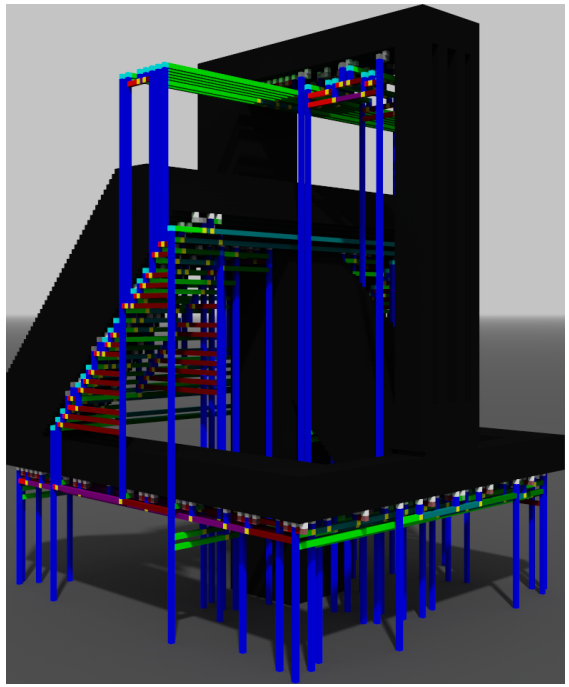


Results



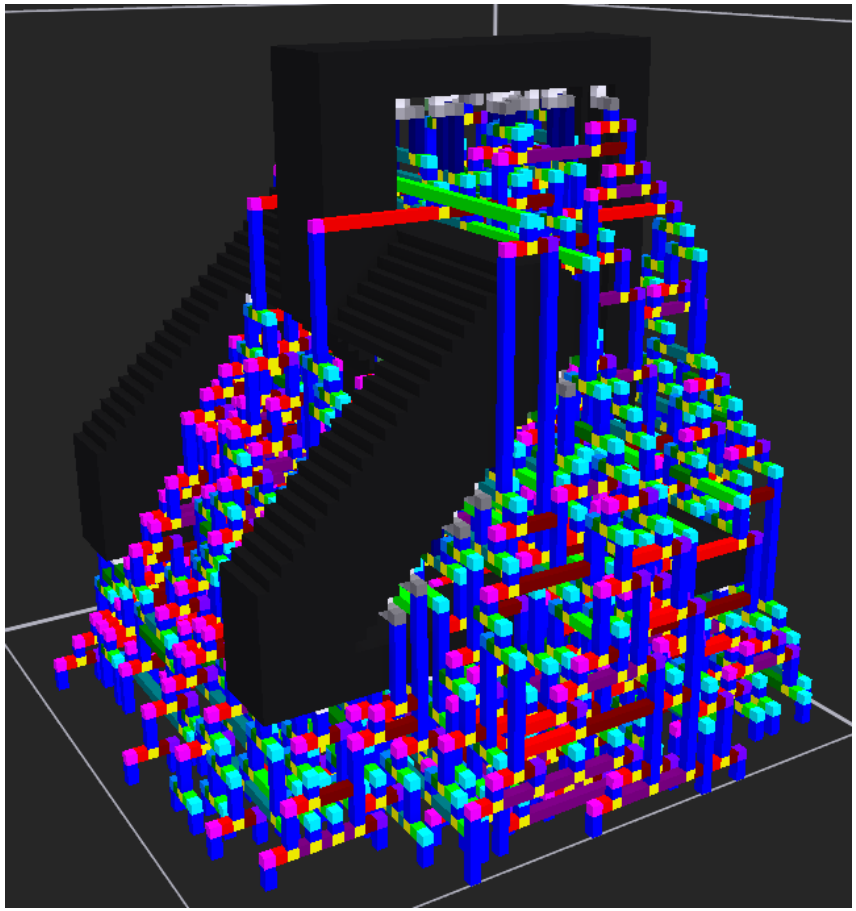




Errors

Lots of tinkering

Exemplar and solver require a lot of fine tuning . . .



Summary

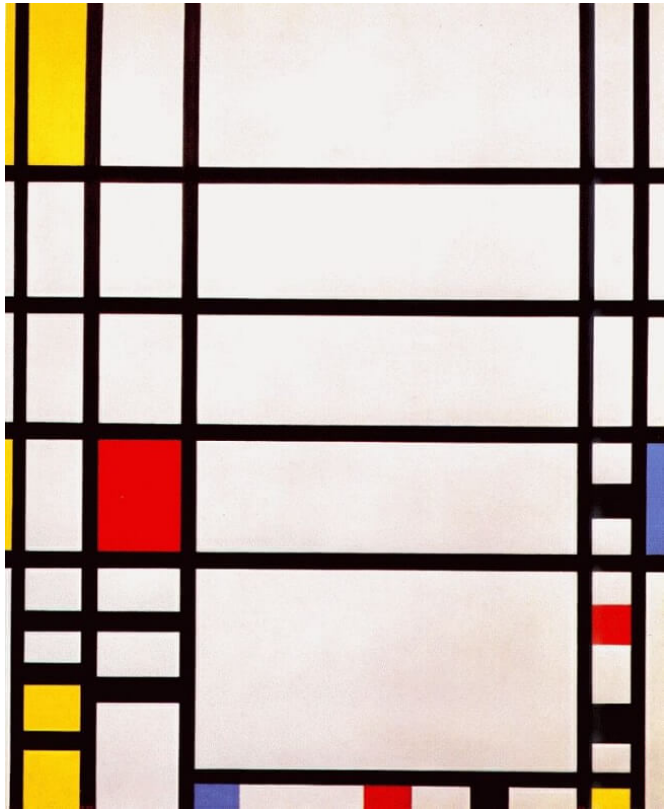
Results

Fast	~ 1 min for 128^3 grids
Efficient	Produces sparse supports
Avoidance	Due to constraints, supports avoid the piece

Further questions

What about support reliability?

Questions



Piet Mondrian
Trafalgar Square
1939-43

Questions?