# Level Design with Impossible Geometry

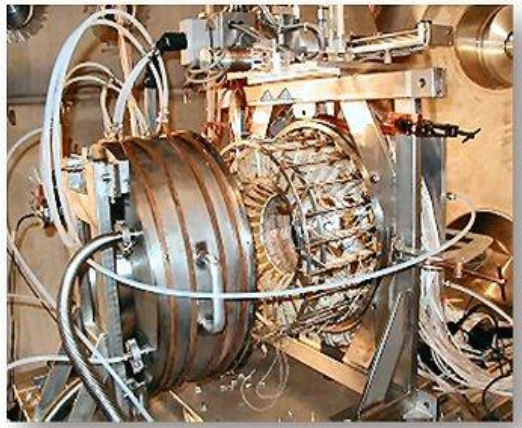
**William Chyr**

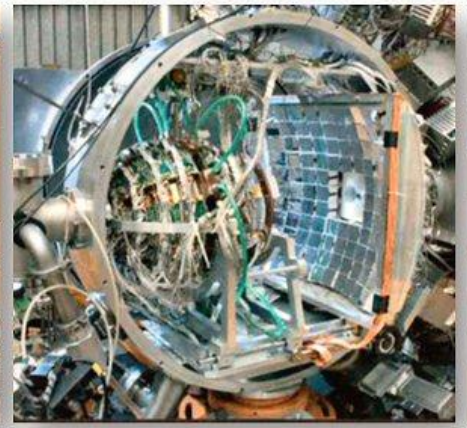
(@williamchyr)

Independent Game Developer

**Manifold Garden**

# William Chyr

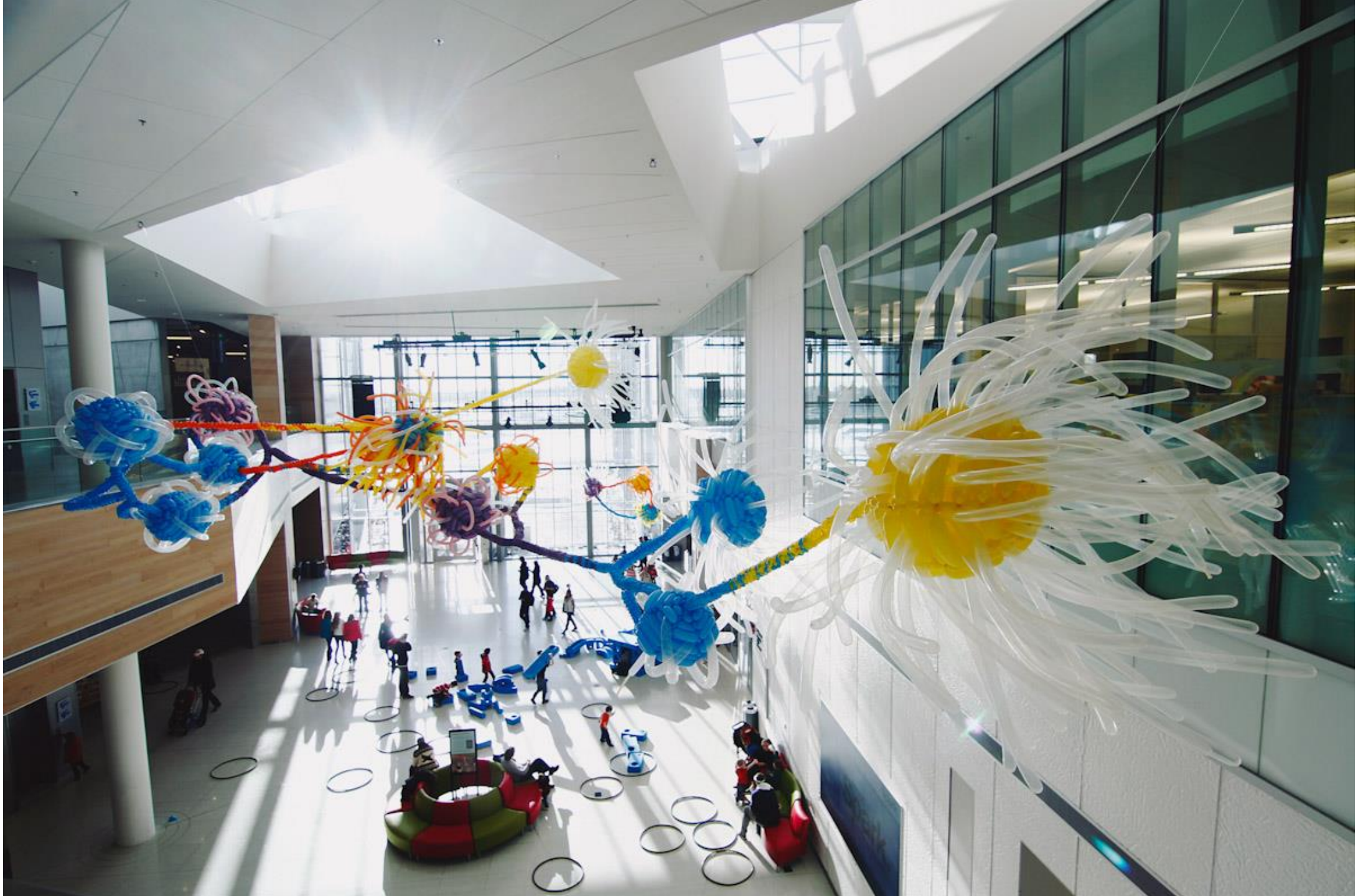


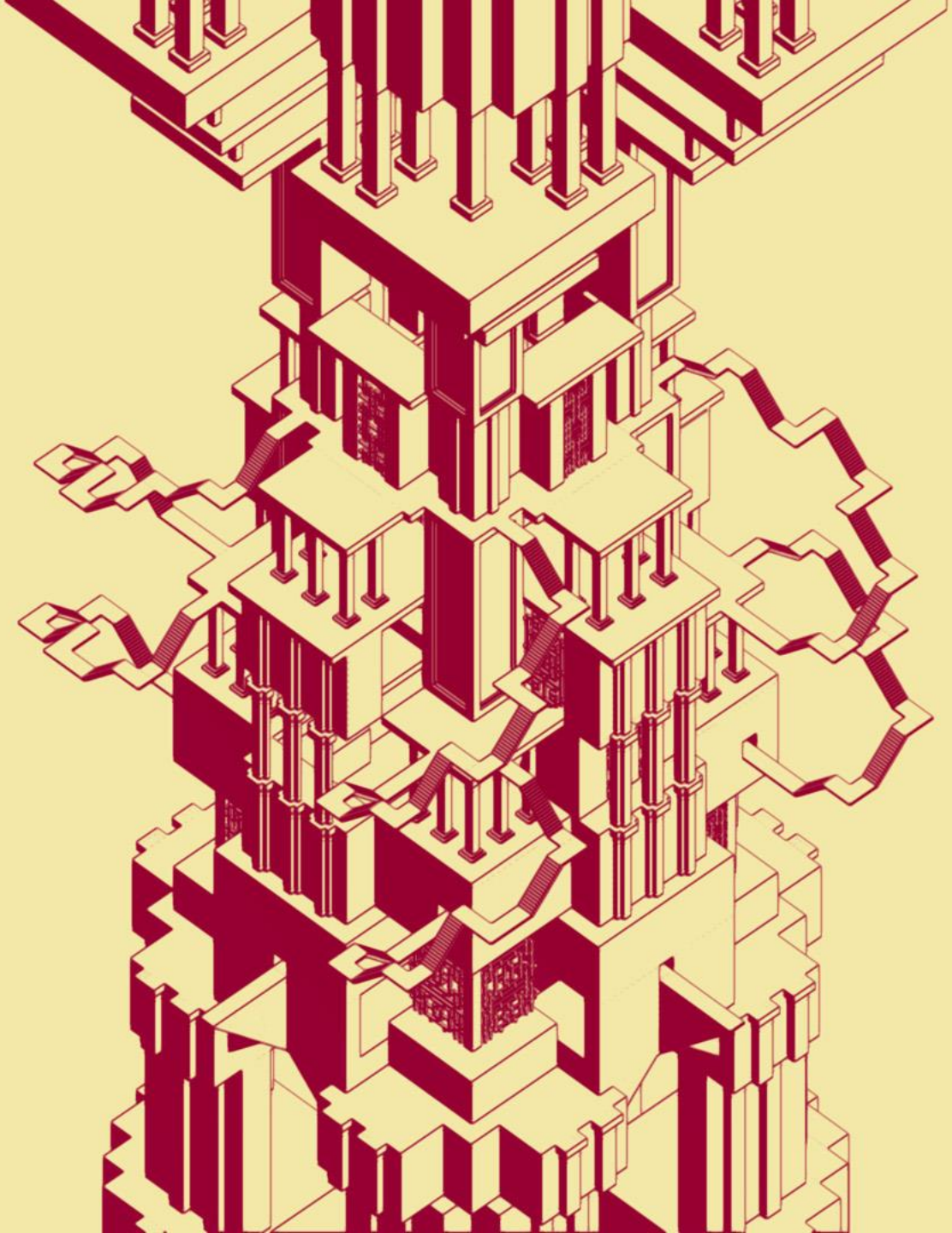


INFN

Istituto Nazionale
di Fisica Nucleare

Laboratori Nazionali di Legnaro

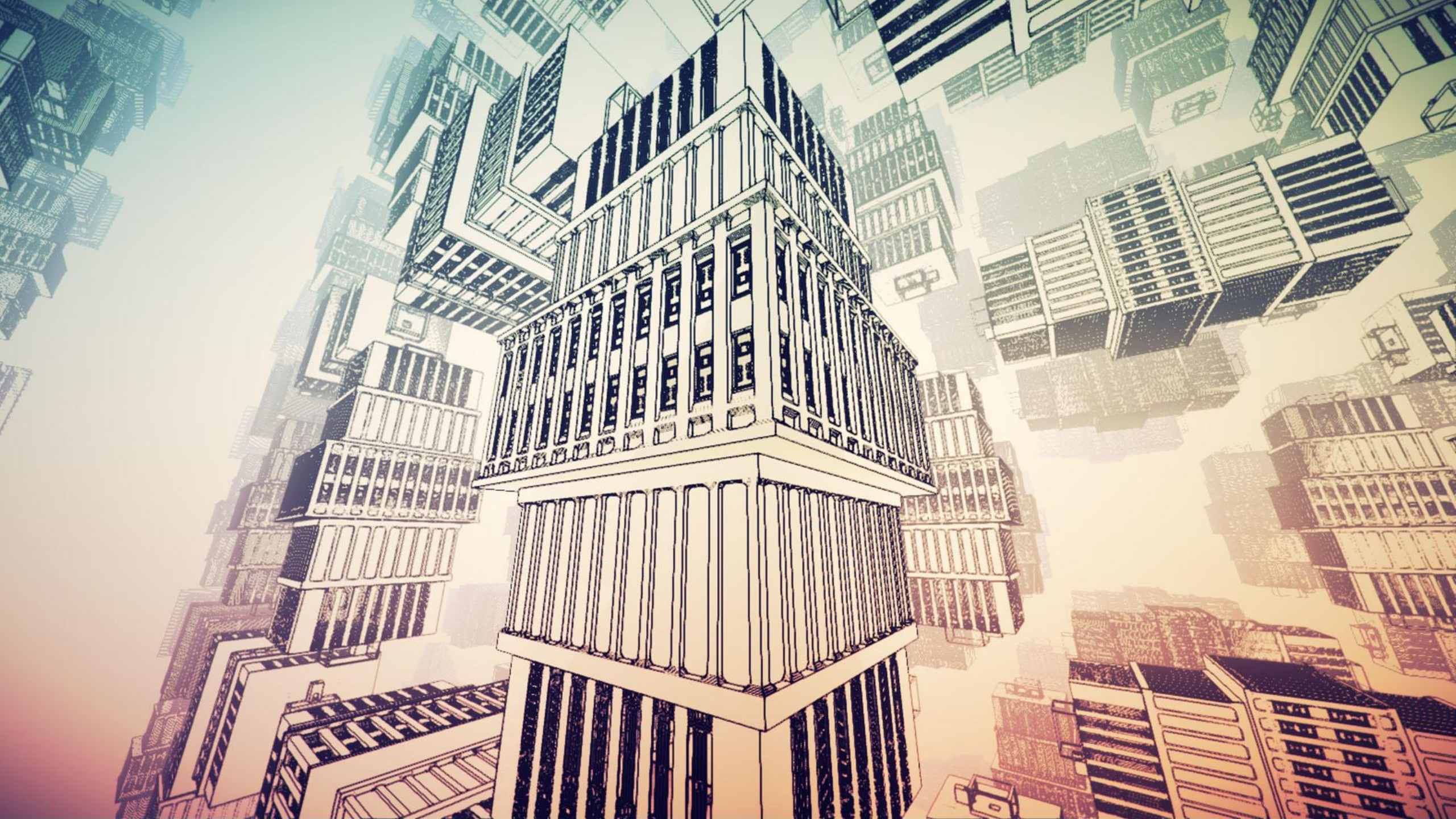


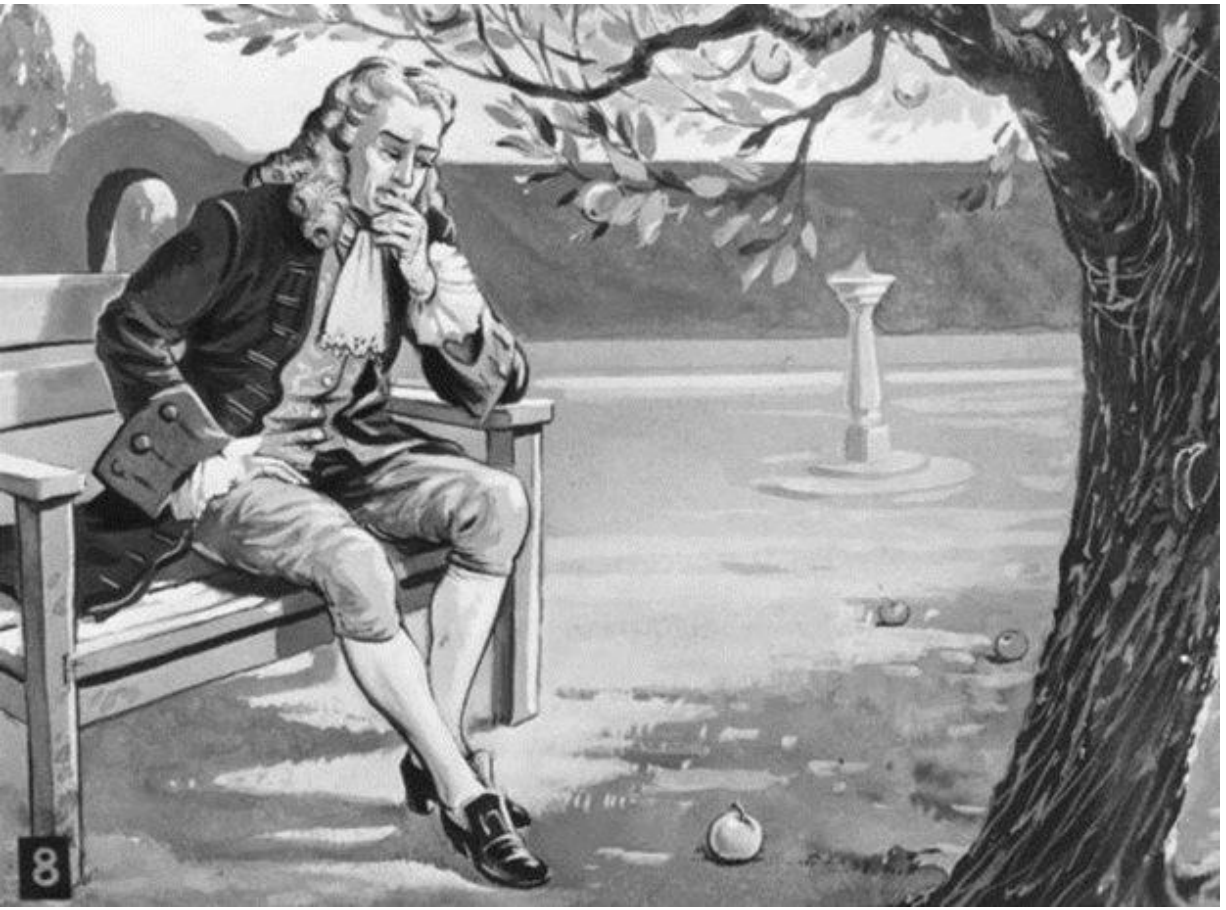


WILLIAM CHYR STUDIO

# MANIFOLD GARDEN

# What is Manifold Garden?

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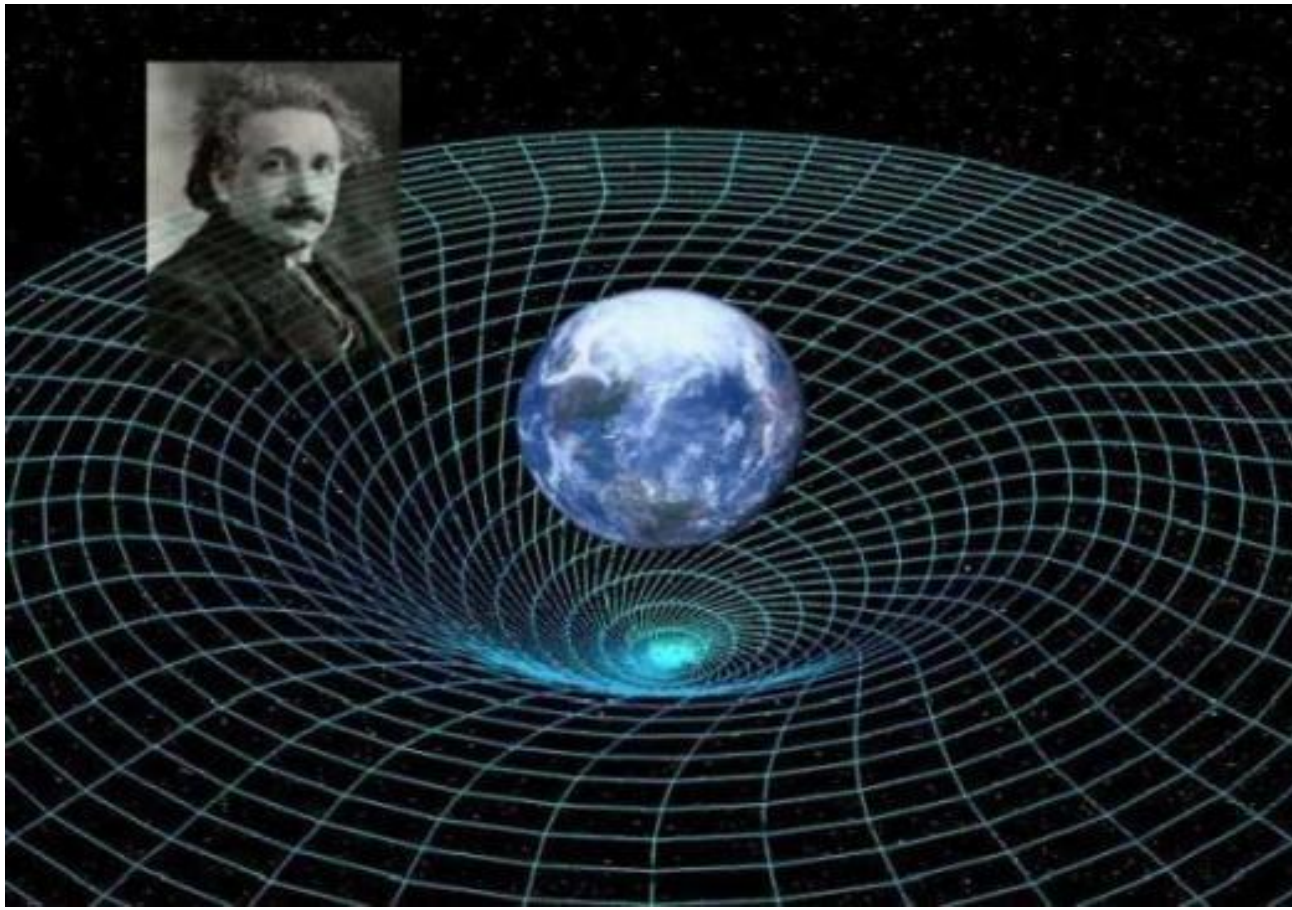
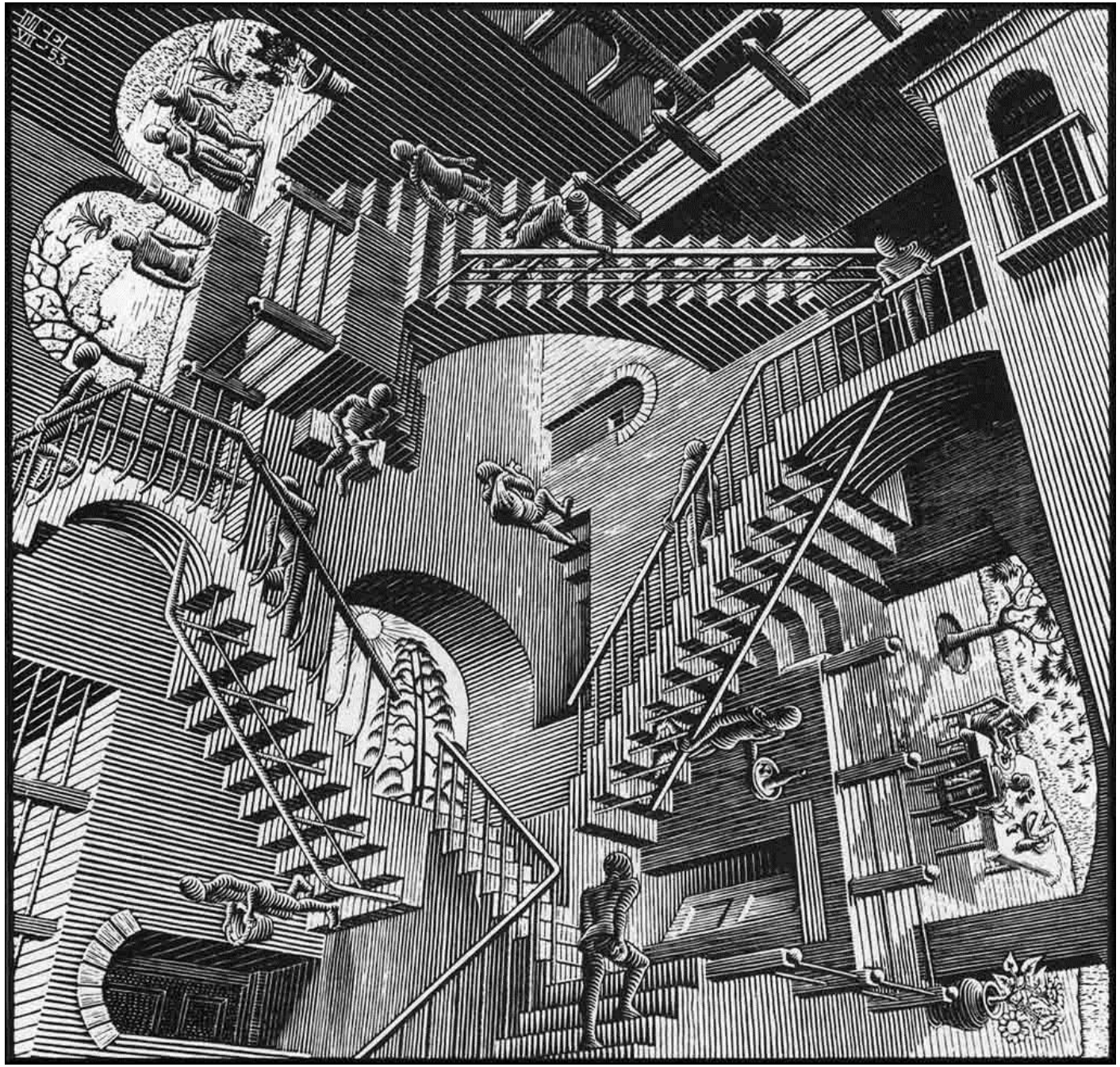


# Key Features

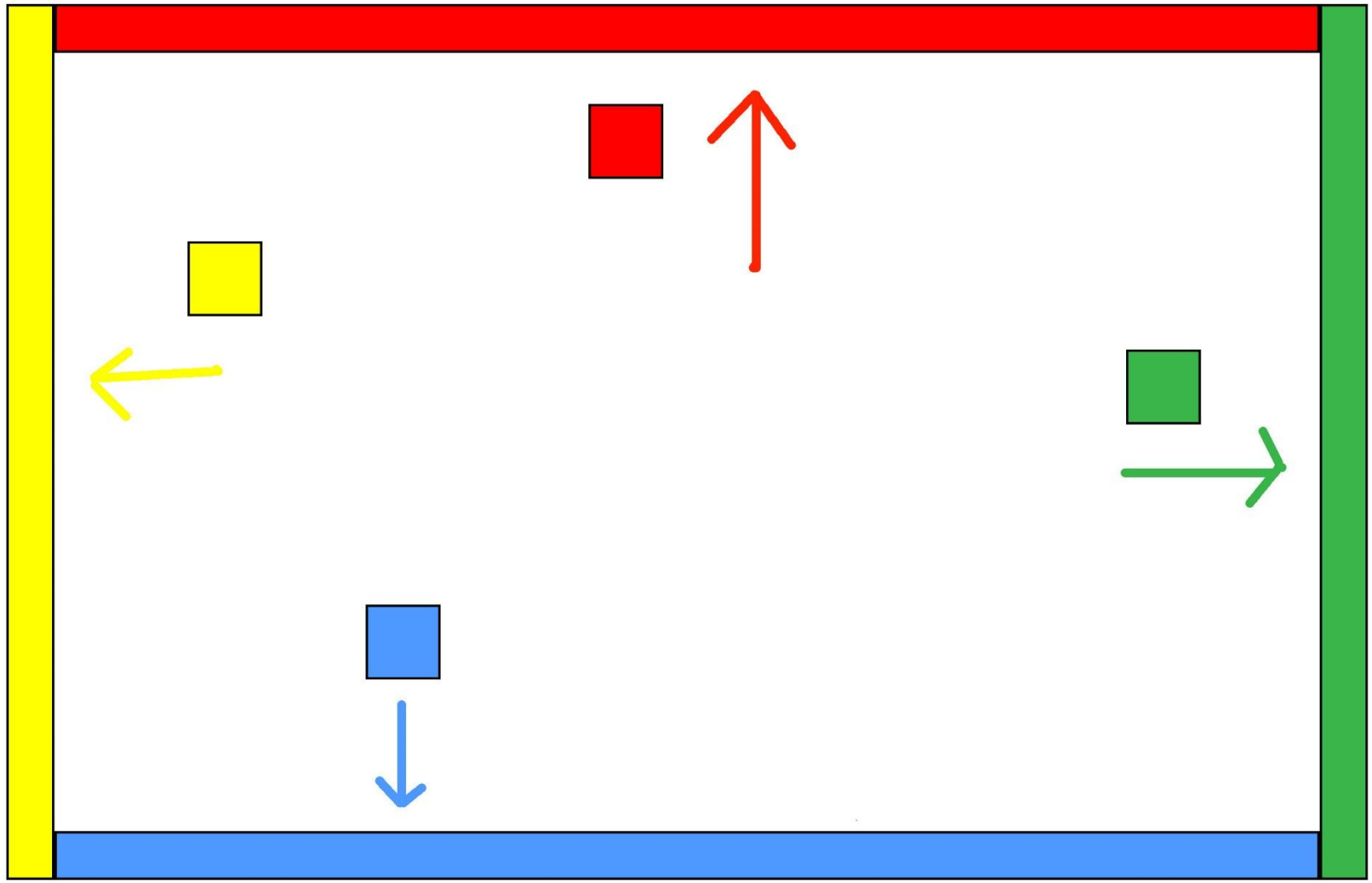
1. Traversal - Gravity Shifting

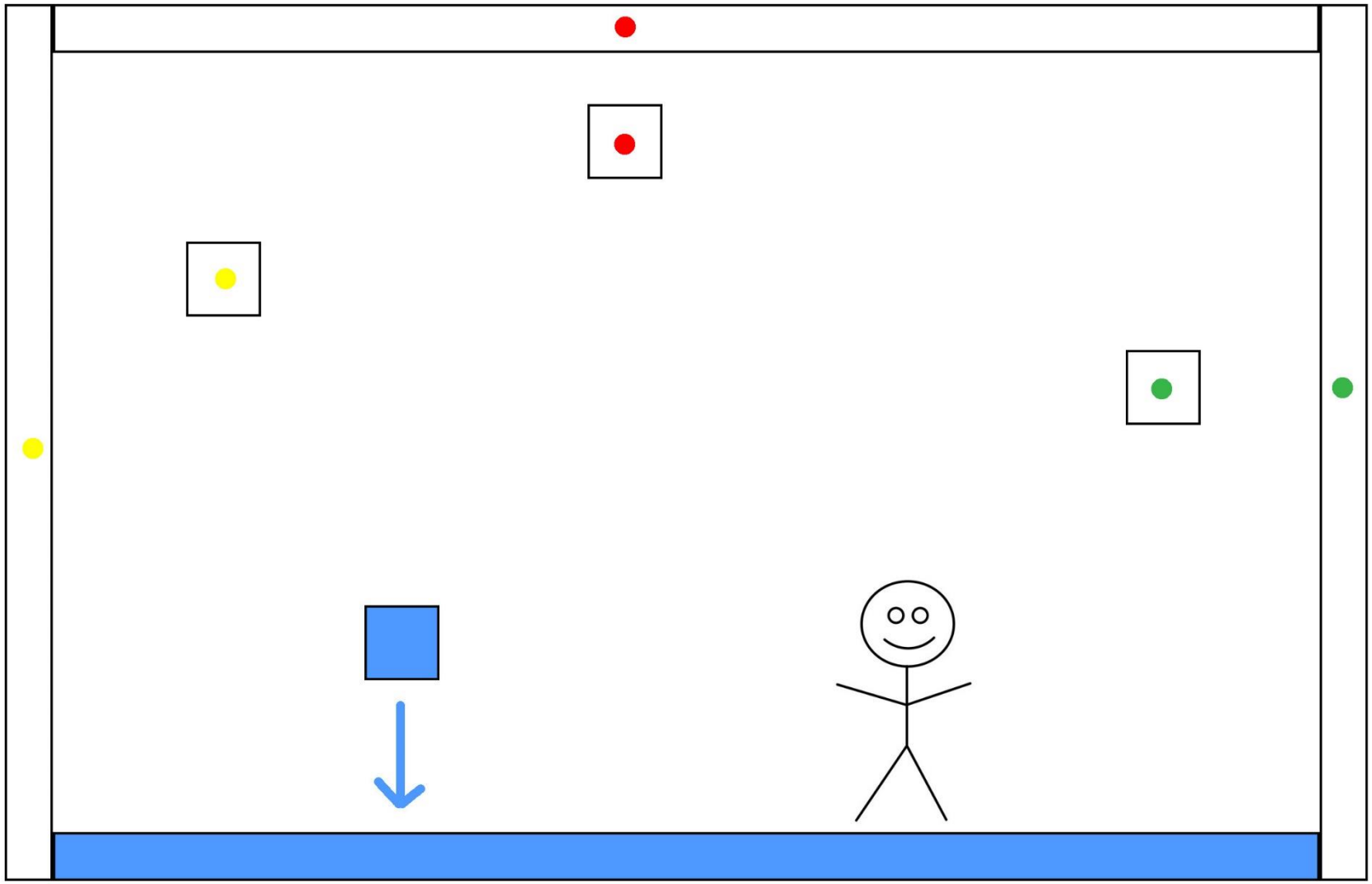
2. Geometry - 3D world wrapping

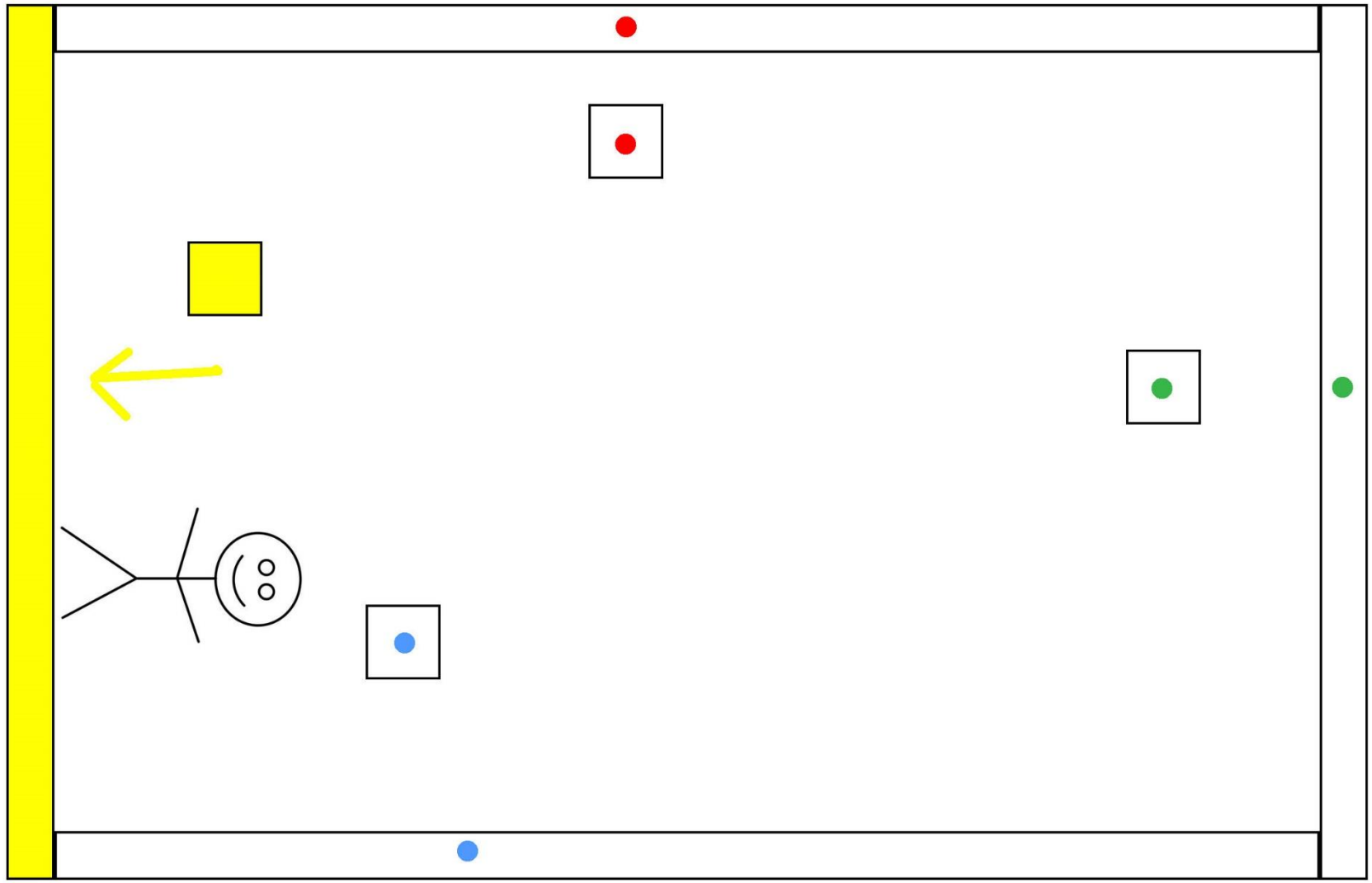
# Traversal - Gravity Shifting

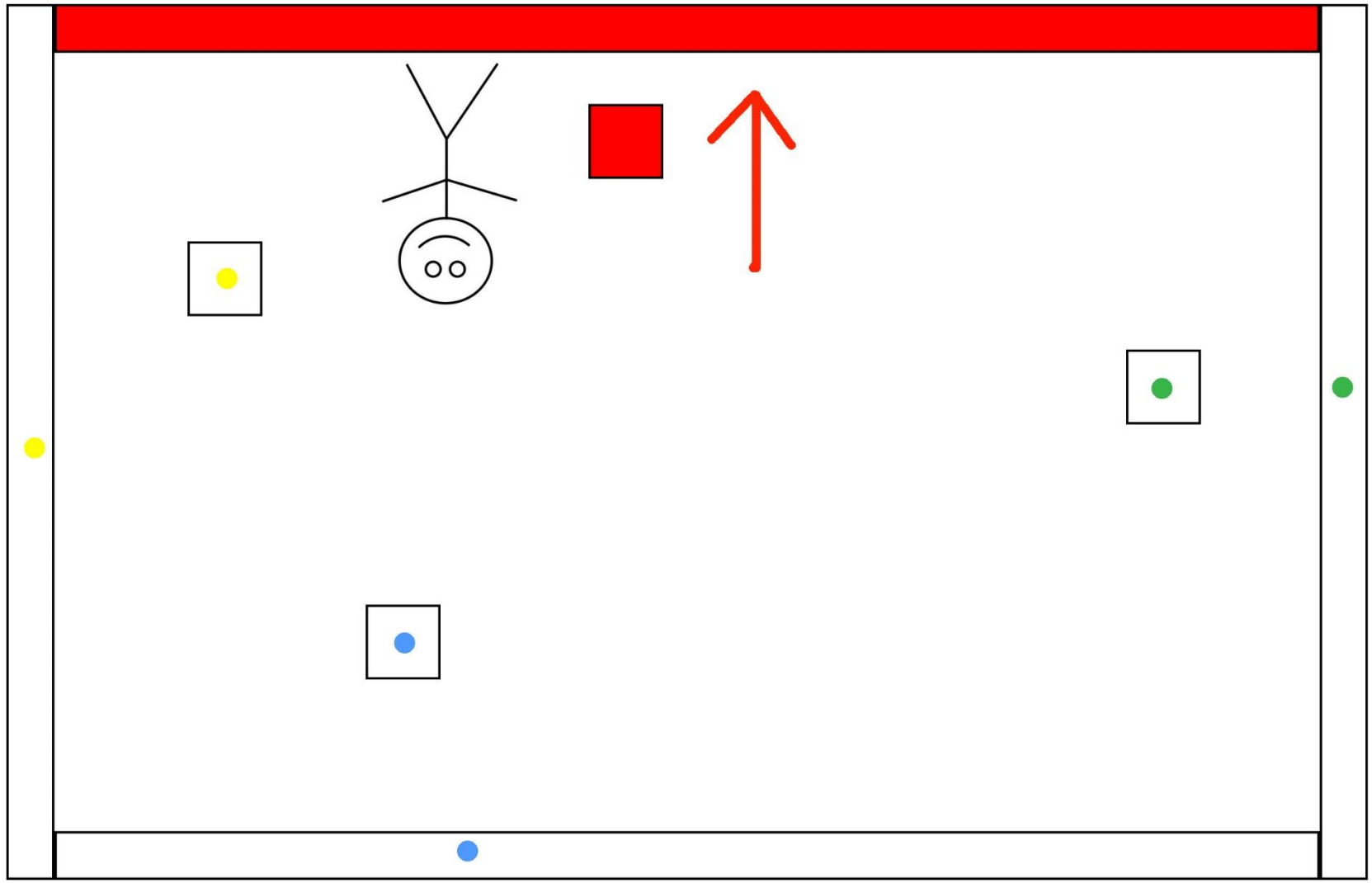


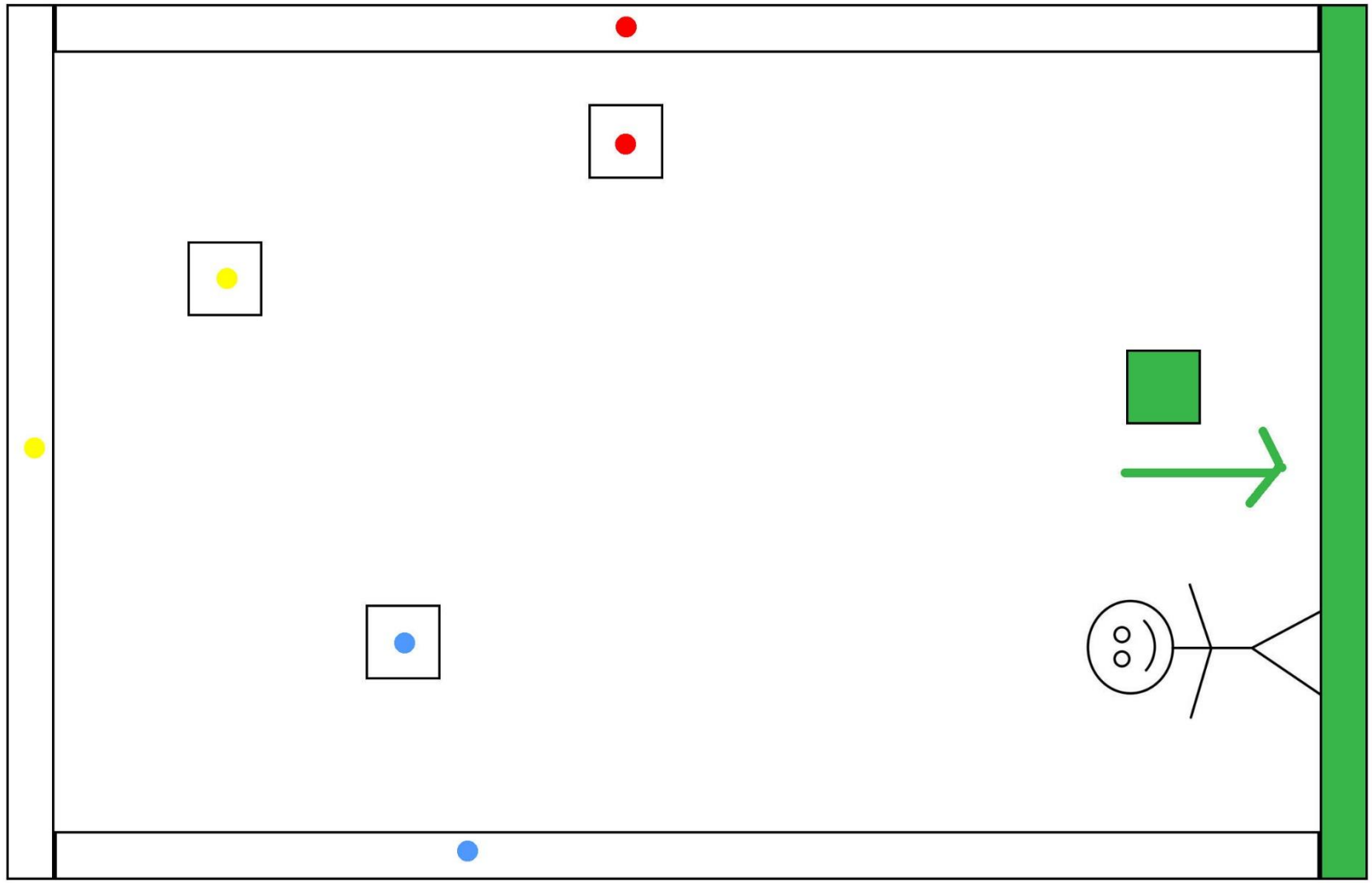
‘Relativity’ by M.C. Escher

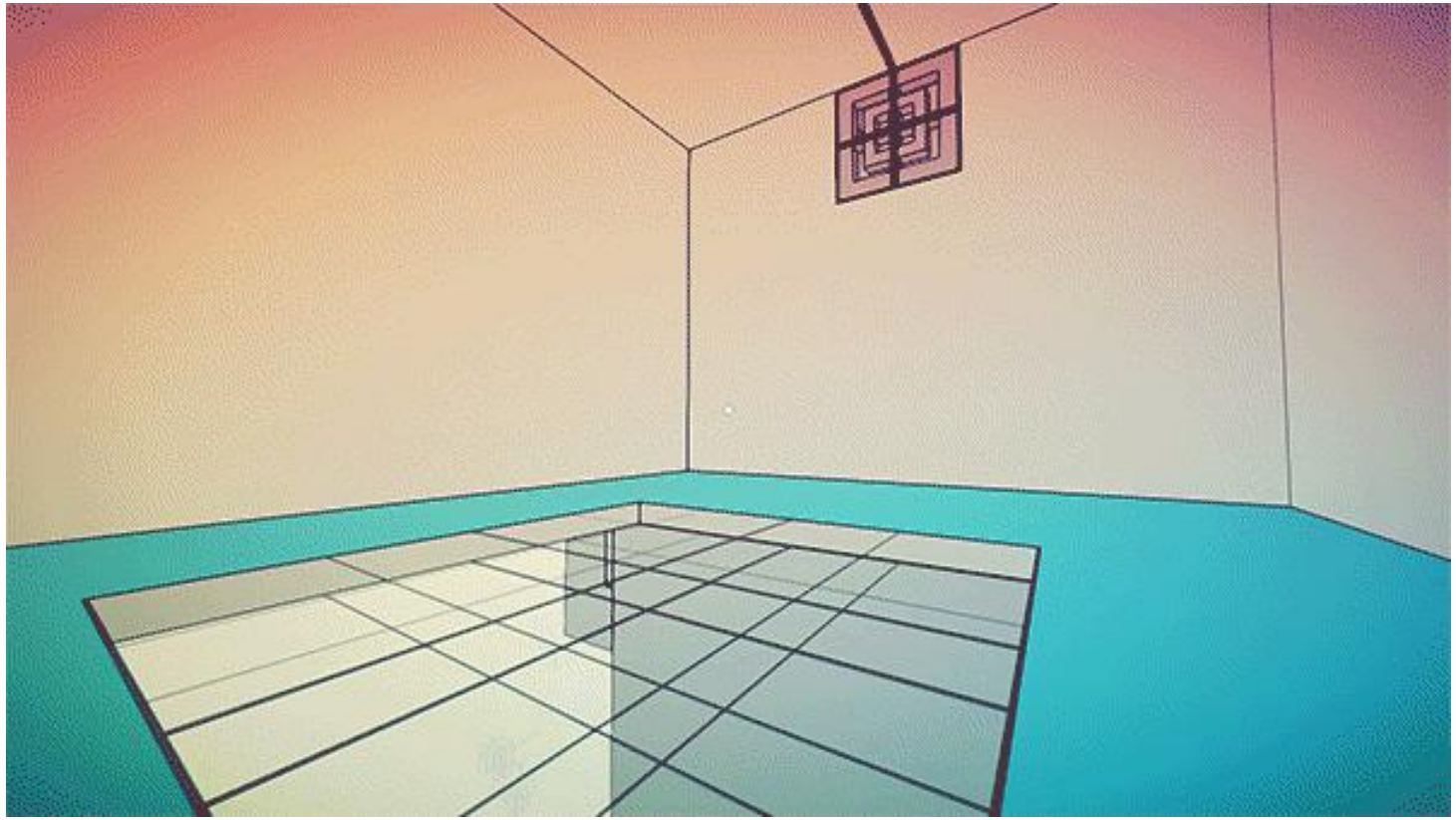




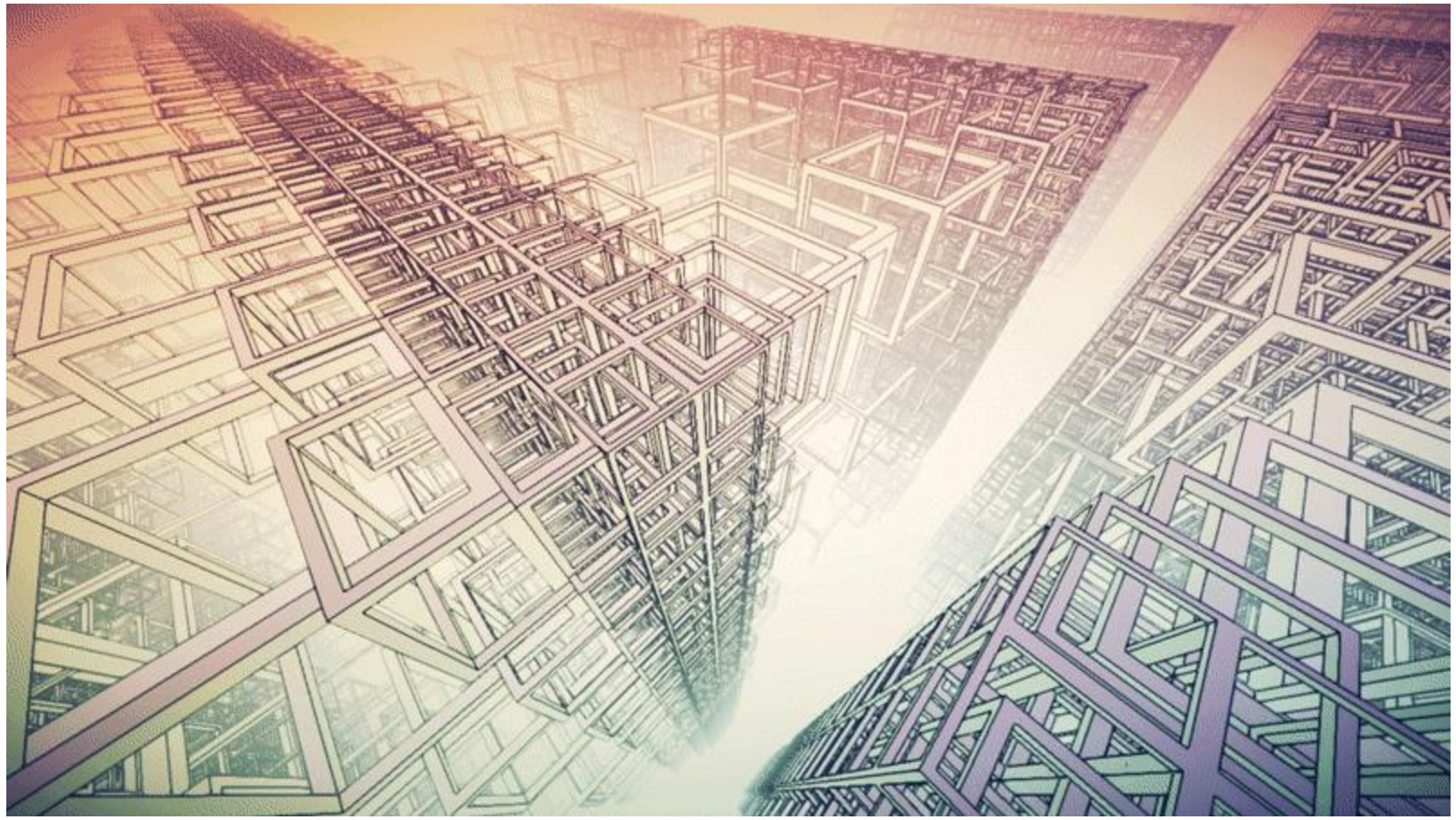








# Geometry – 3D World Wrapping



# Impossible Geometry

# Impossible Geometry

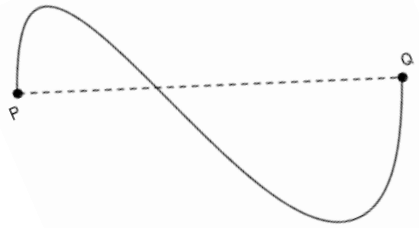
"Weird geometry that we don't see in real life"

- It's hard to generalize
- I will focus on issues and challenges specifically based on geometries and mechanics in Manifold Garden

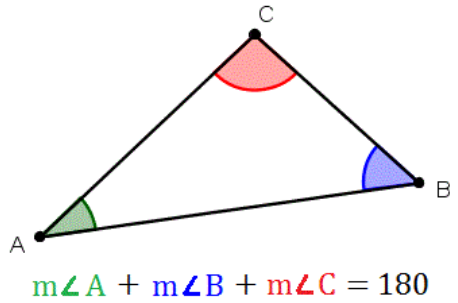
Impossible geometry =/= Non-Euclidean Geometry

# Euclidean Geometry = Flat space

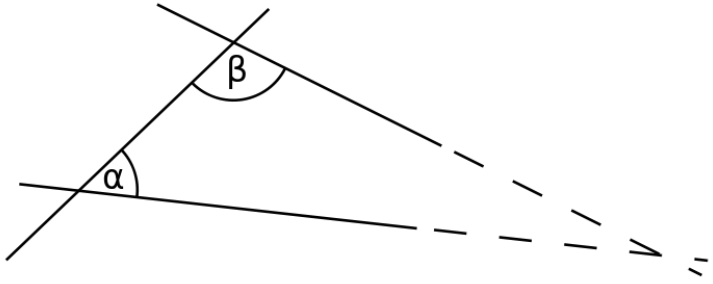
- Shortest distance between two points is a line



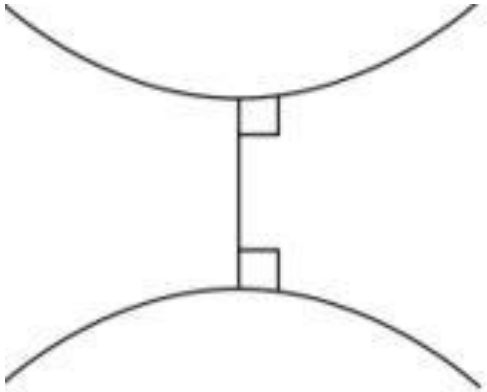

- Sum of angles in a triangle is 180



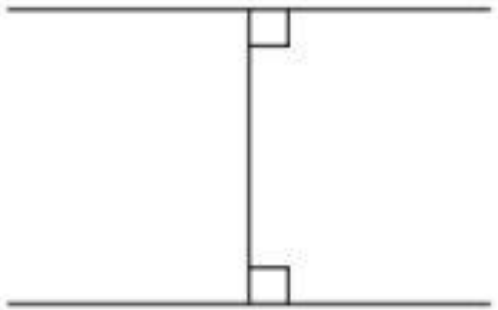

- Parallel lines don't intersect



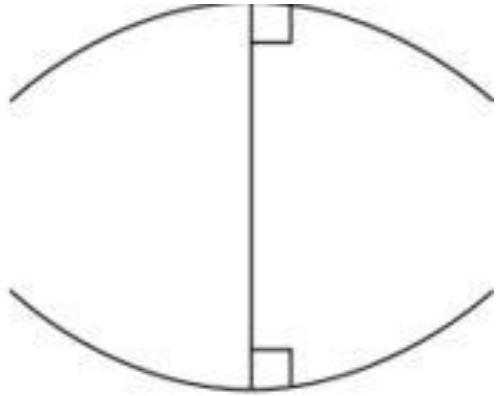
# Non-Euclidean Geometry = Everything Else



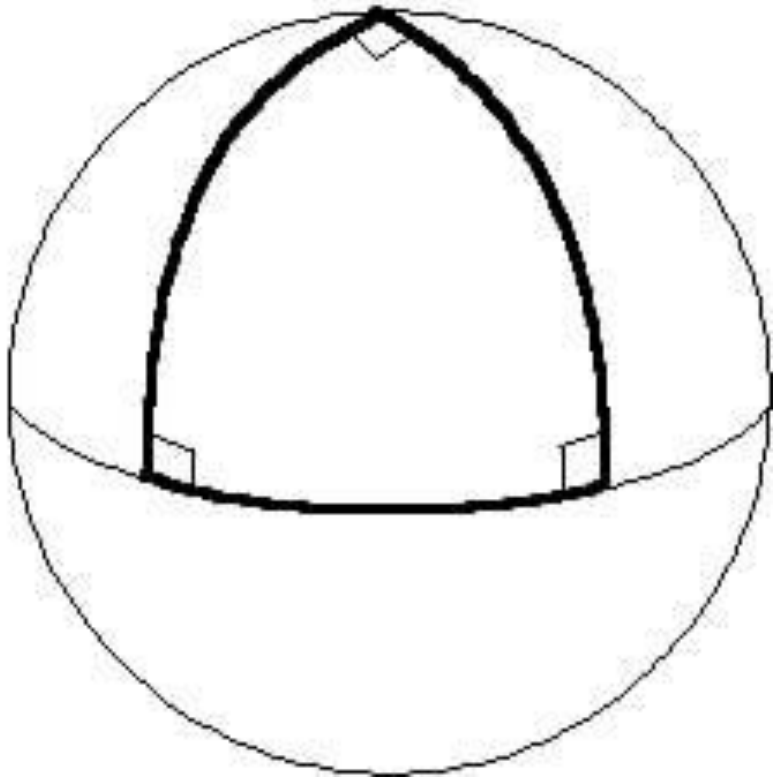
Hyperbolic

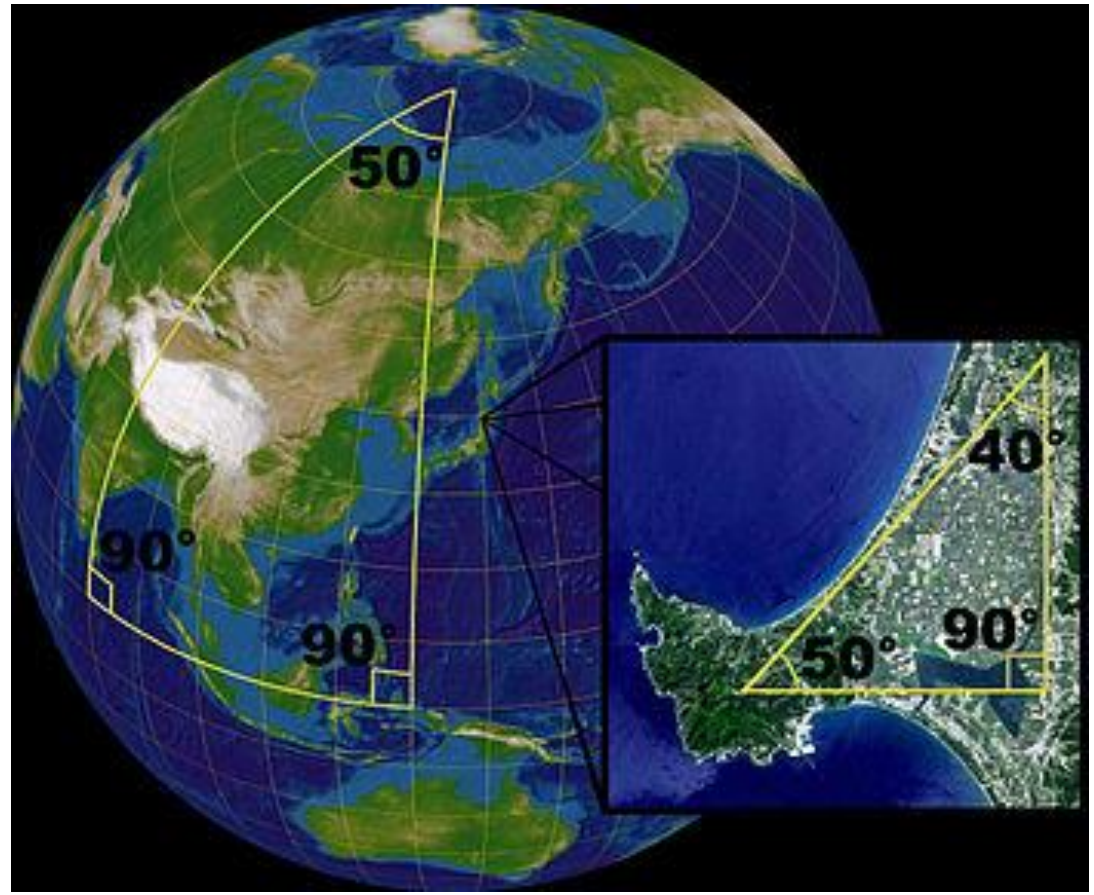


Euclidean

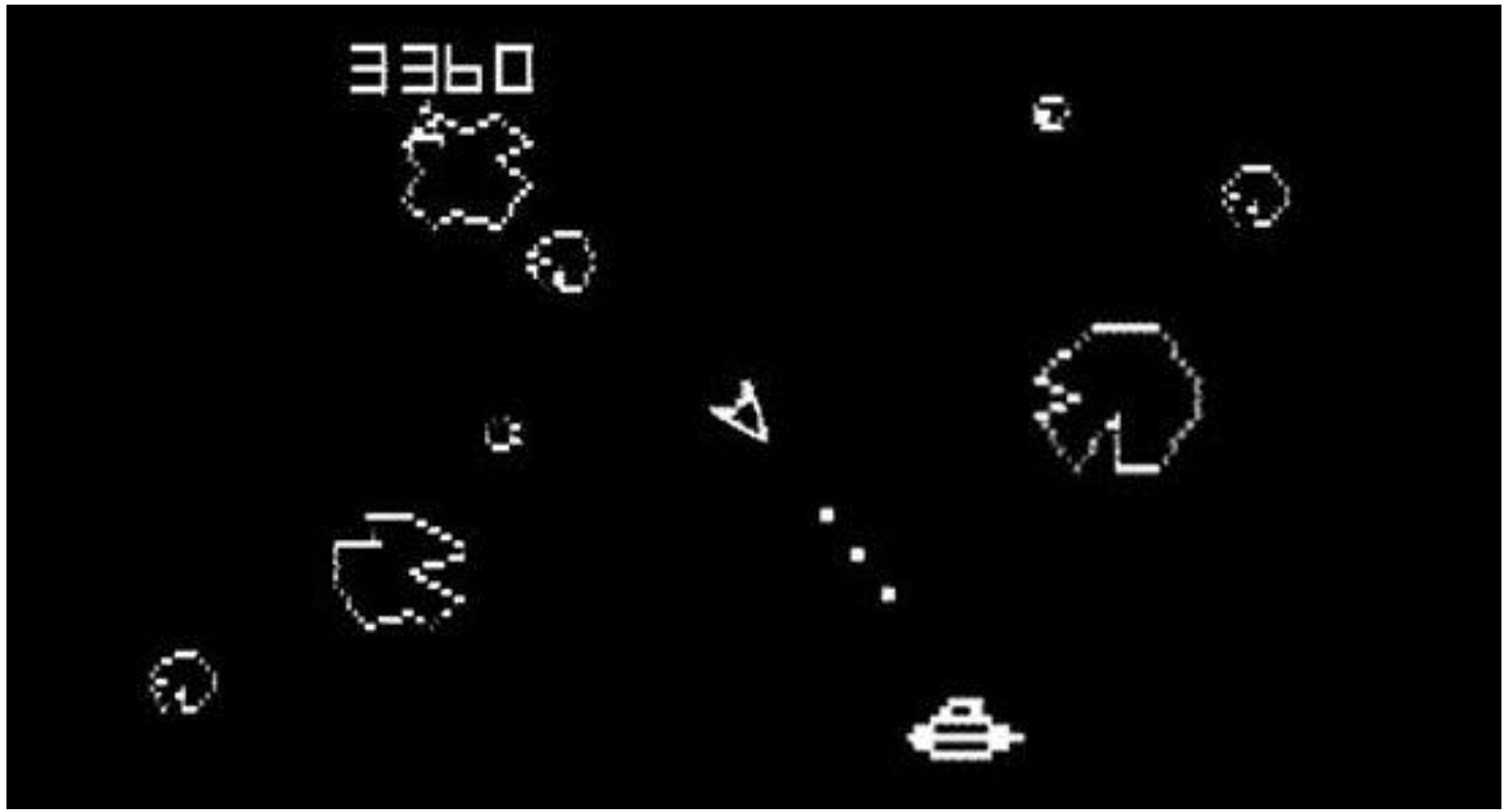


Elliptic




50°
90°
90°
40°
50°
90°

# 2D World Wrapping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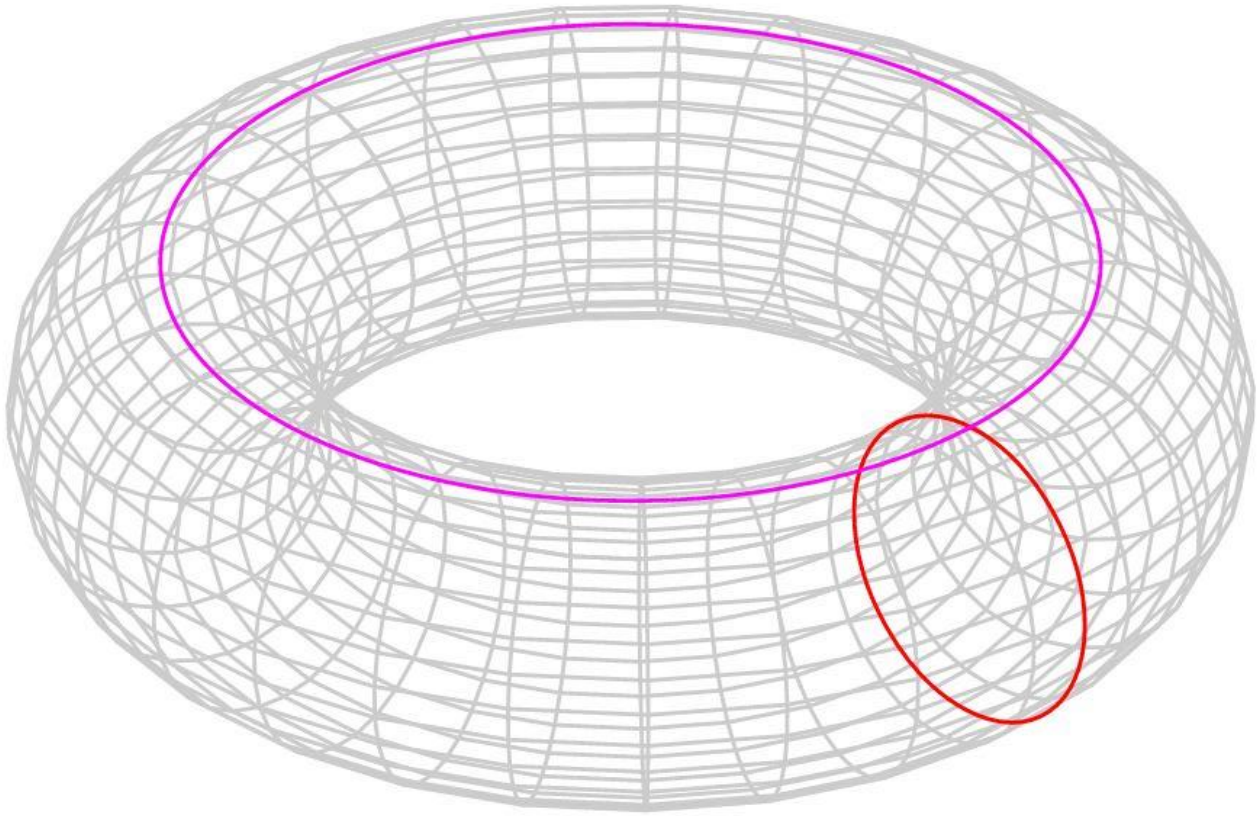
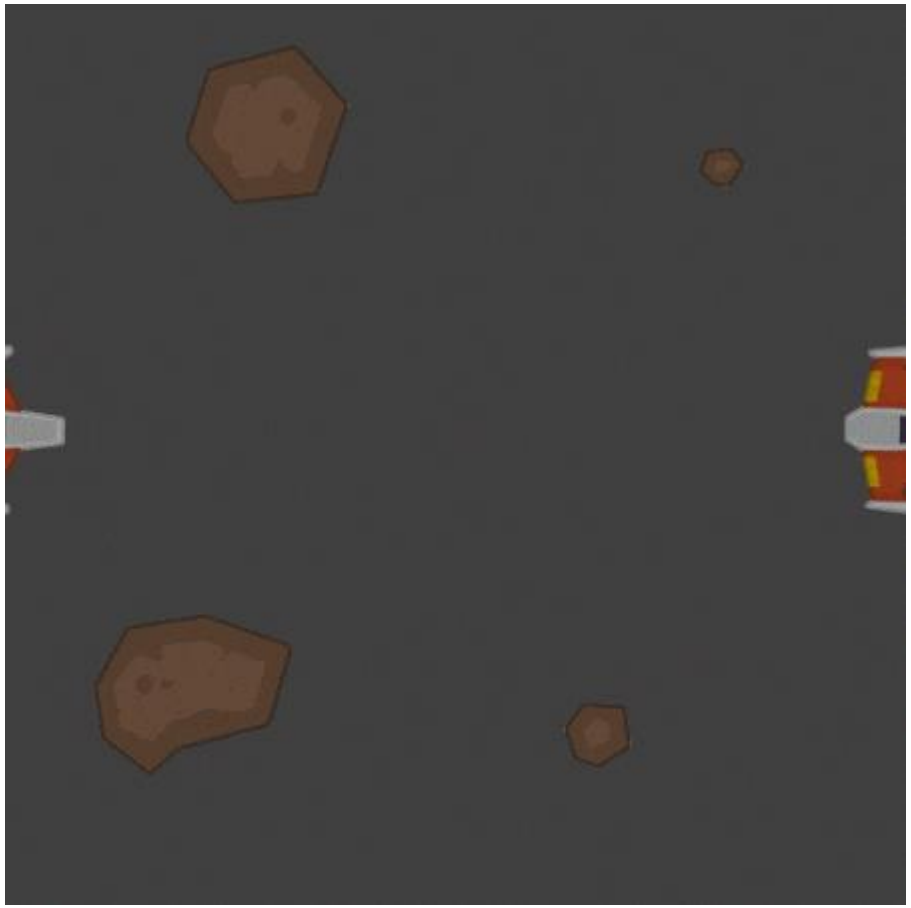
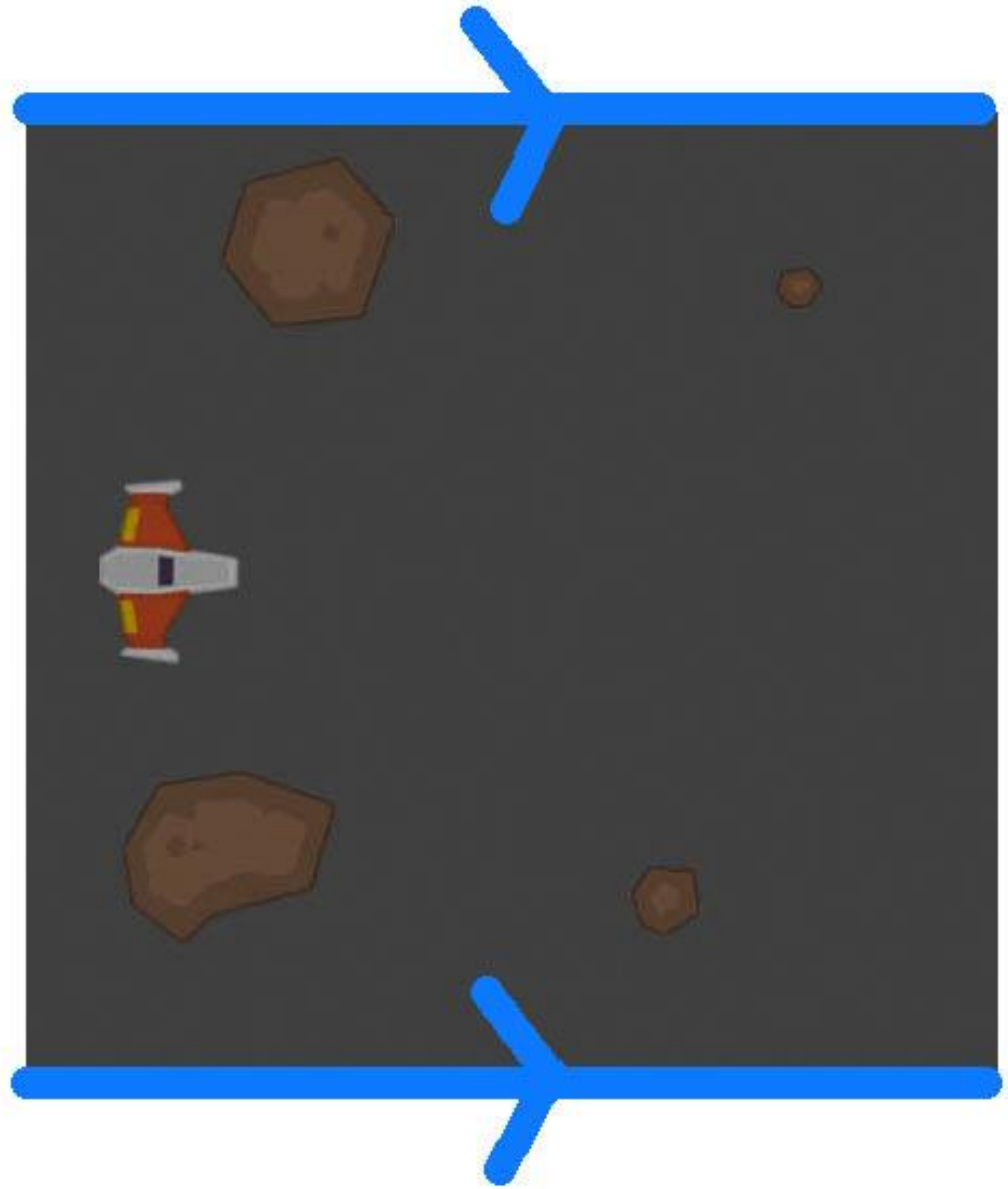
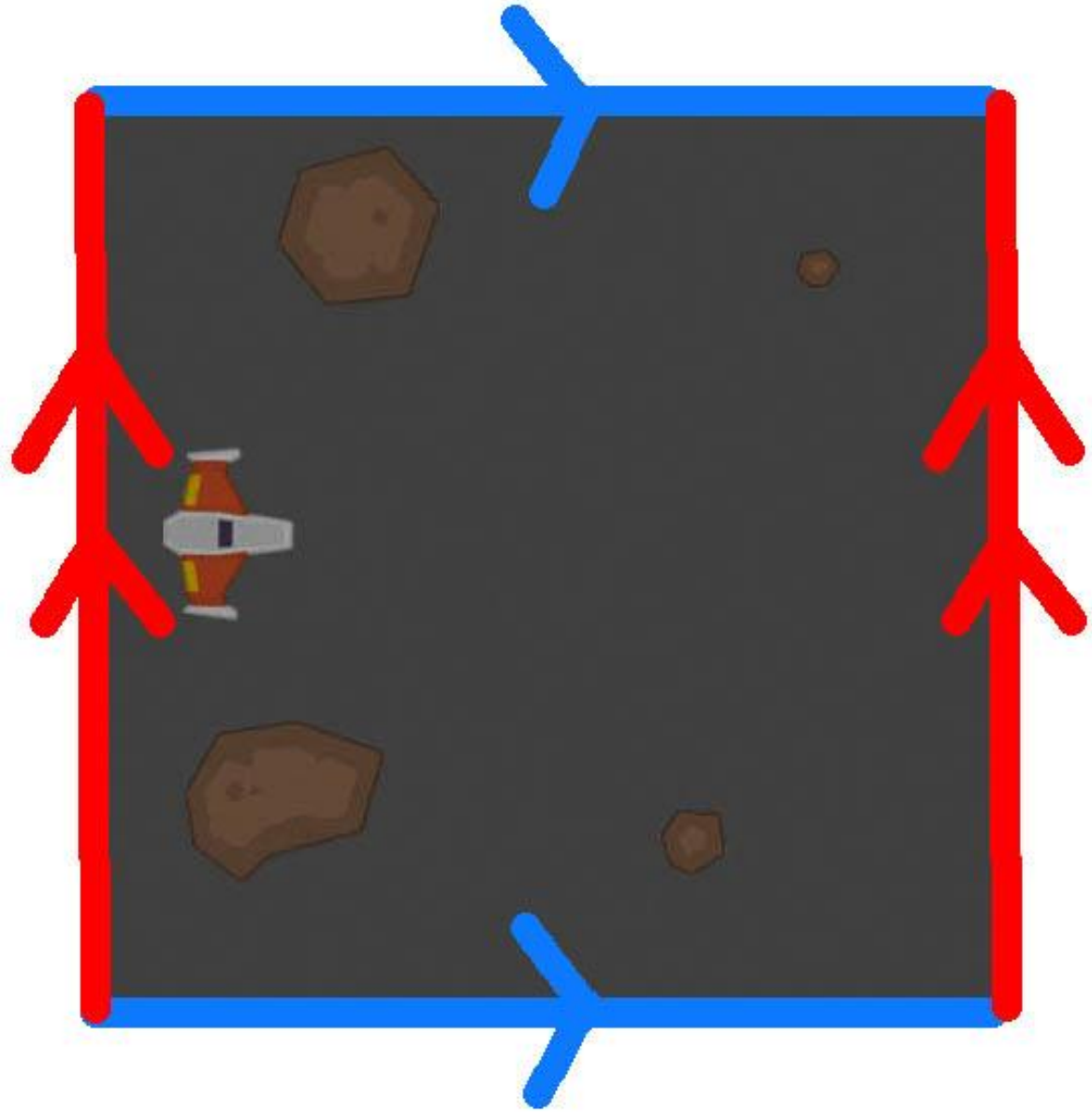
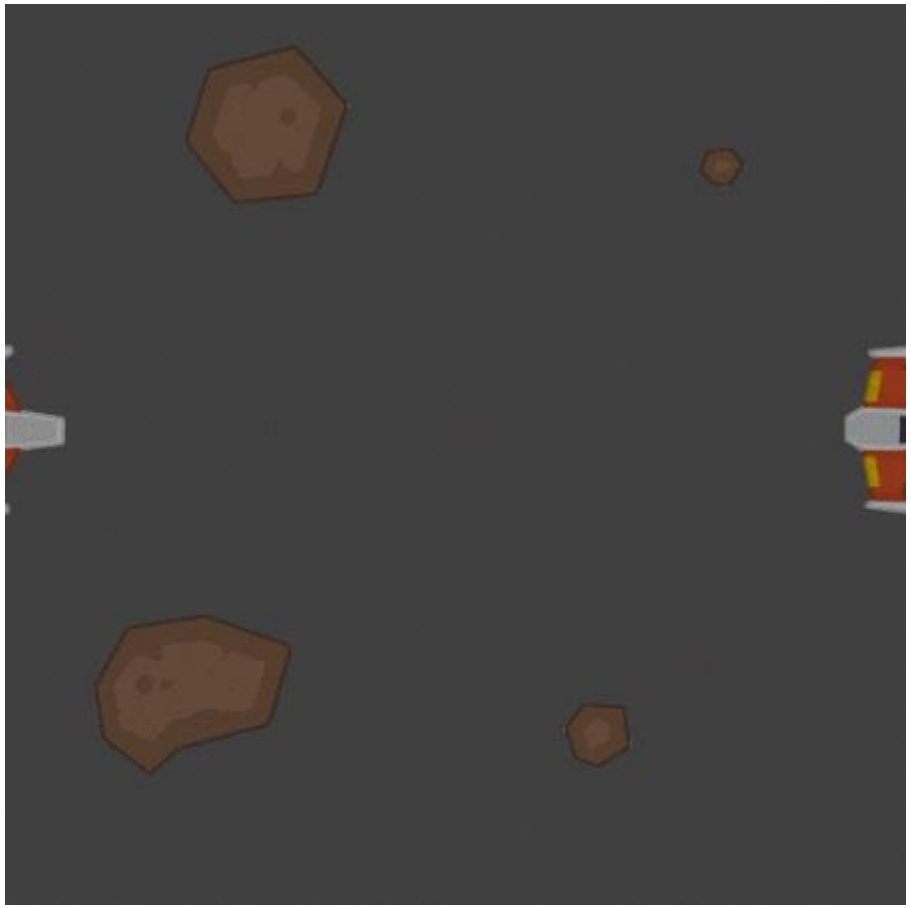
# 2-Torus

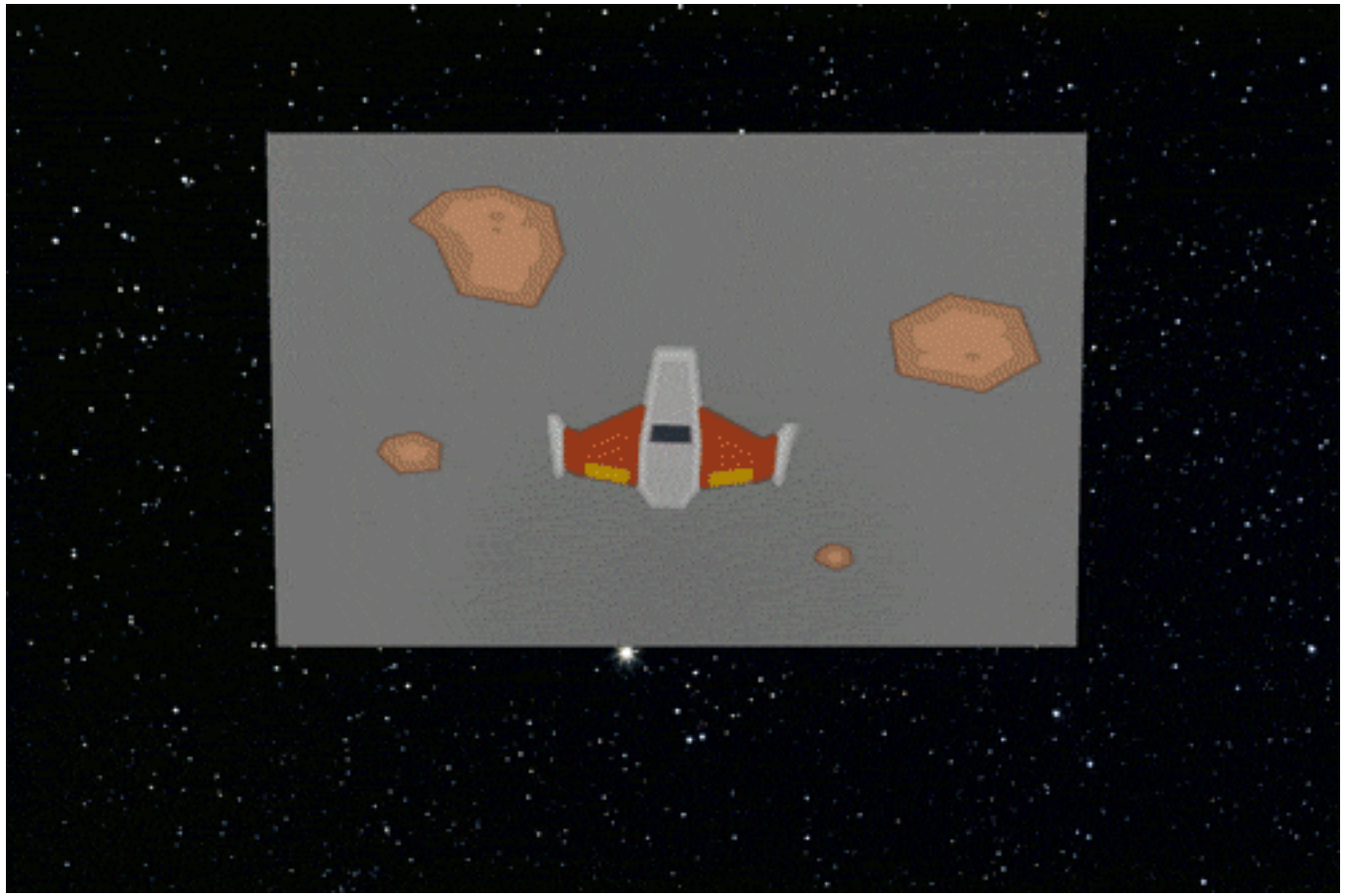












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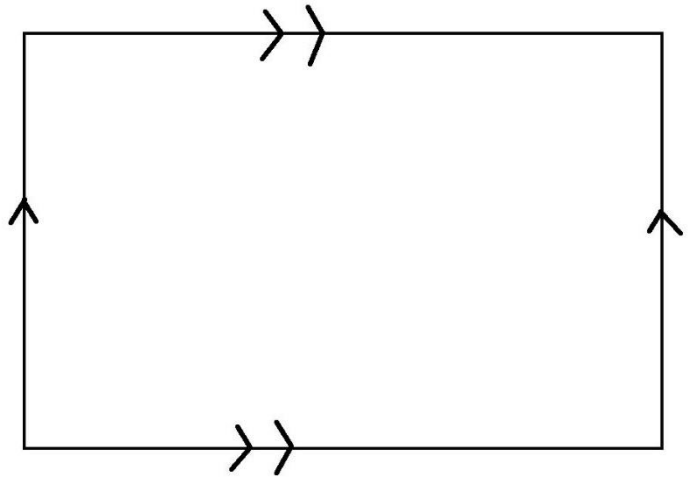

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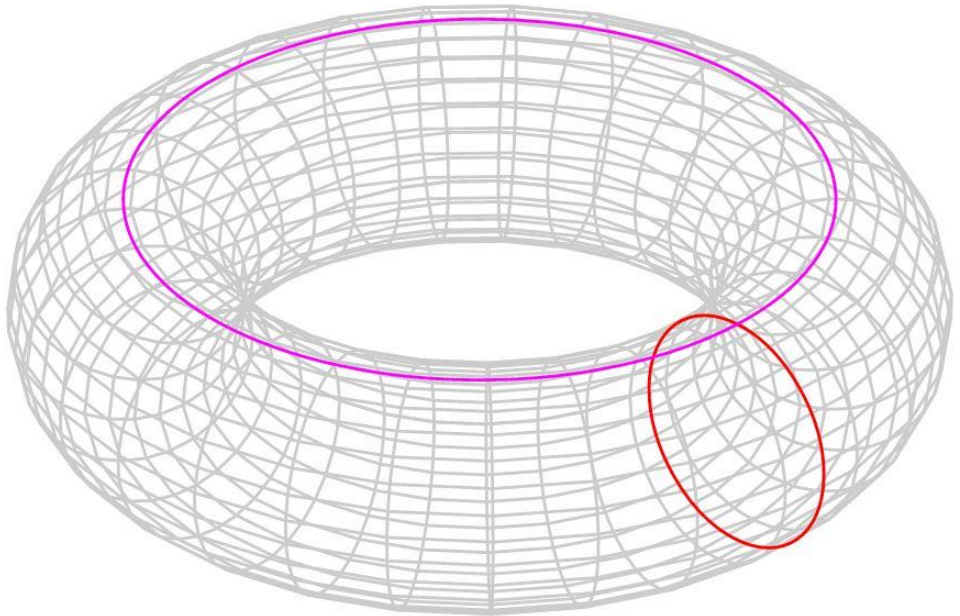
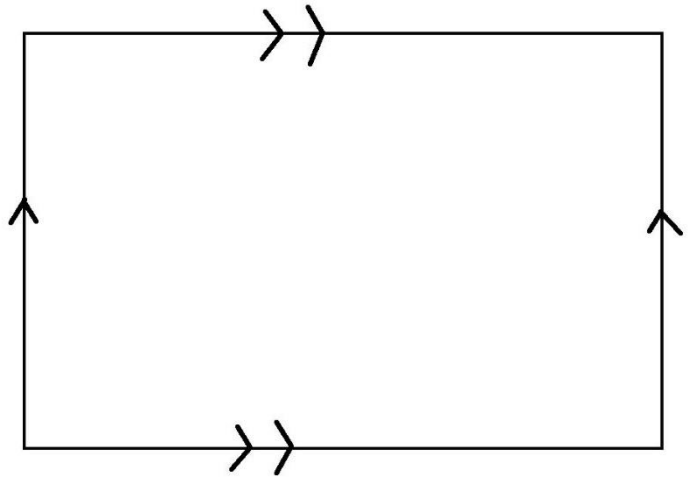


WE NEED TO GO
DEEPER
memegenerator.net

# 3D World Wrapping

# 2-Torus



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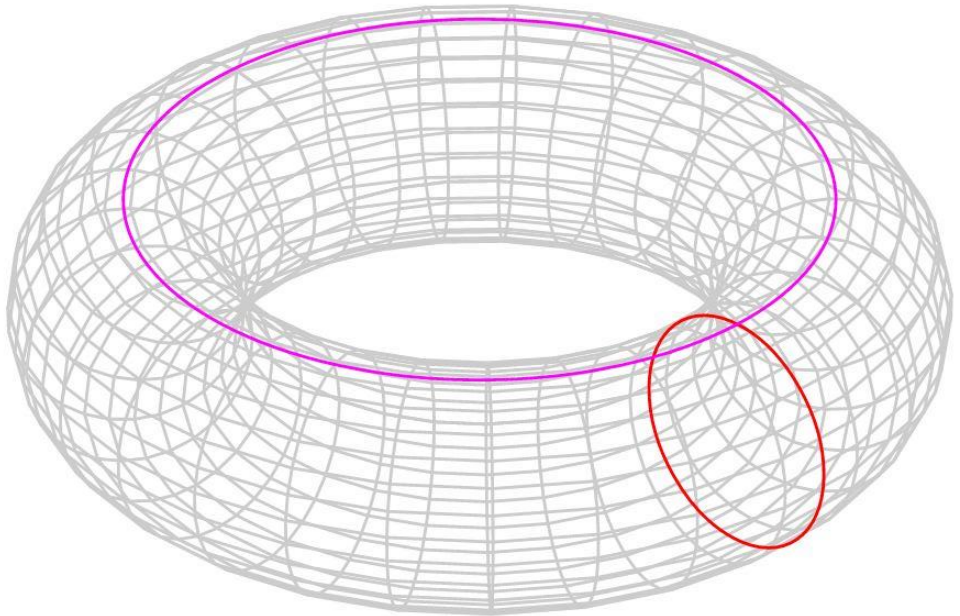

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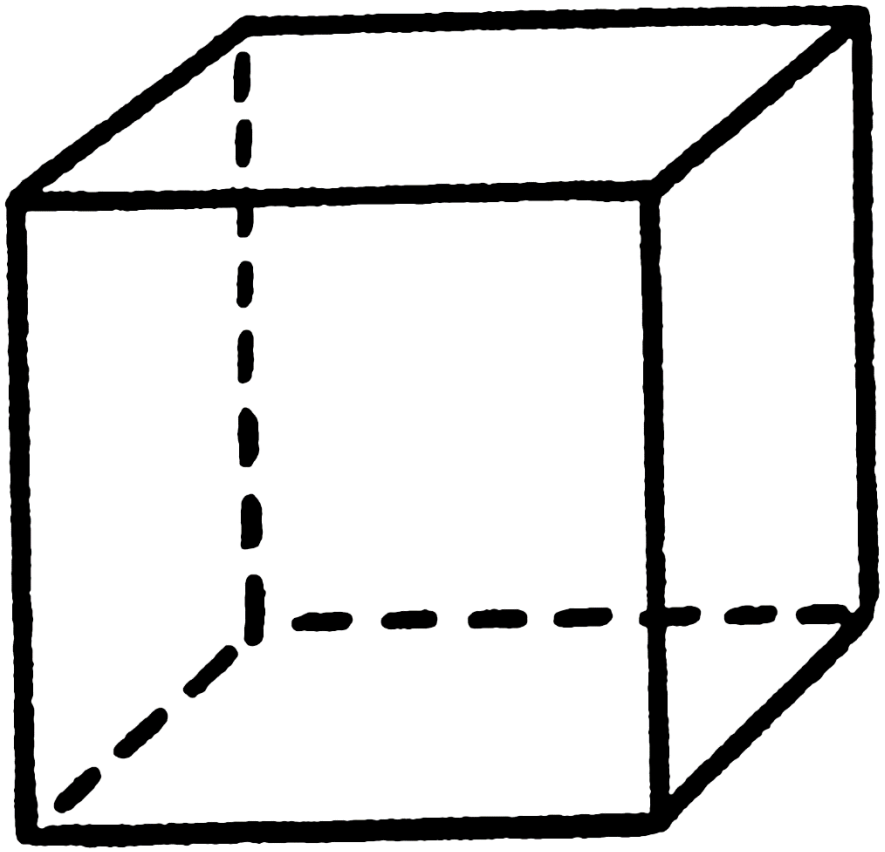

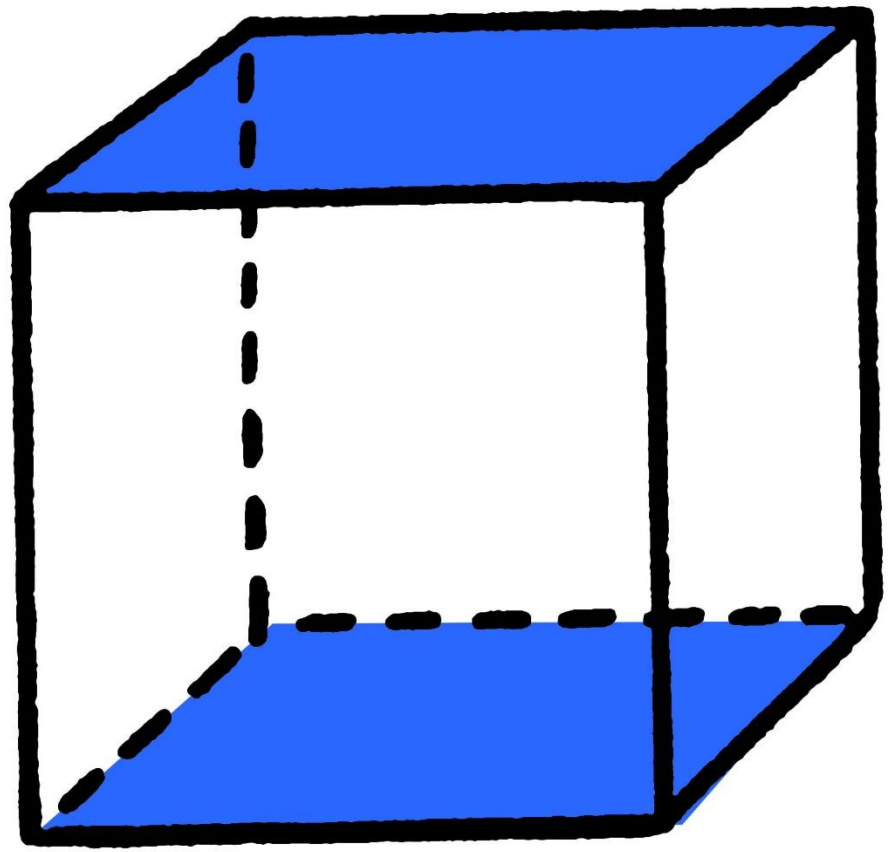

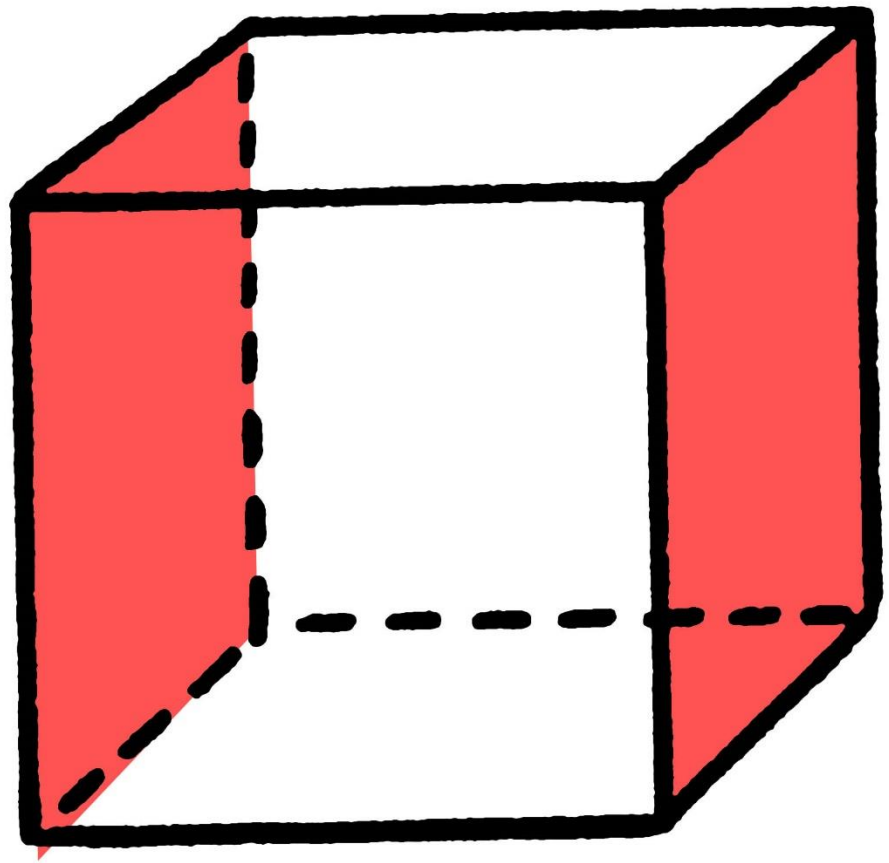

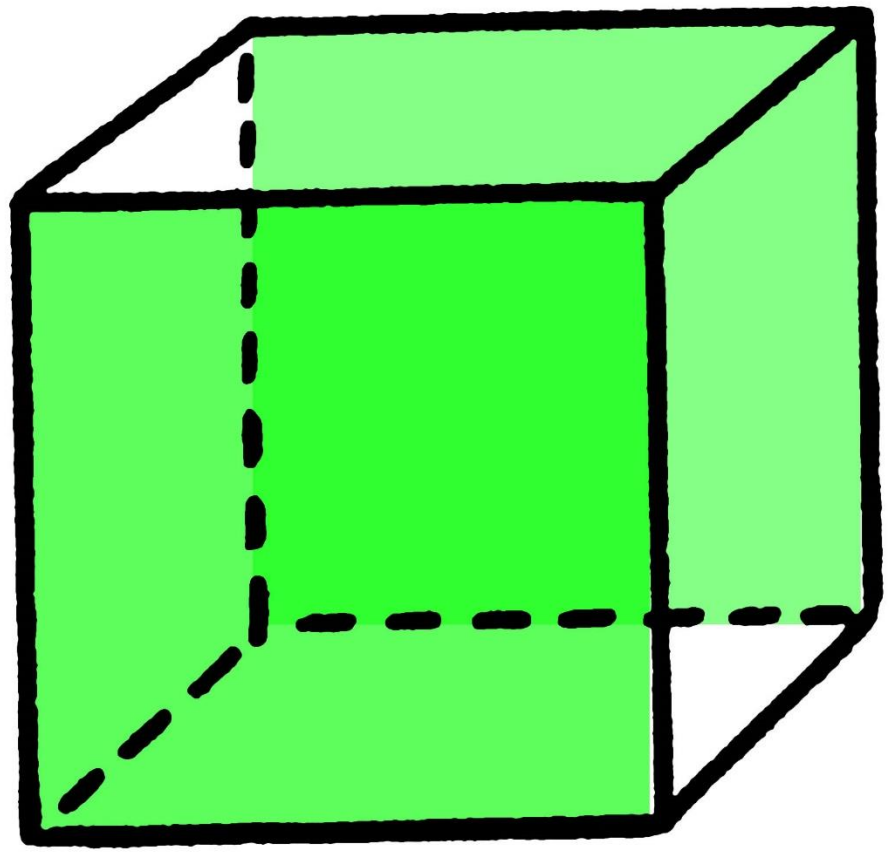

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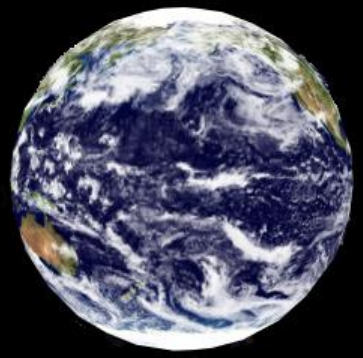
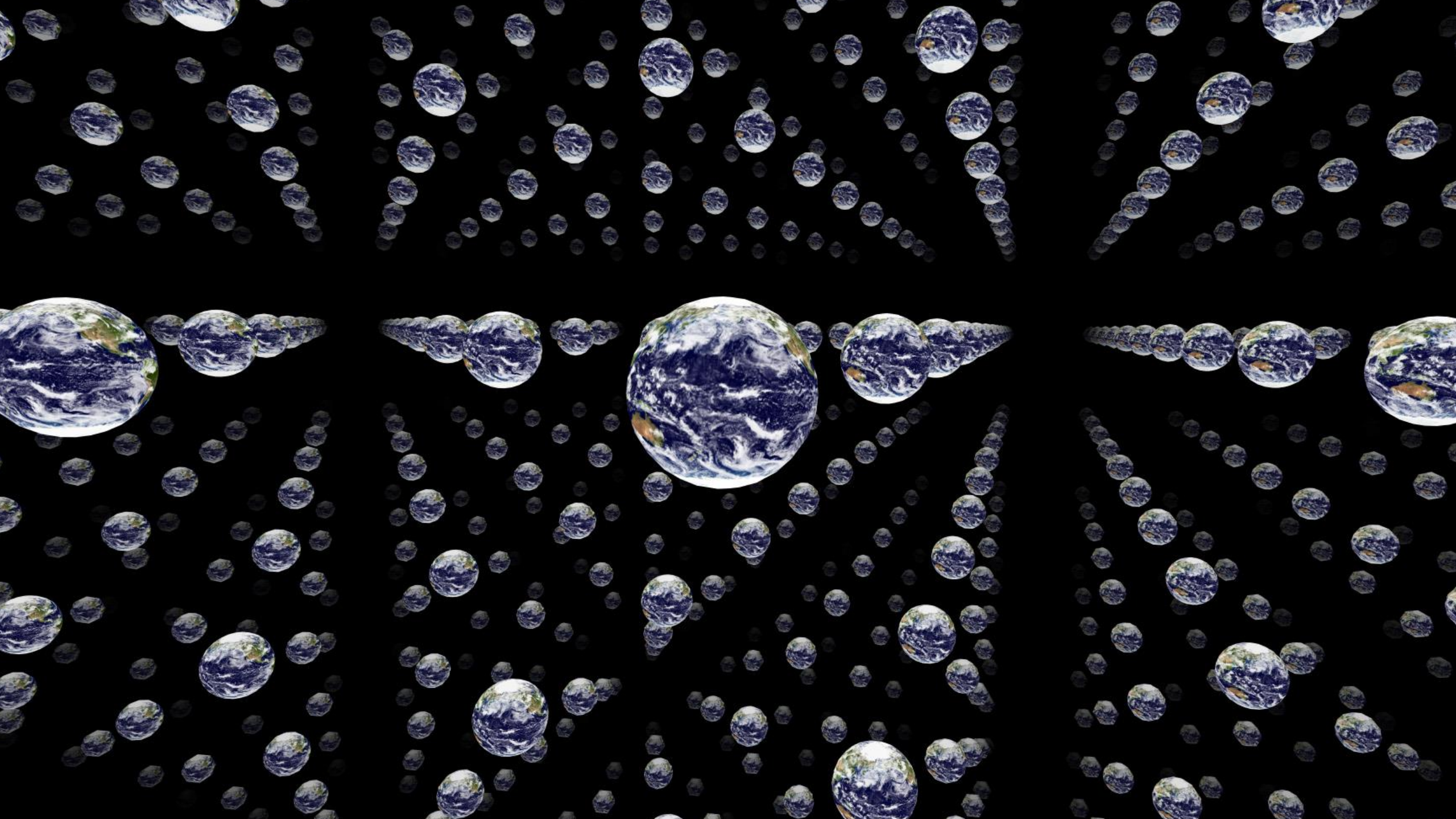
## 2D World Wrapping

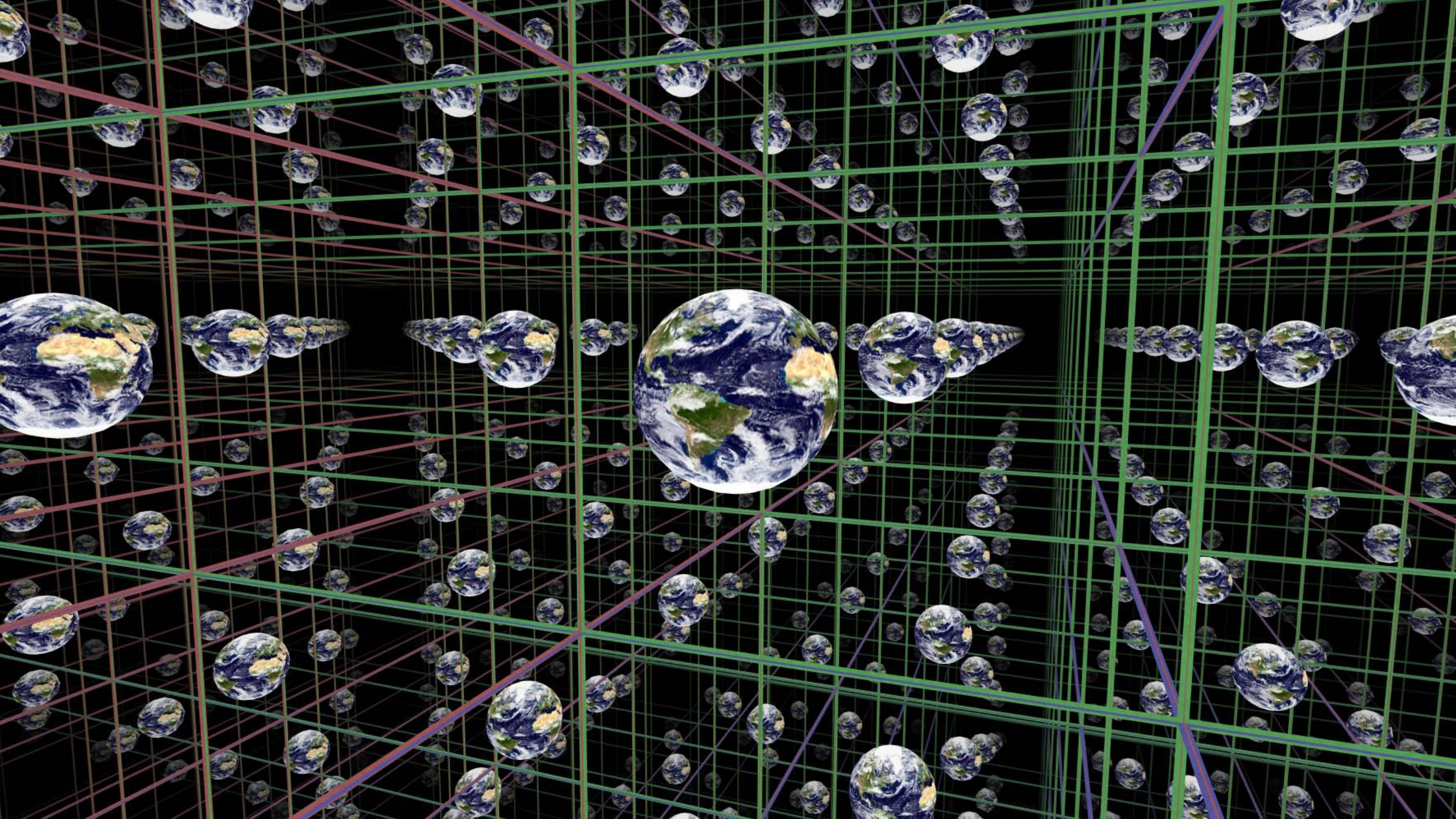
2D character on the 2D surface of a 3D donut

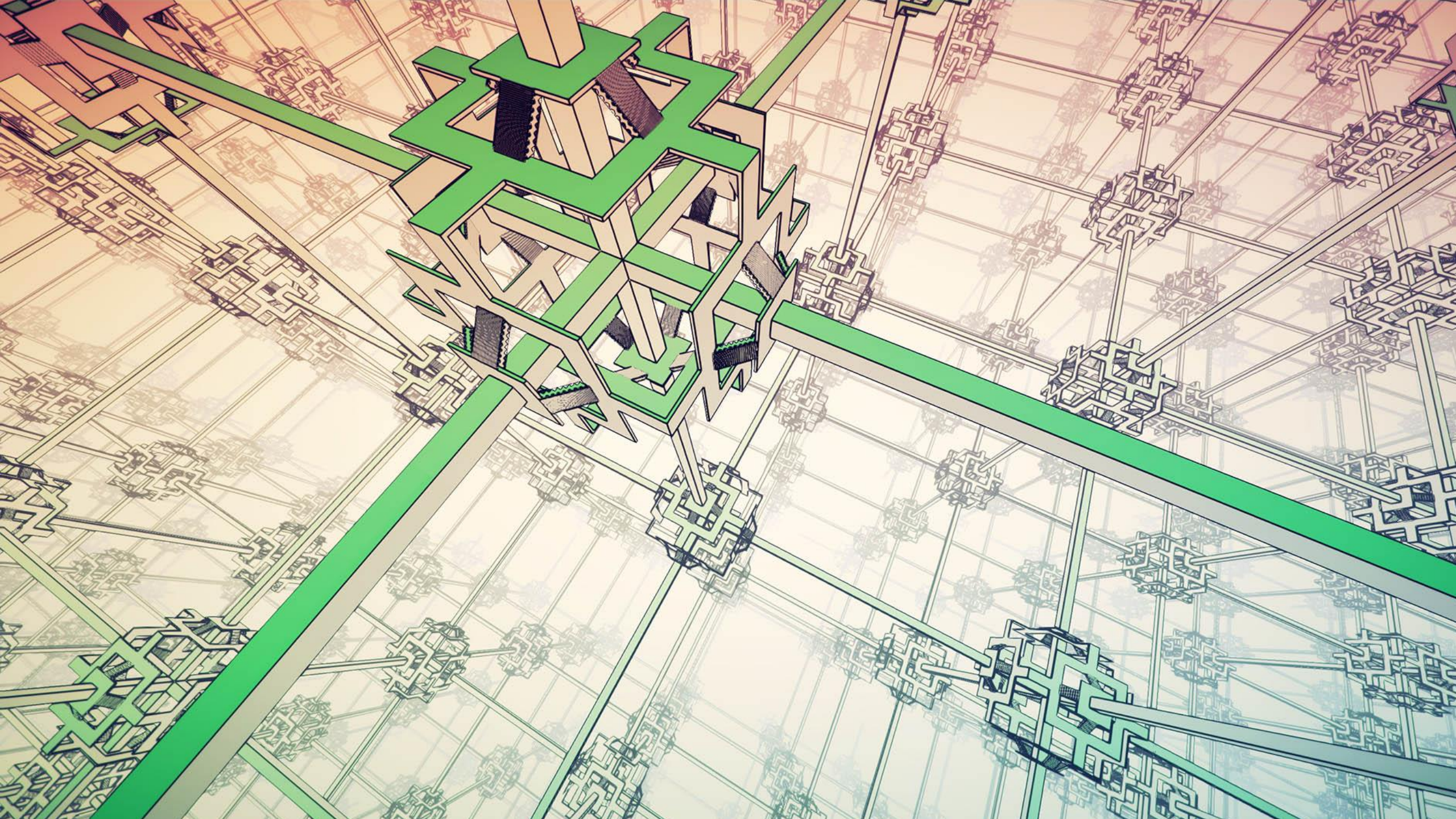
## 3D World Wrapping

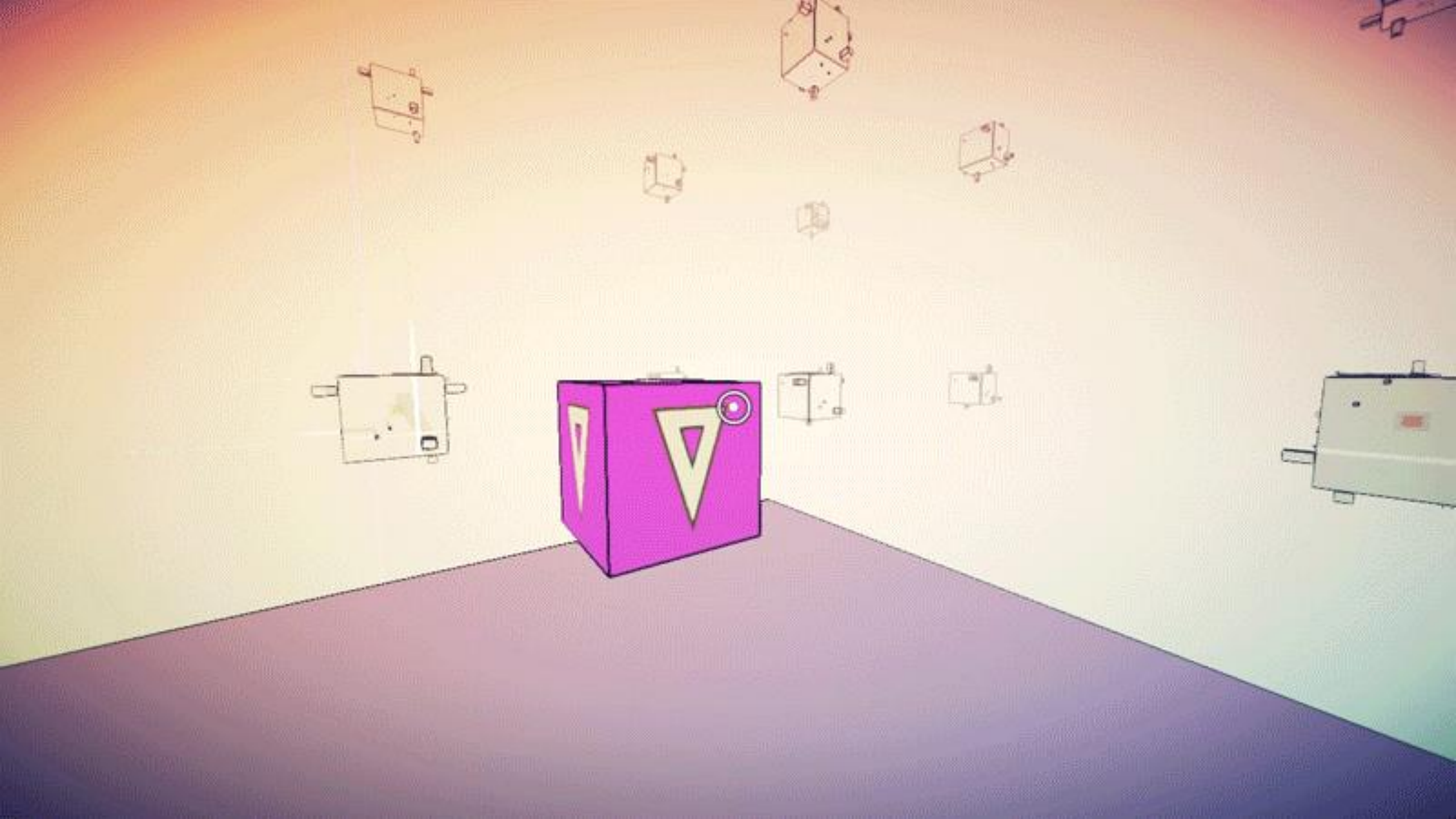
3D character on the 3D surface of a 4D donut

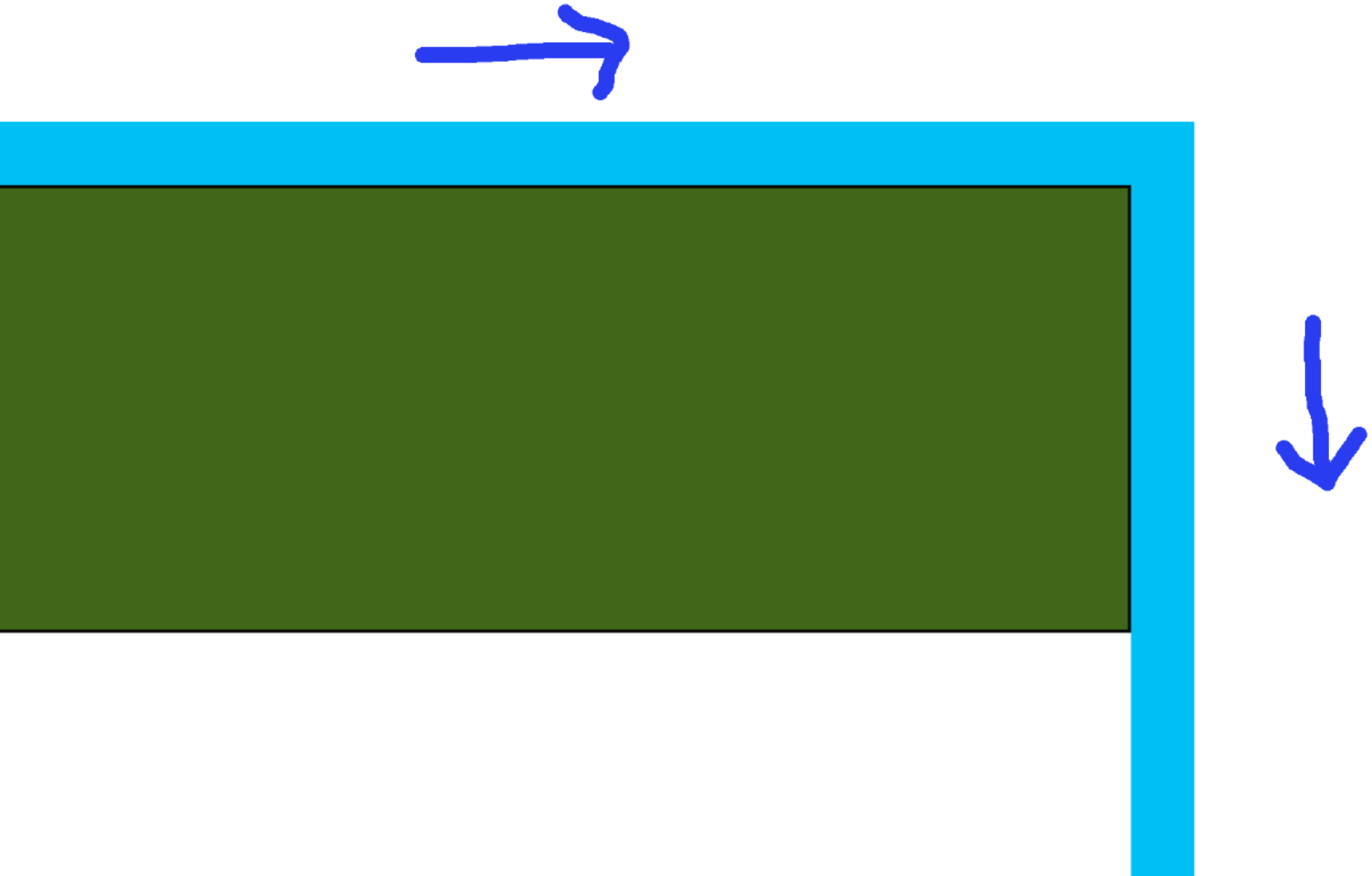


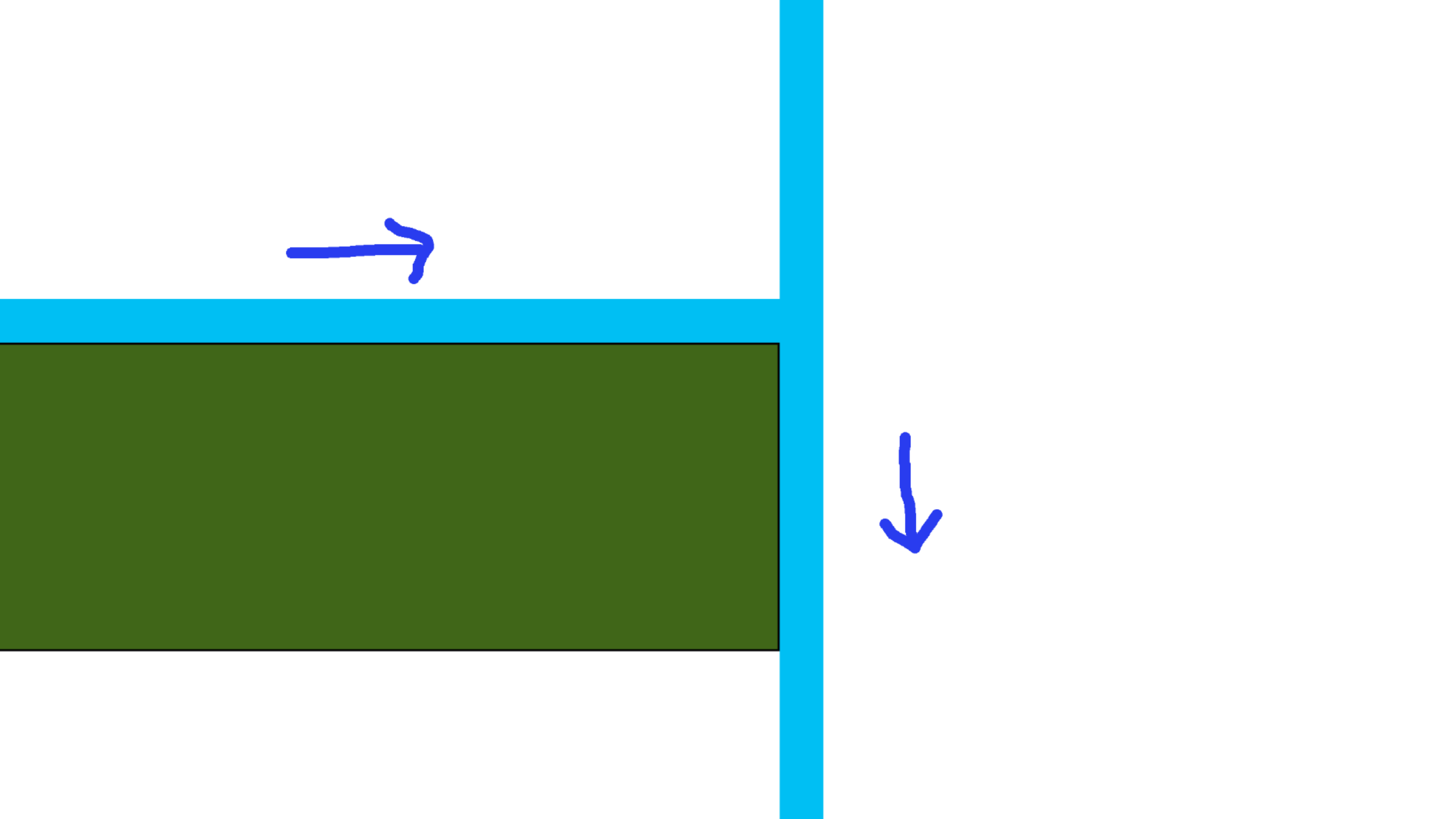


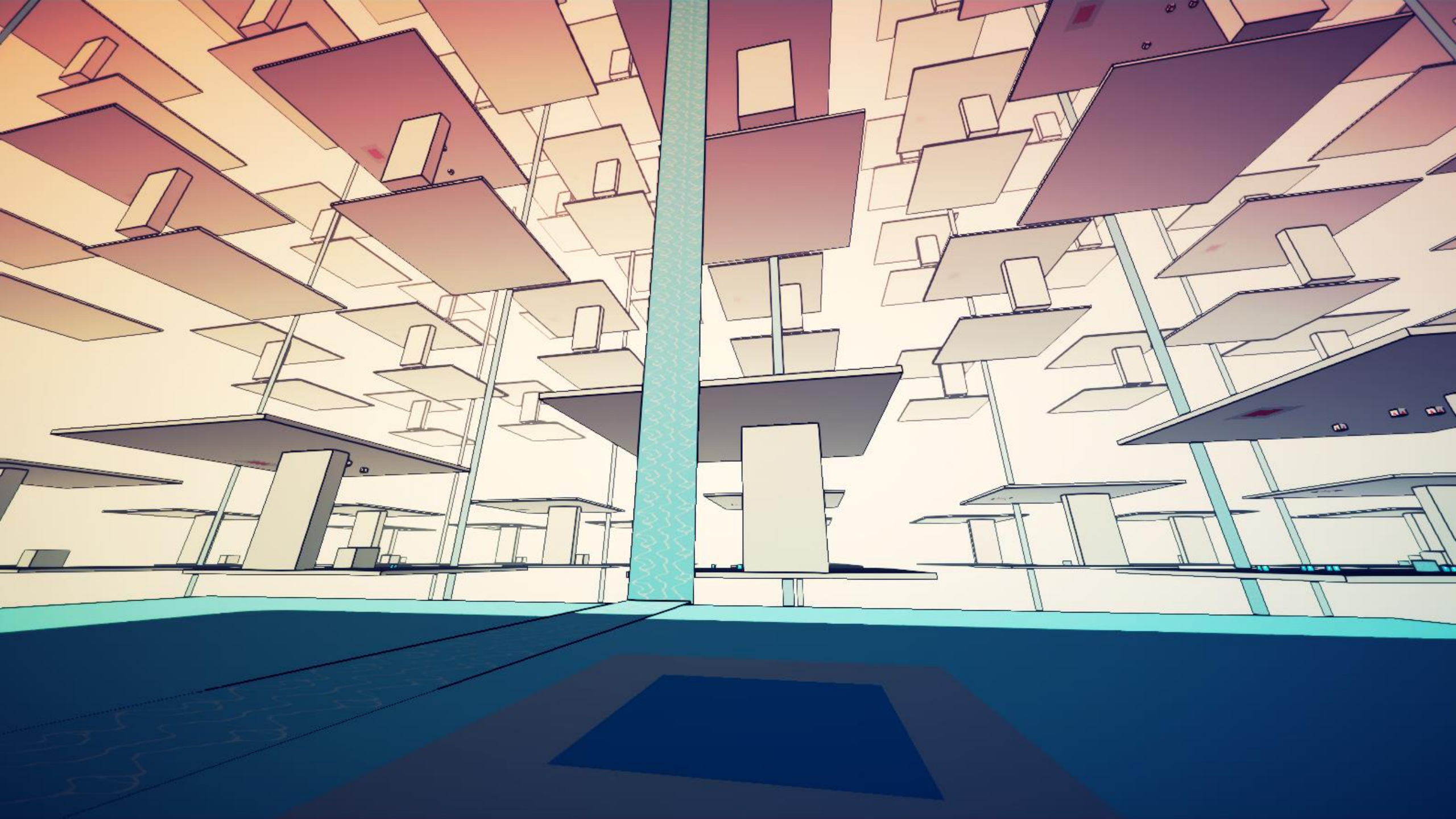


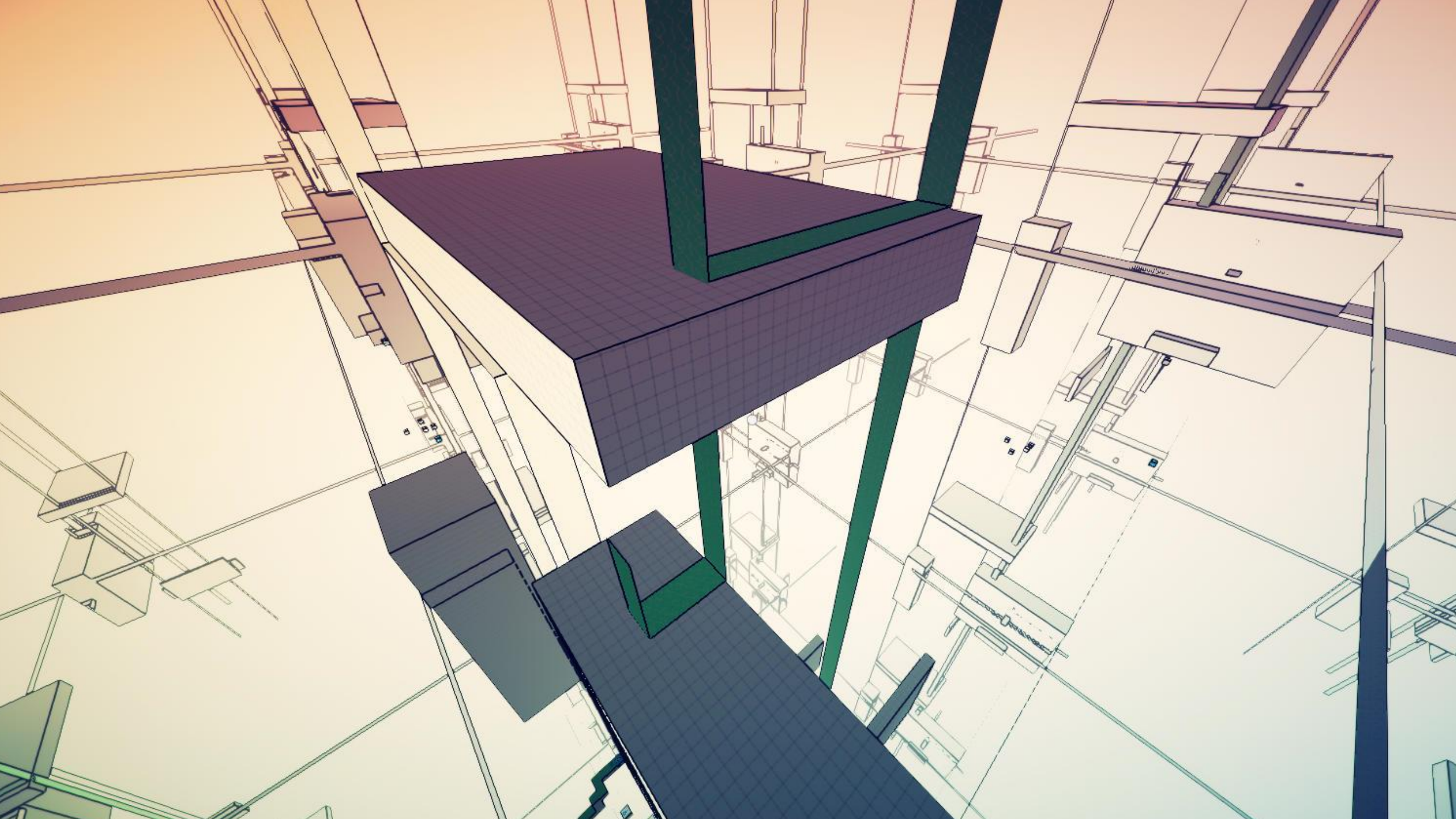






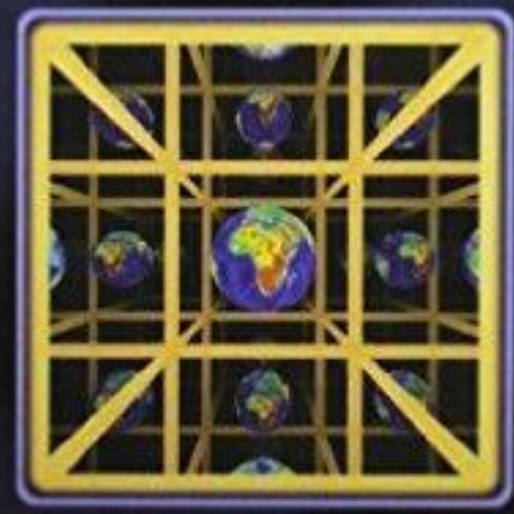






# The SHAPE of SPACE

Second Edition



JEFFREY R. WEEKS

Recipient of the MacArthur Fellowship

# GeometryGames.org

Jeff Weeks'

## Topology and Geometry Software

### Torus Games

*Eight familiar games introduce children age 10 and up to the concept of a finite yet unbounded universe.*

iOS, Android, Mac, Windows

info | download

### KaleidoPaint

*Create colorful symmetrical paintings based on the 17 tiling patterns.*

iOS

info | download

### KaleidoTile

*Explore polyhedra and tessellations while creating colorful works of art.*

Mac, Windows

info | download

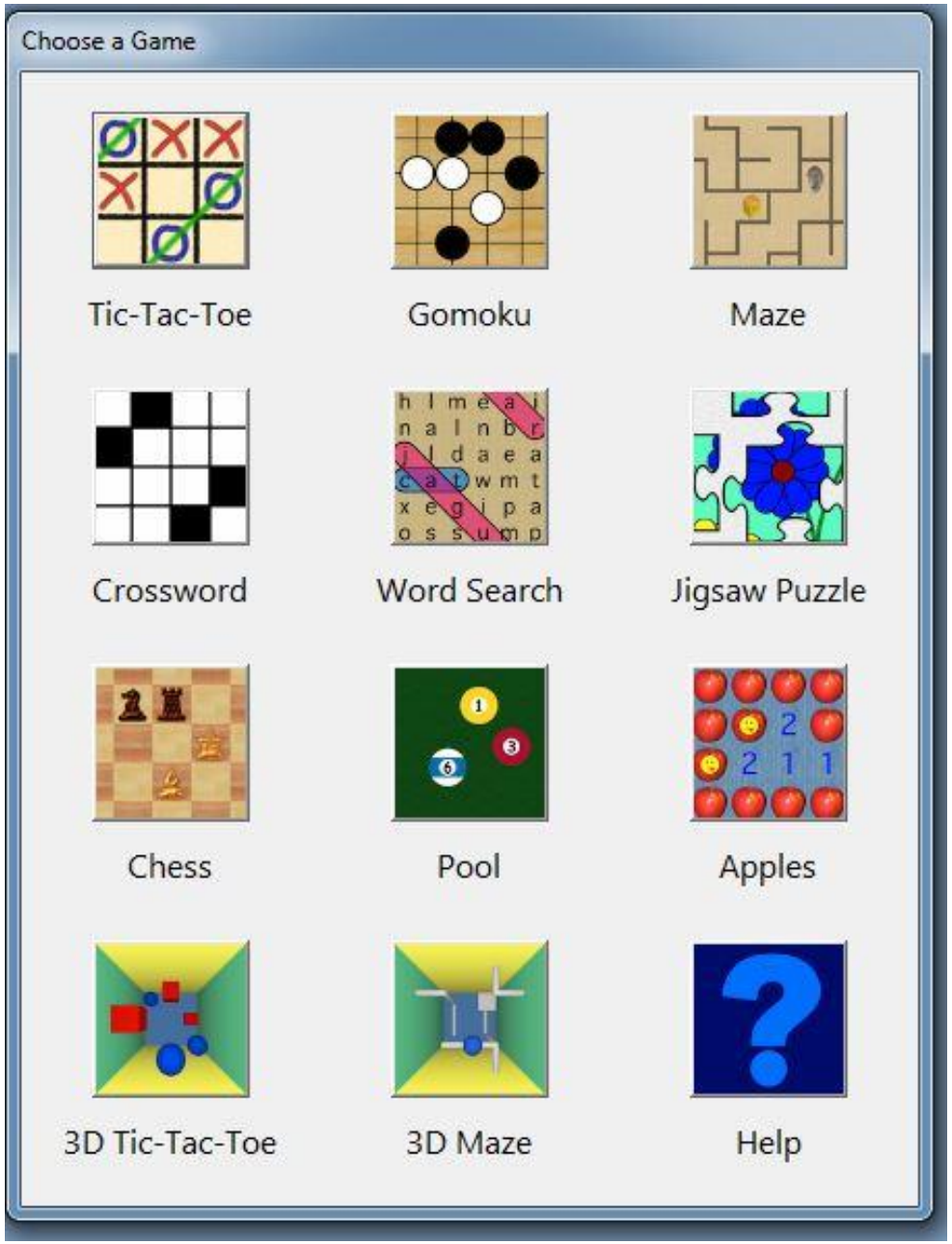
### Curved Spaces

*Fly in a multiconnected universe* (for math and physics students).

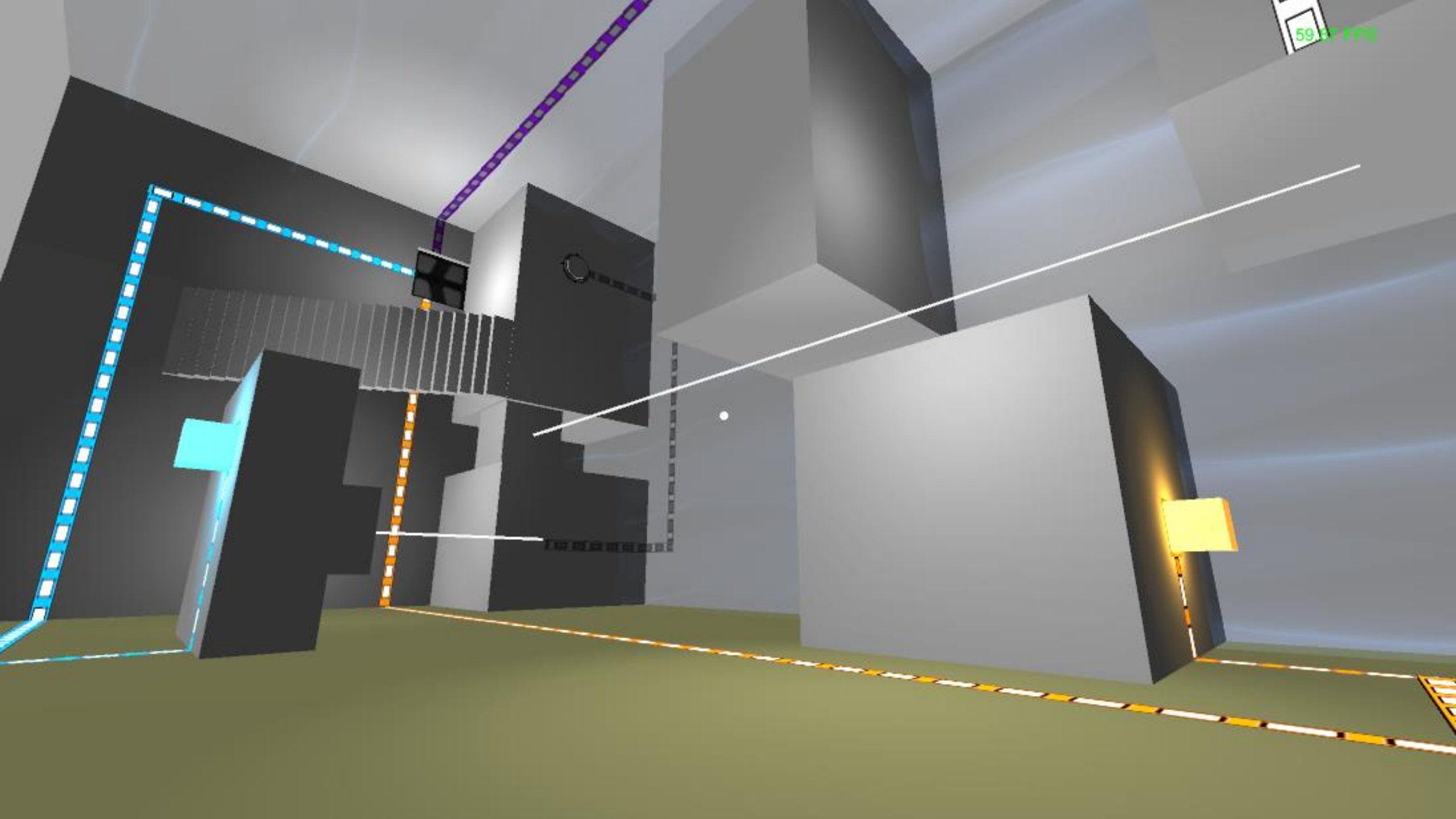
Mac, Windows

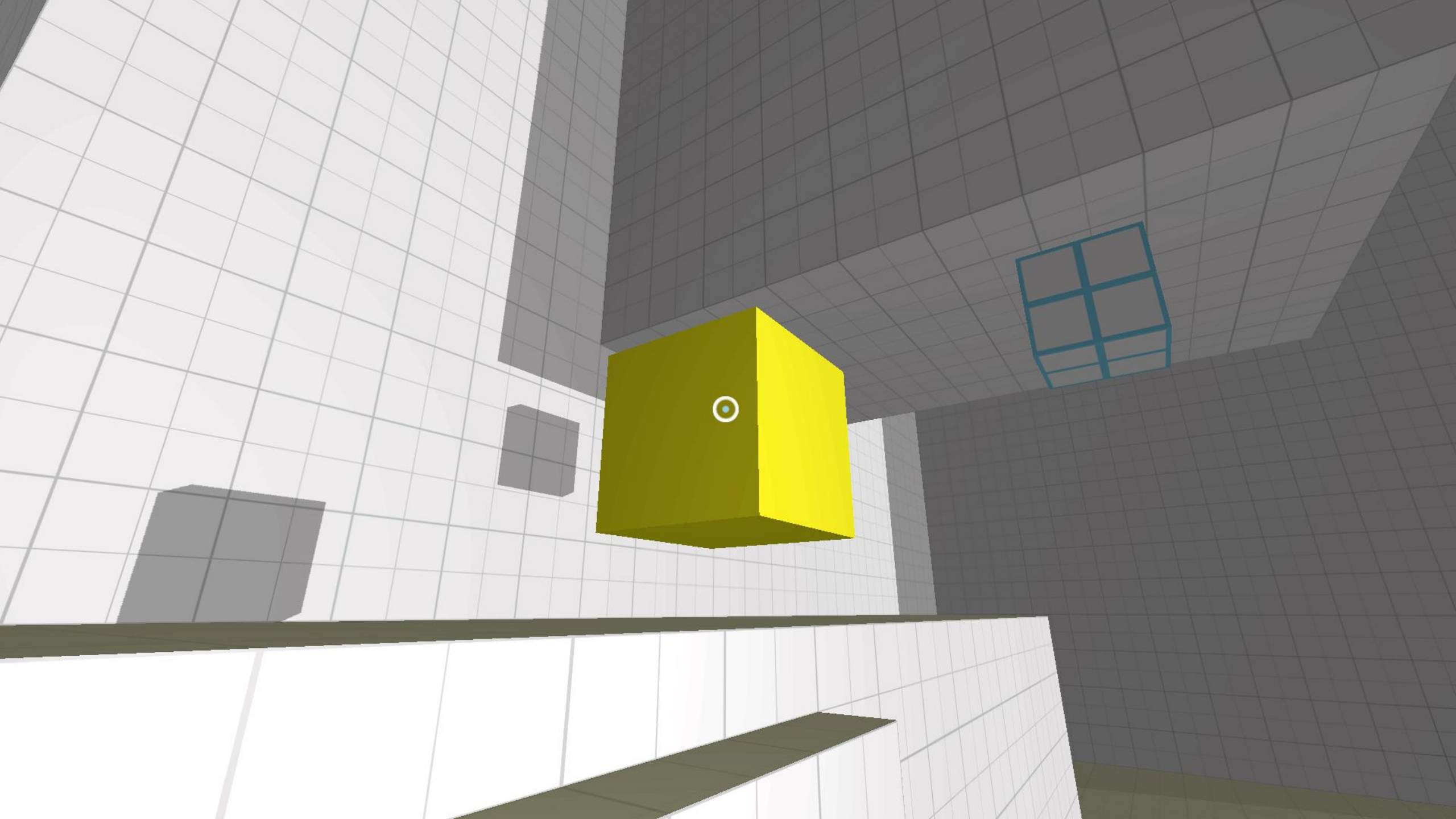
info | download

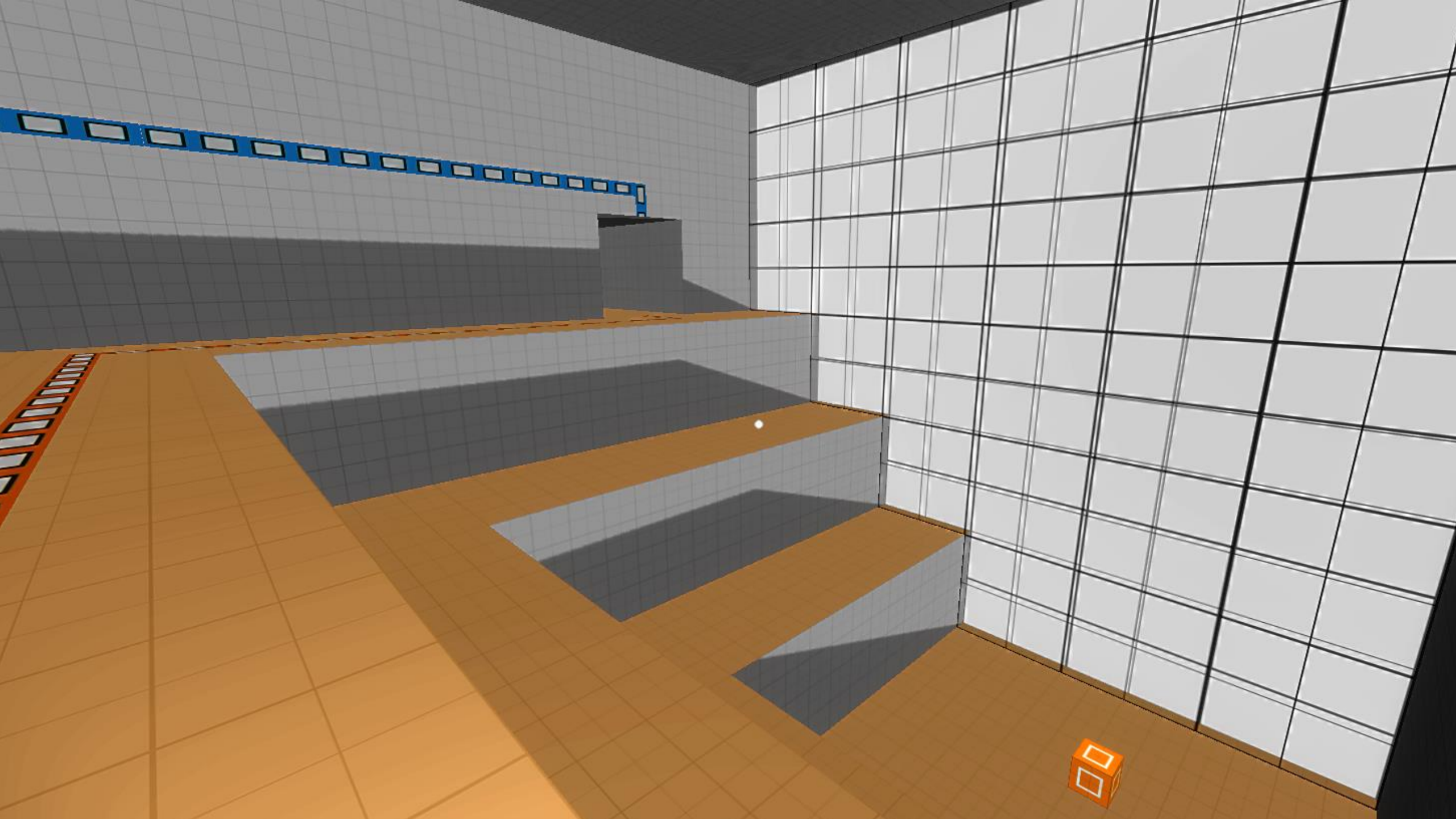
# Torus Games

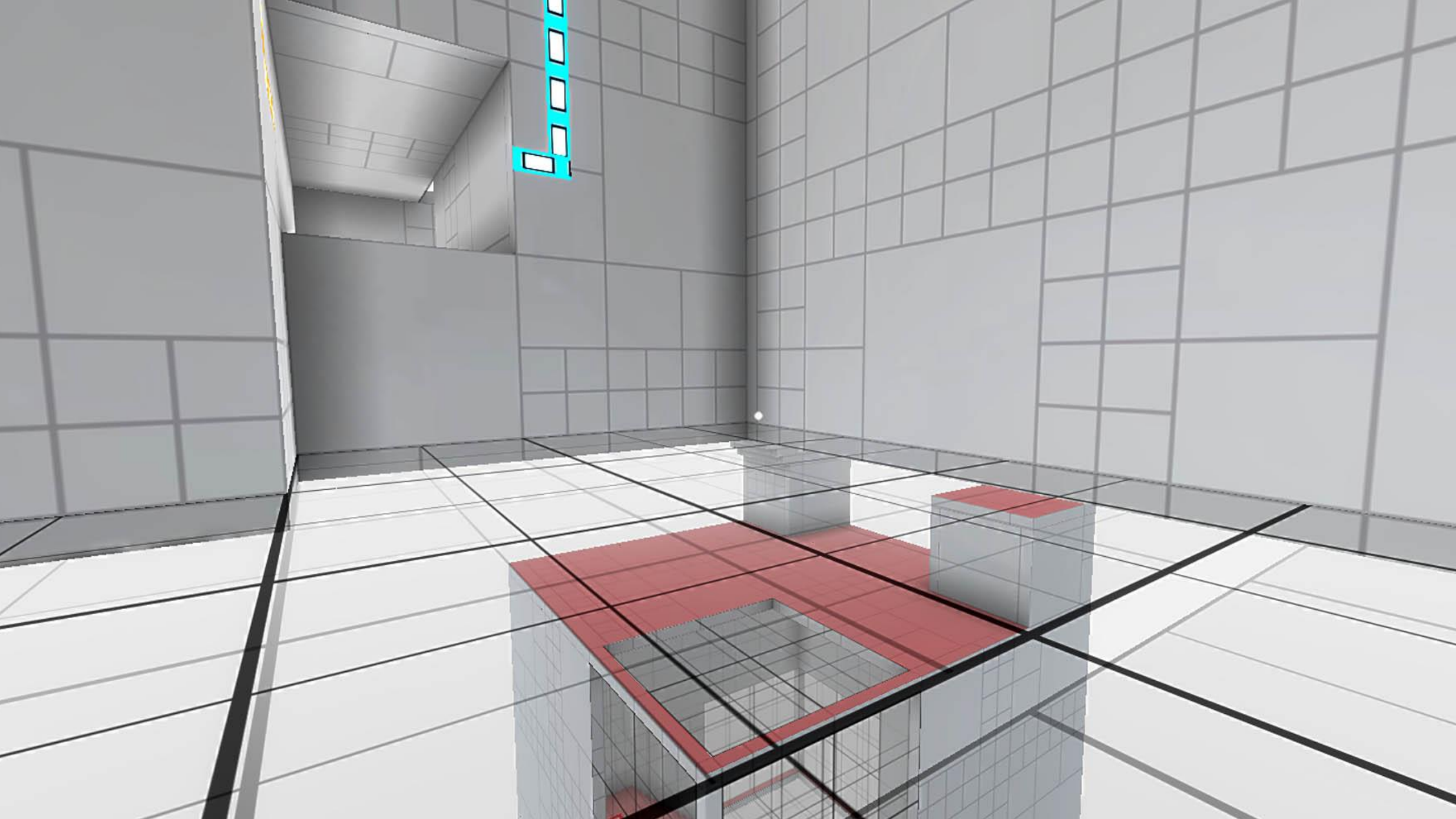

Choose a Game
Tic-Tac-Toe
Gomoku
Maze
Crossword
Word Search
Jigsaw Puzzle
Chess
Pool
Apples
3D Tic-Tac-Toe
3D Maze
Help

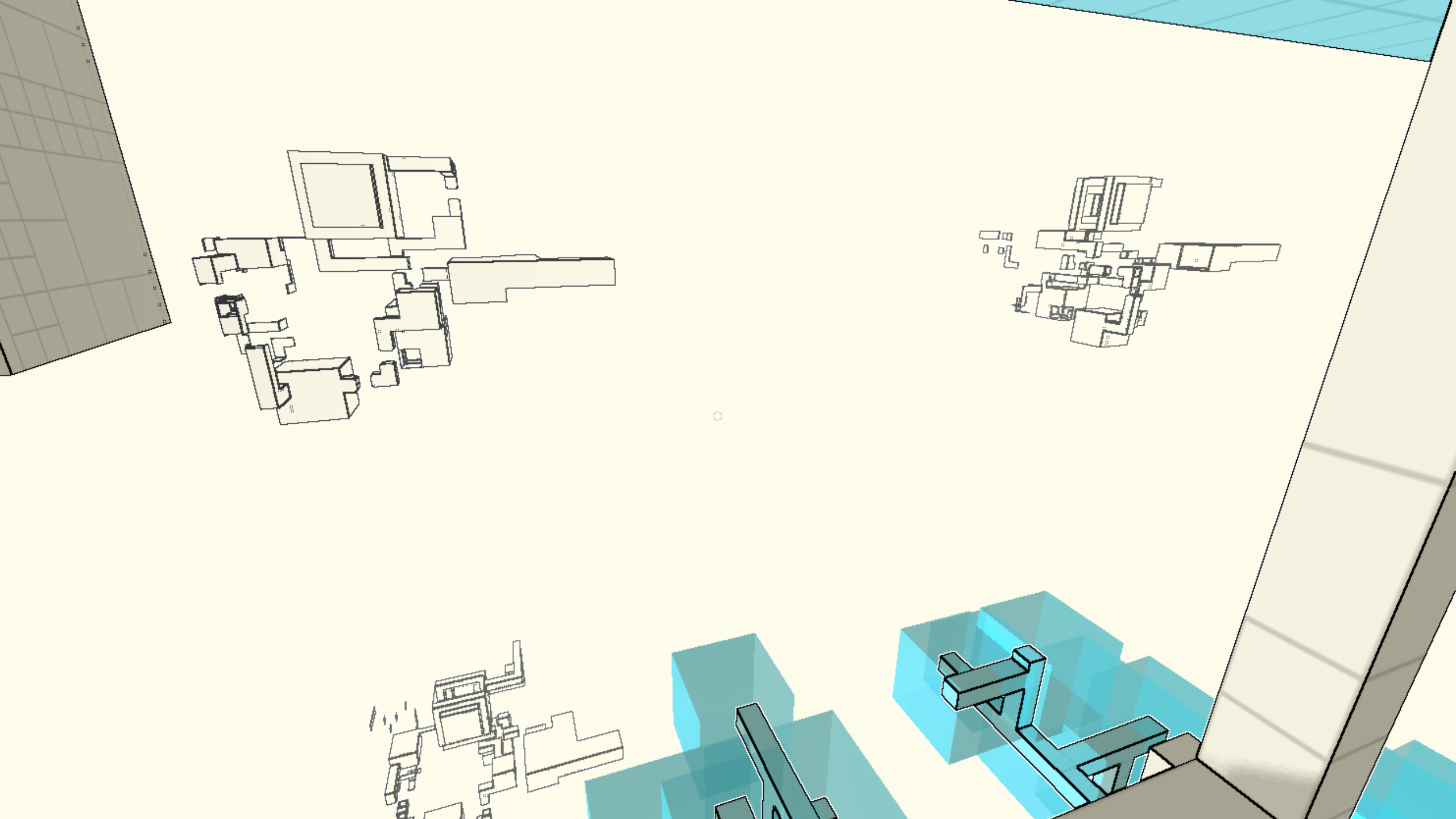
# How did 3D world wrapping get added to Manifold Garden?

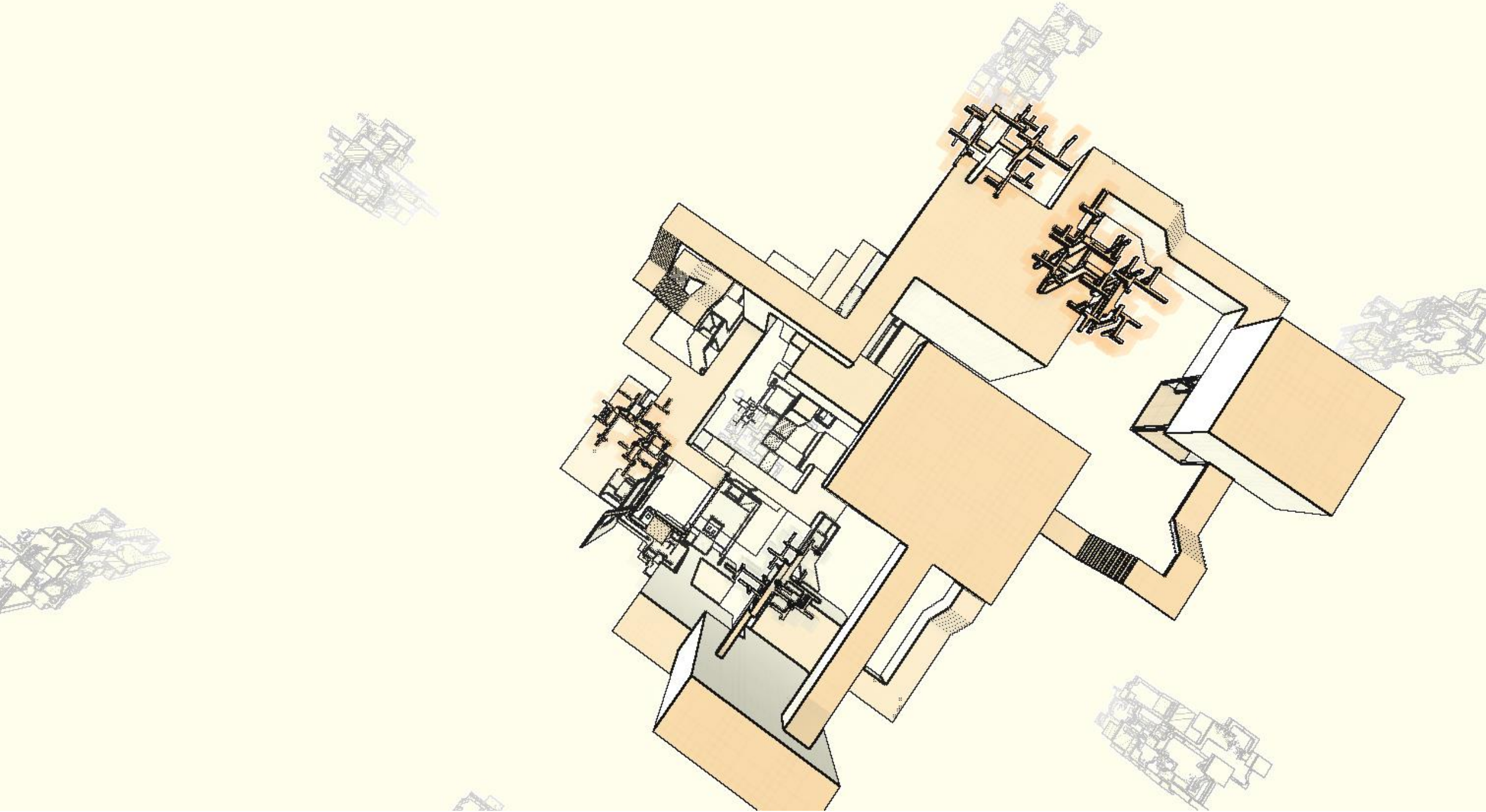

59.97 FPS

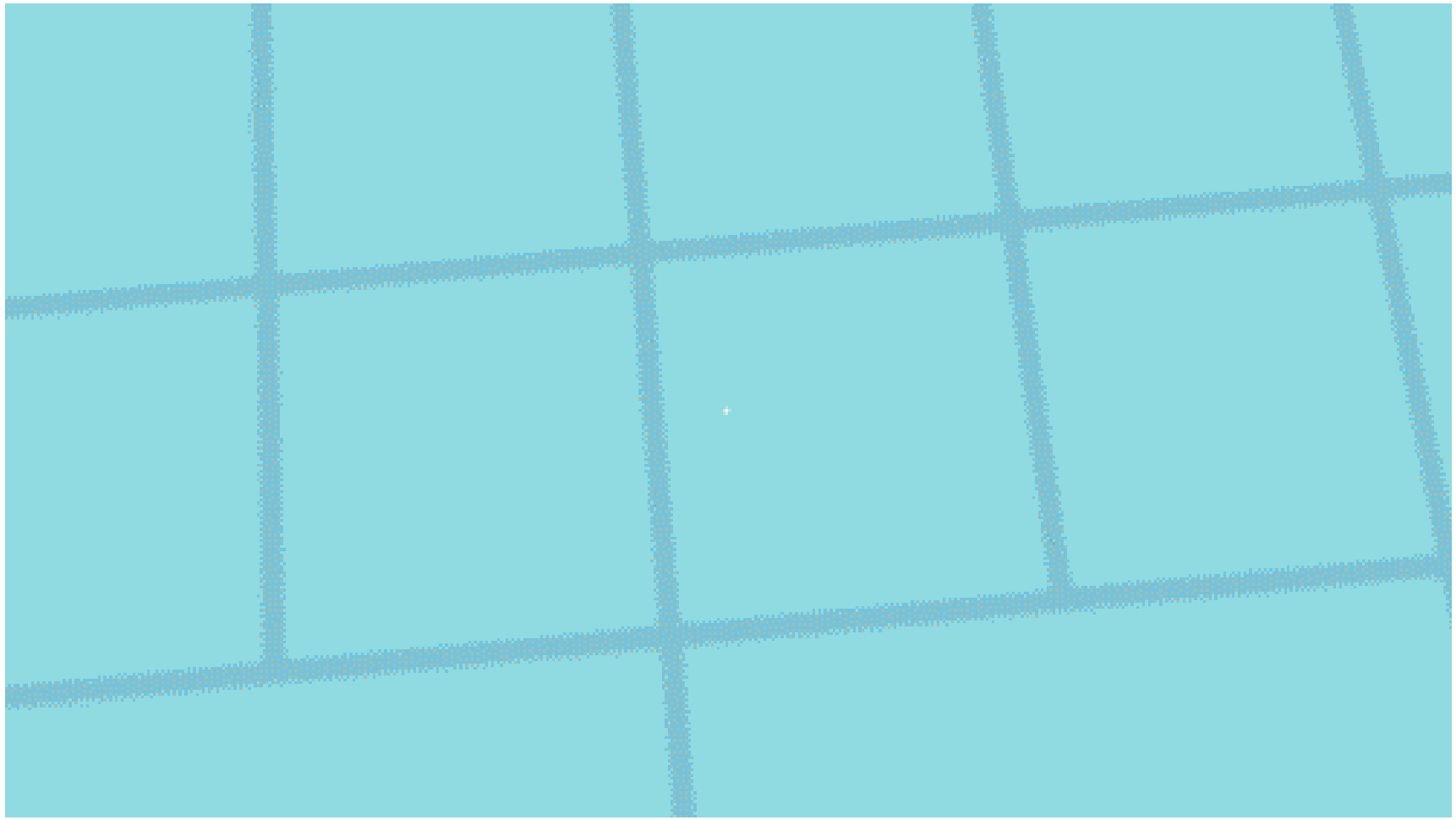




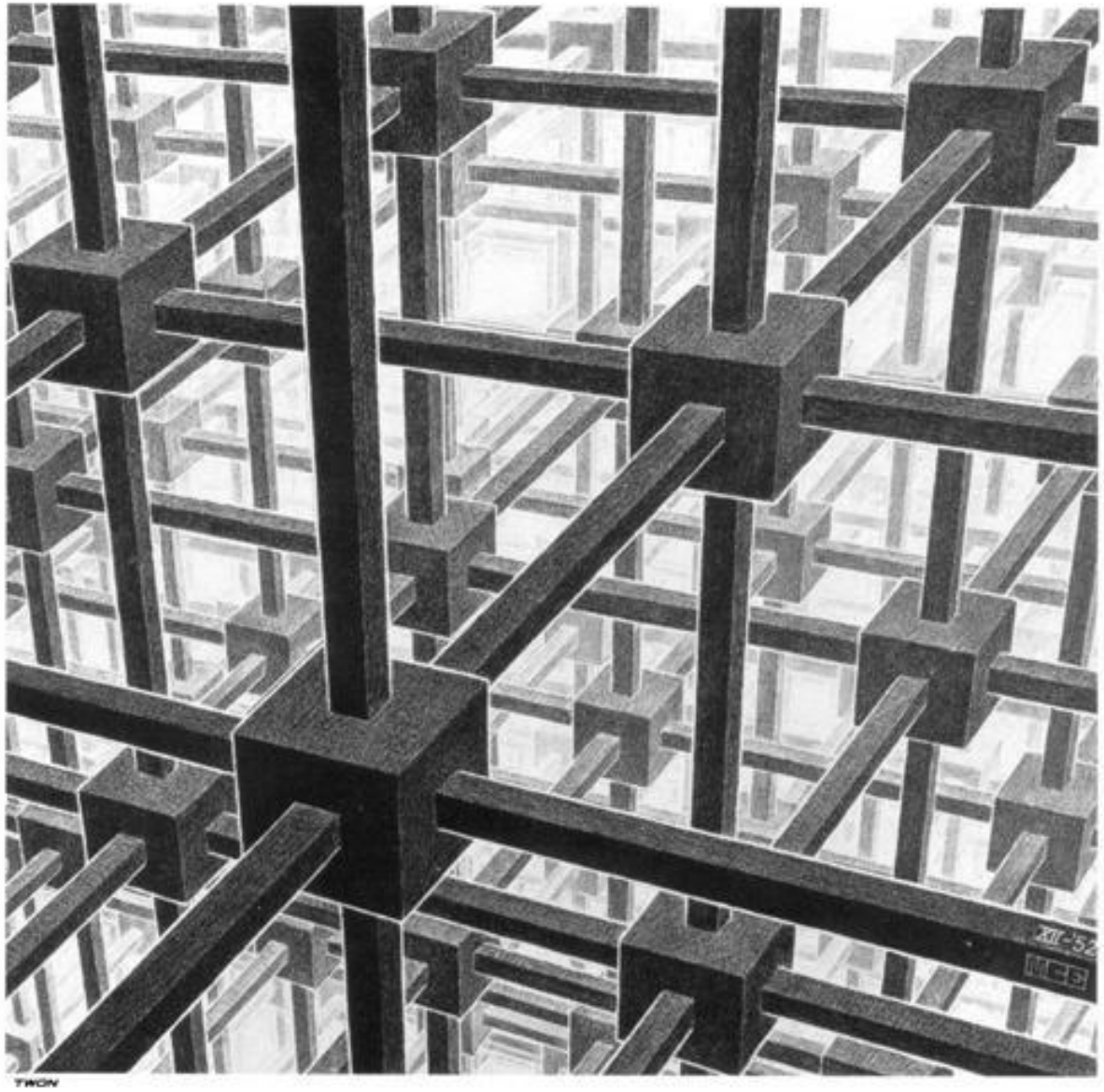






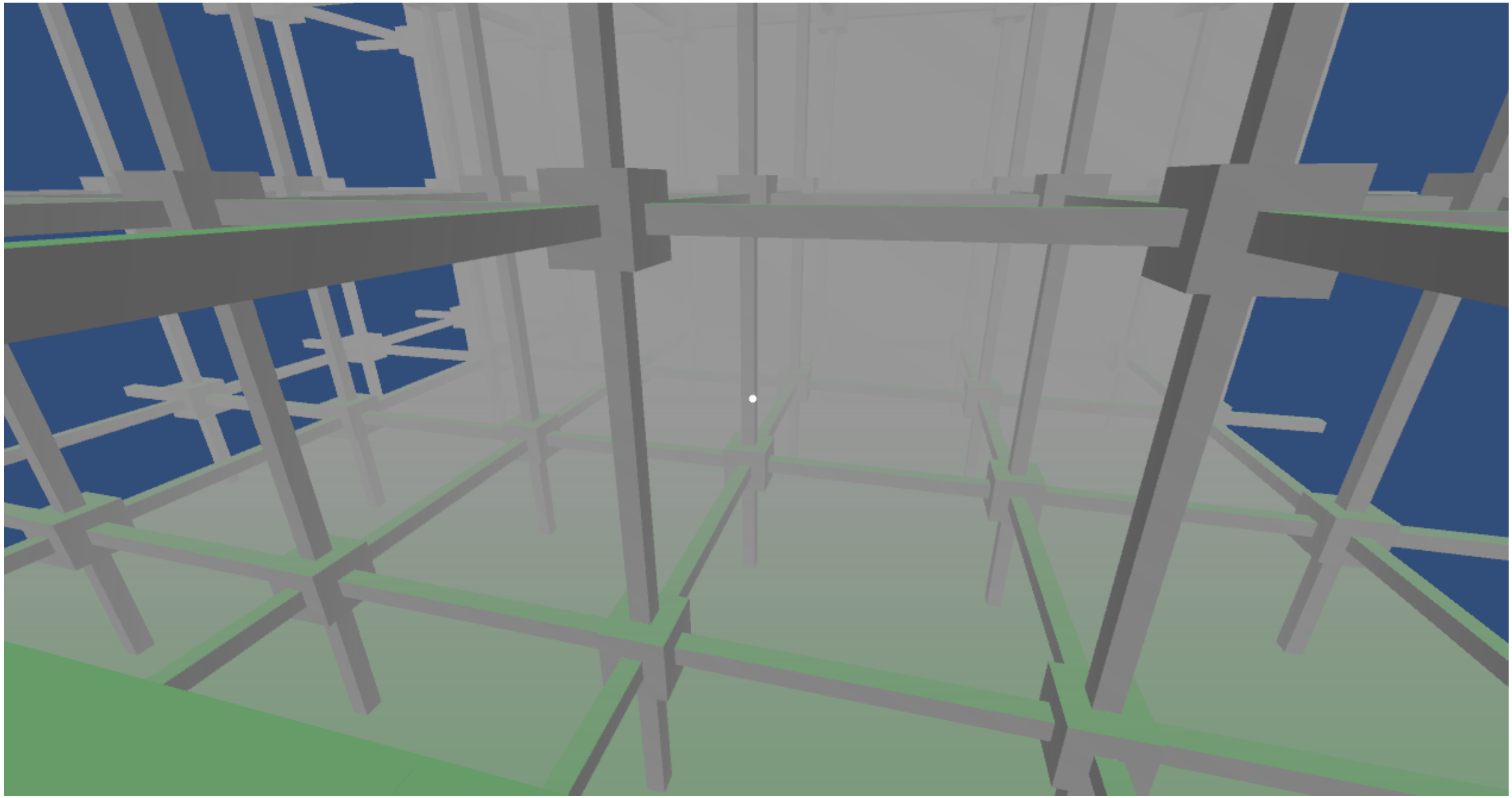


# Unexpected Solutions to Previous Problems

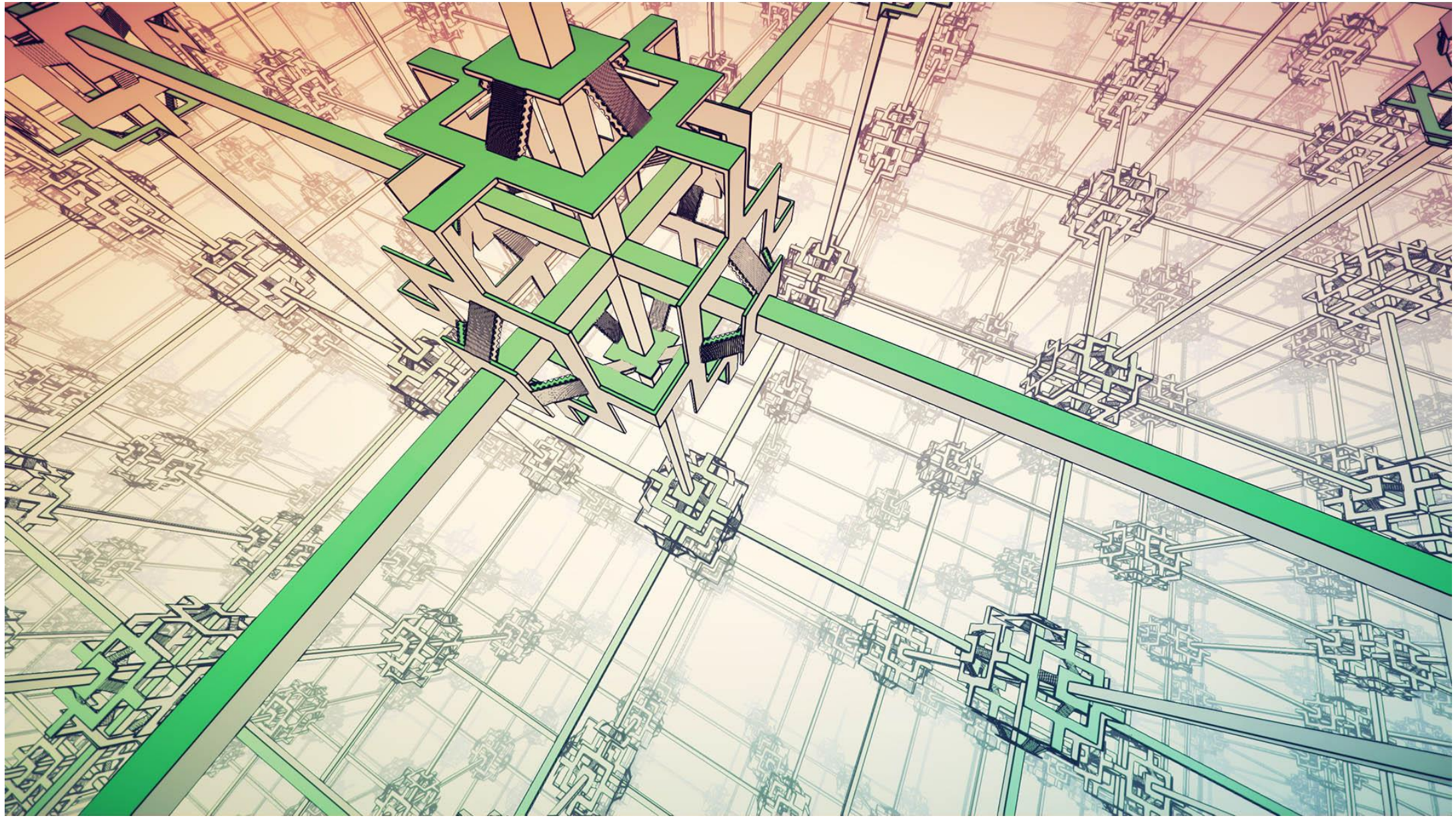


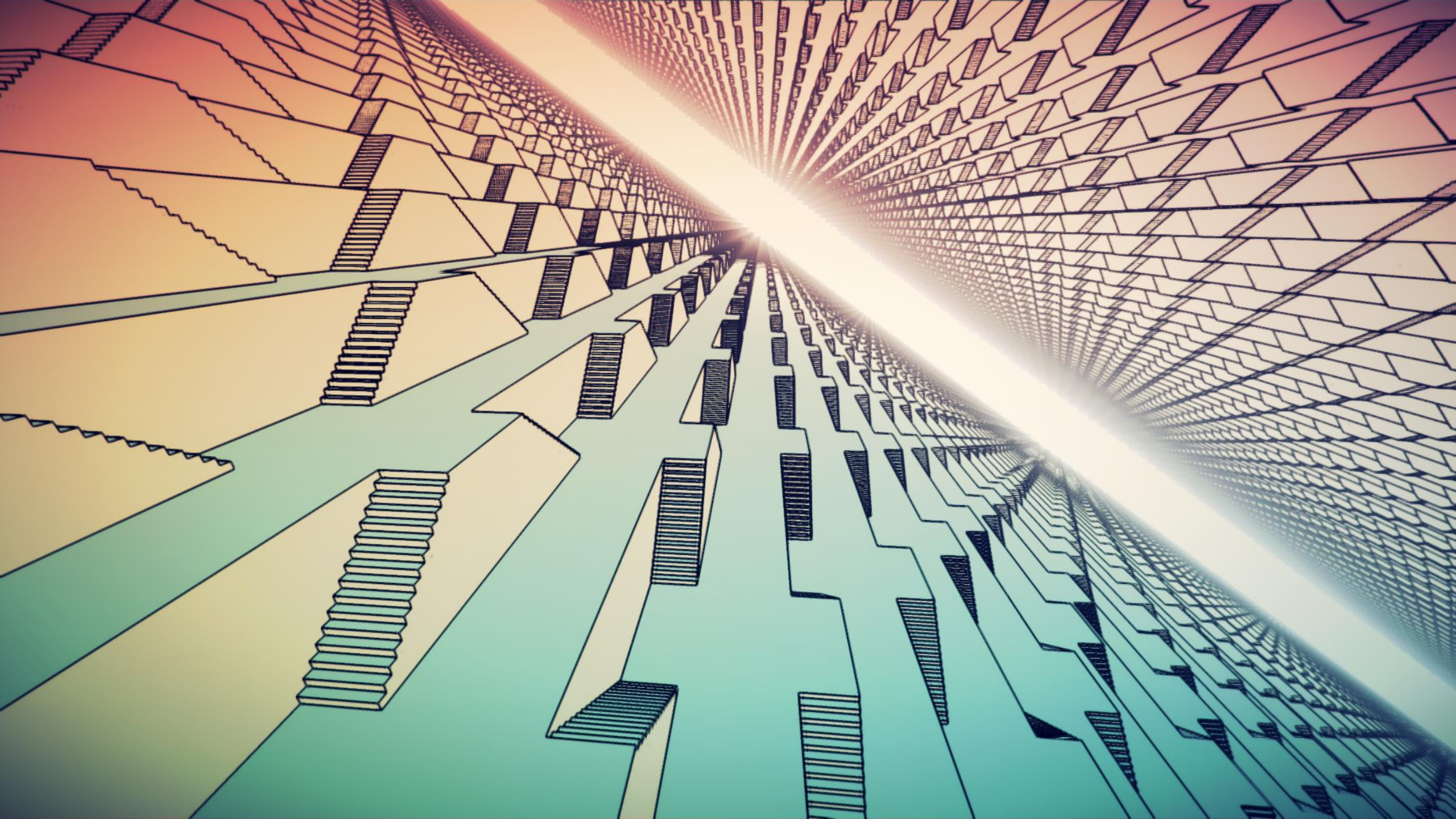
‘Cubic Space Division’ by M.C. Escher

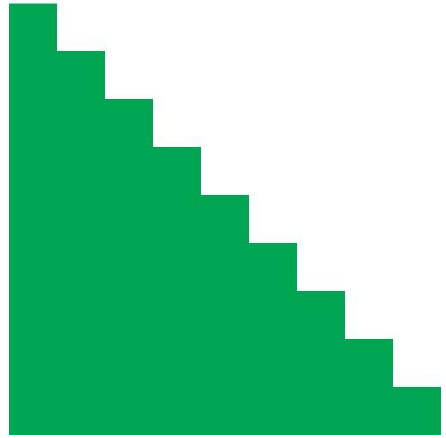
July 2013 – No world wrapping.

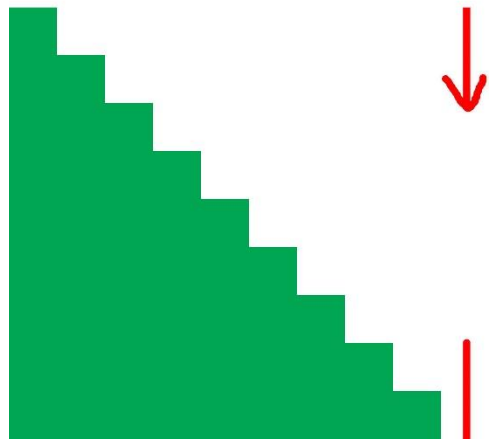


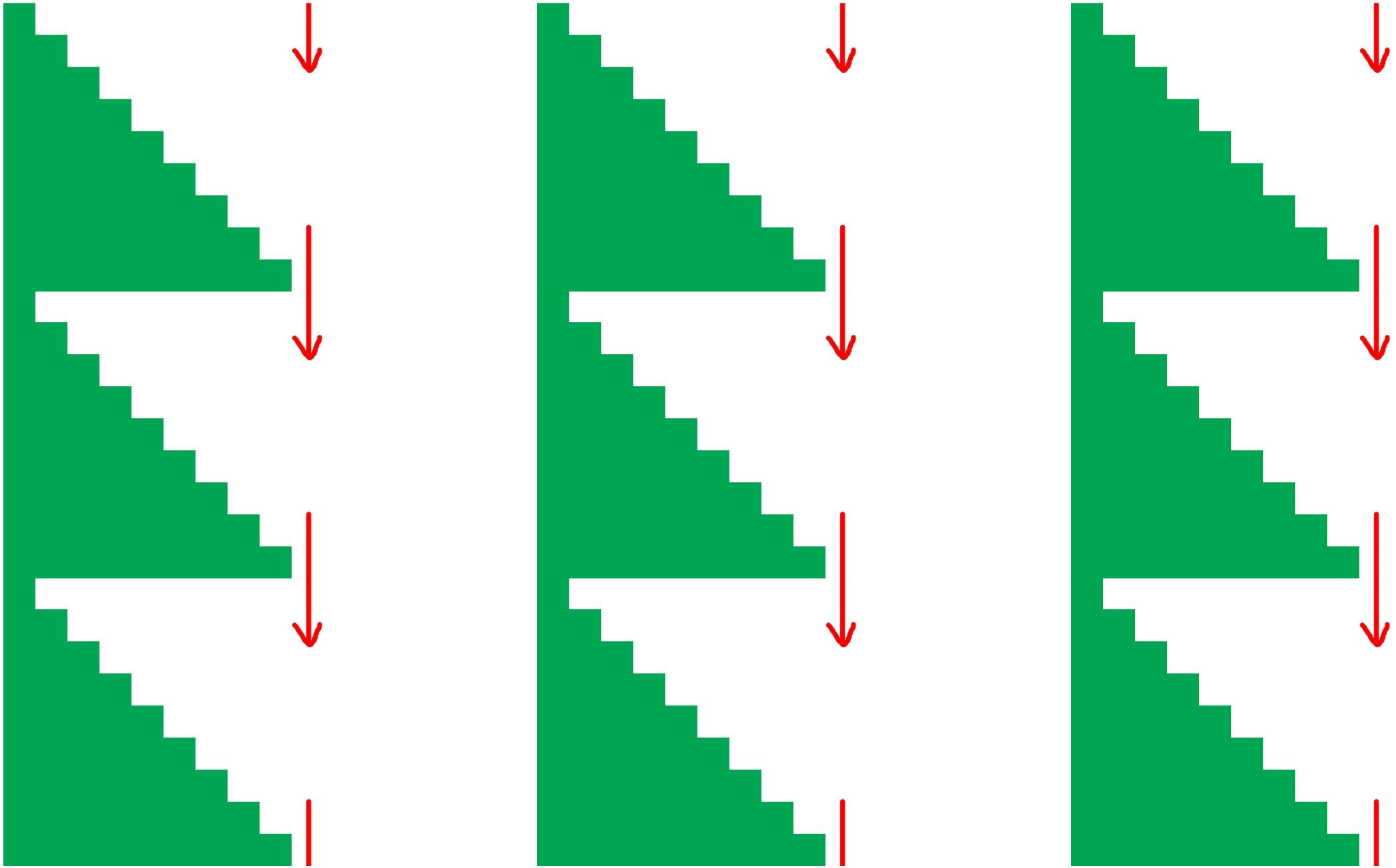
December 2015 – With world wrapping.

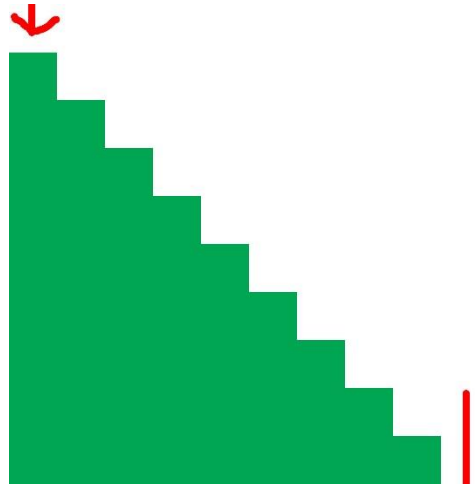


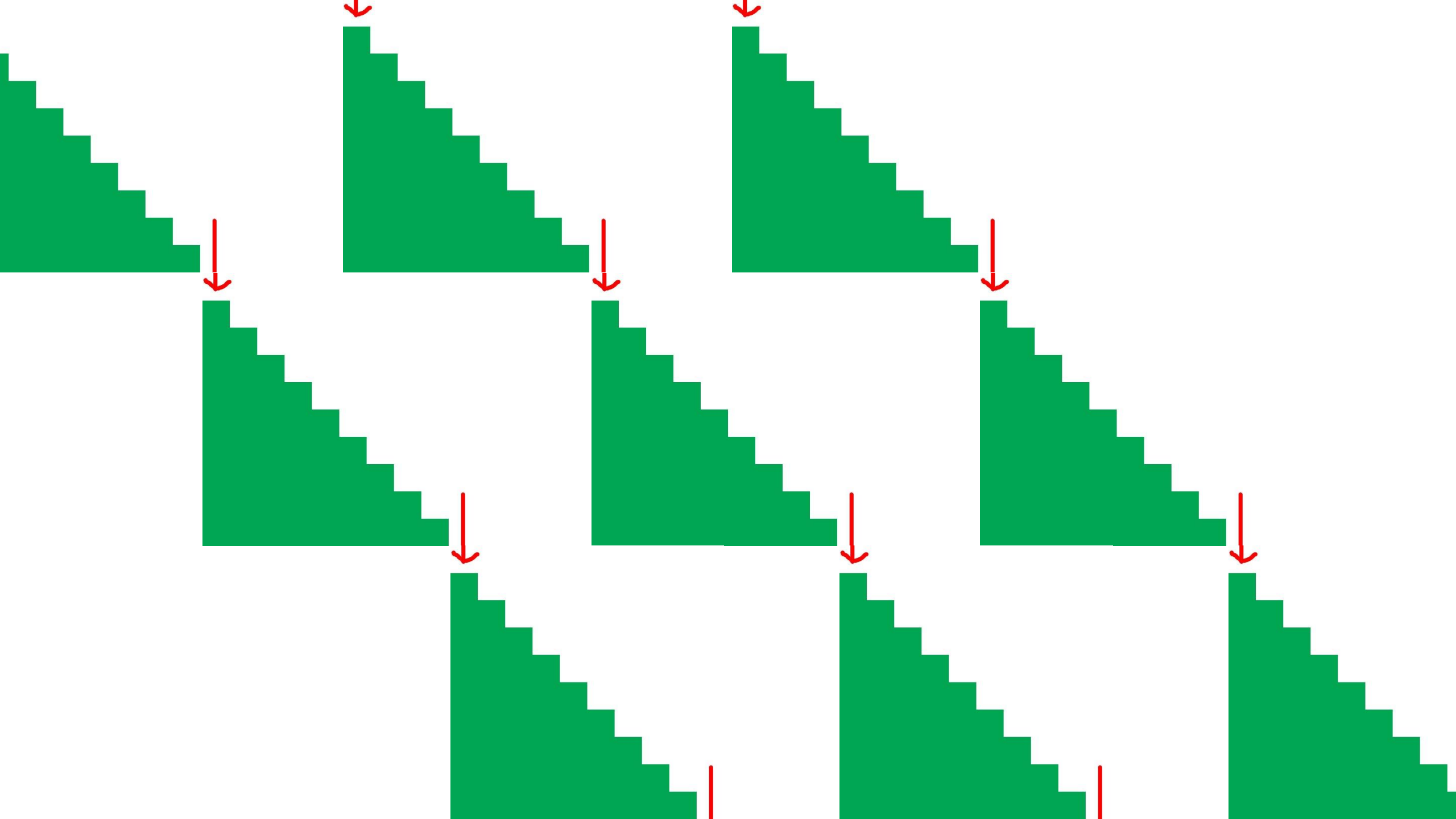


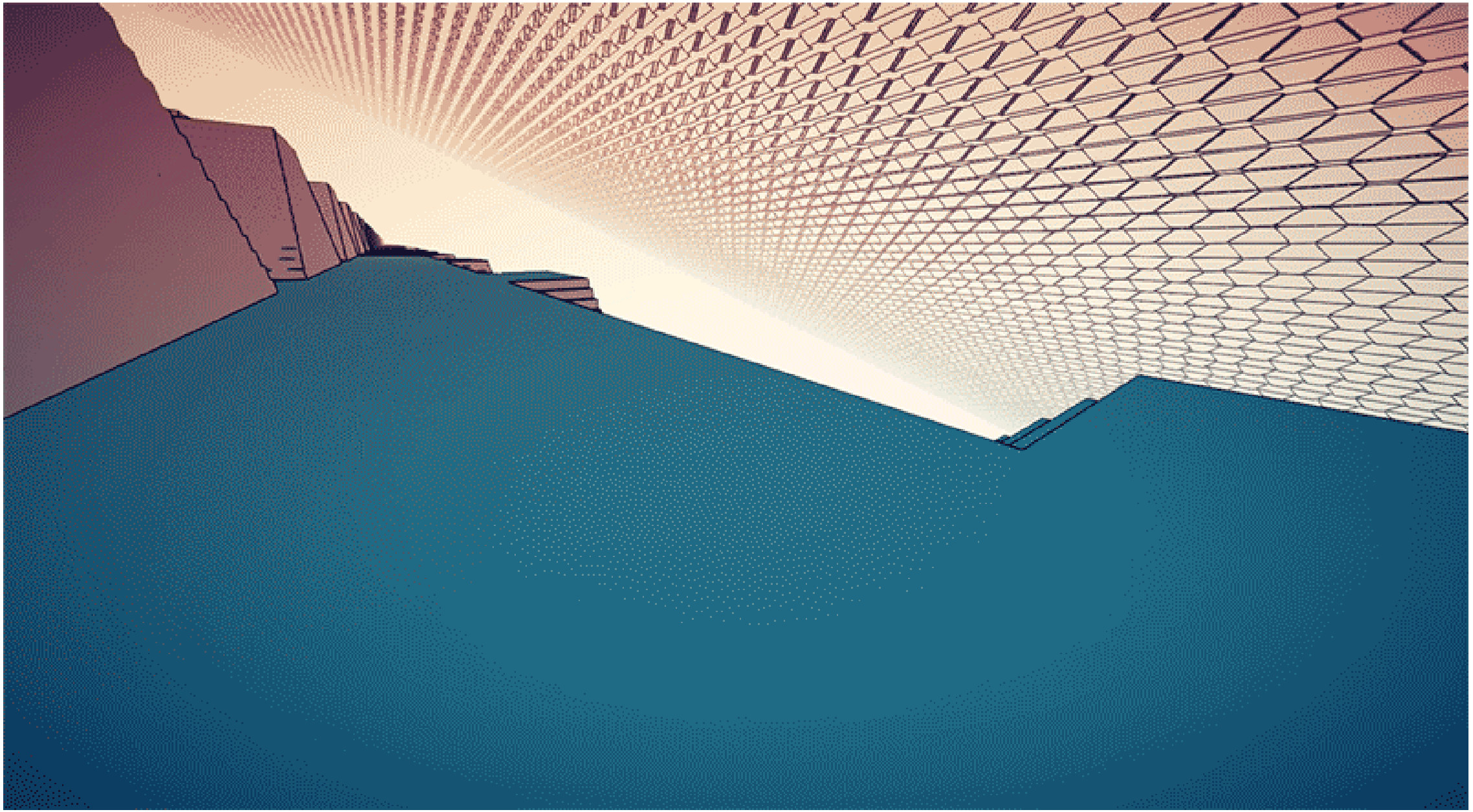


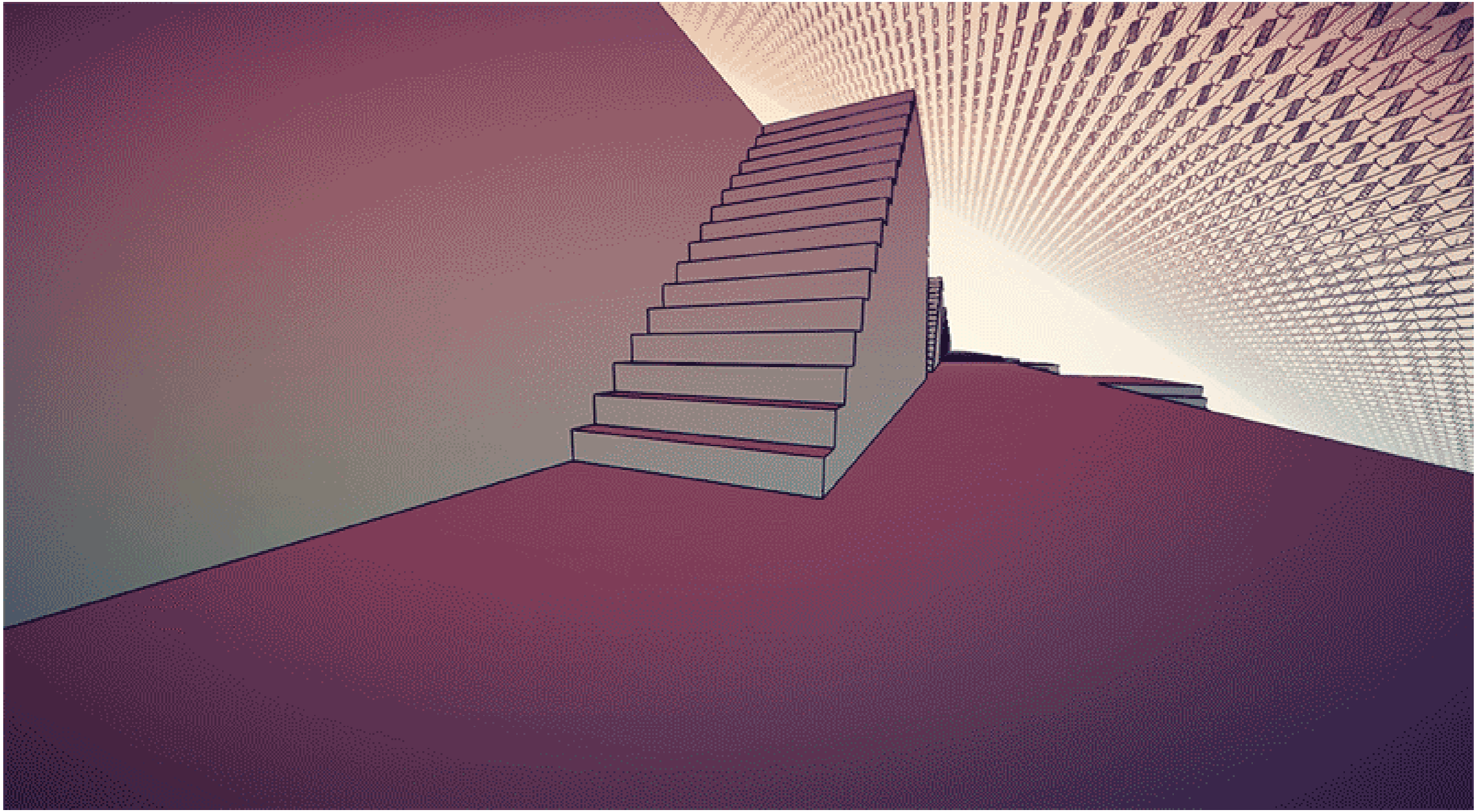








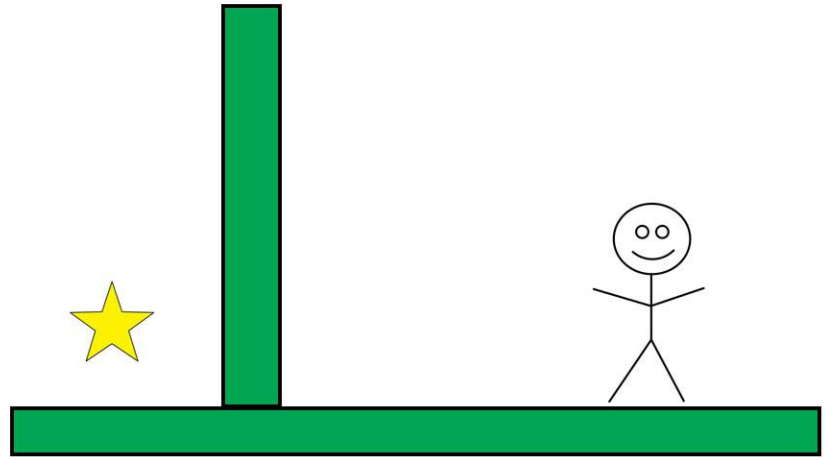


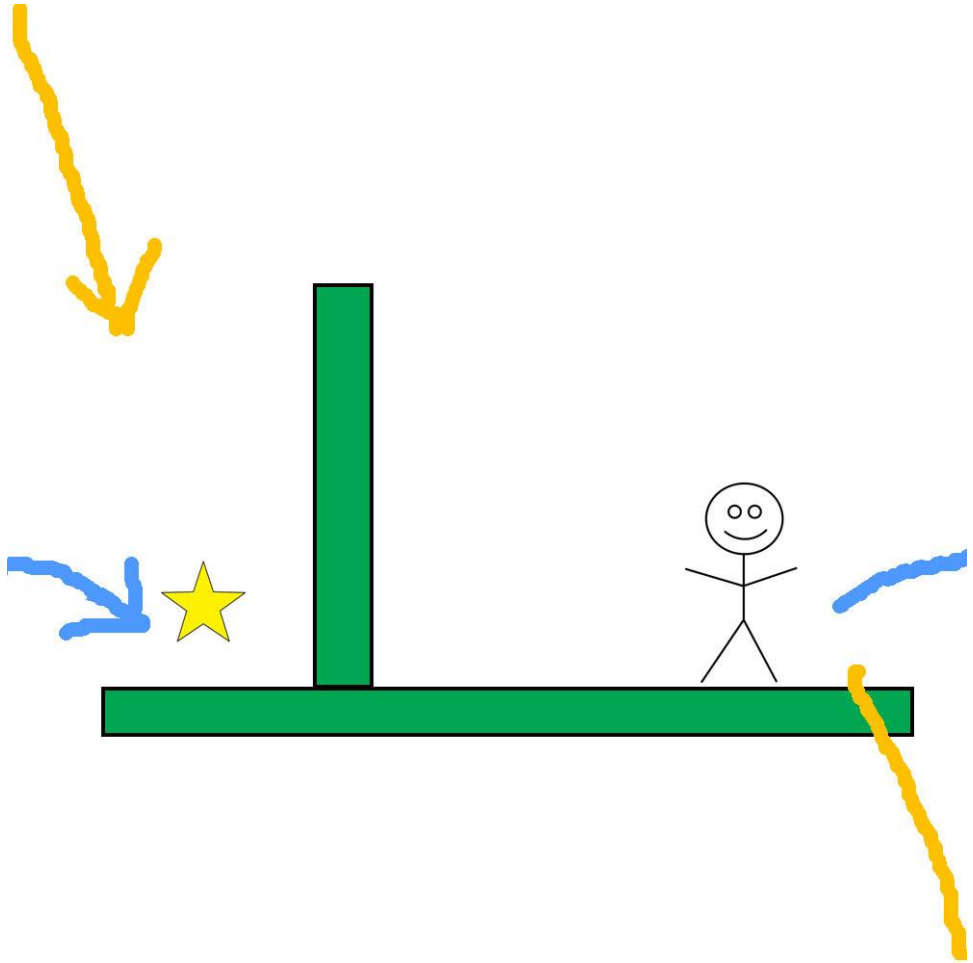


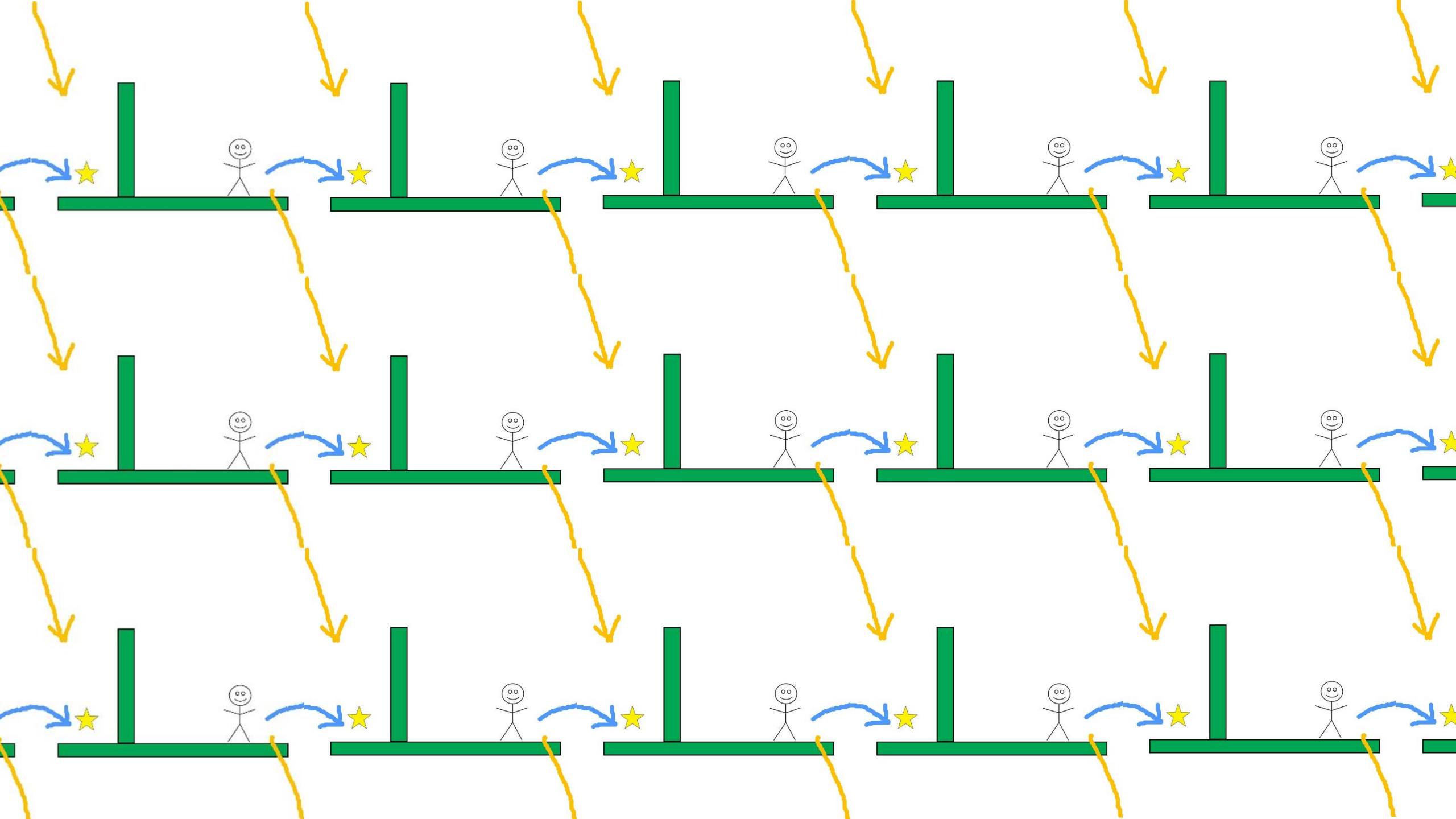
# New Problems

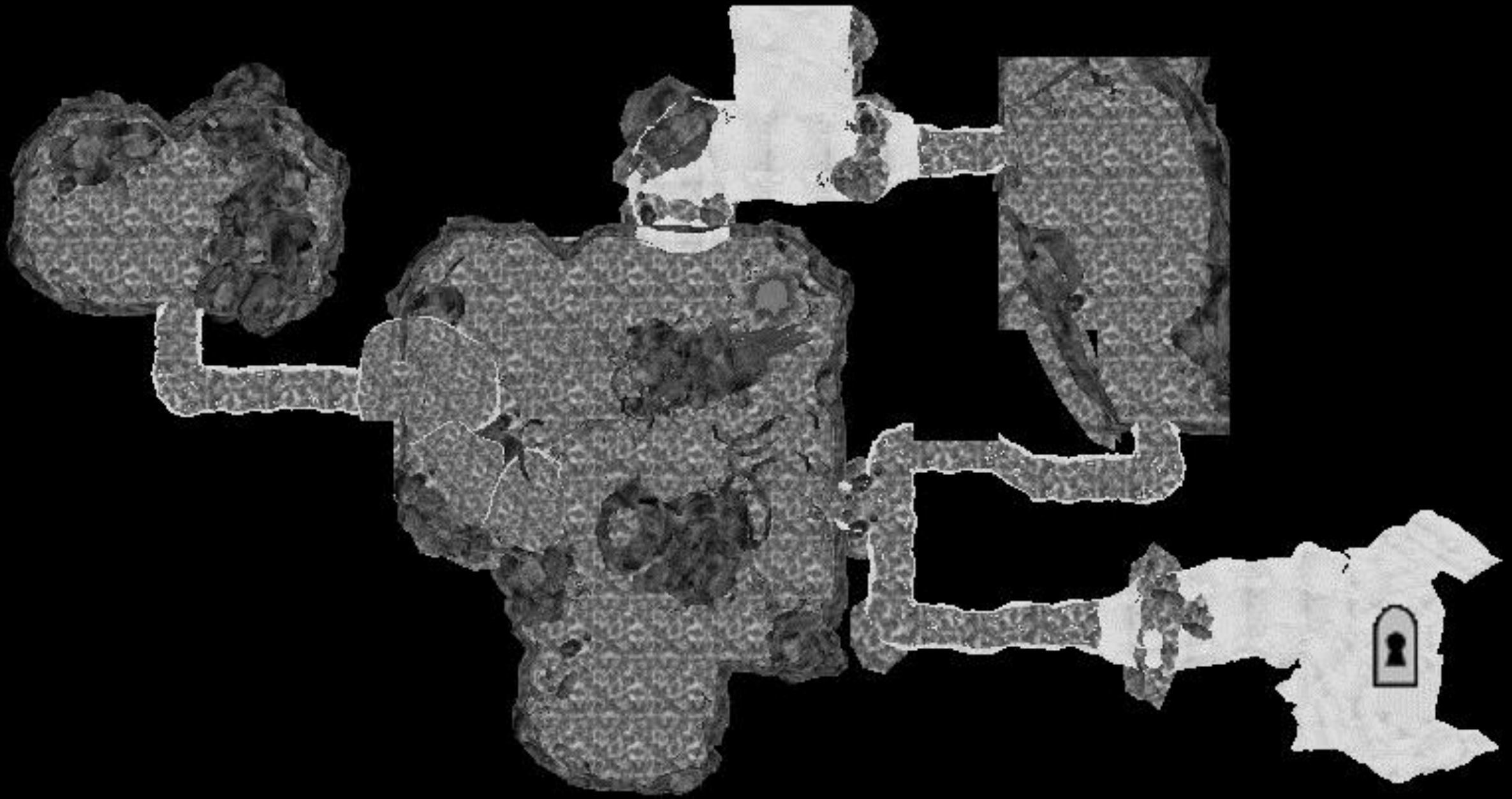
Problem:

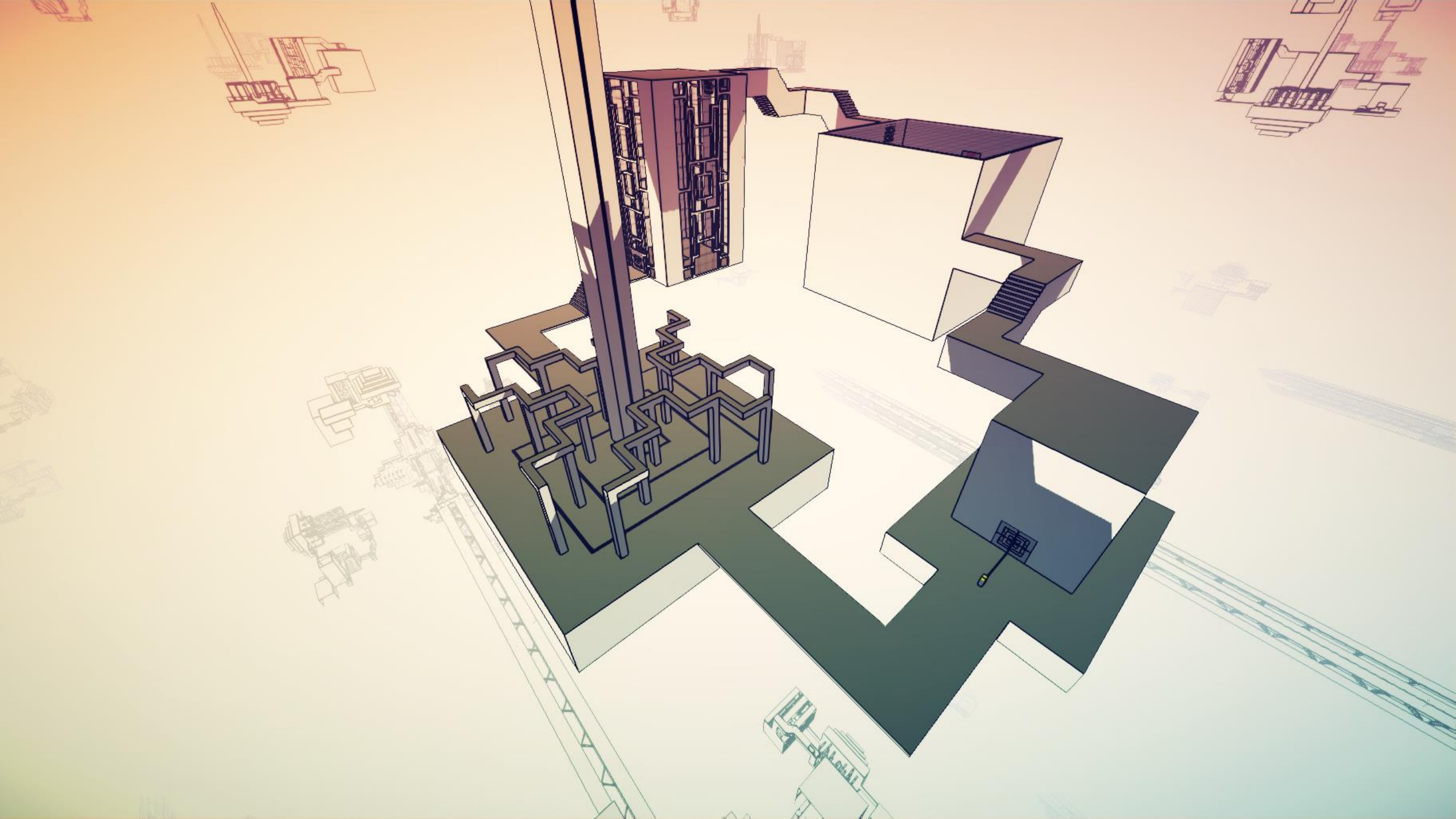
Gating

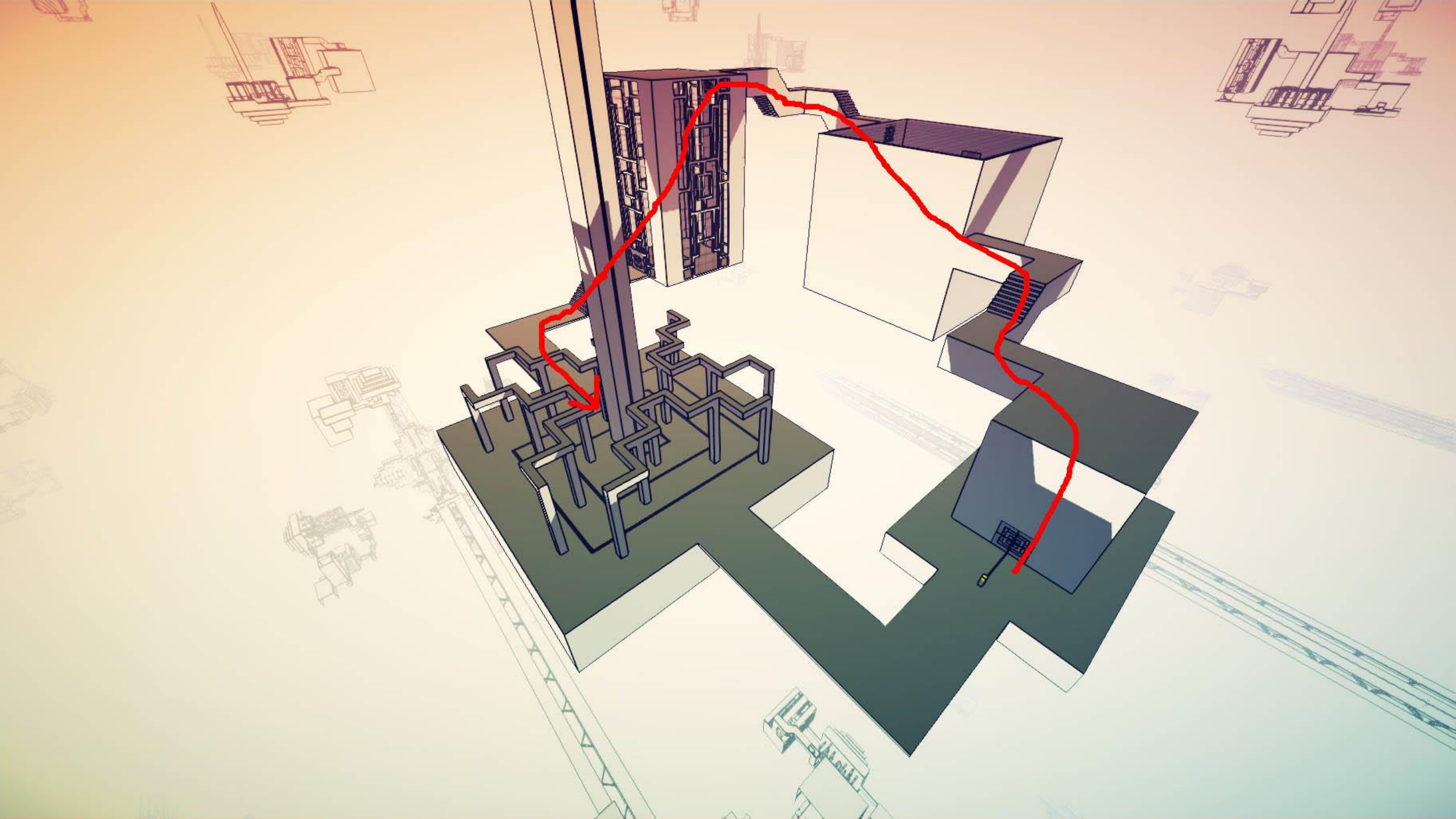








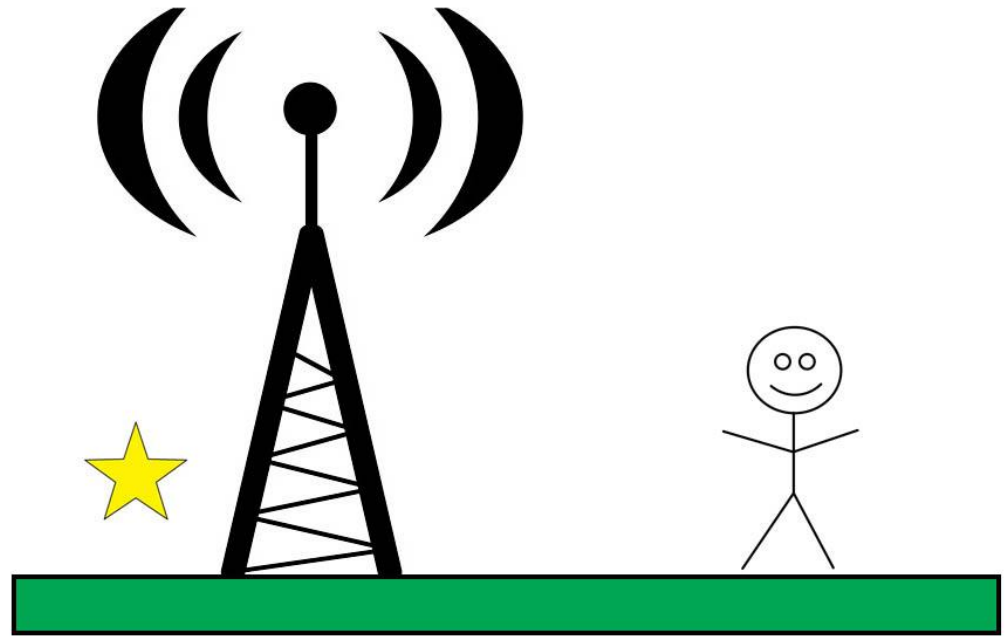


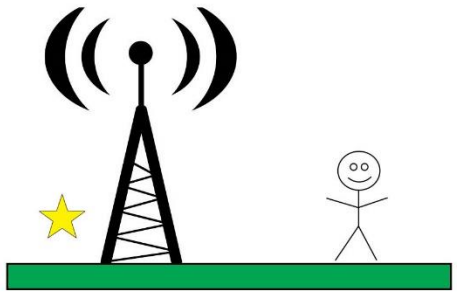
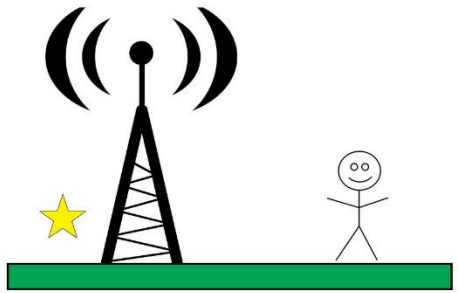
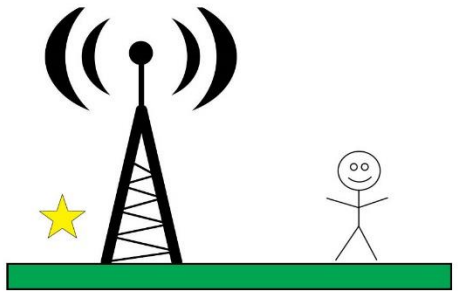
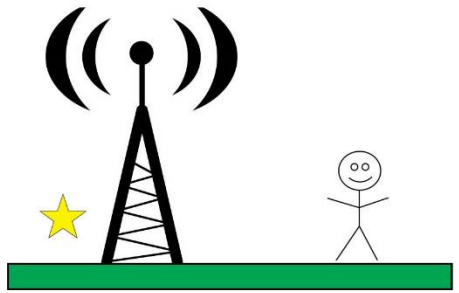
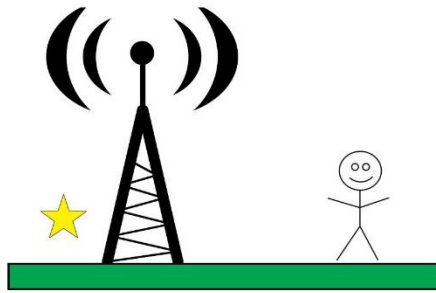
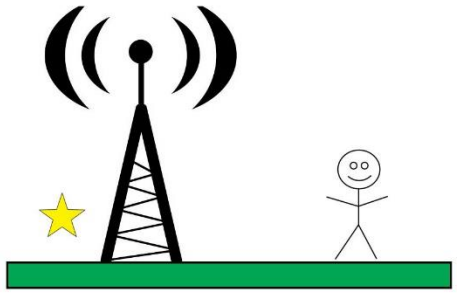
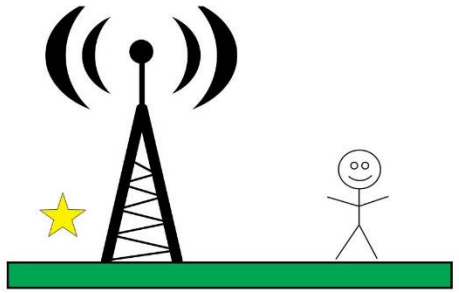
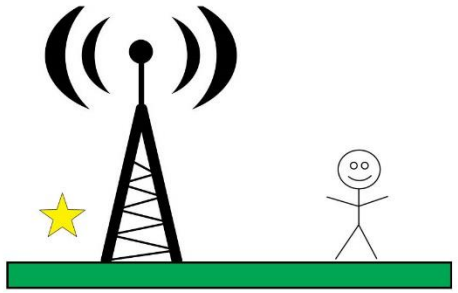
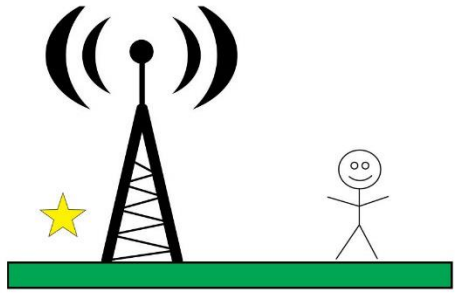
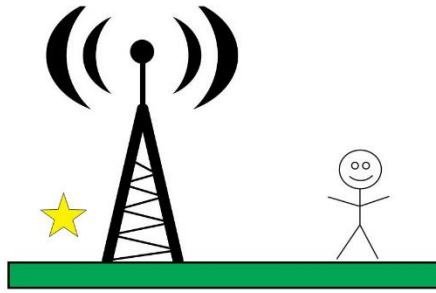
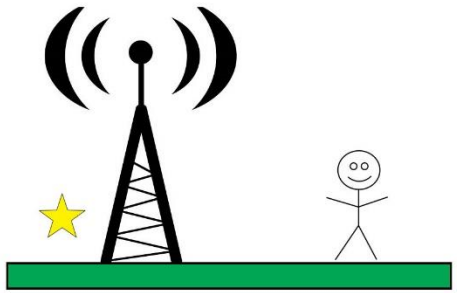
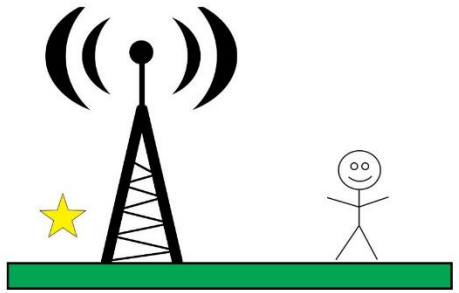
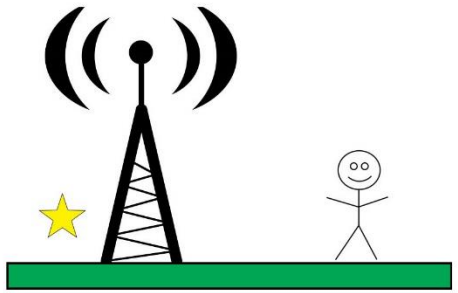
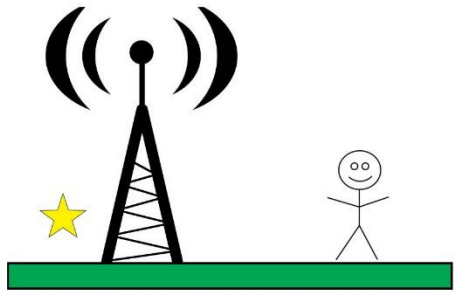
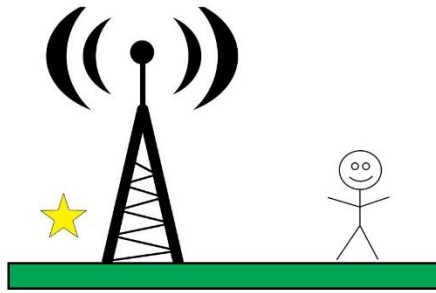


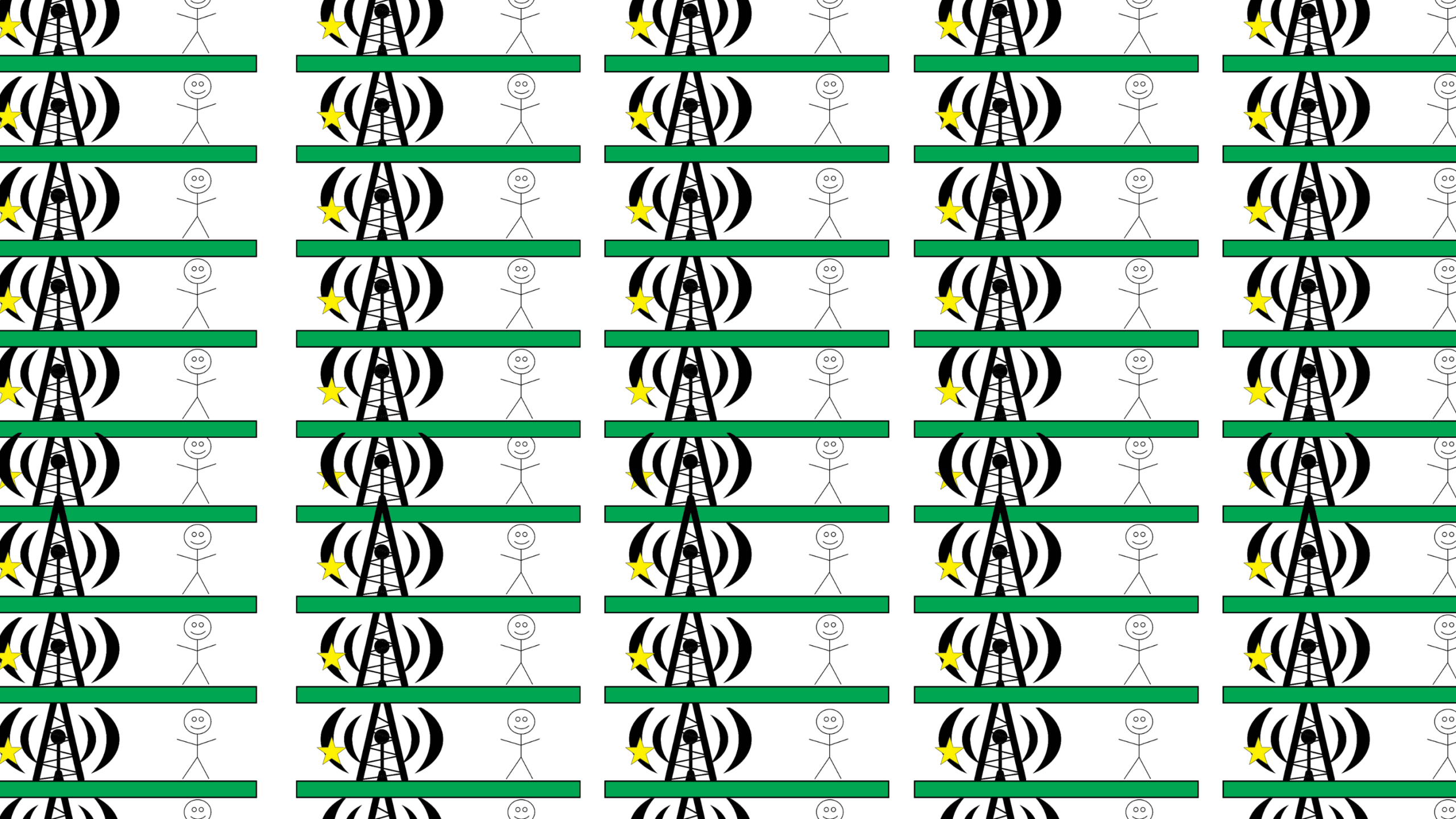
Problem:

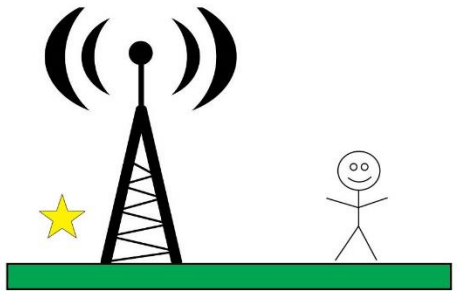
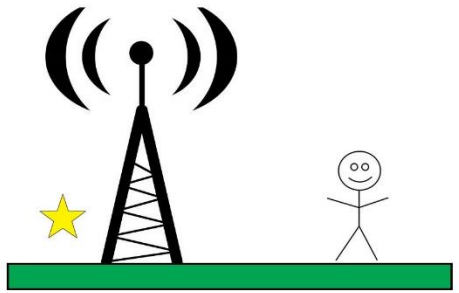
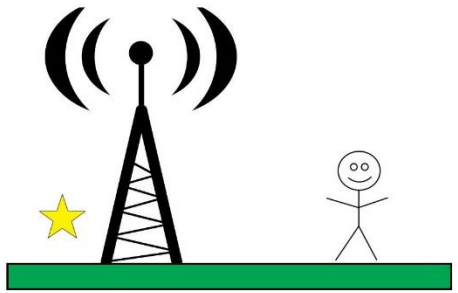
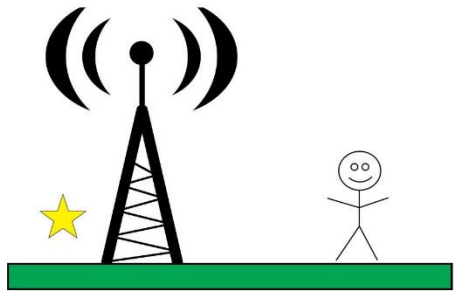
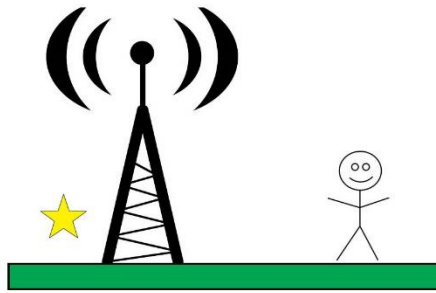
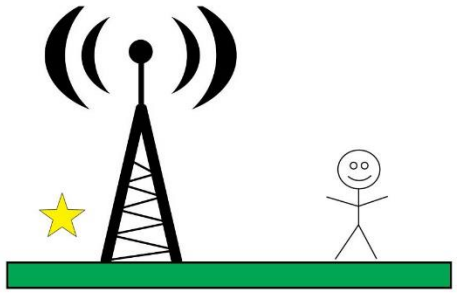
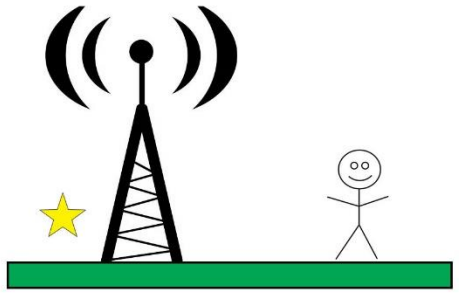
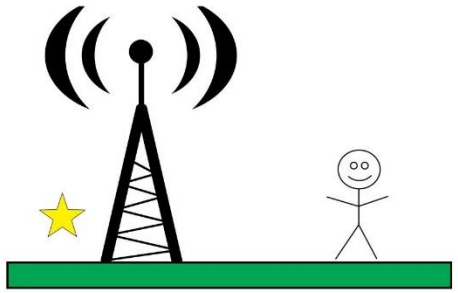
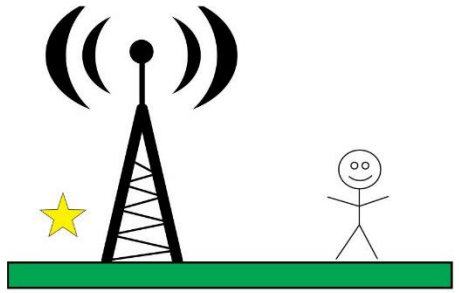
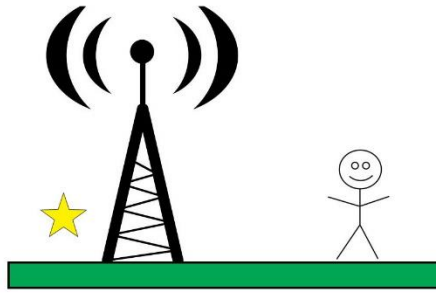
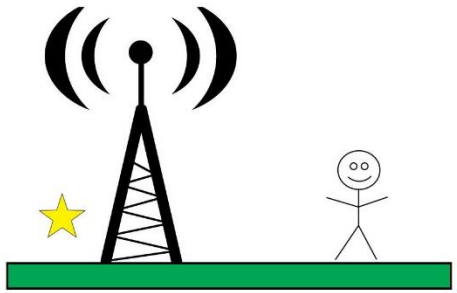
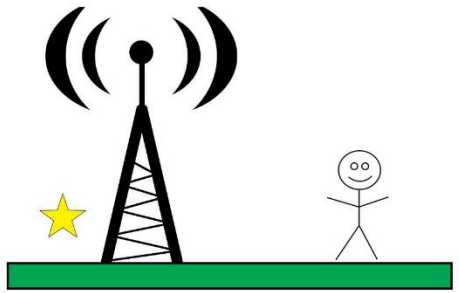
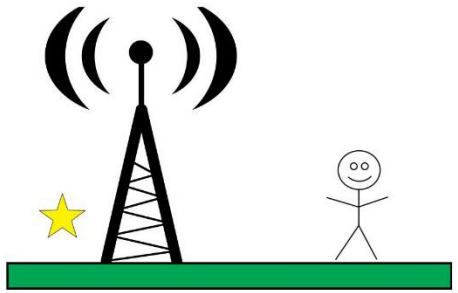
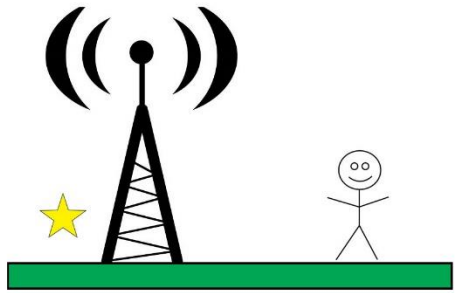
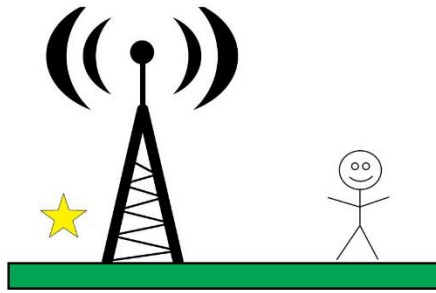
Height and Directions are meaningless

WC
TTK BANK
A





North

East

South

West

Up

Down

Left

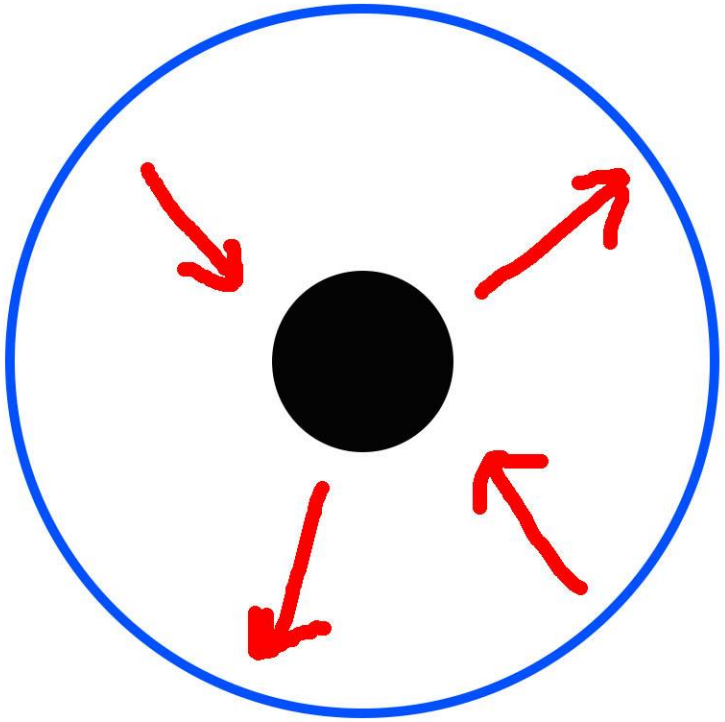
Right

Directions

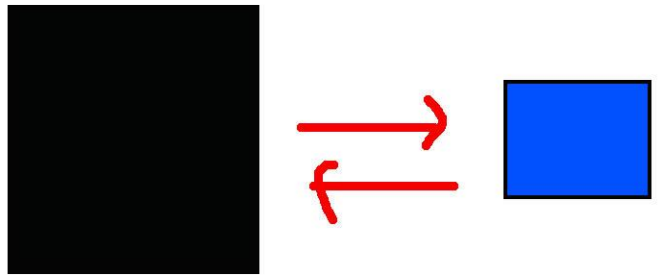
Height

# Embrace the problems

Design with the geometry instead of against it



Better
than



Radial

Directional (?)

# Techniques

# Techniques that have worked well

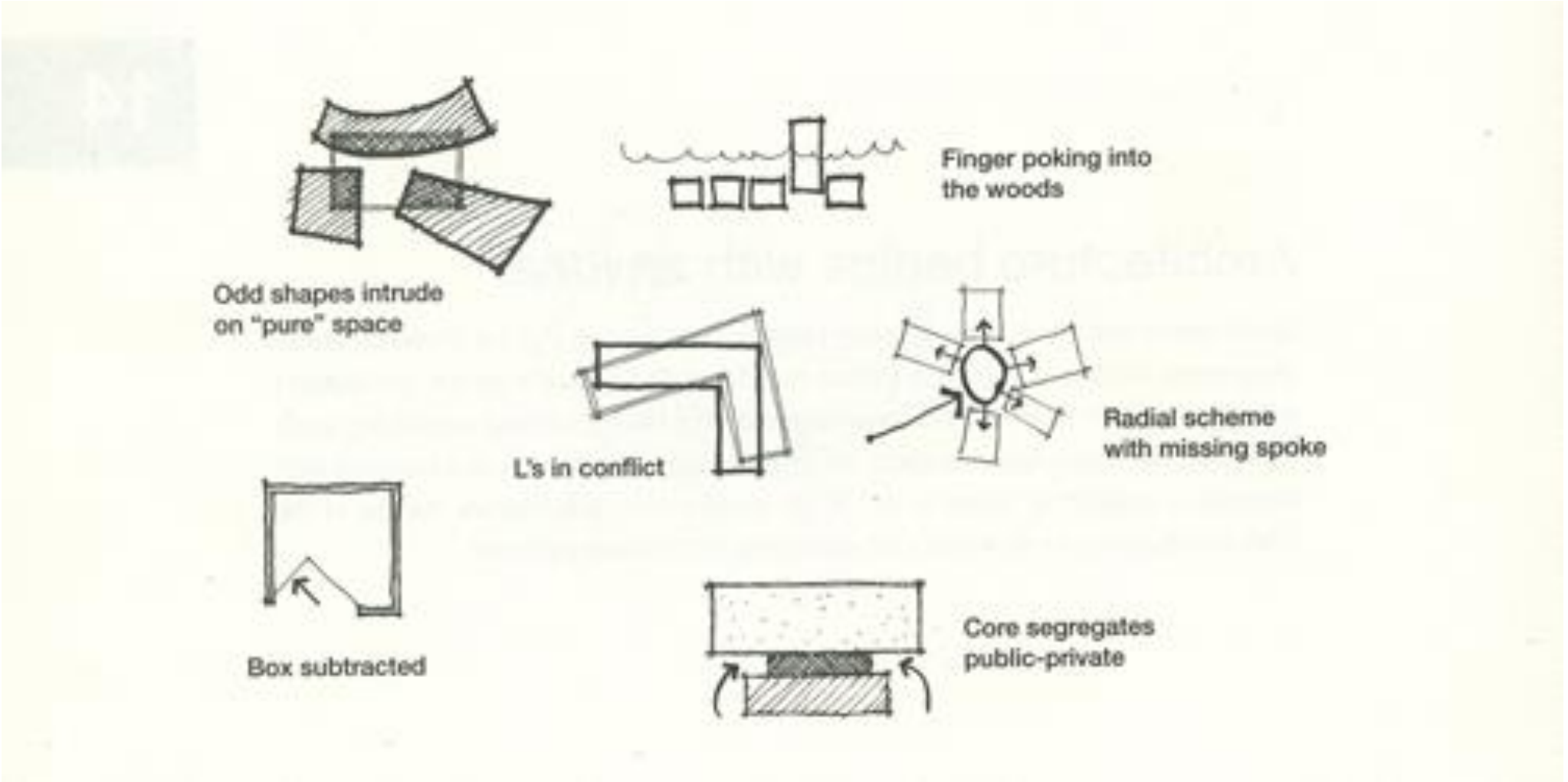
1. **Macro**

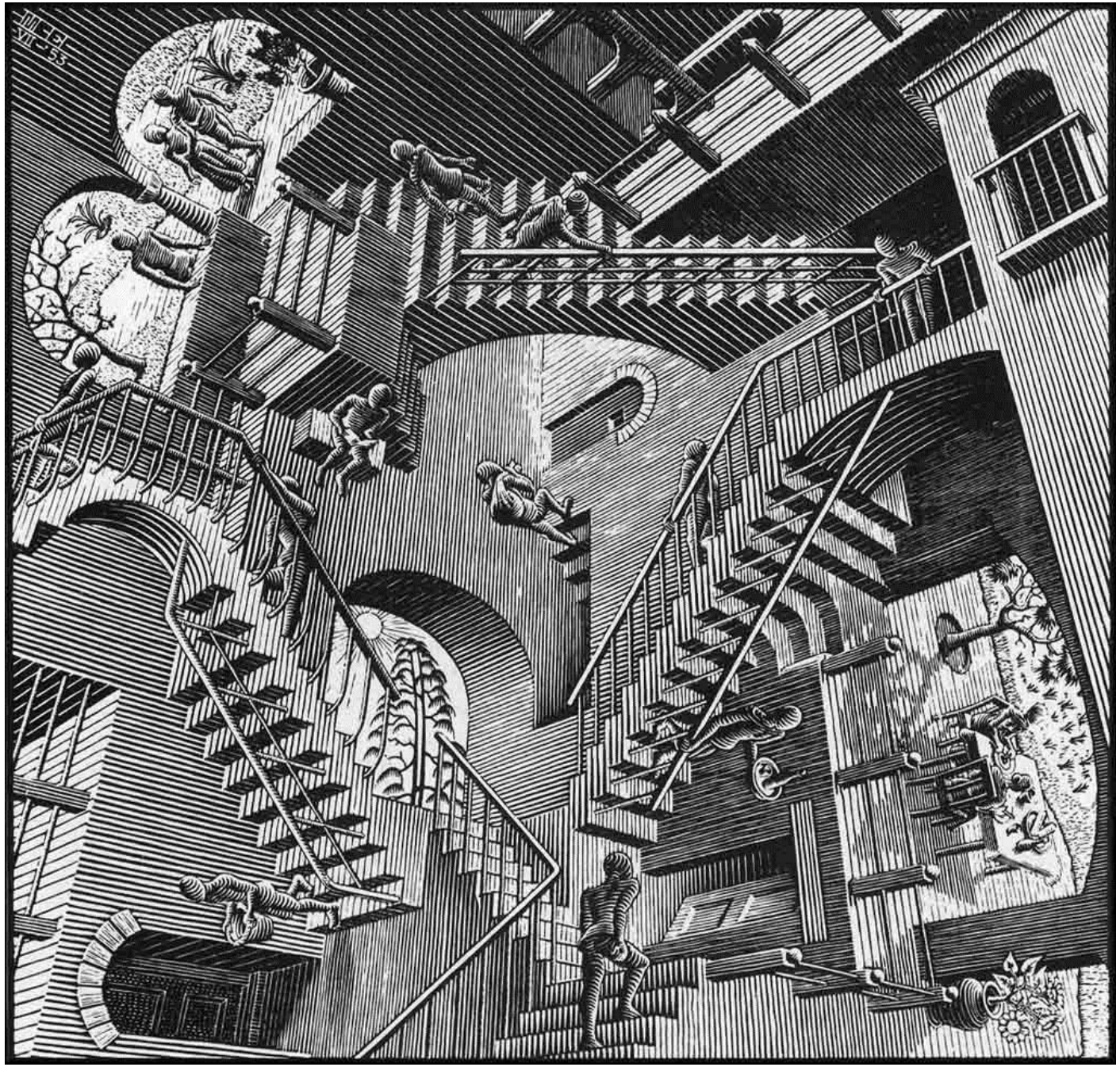
   - Iconic parti (overall layout)
   - Logic to level

2. **Micro**

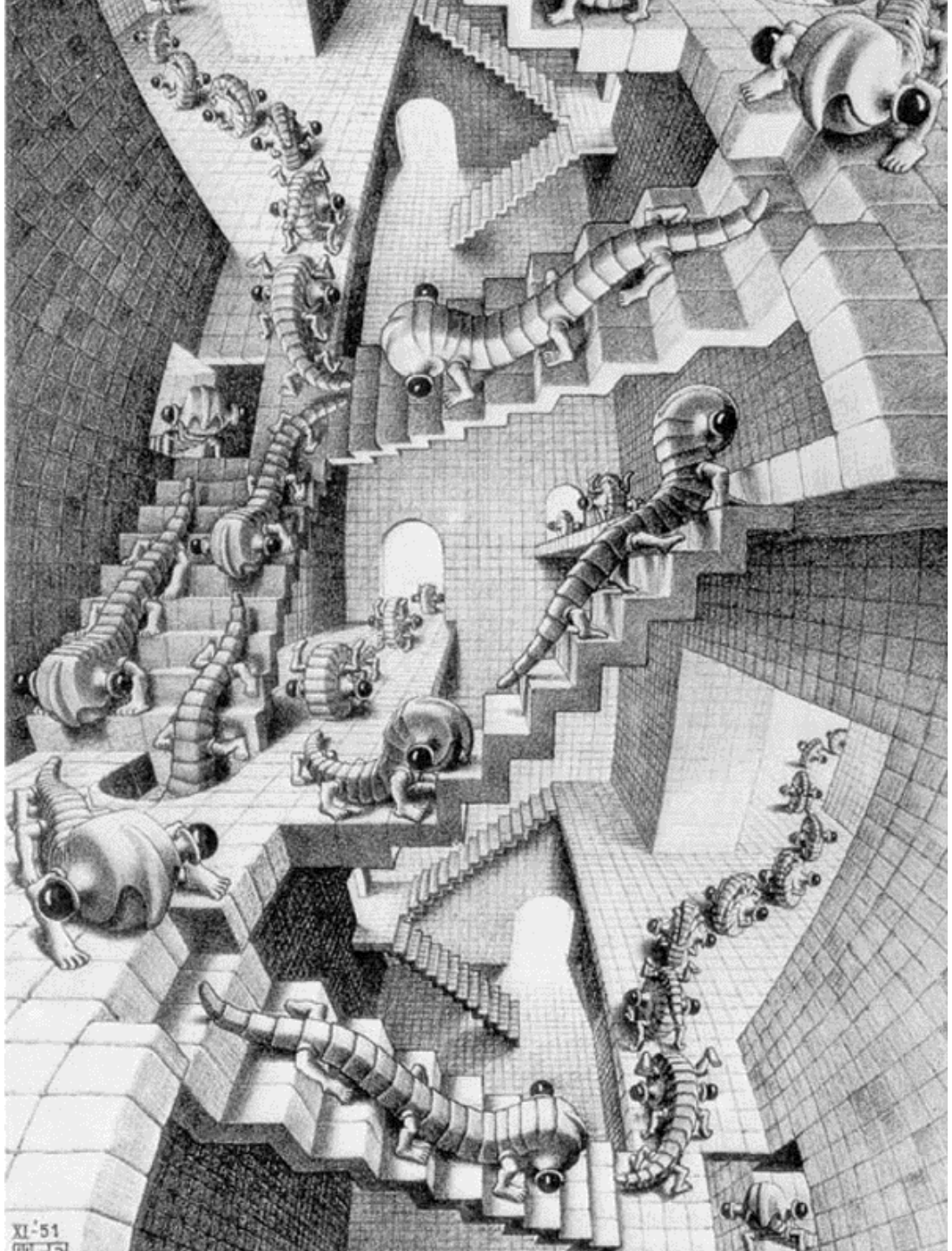
   - Intentional architecture
   - Patterns in architectural elements

# Macro Technique – Iconic Parti



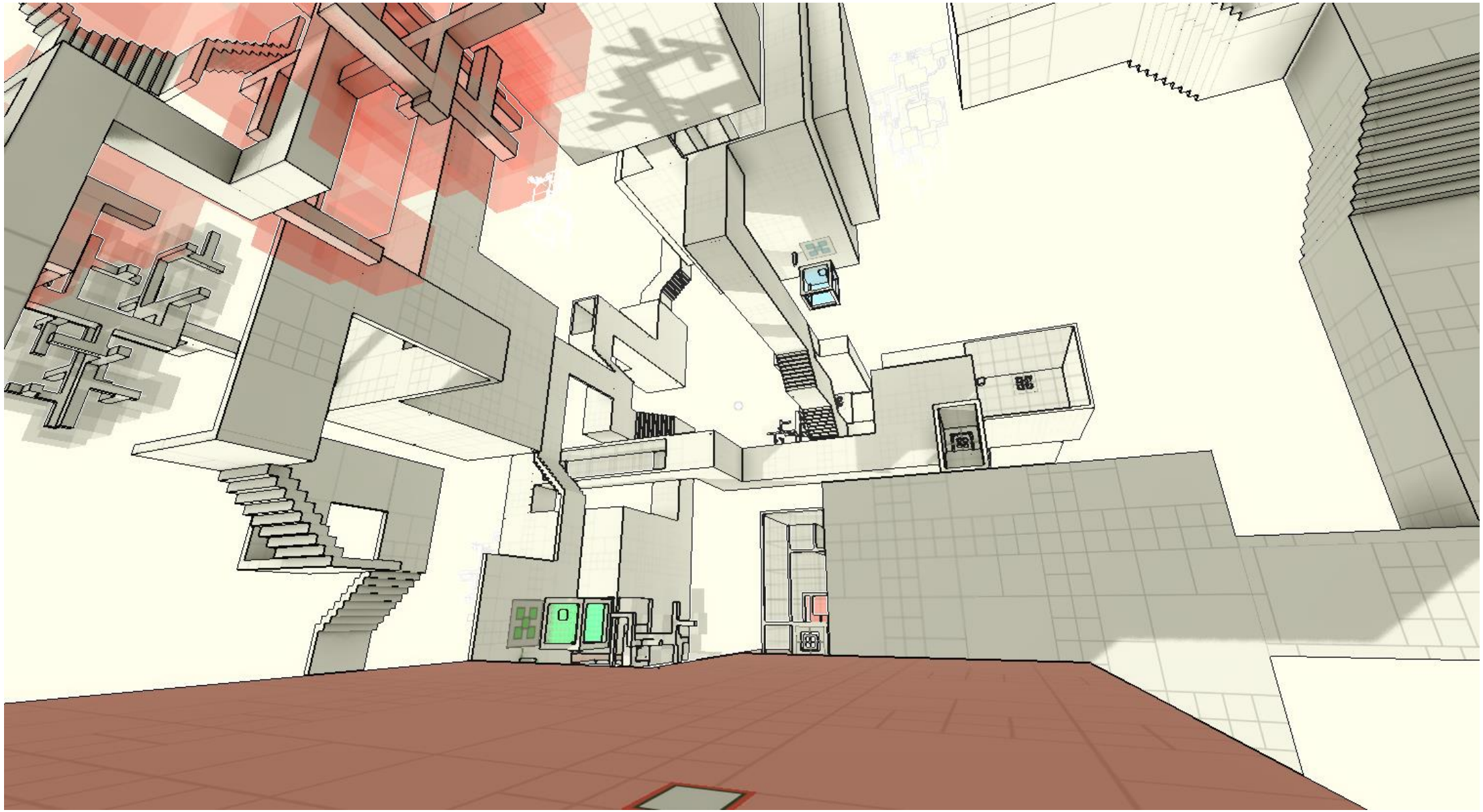


‘Relativity’ by M.C. Escher




‘House of Stairs’ by M.C. Escher

April 2014



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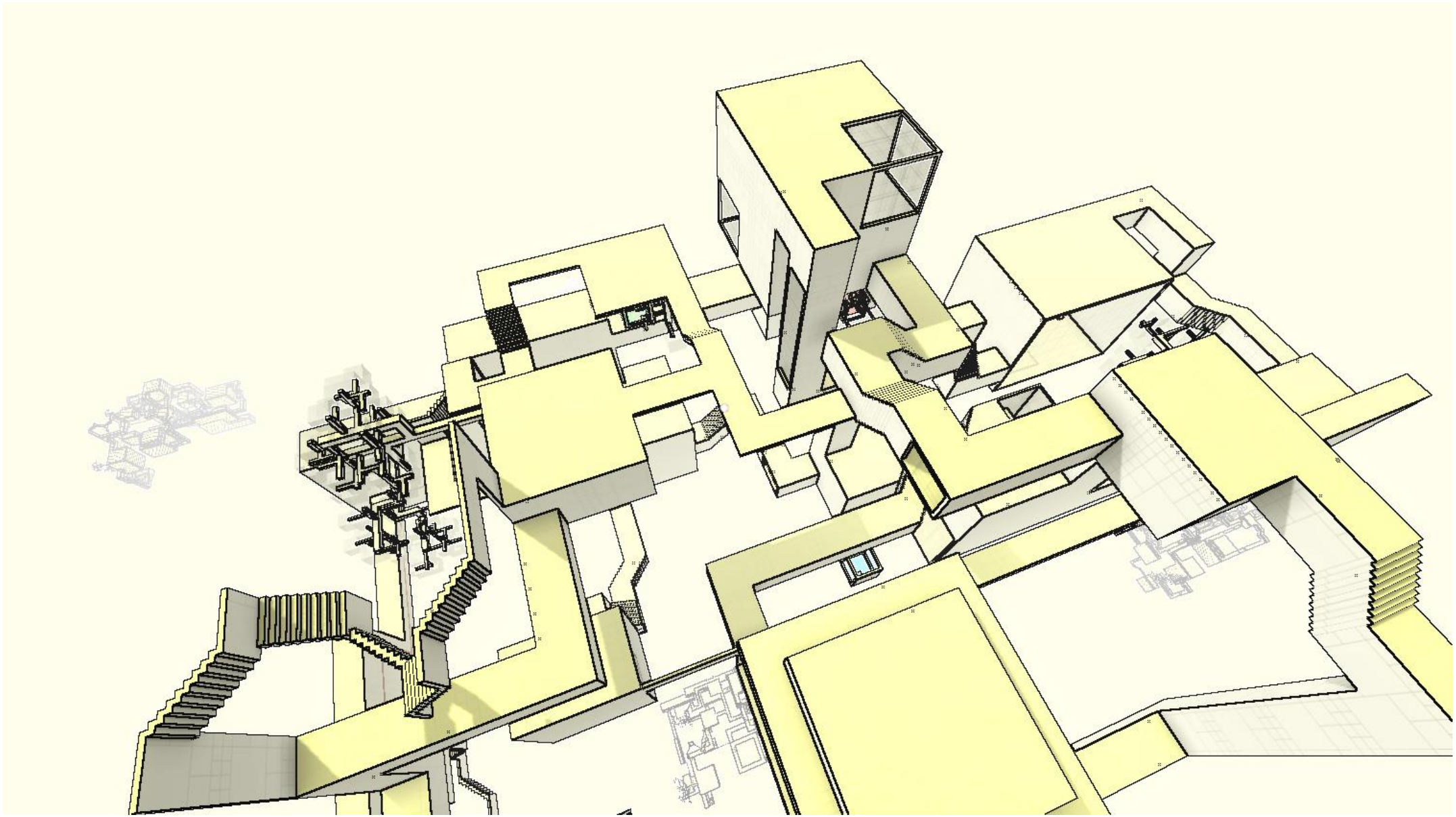

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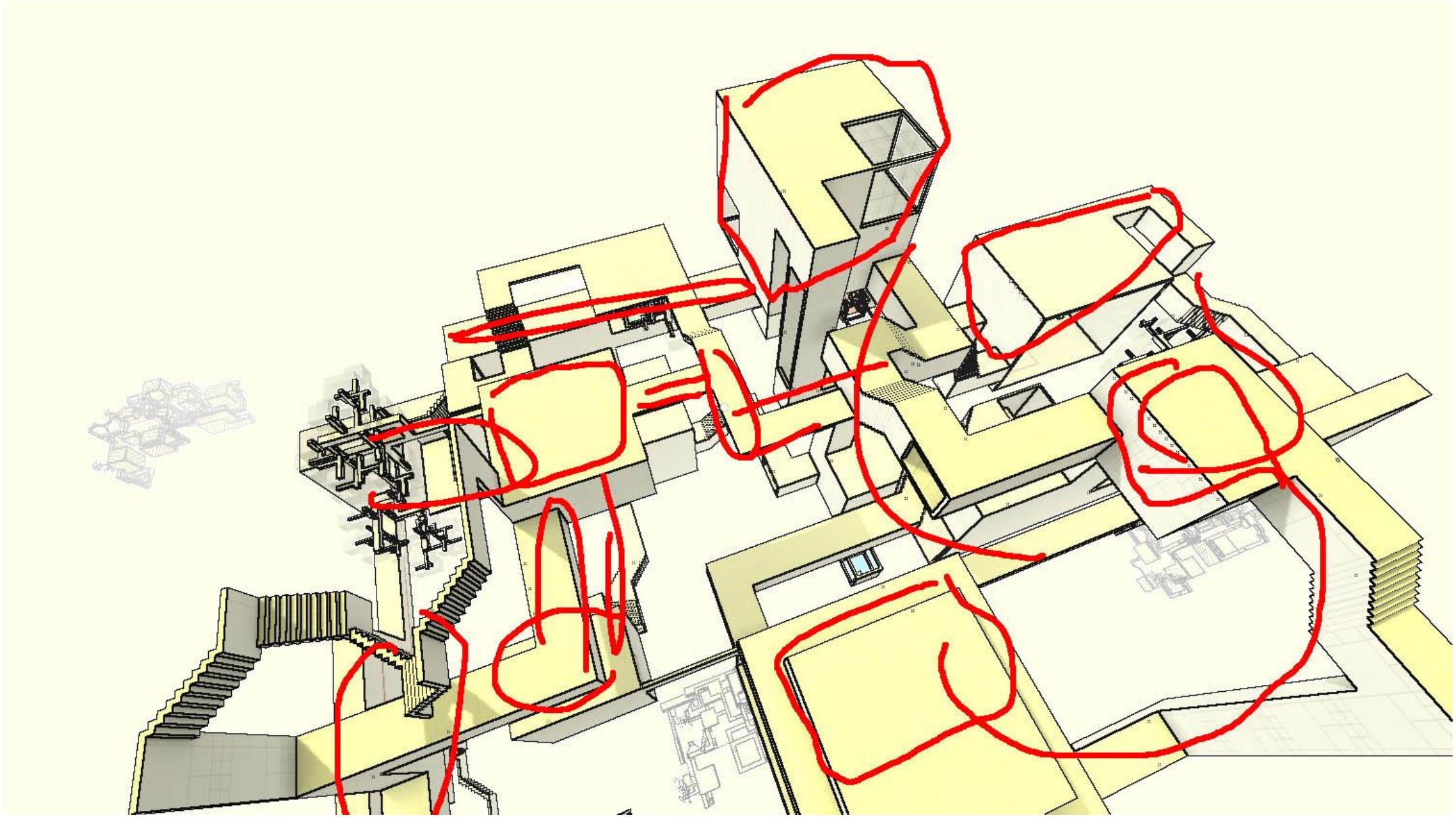

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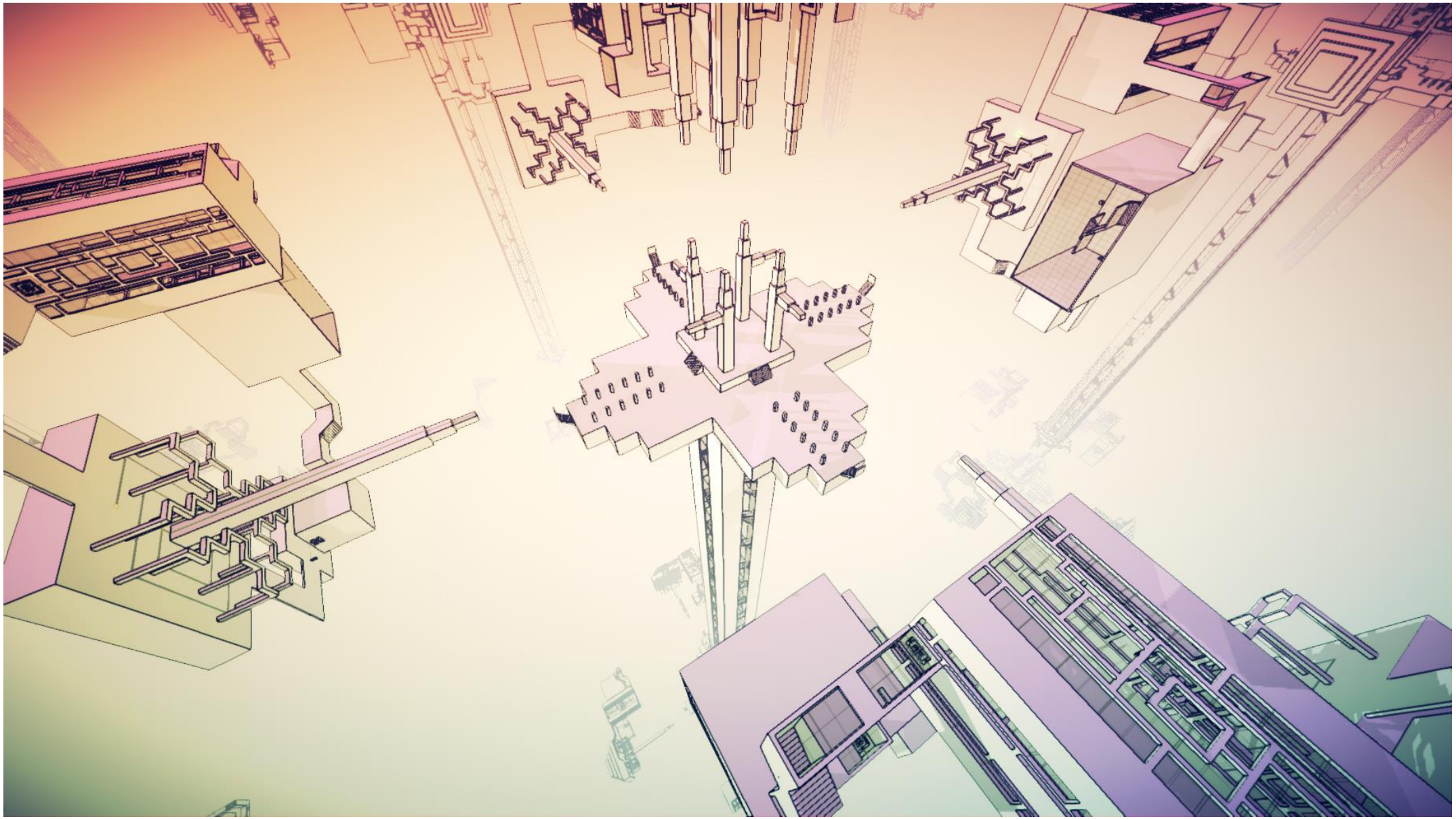

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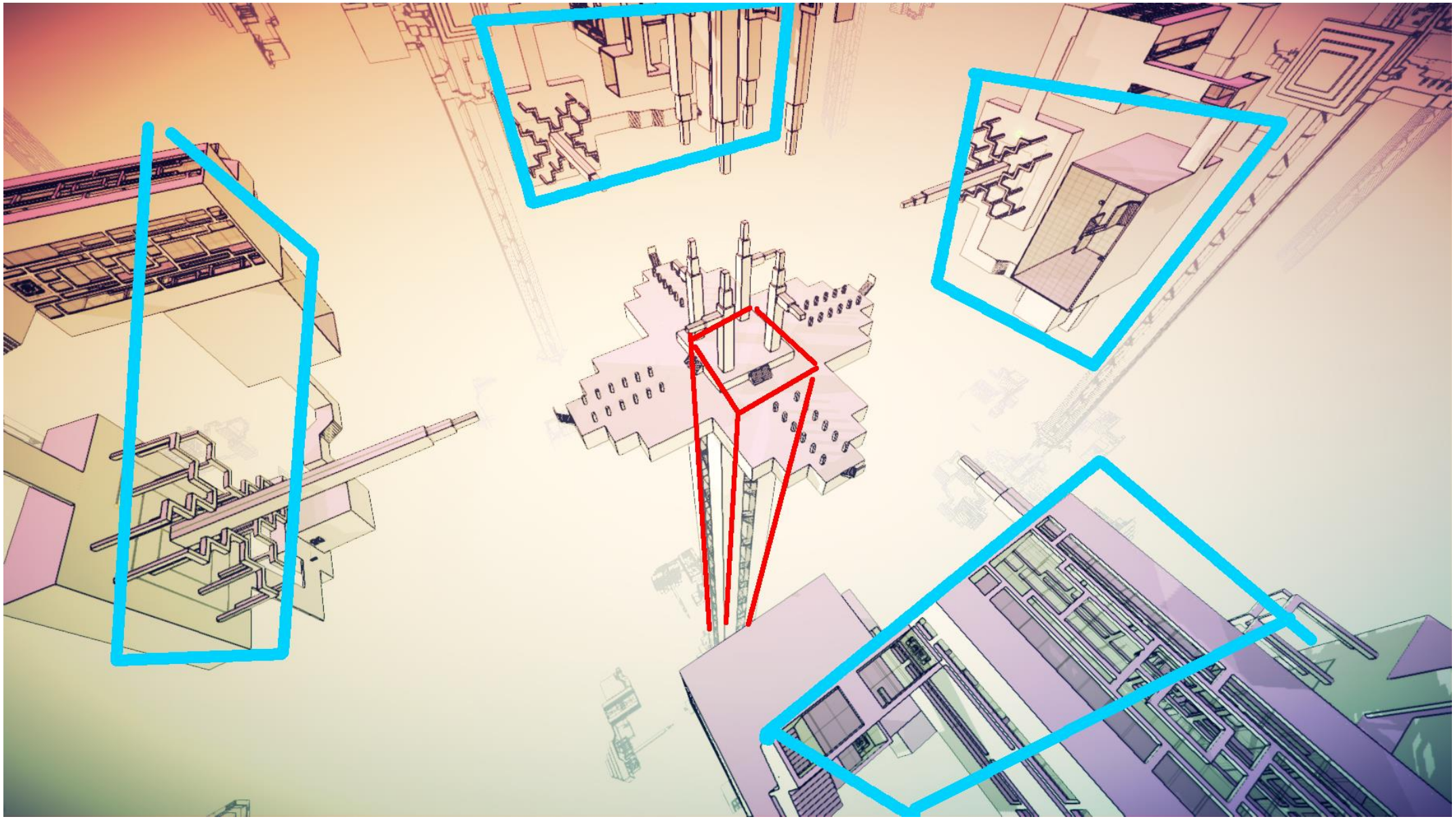

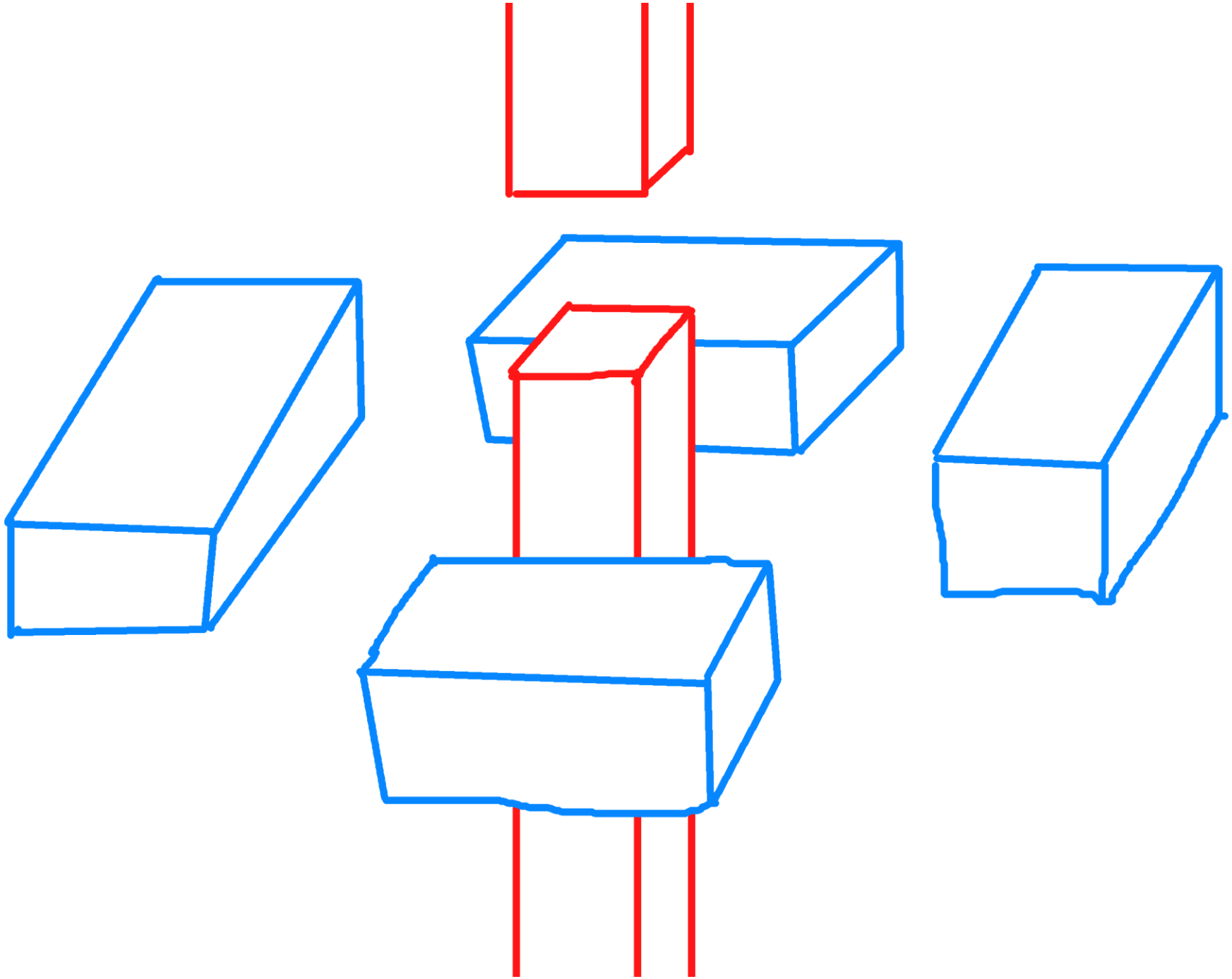

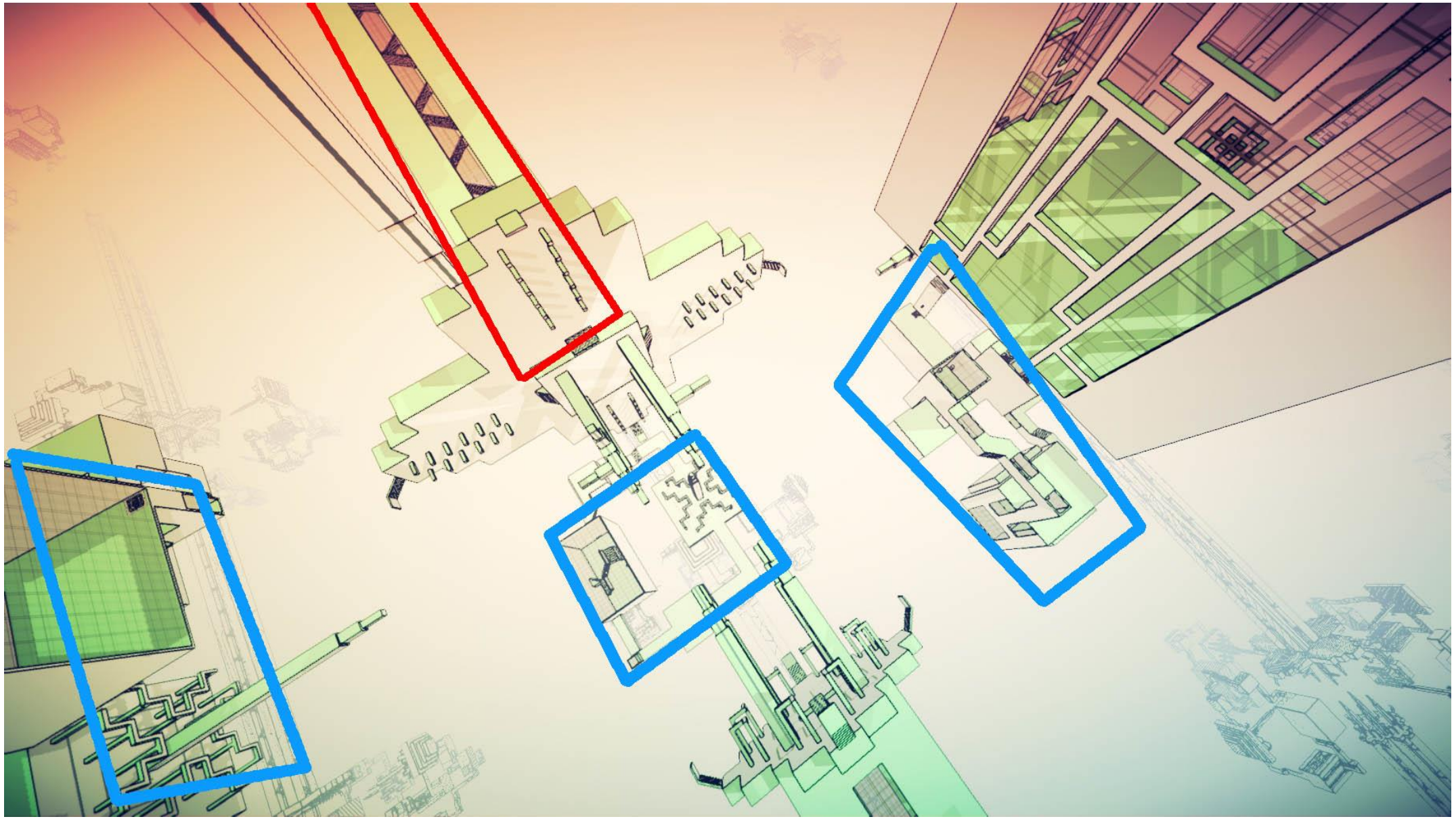

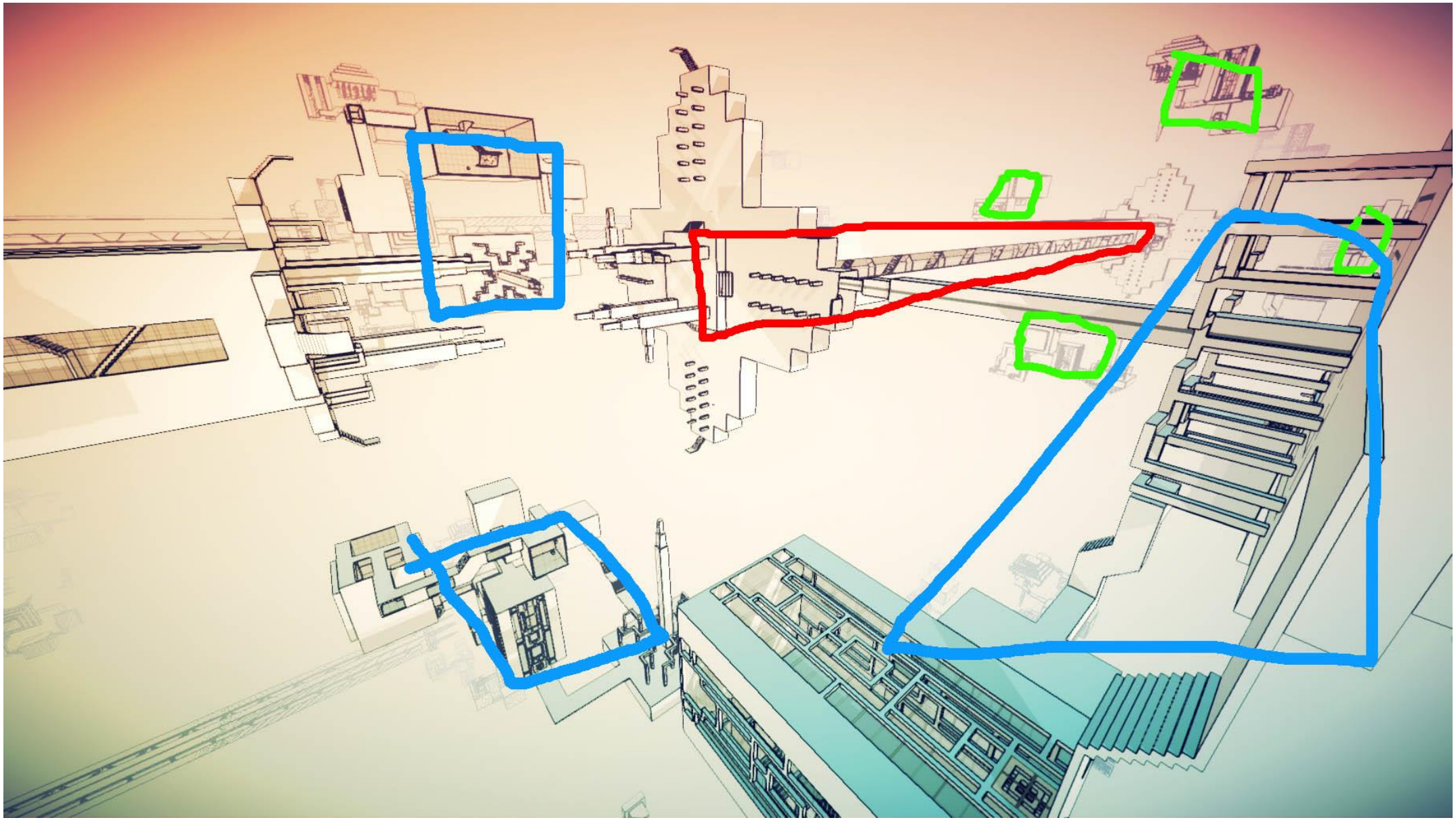

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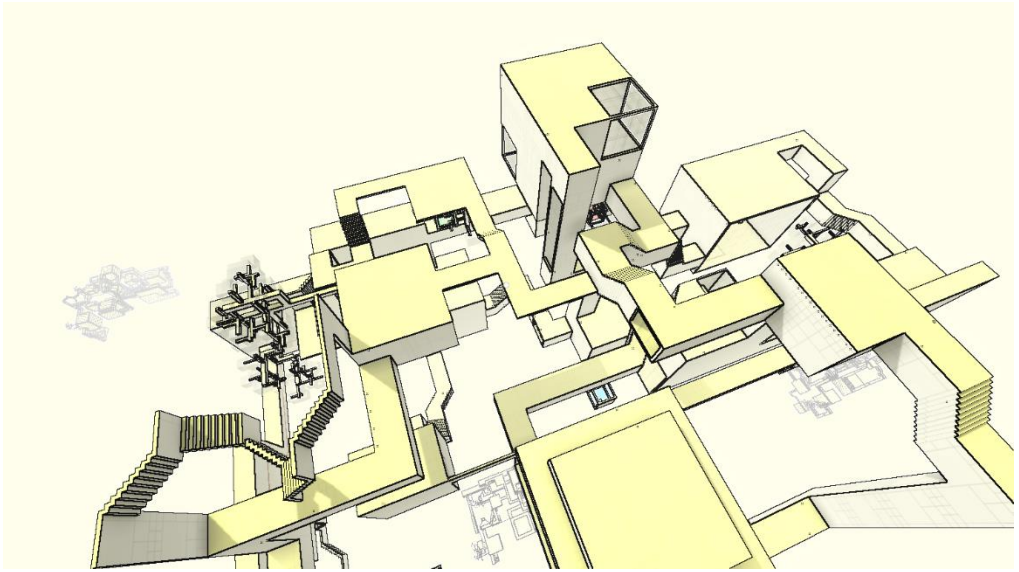

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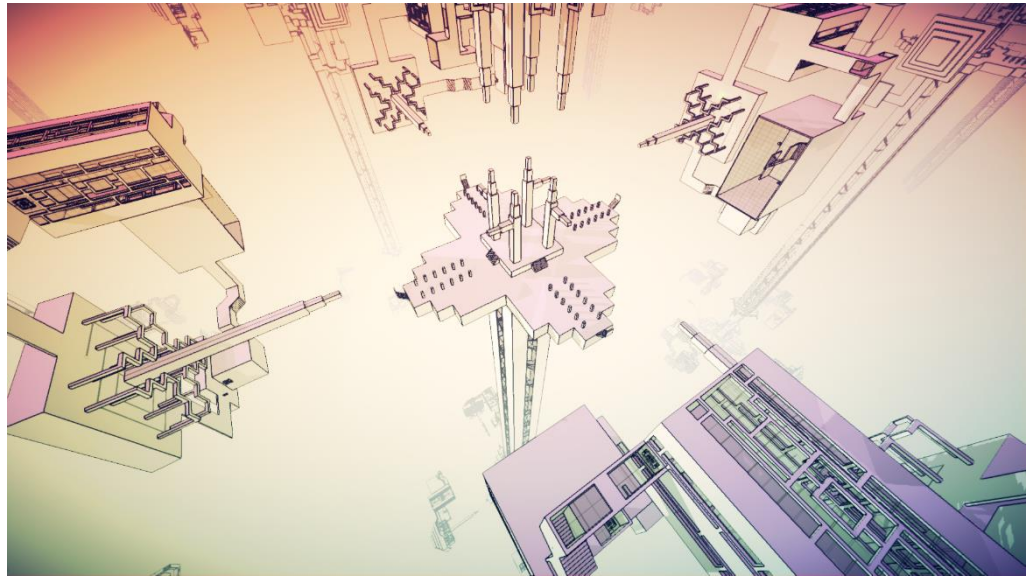
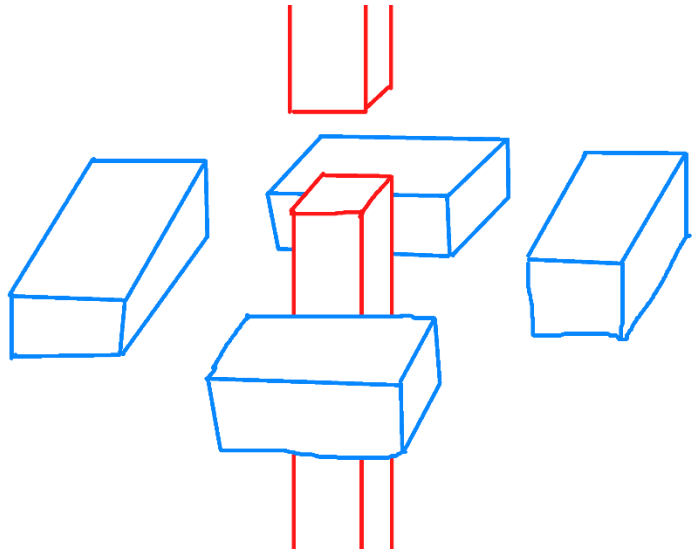
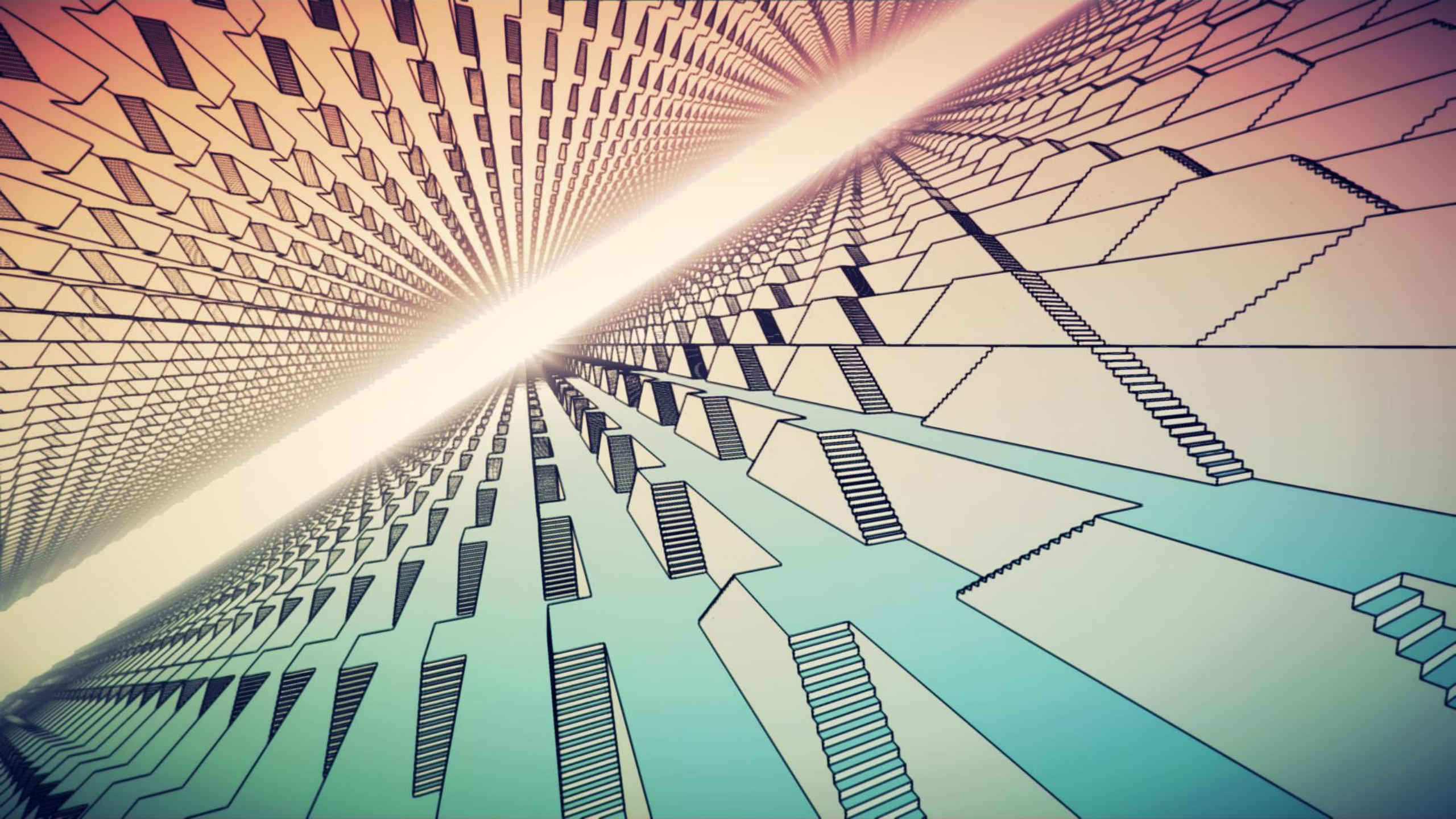
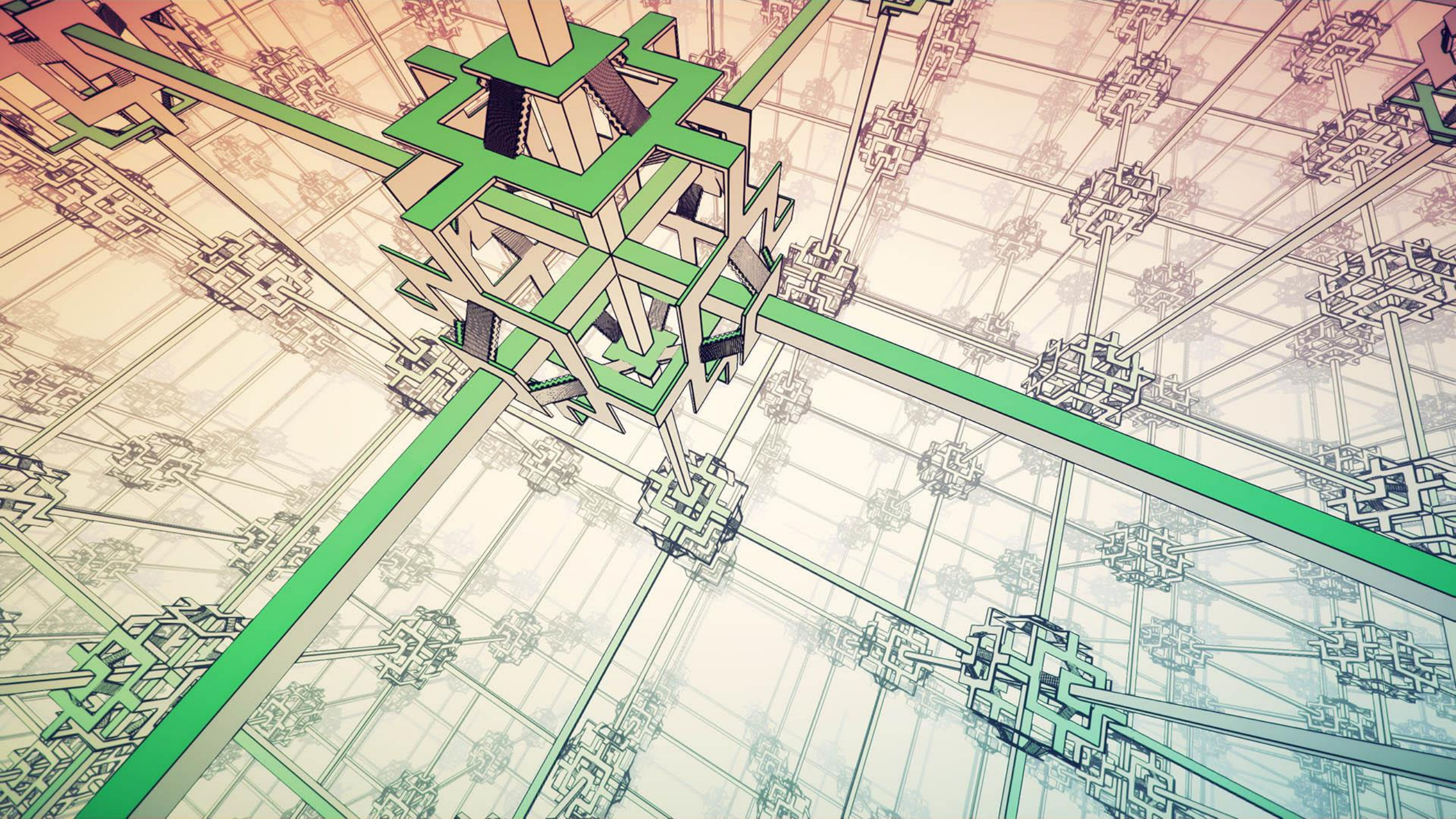
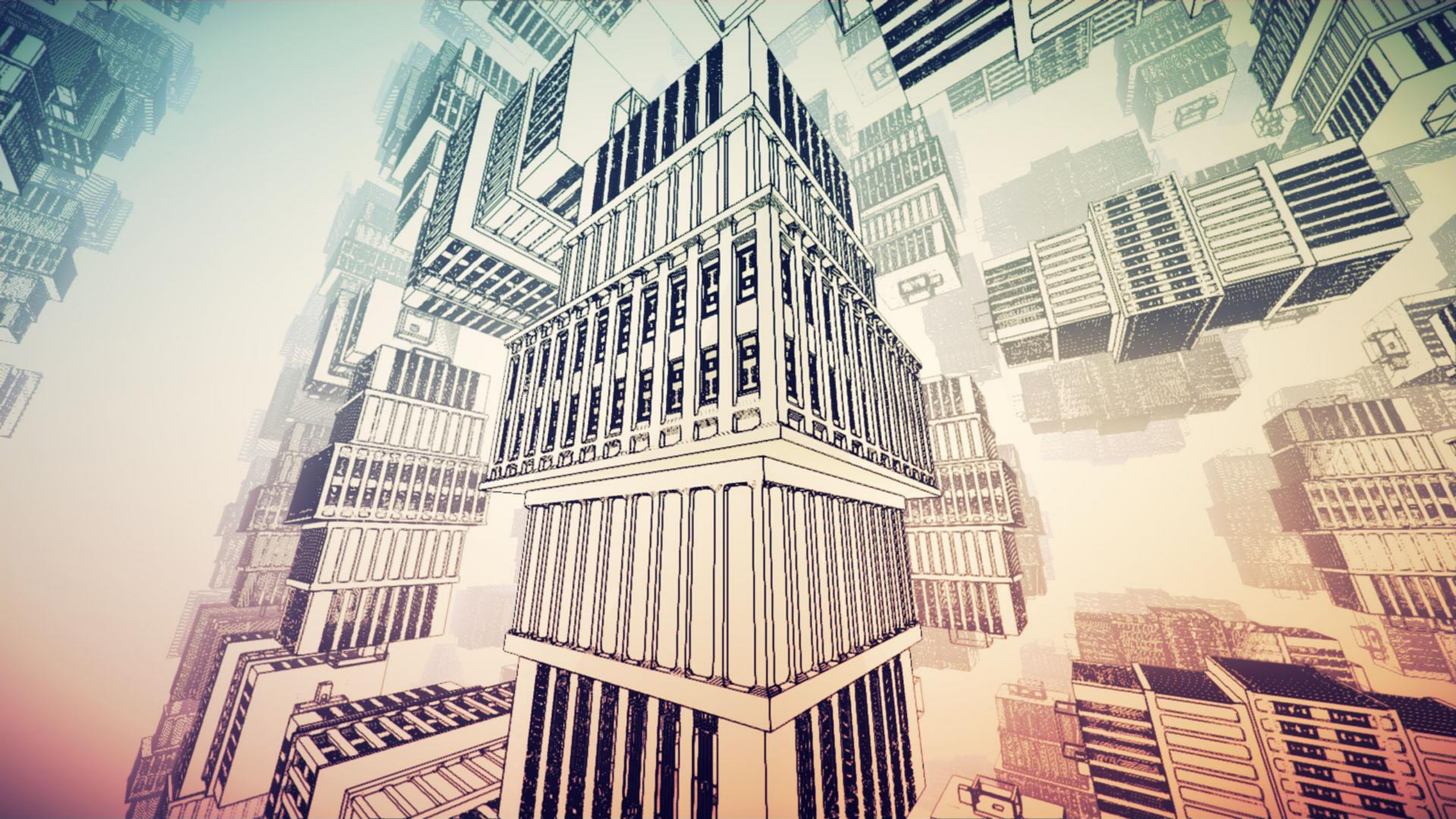


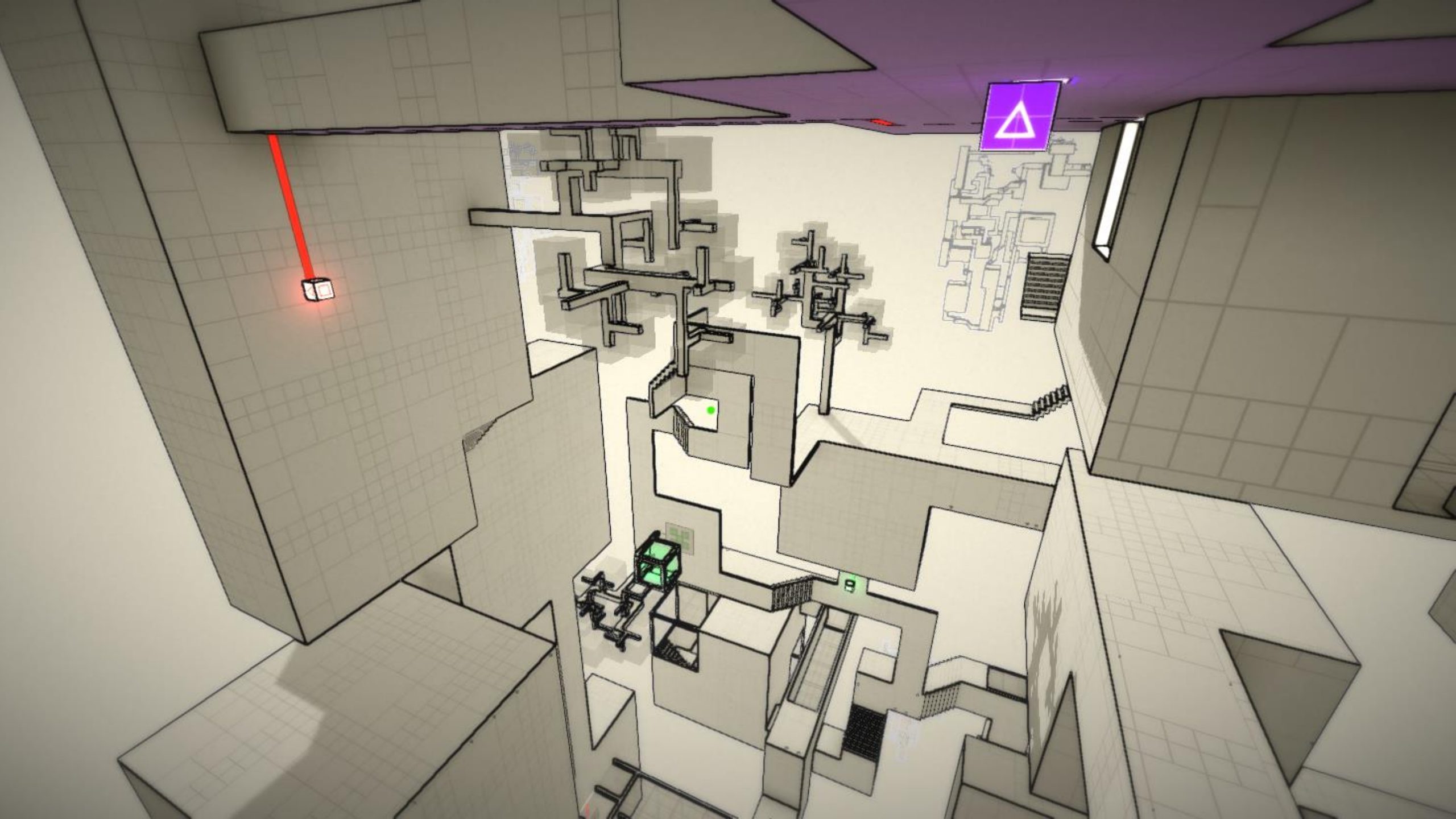


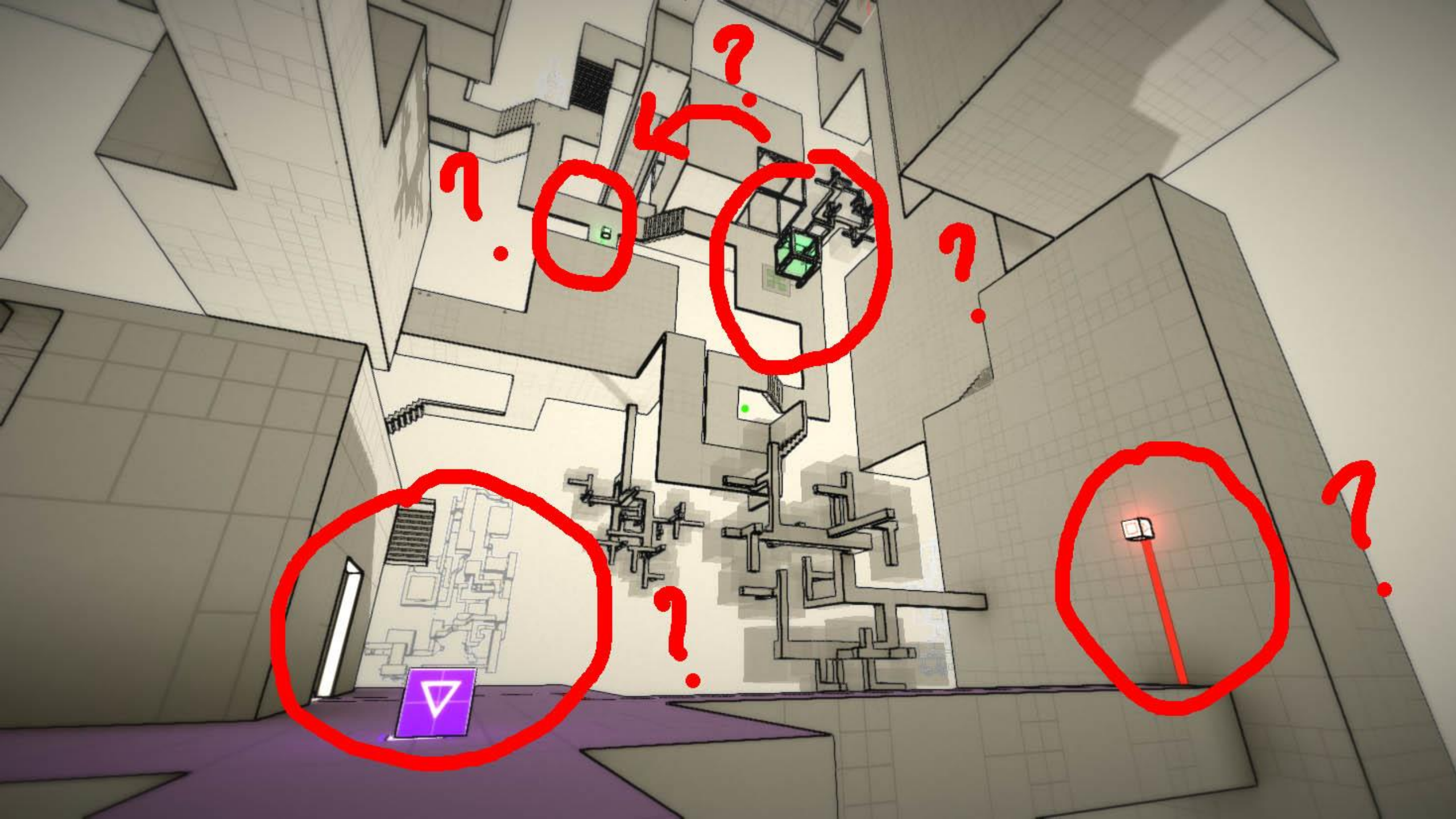


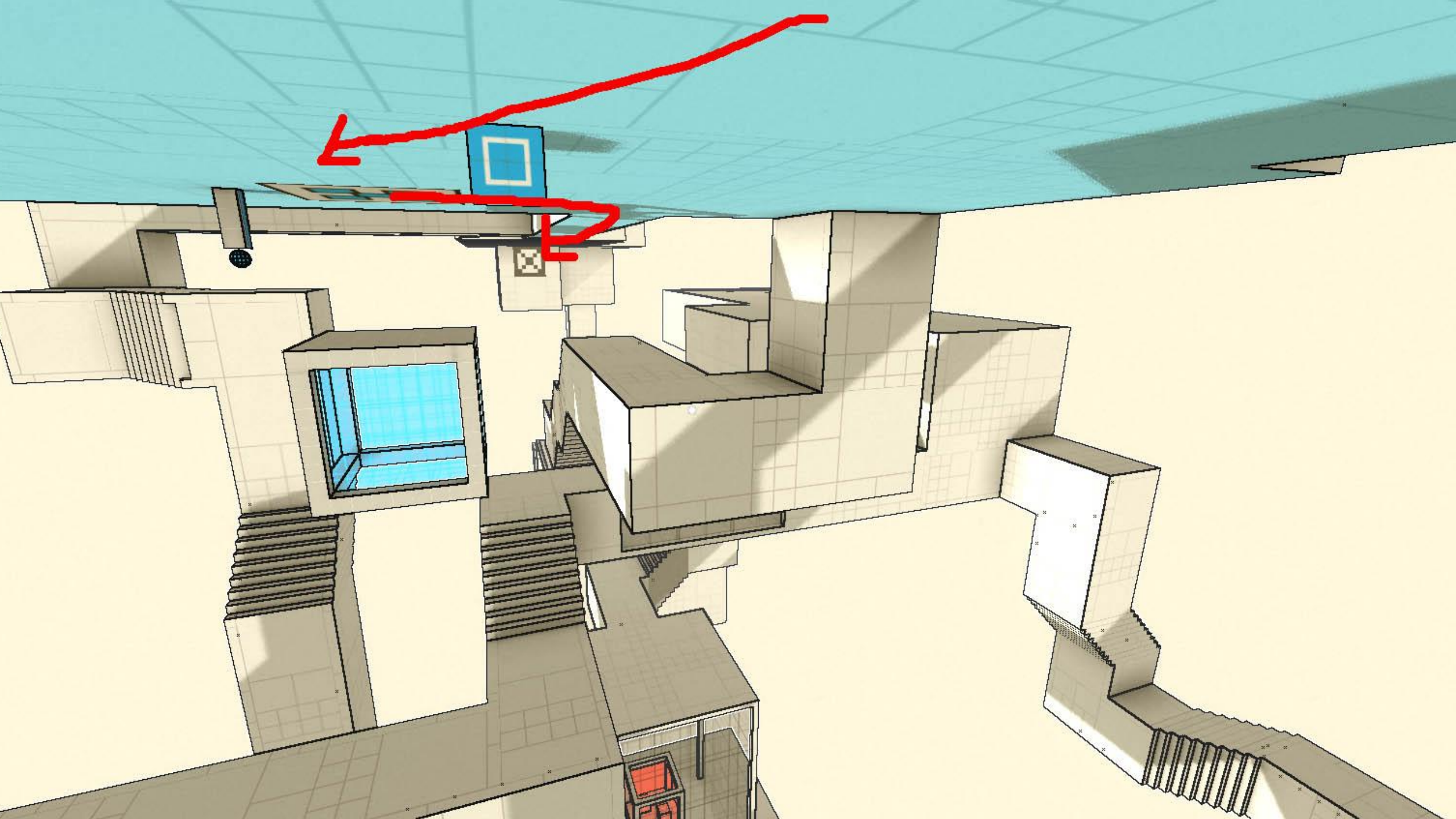


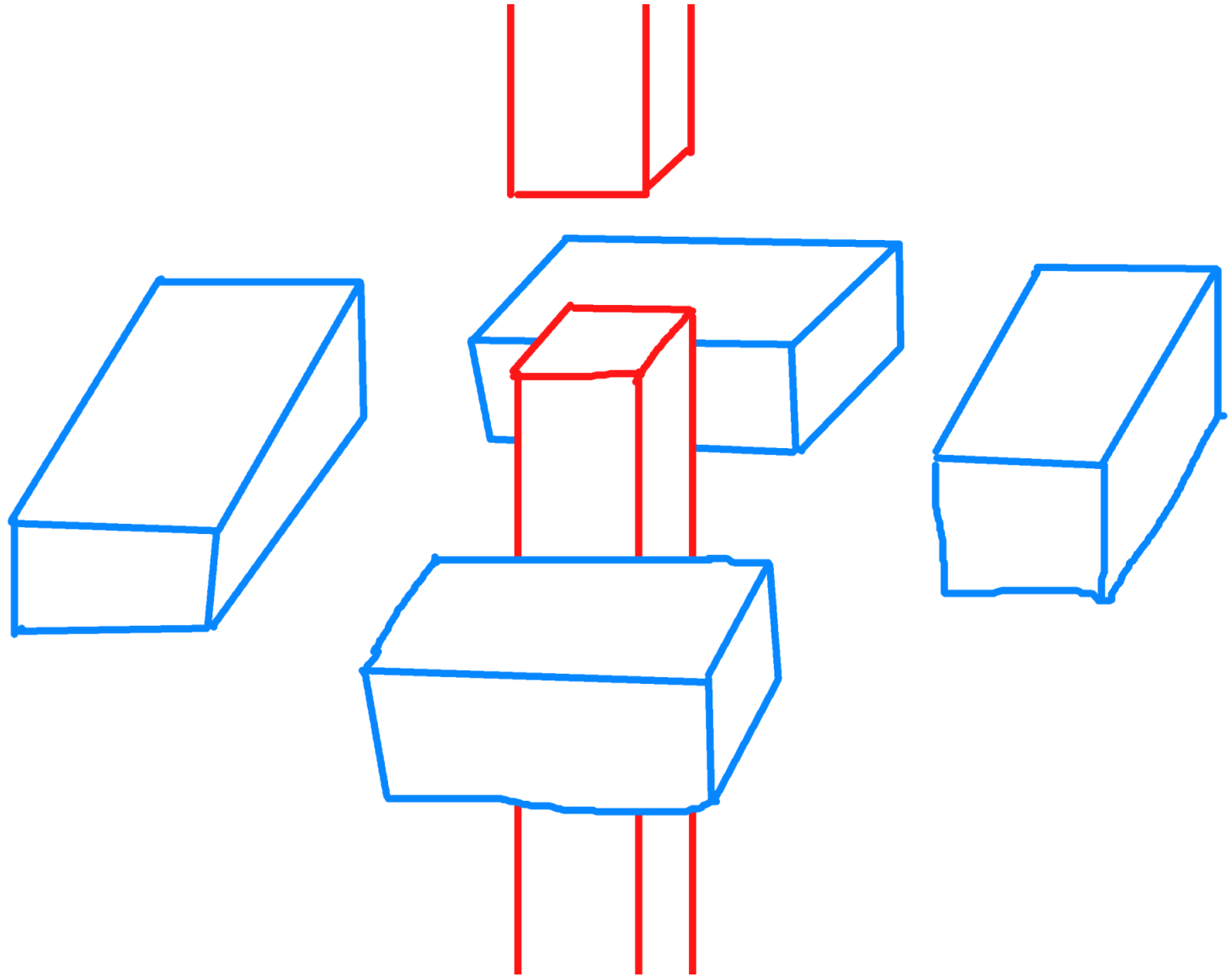


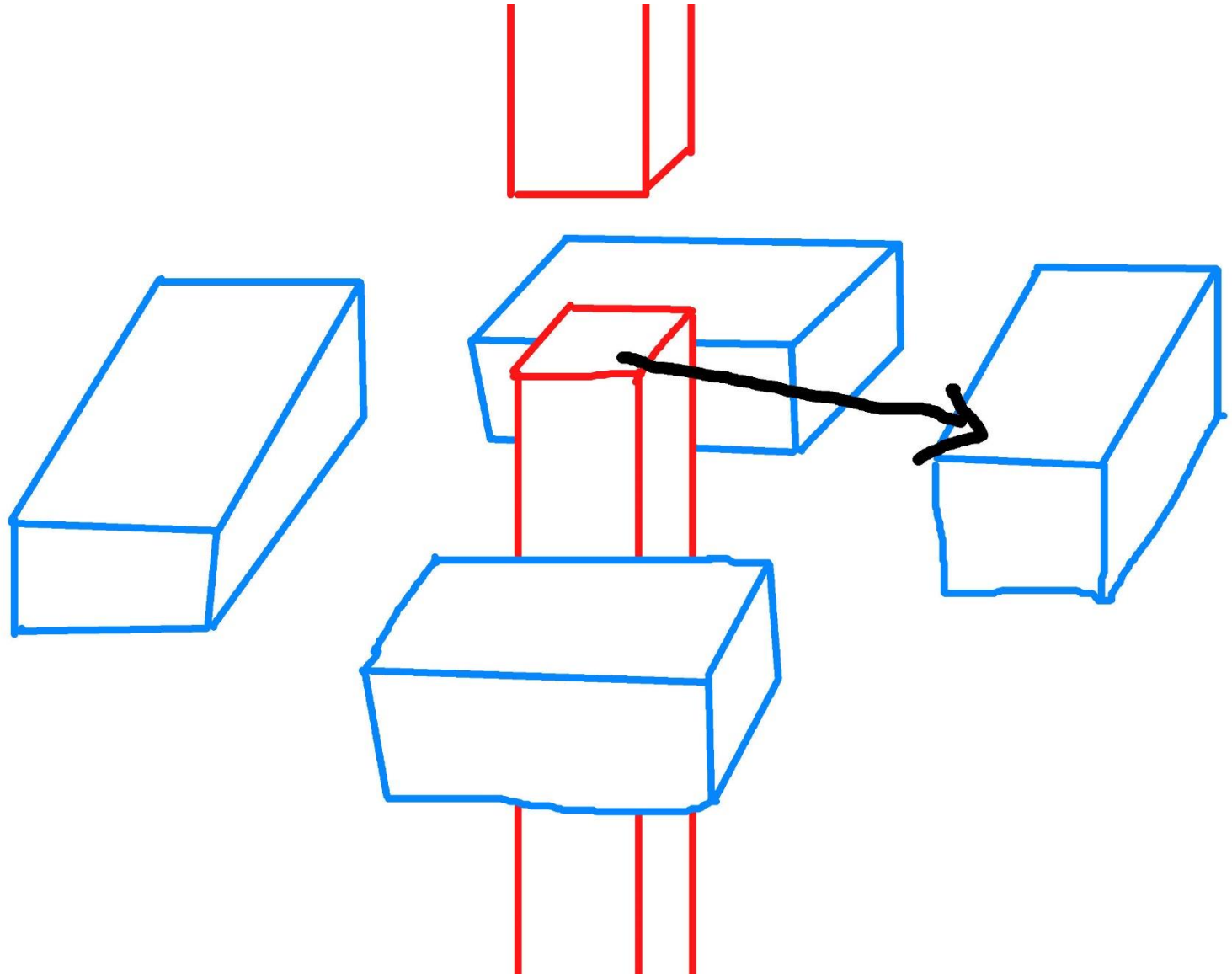
# Macro Technique – Logic to Level

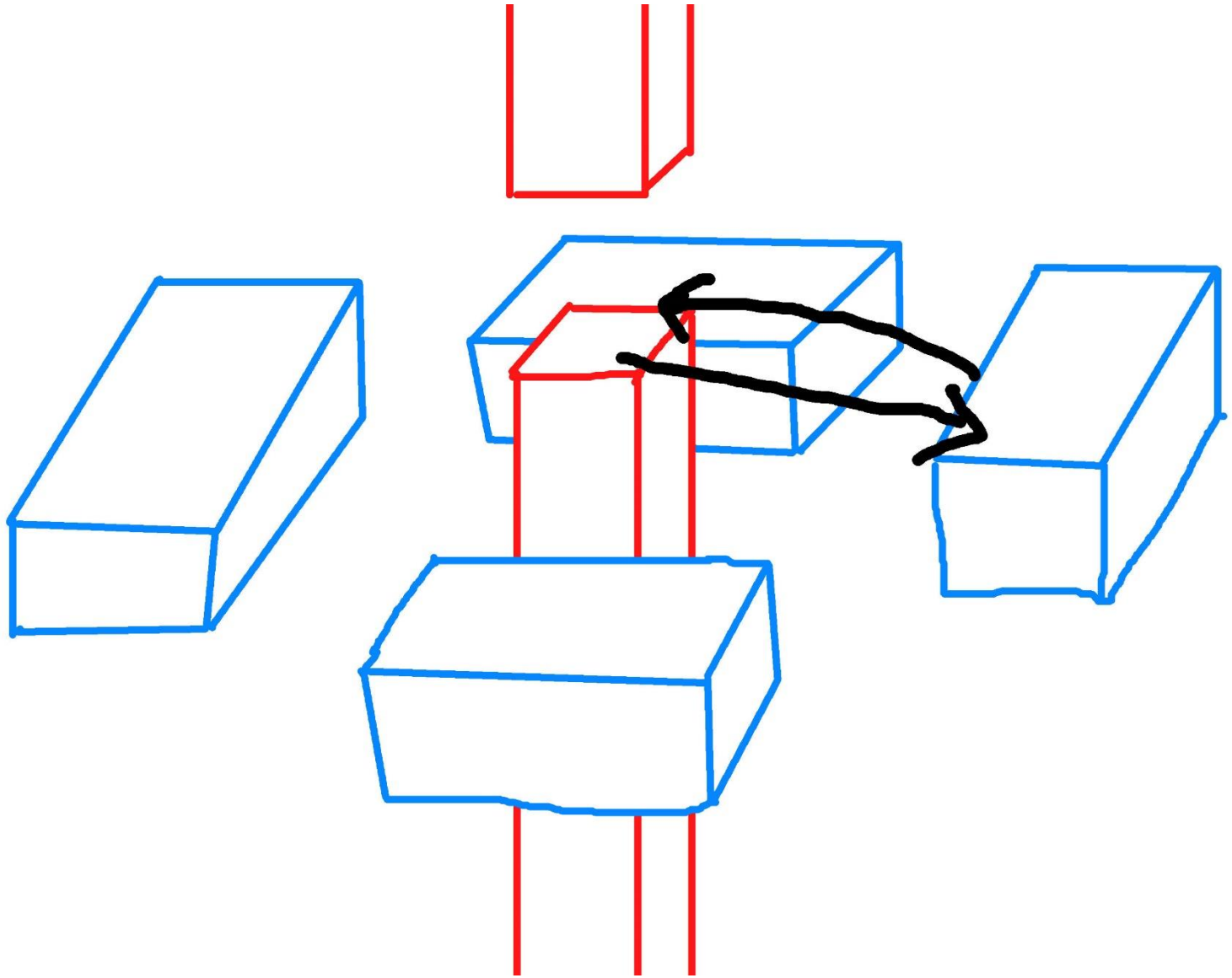


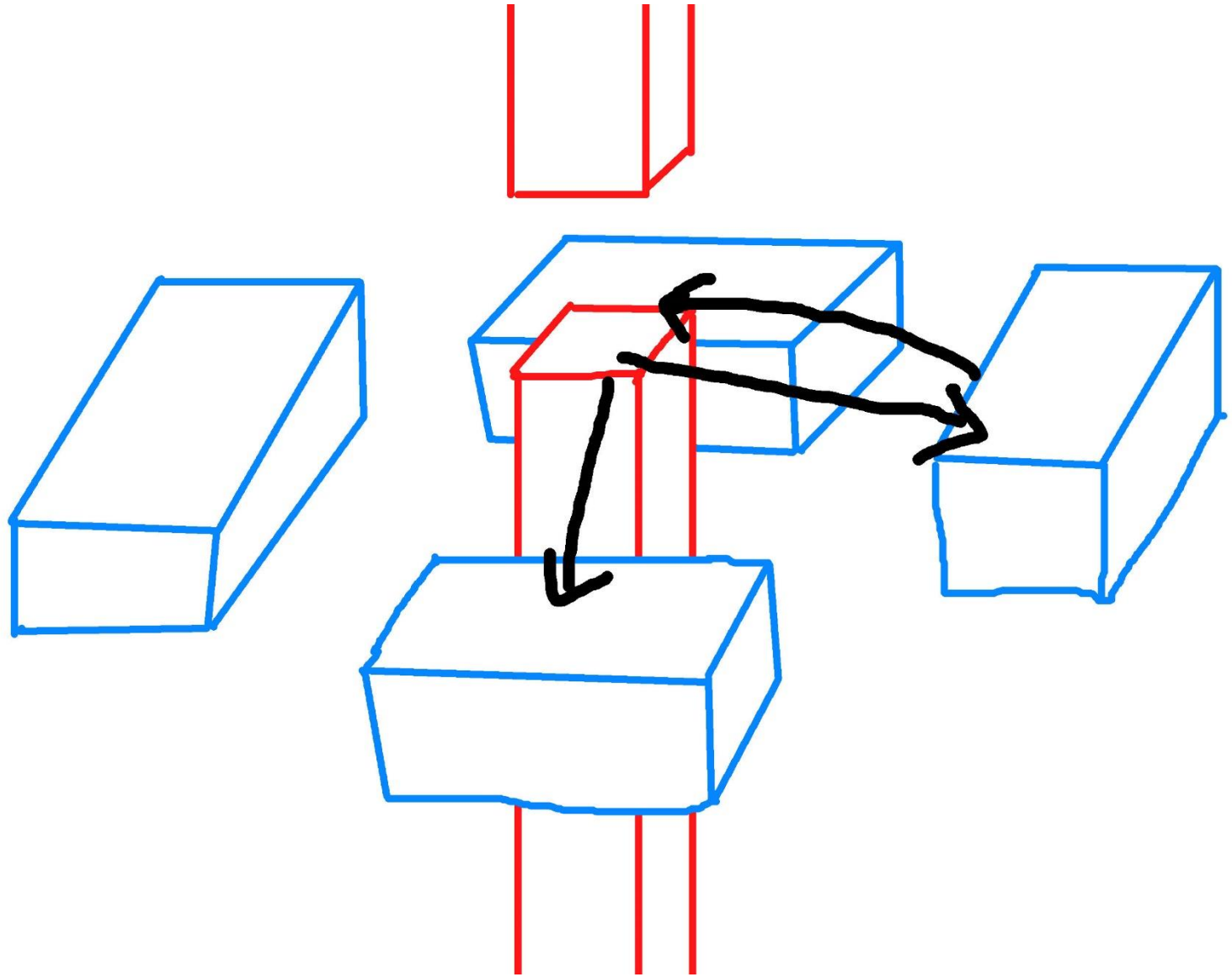


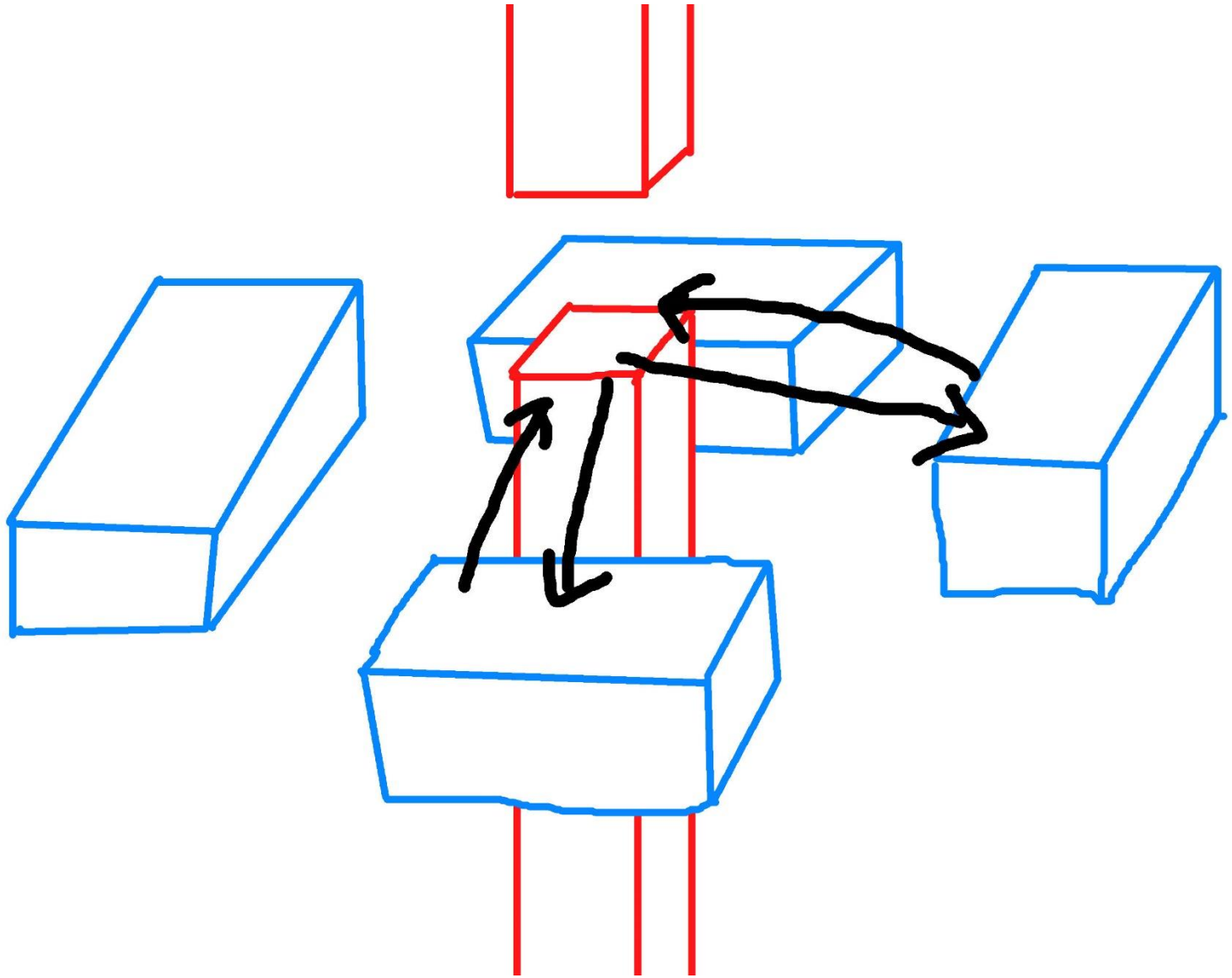


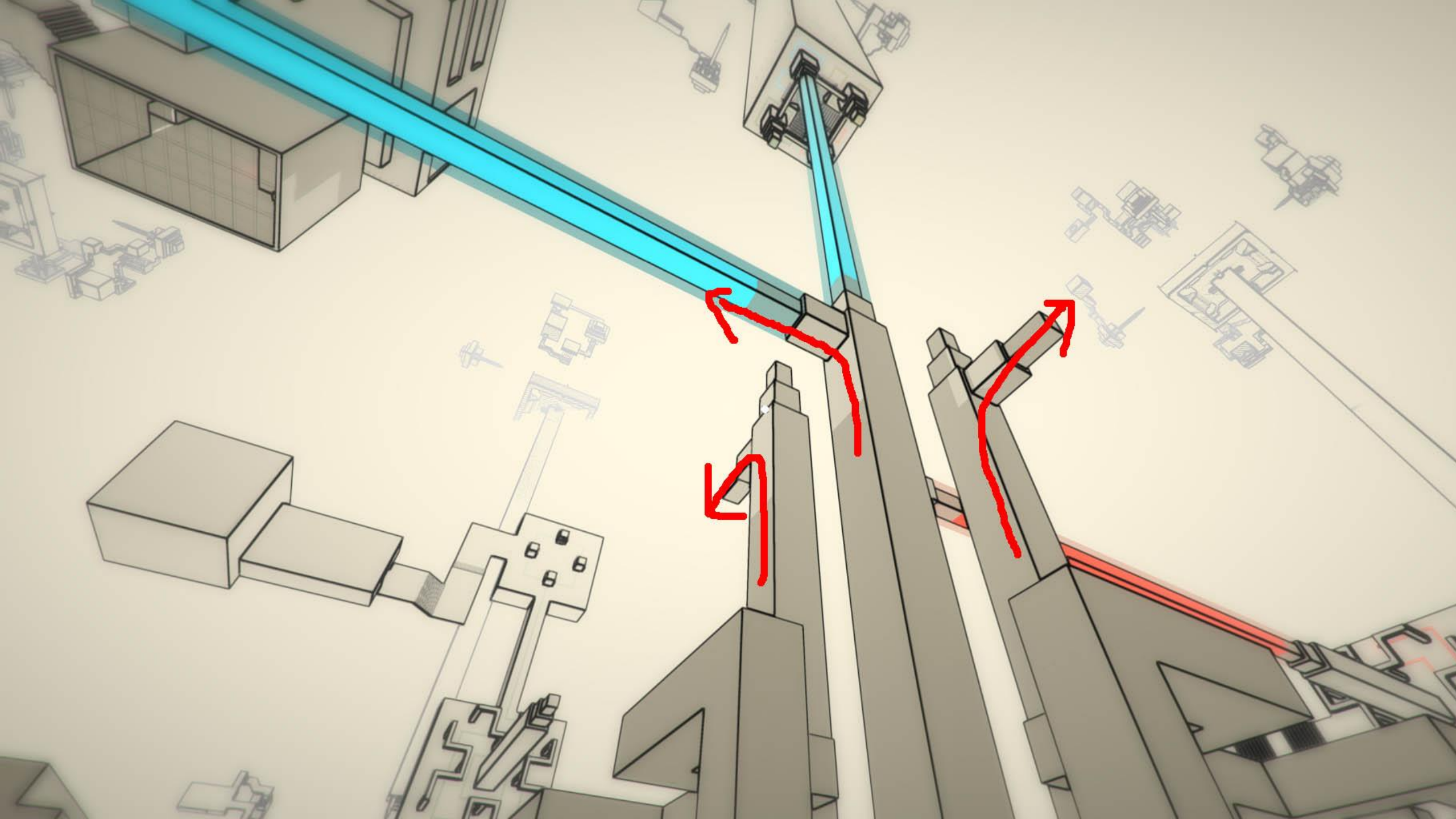












# Micro Technique – Intentional Architecture

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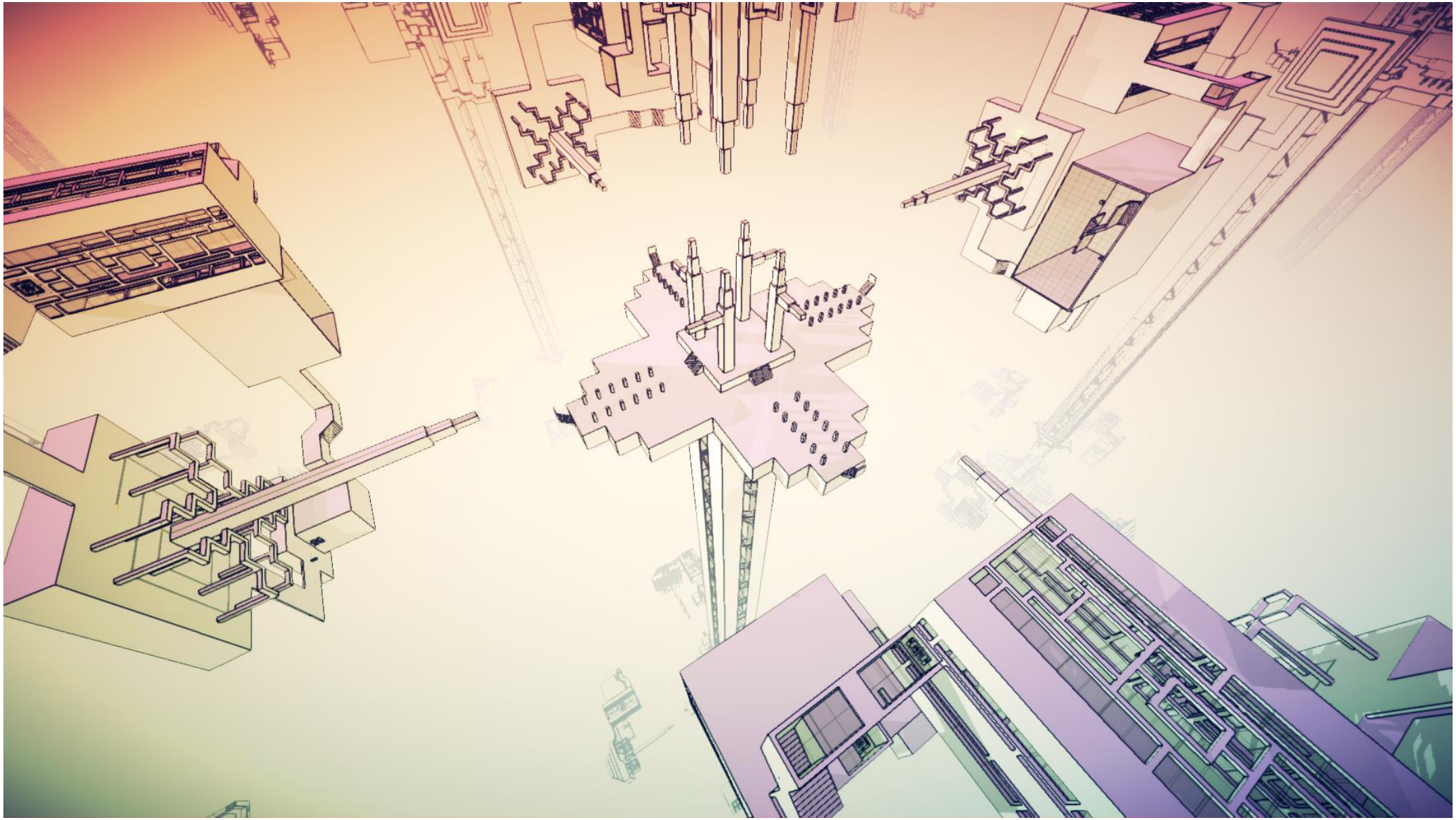

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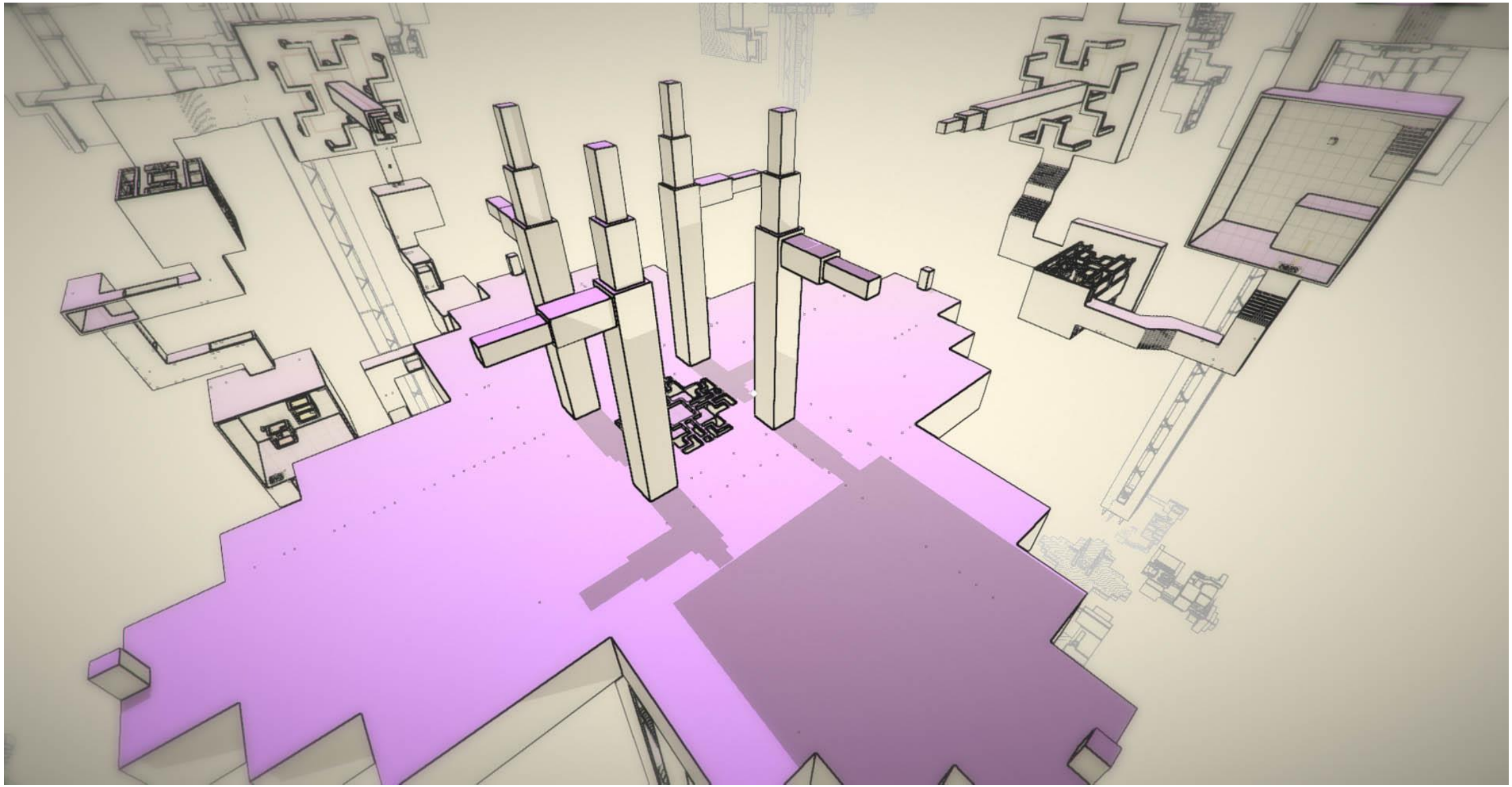

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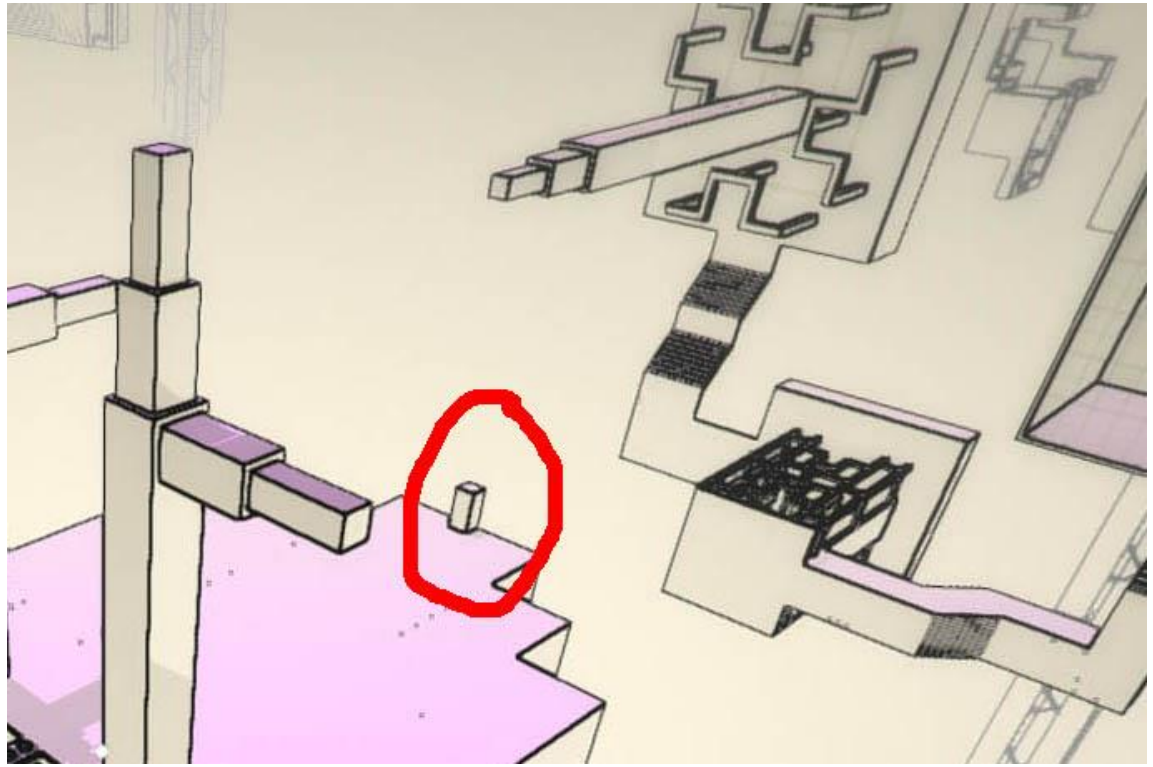

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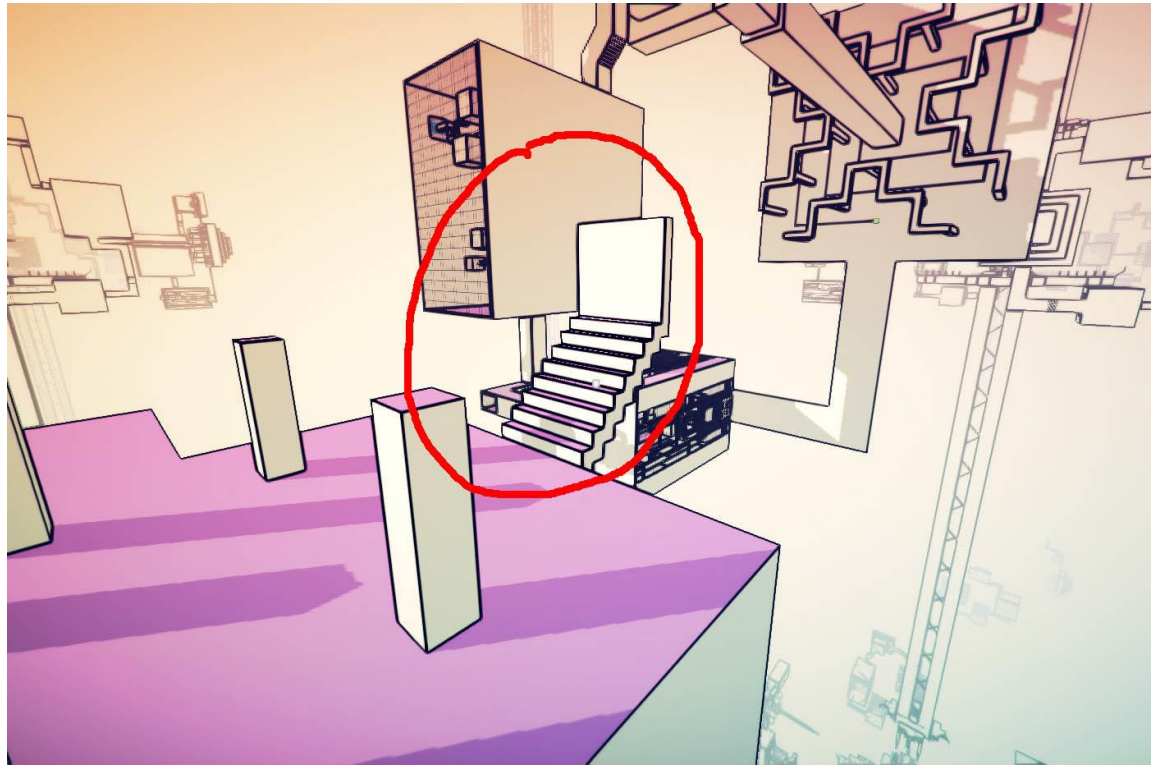
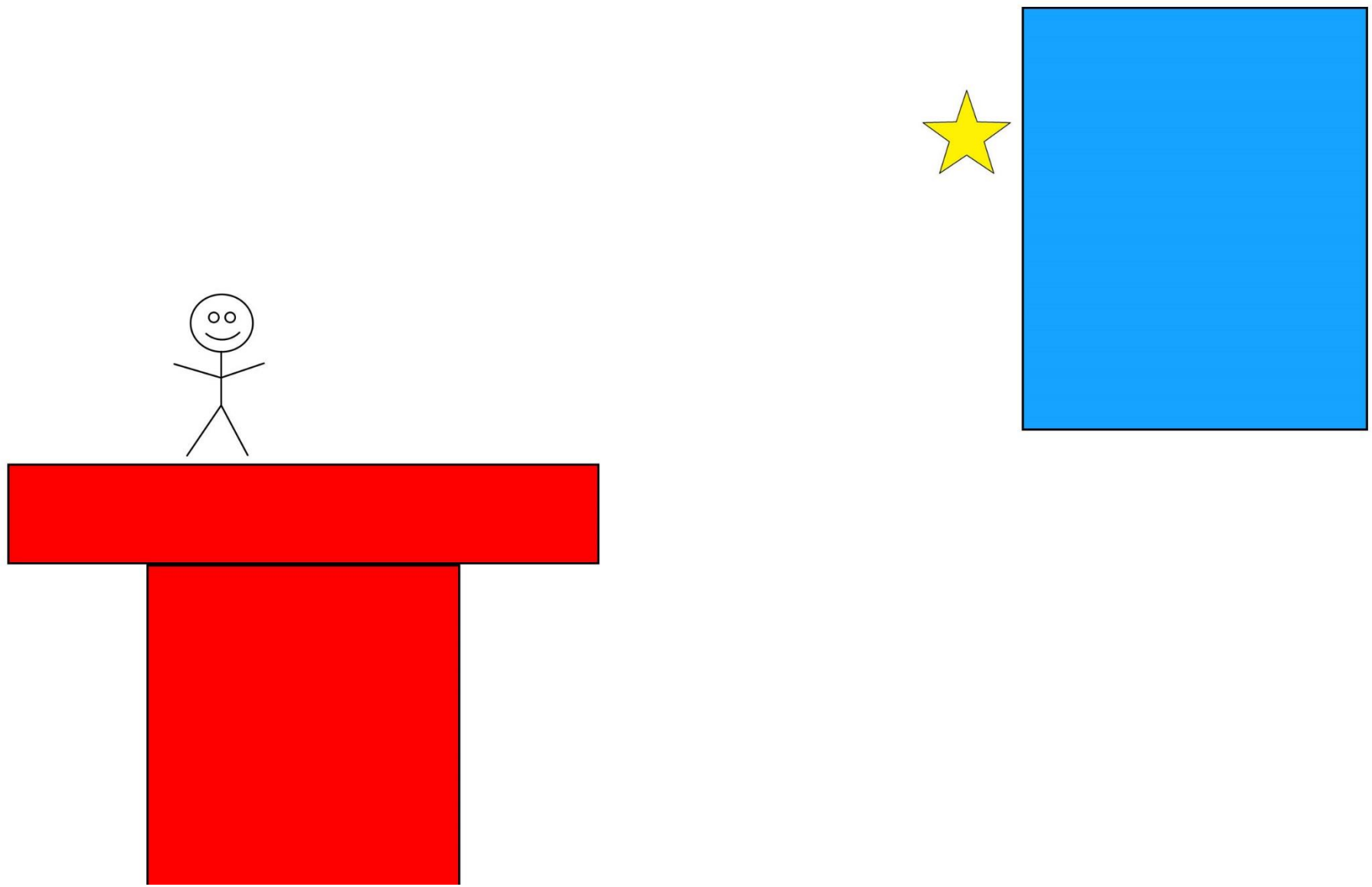
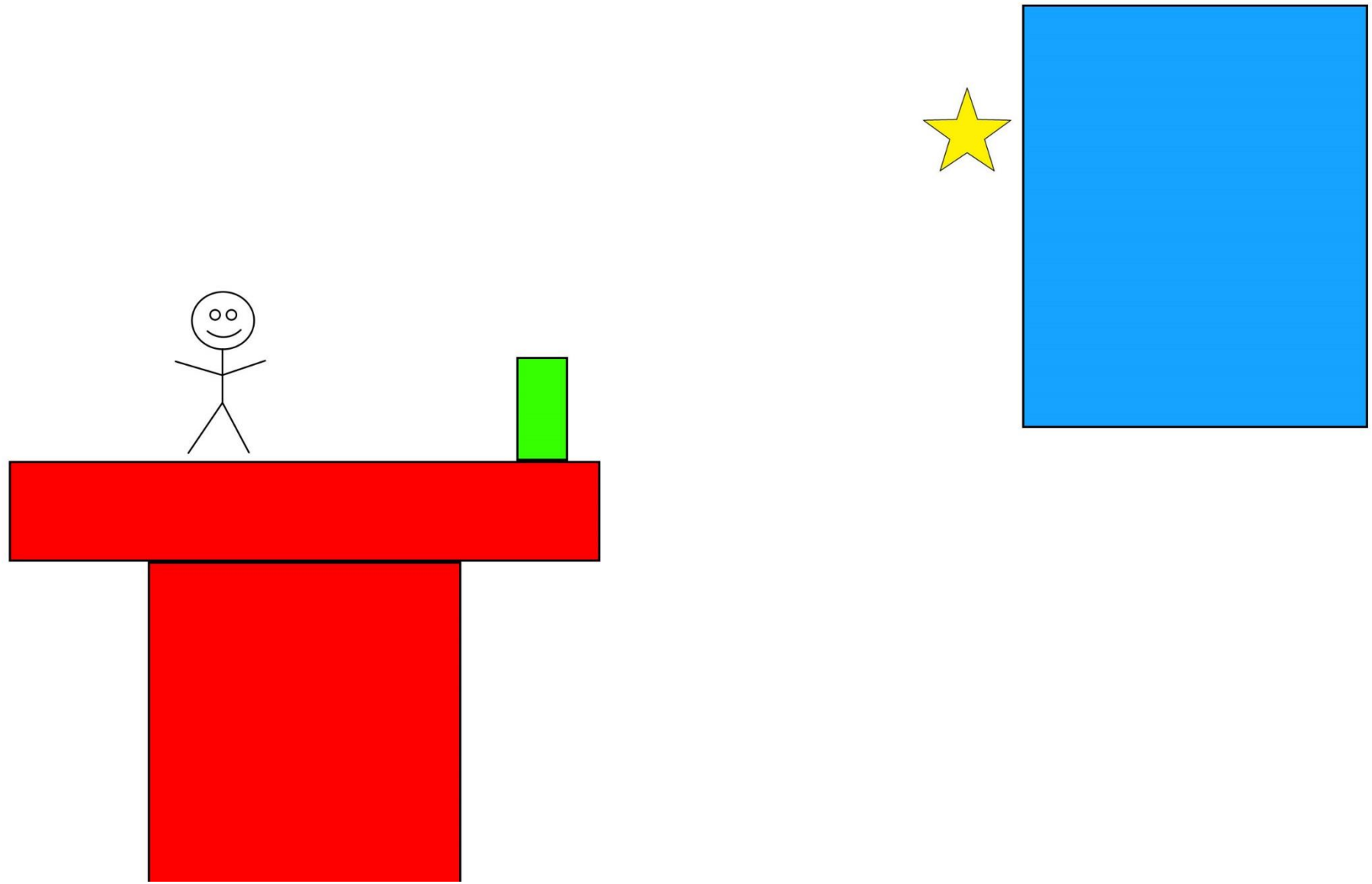
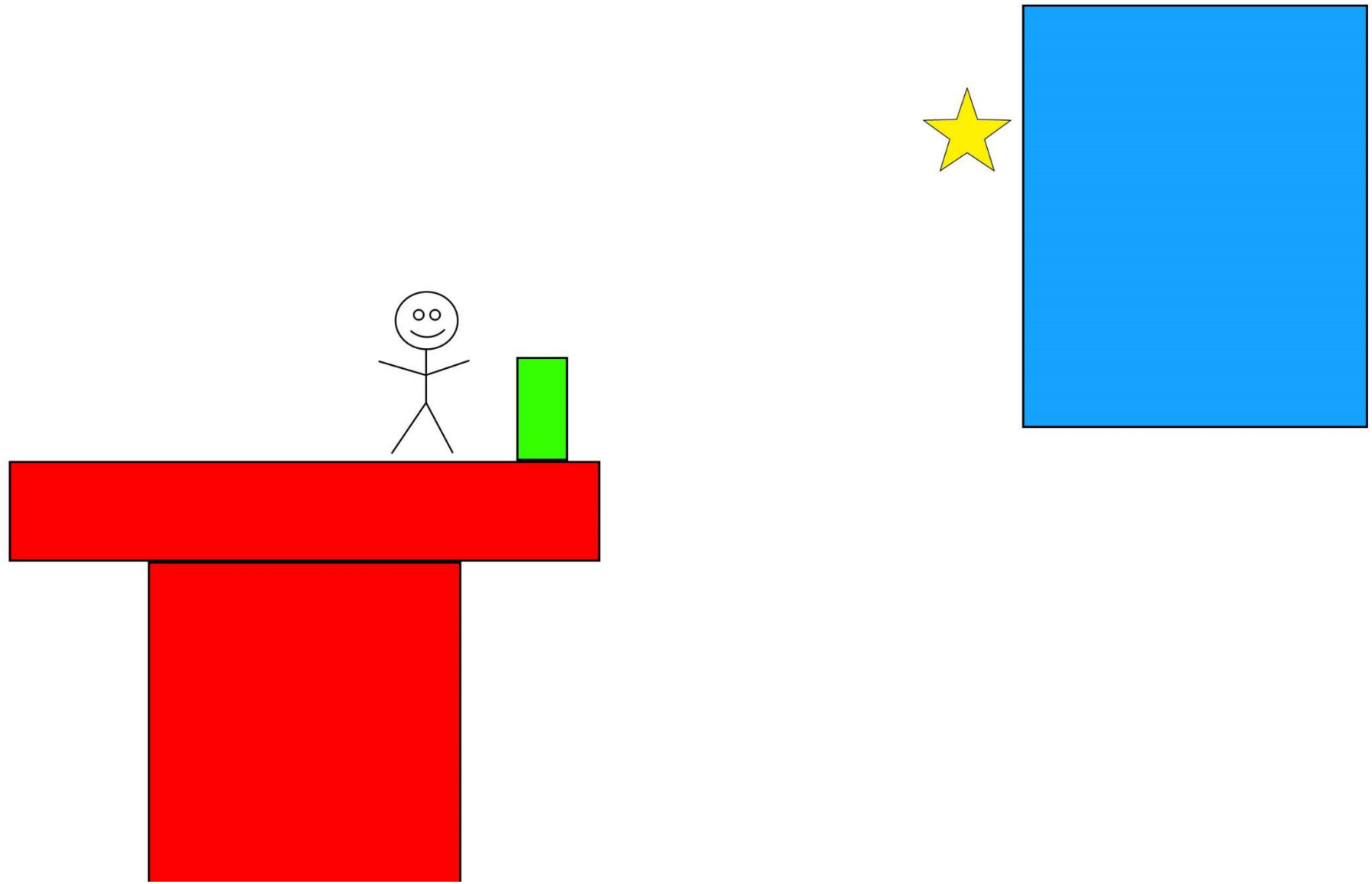
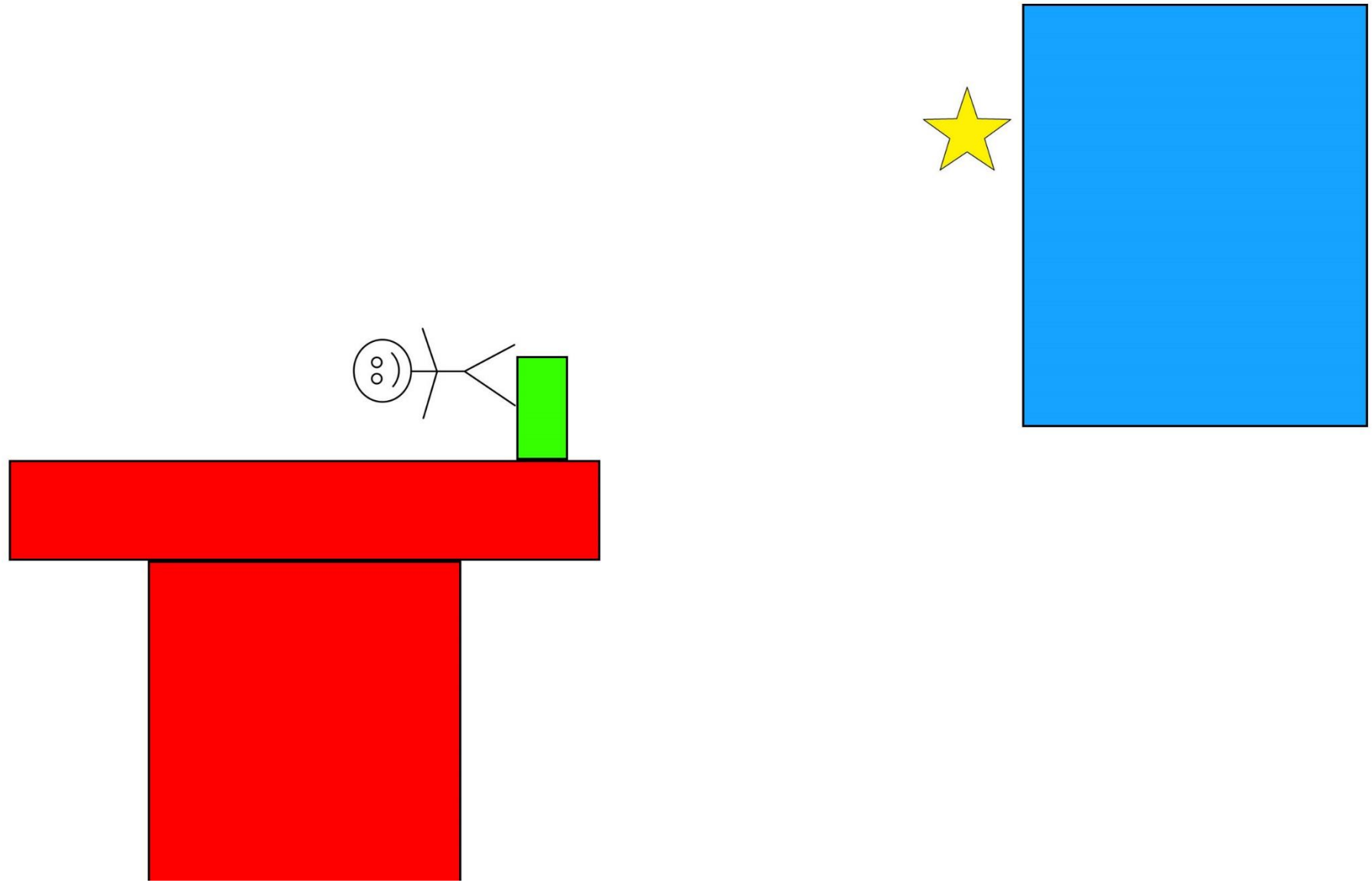
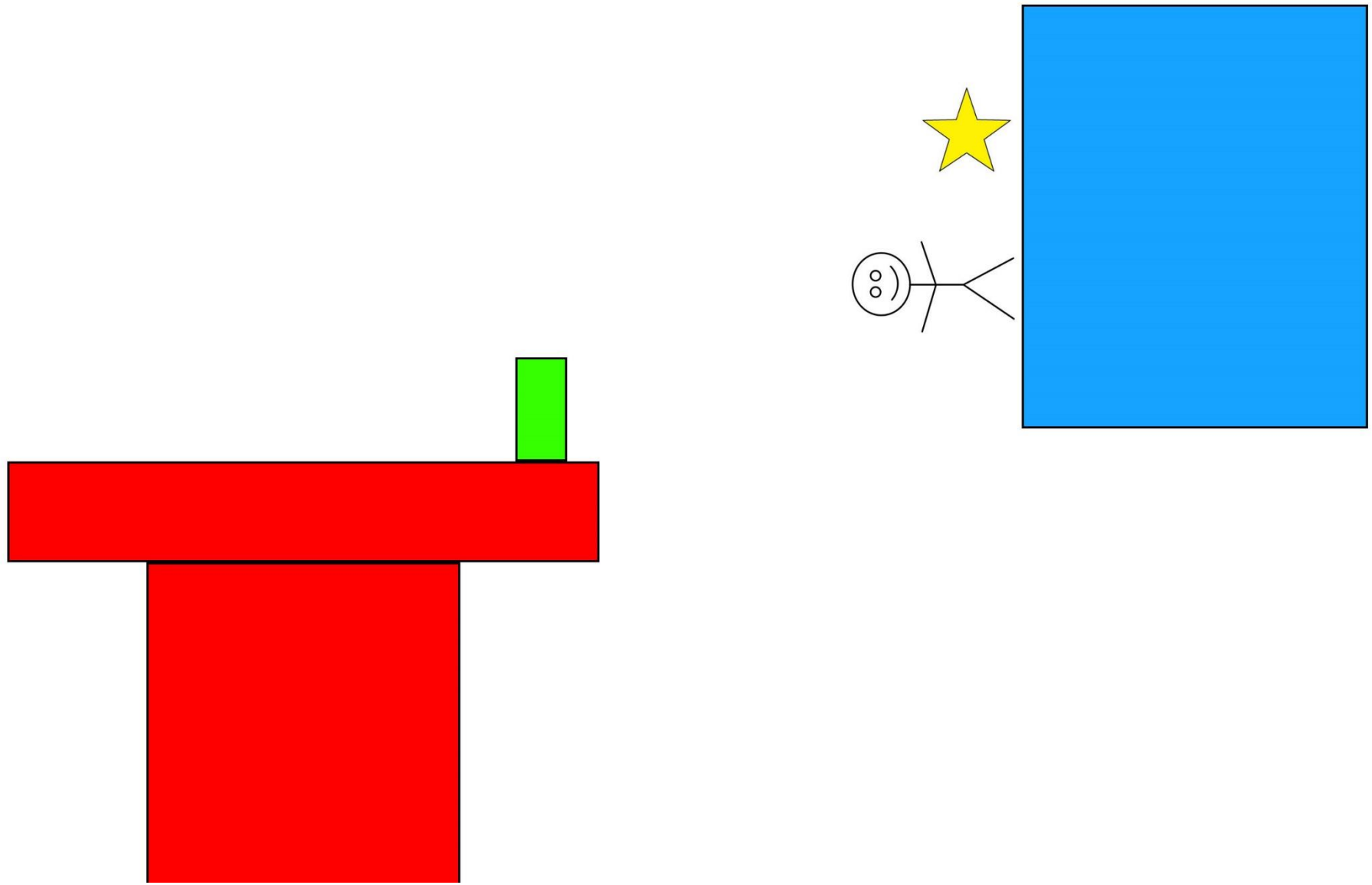


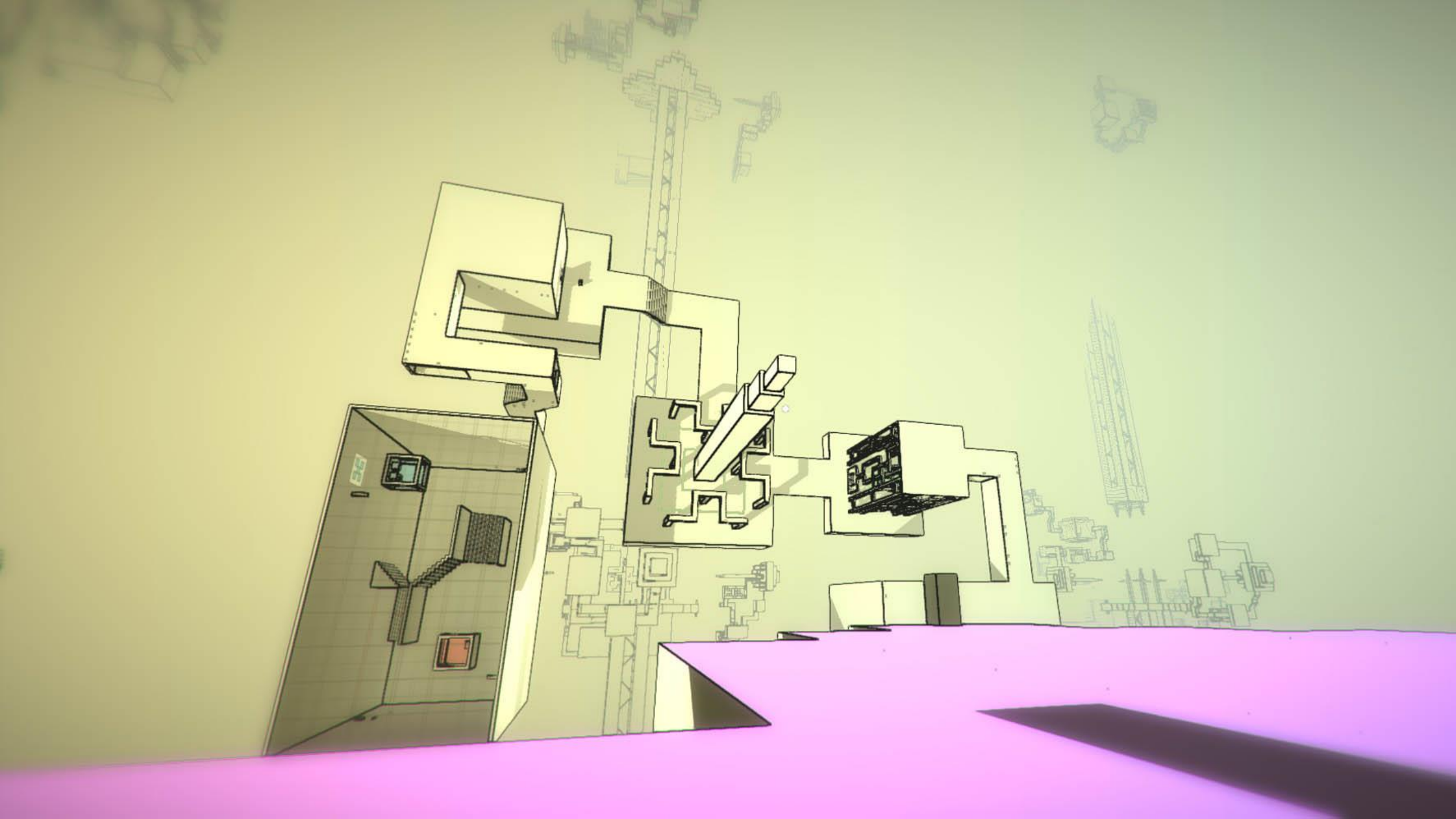


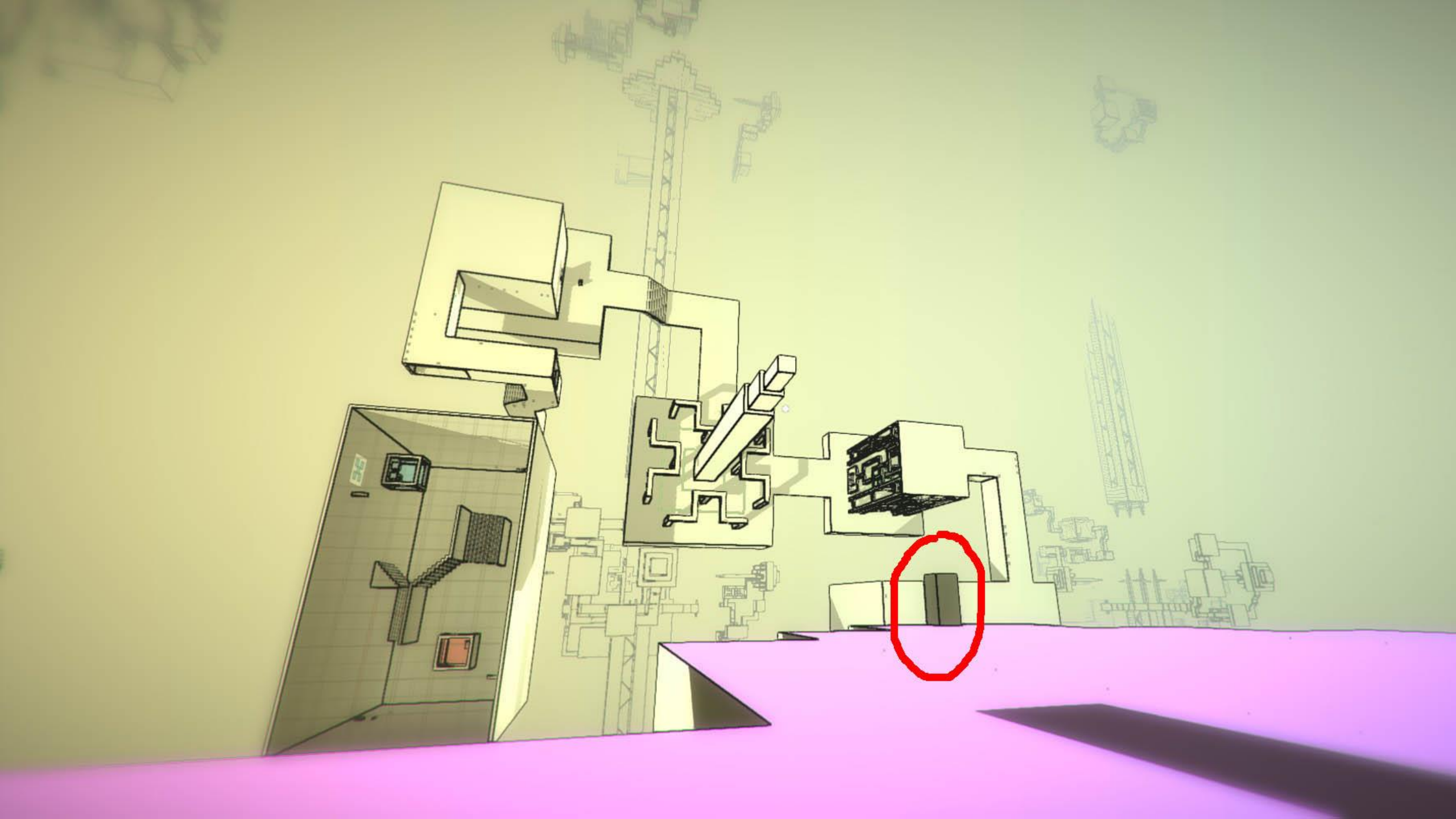


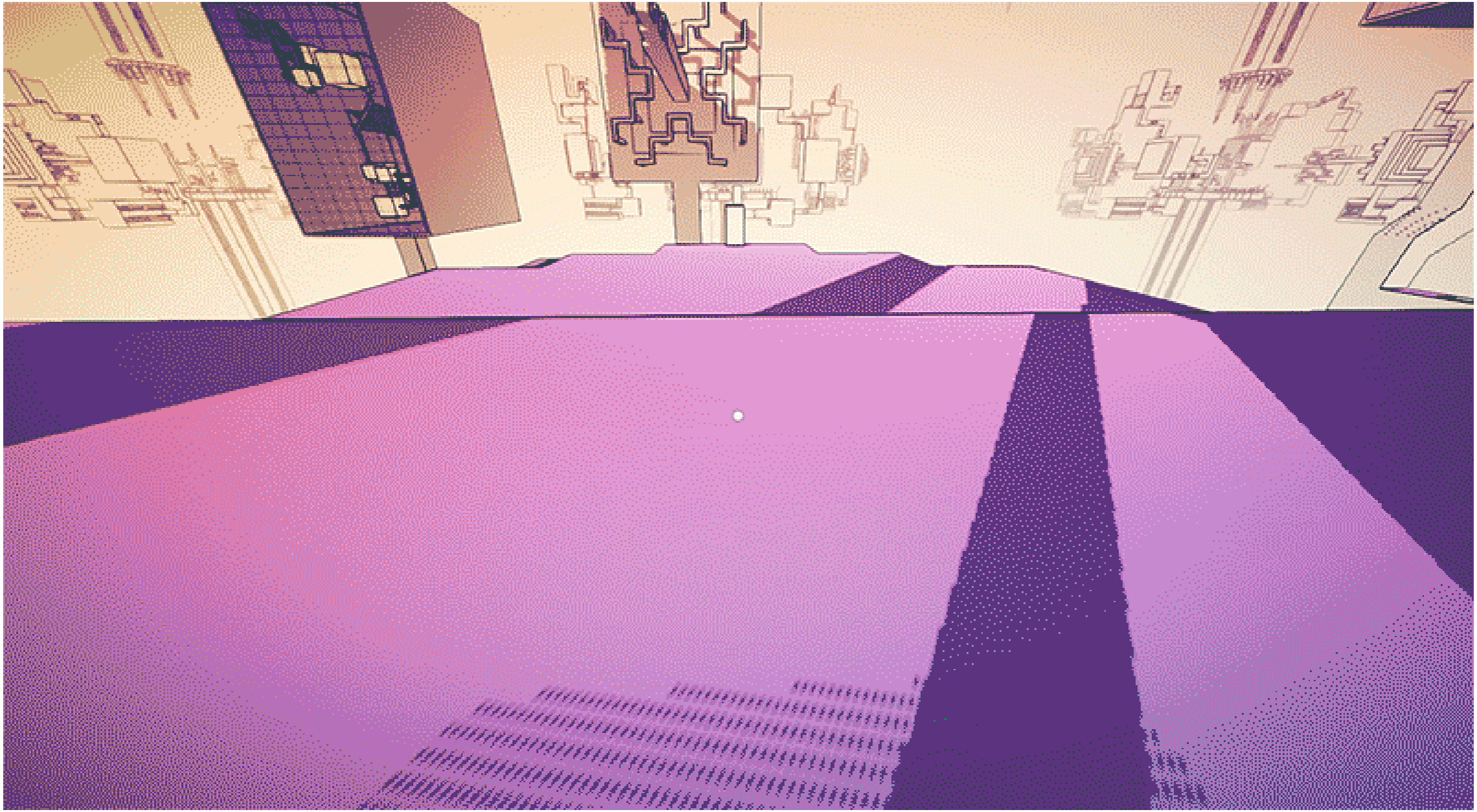


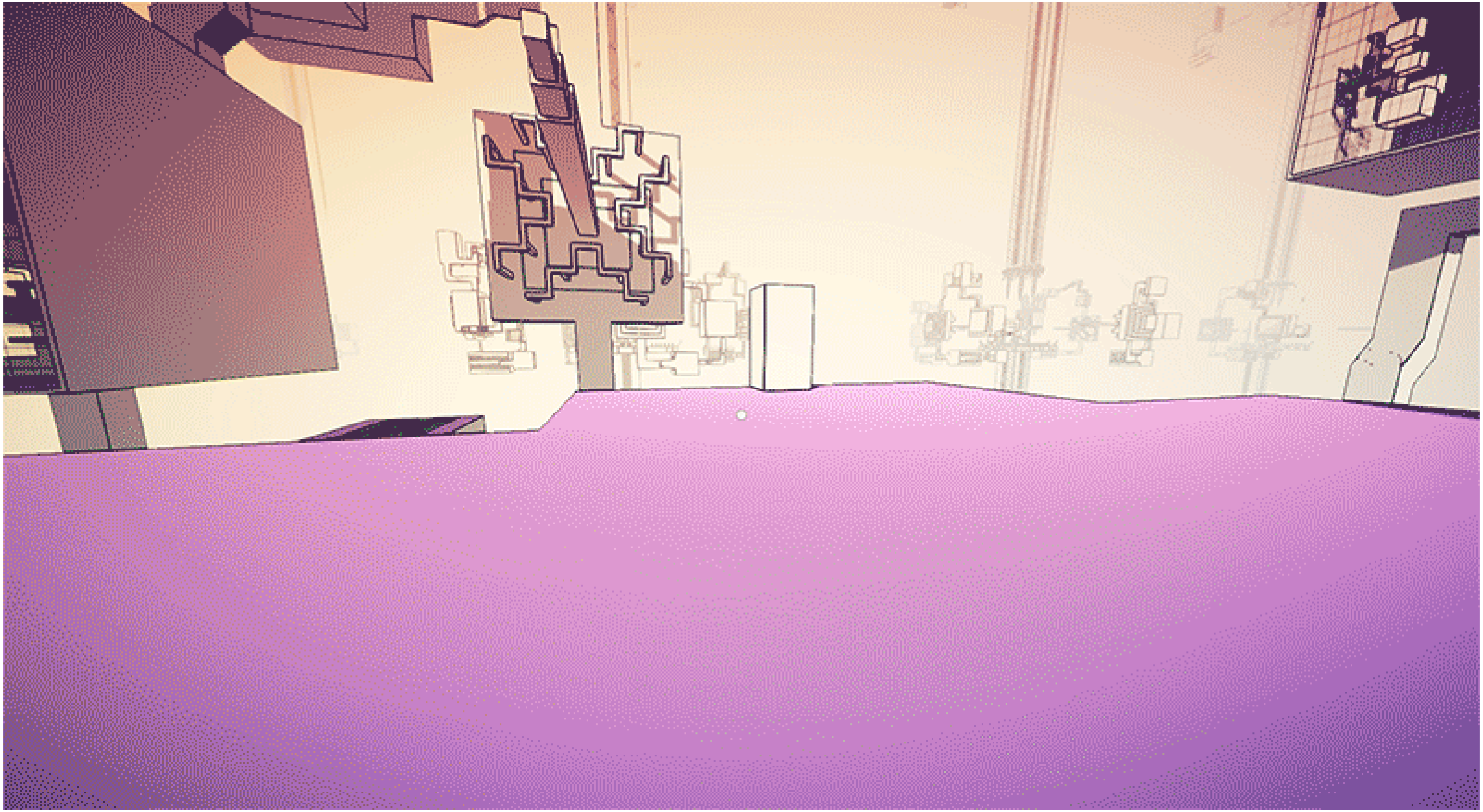


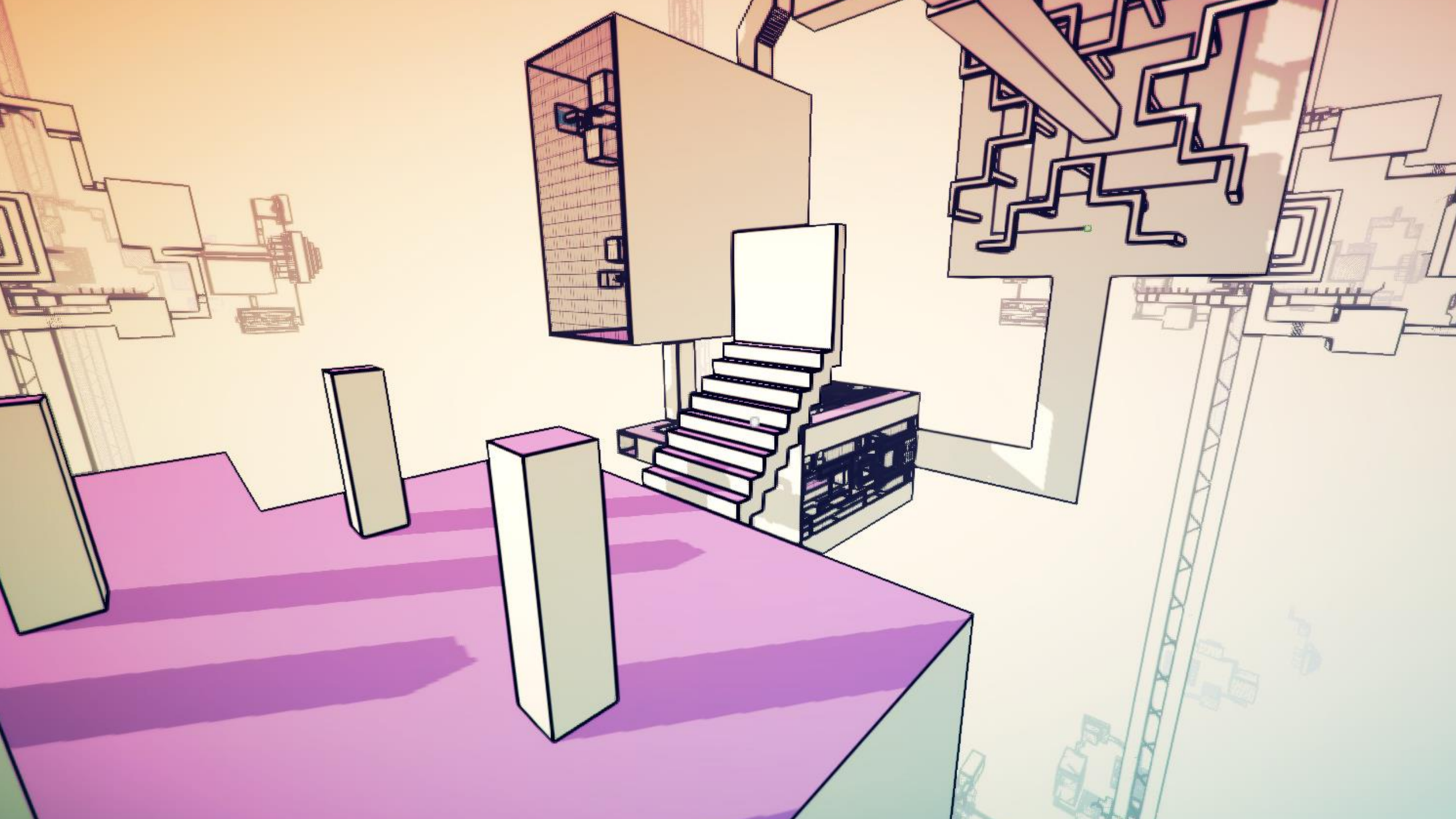


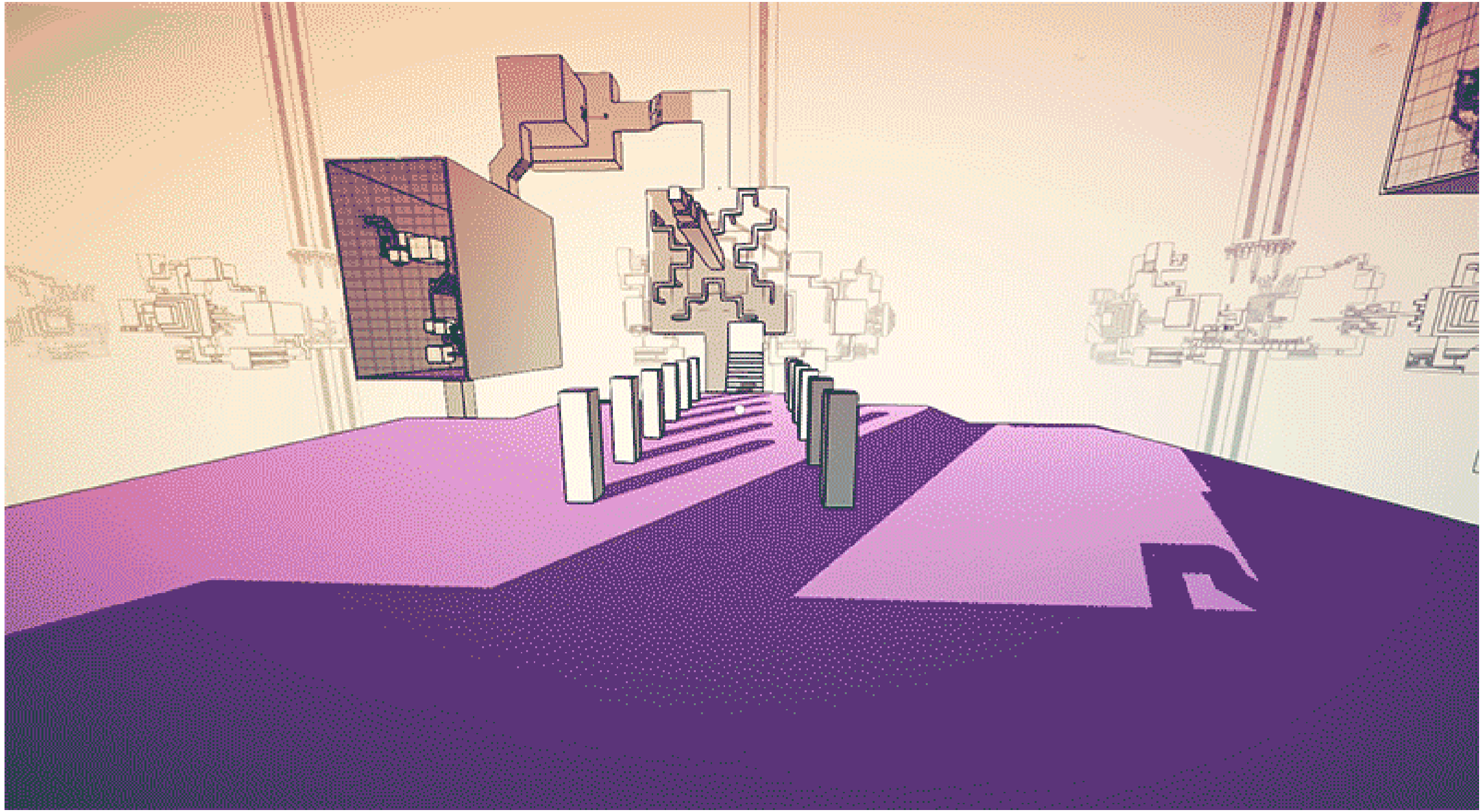


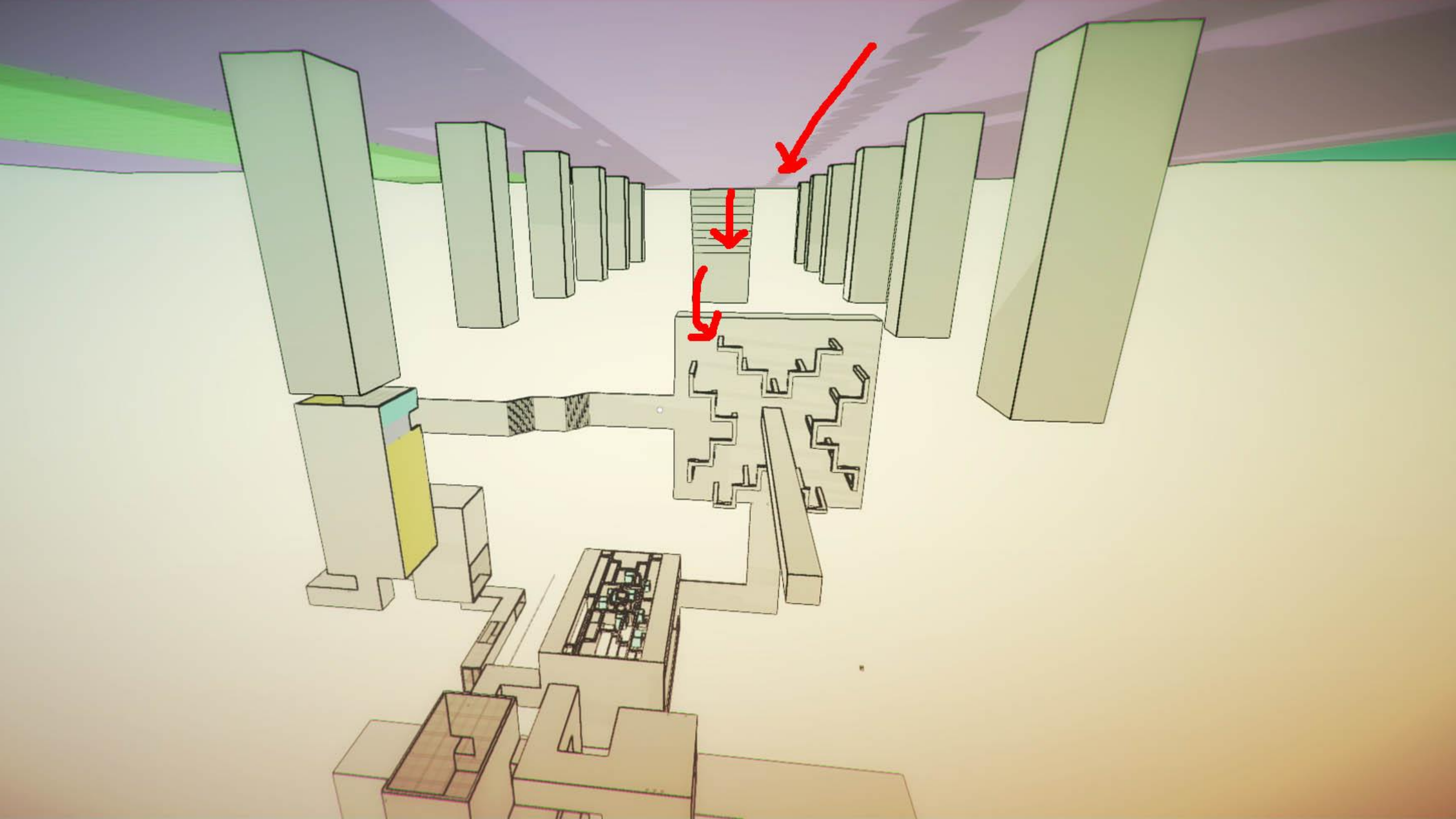




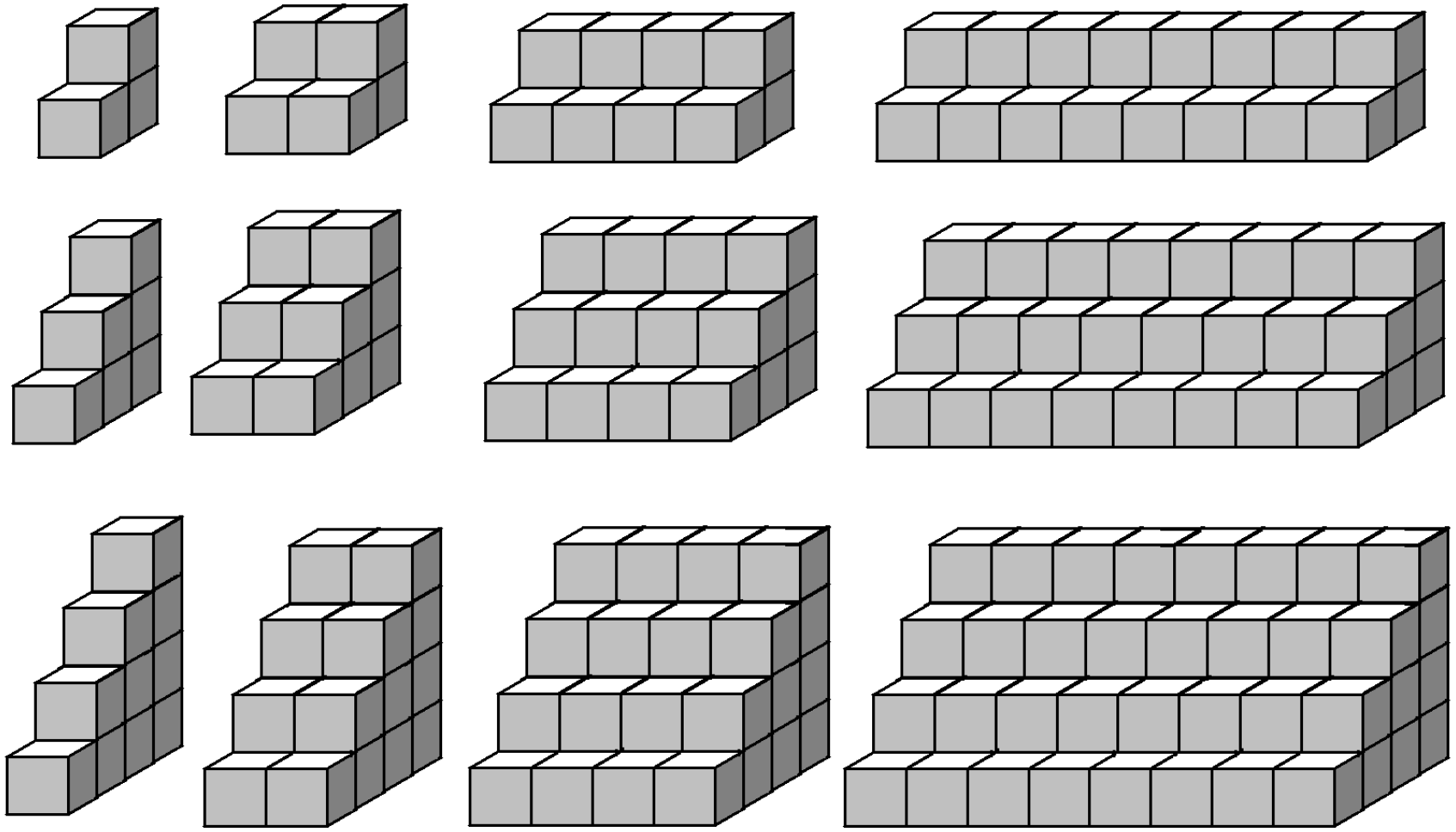


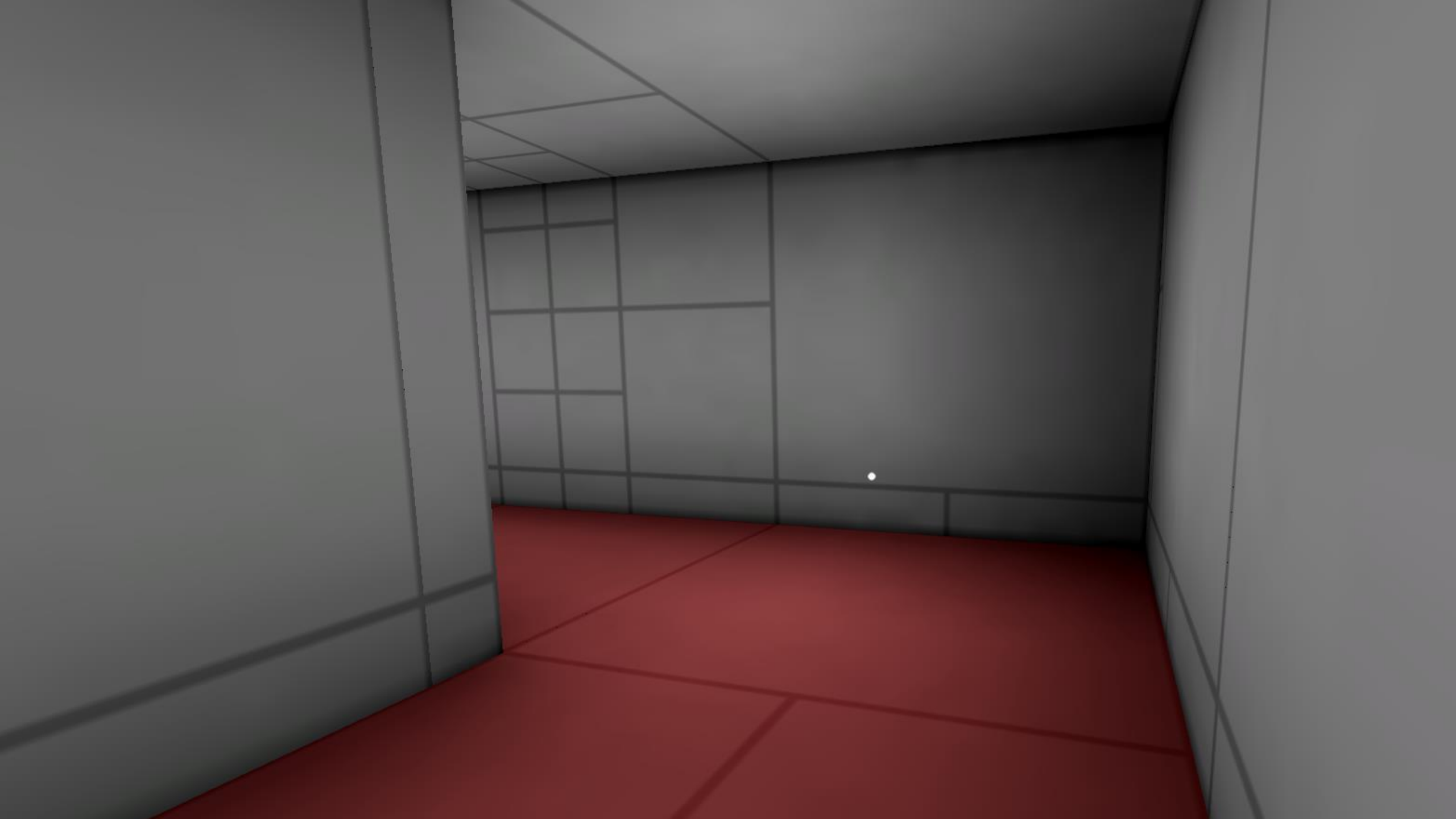


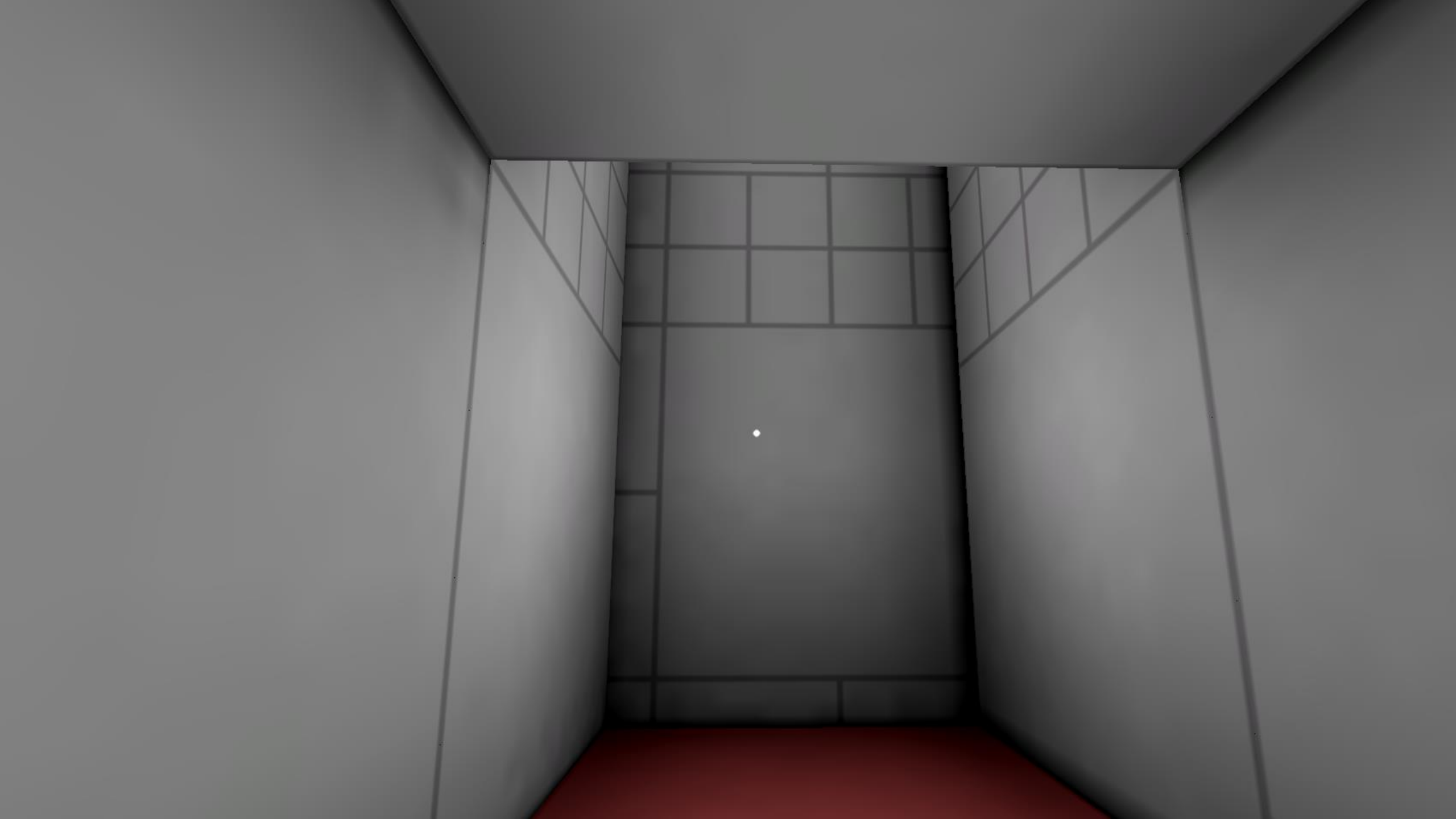


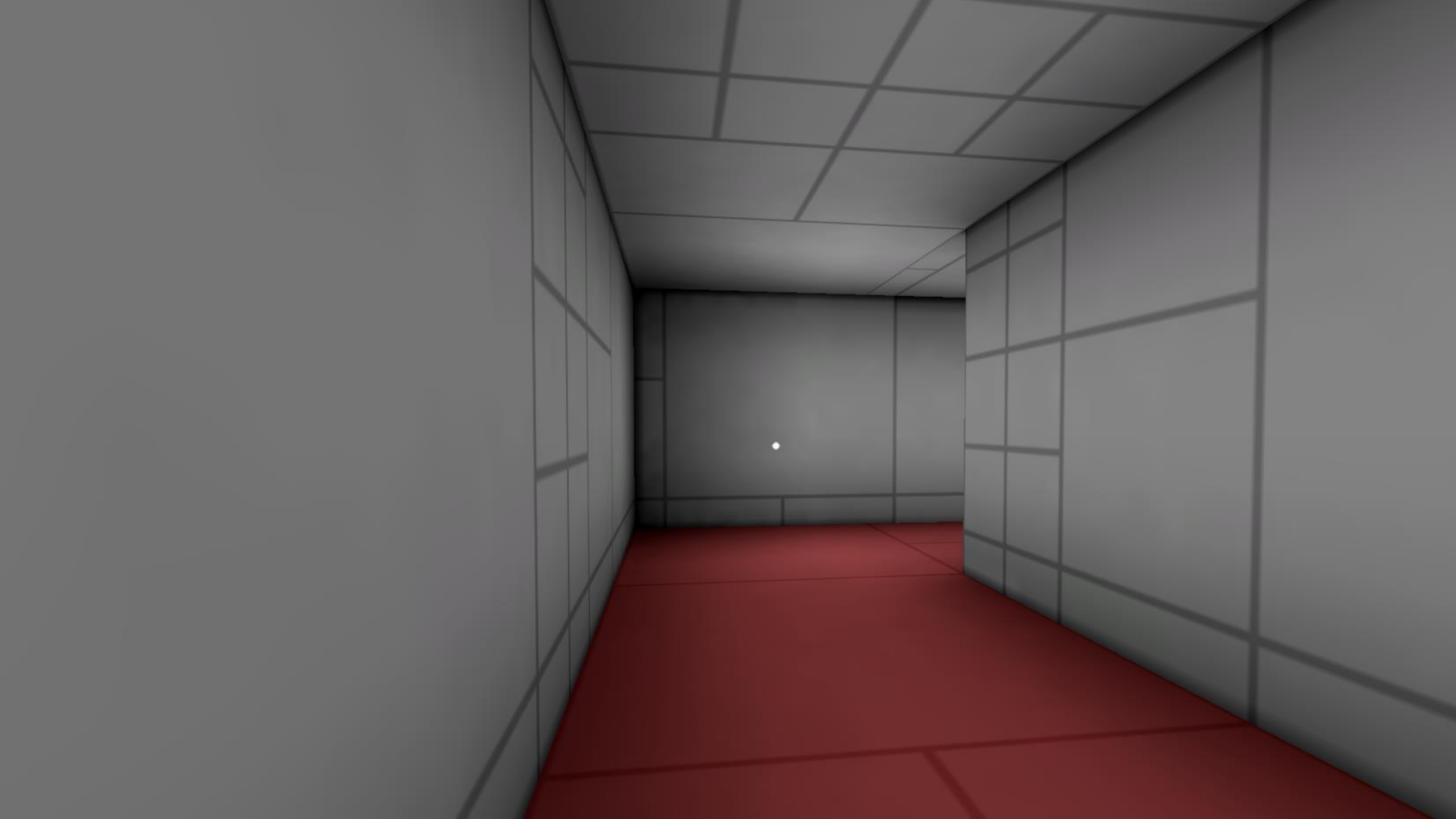


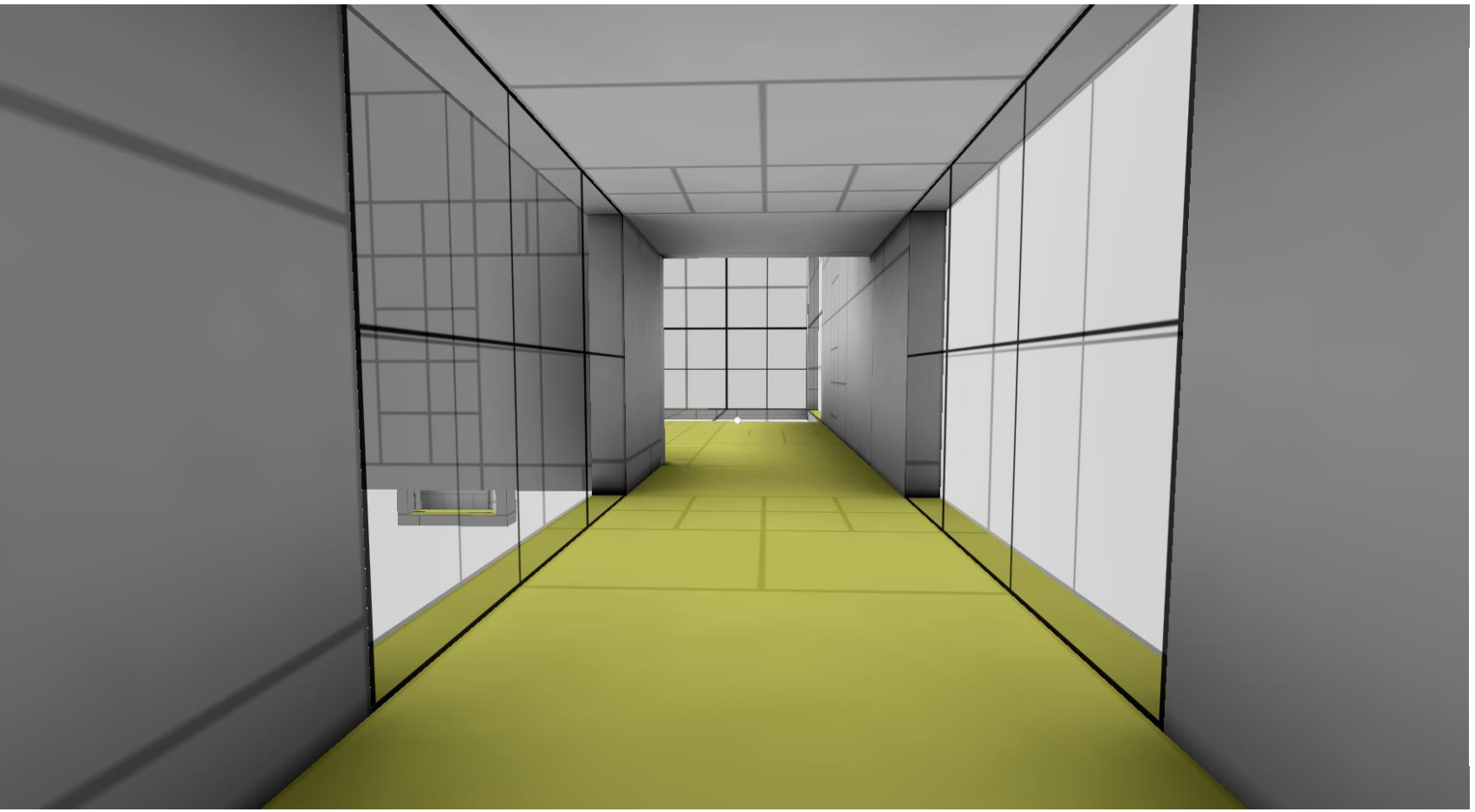
# Micro Technique – Patterns in Architectural Elements

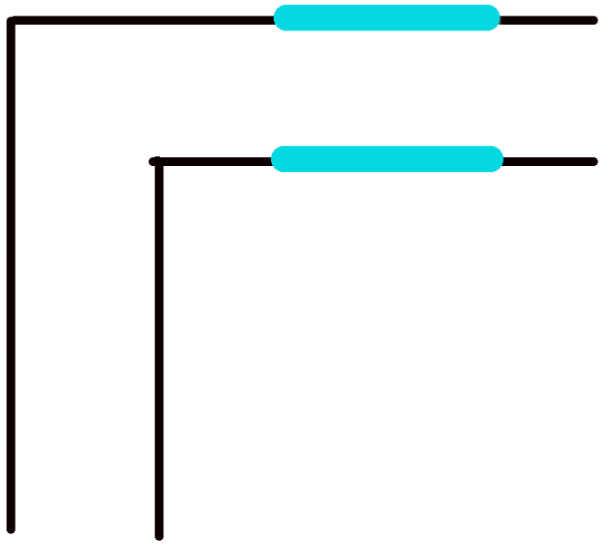












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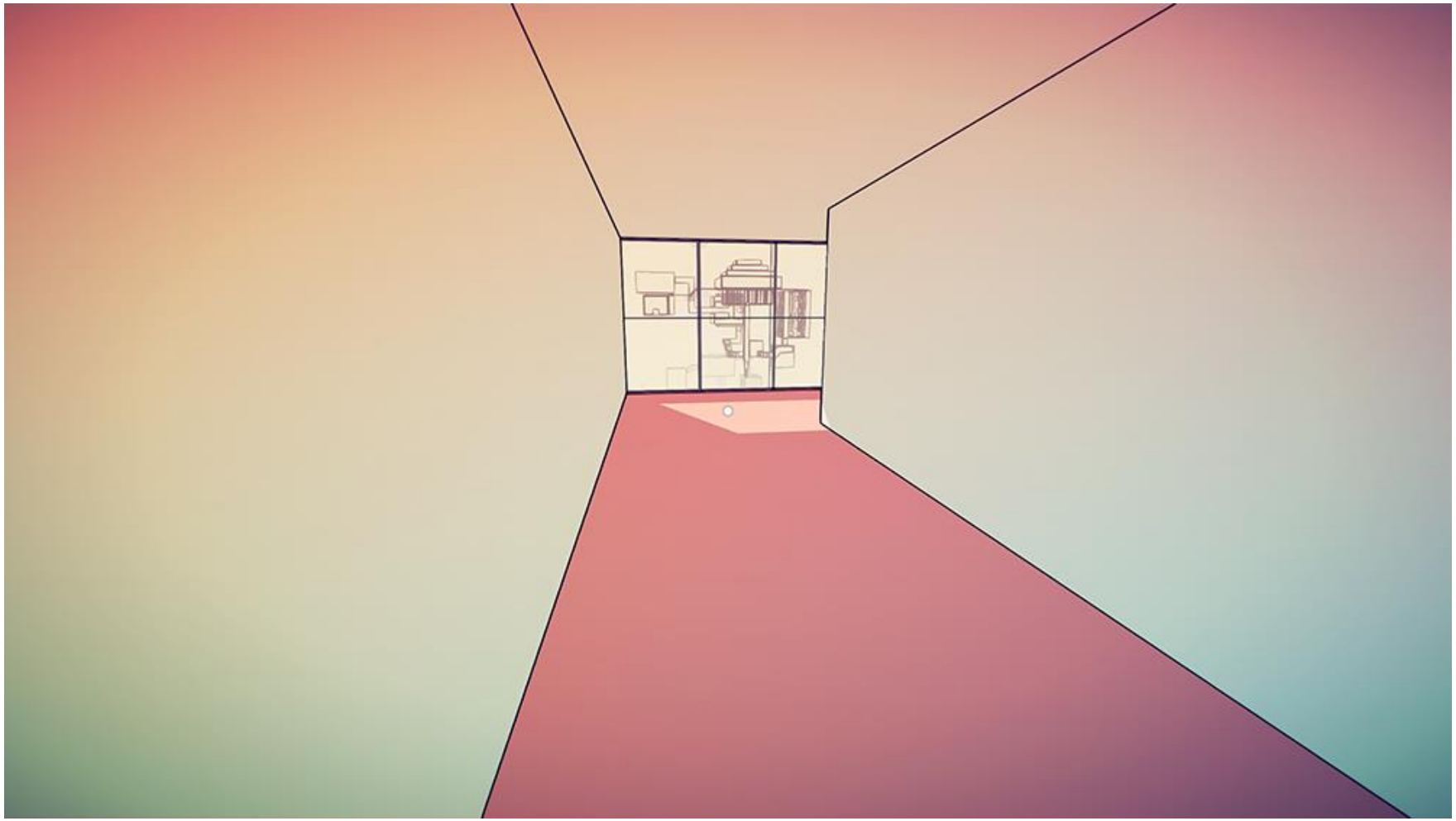
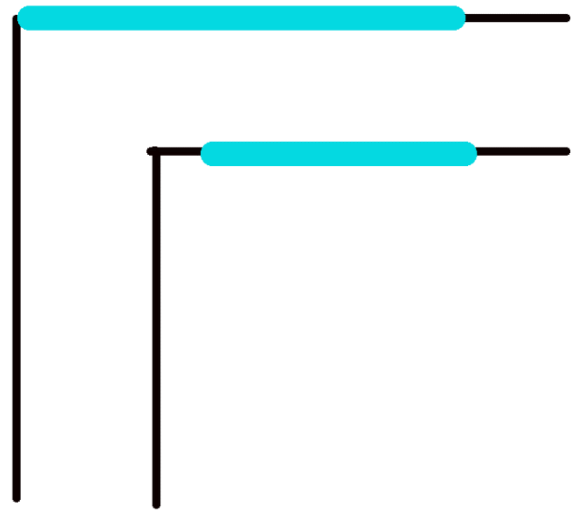
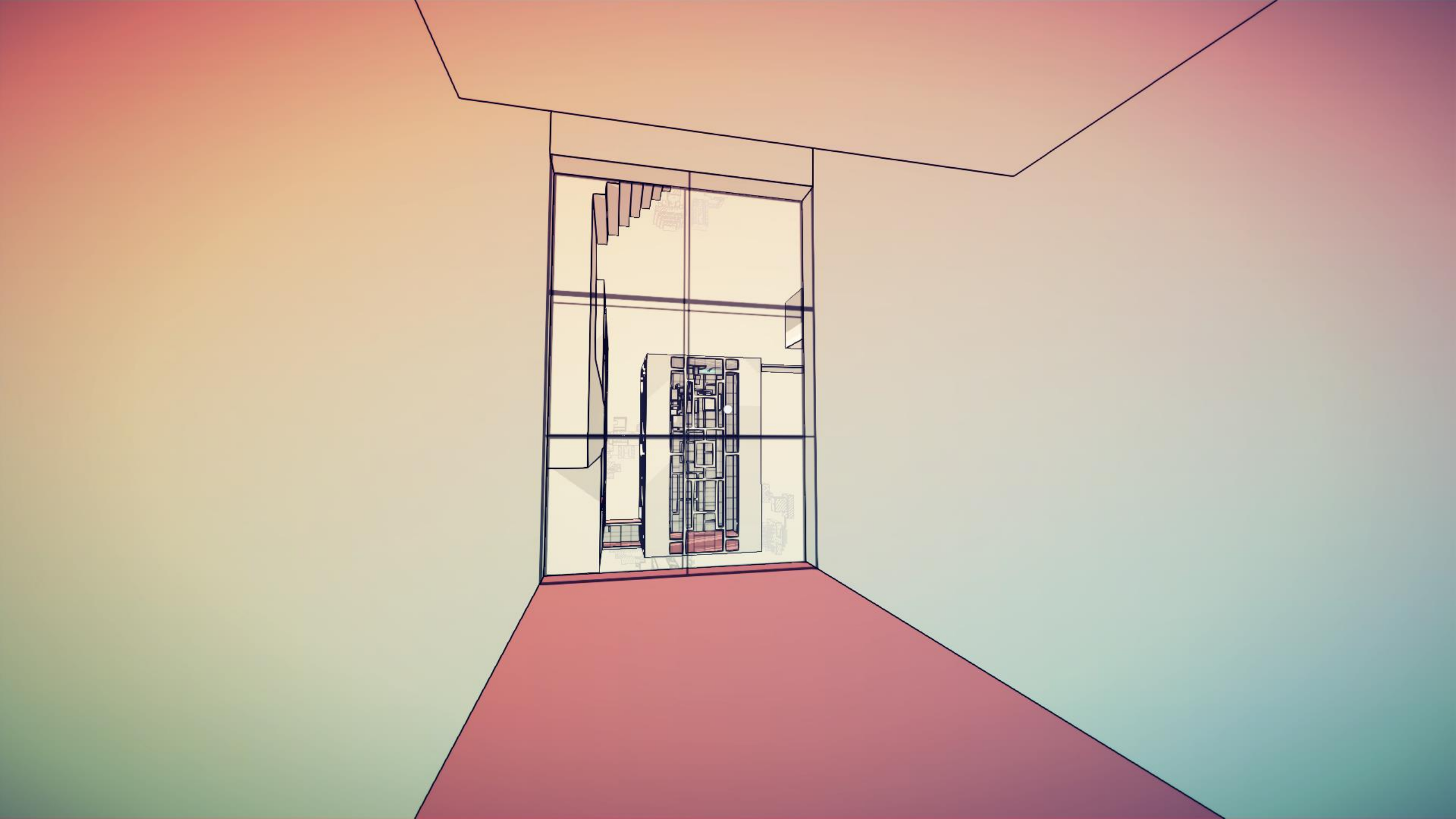
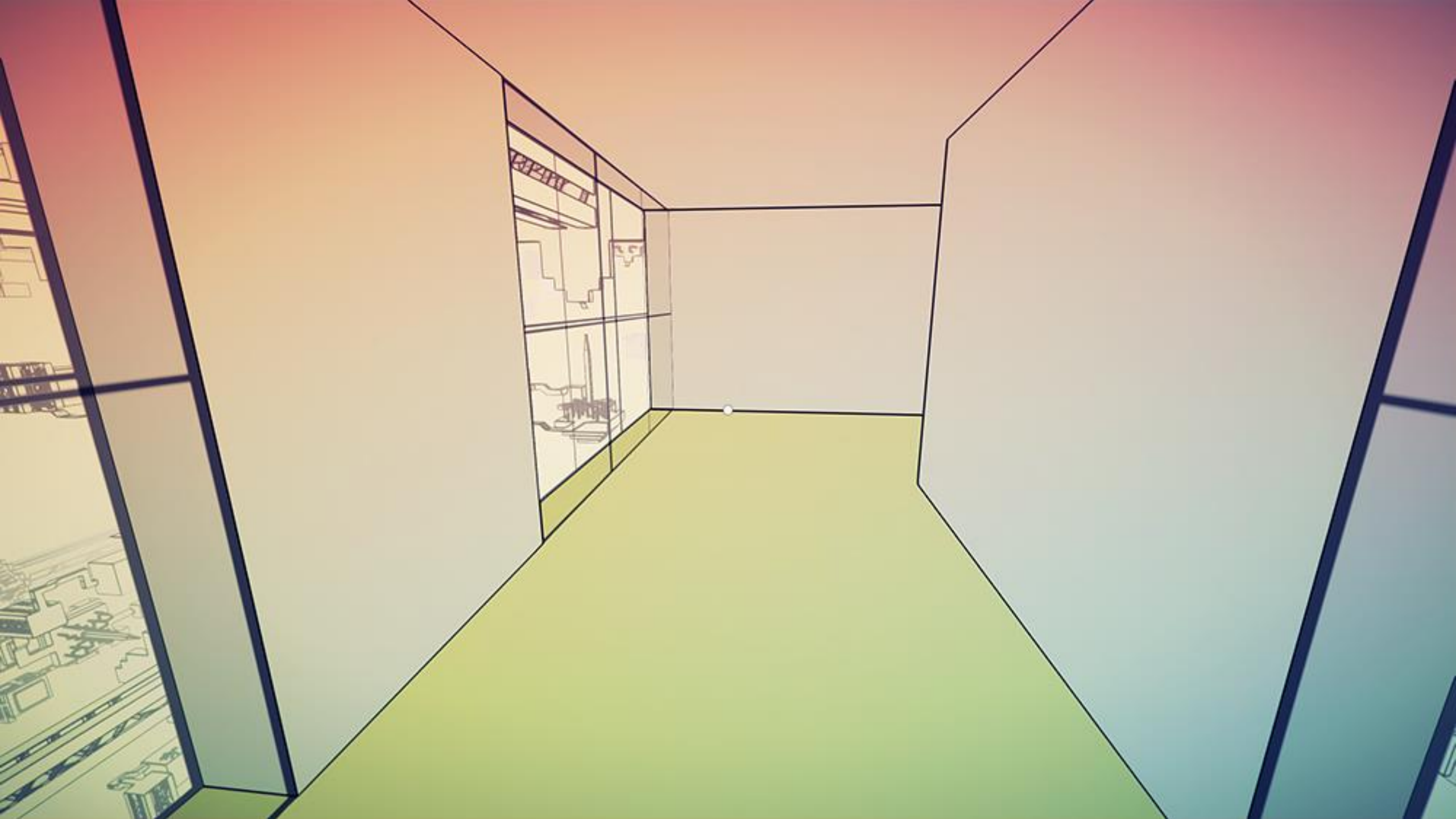


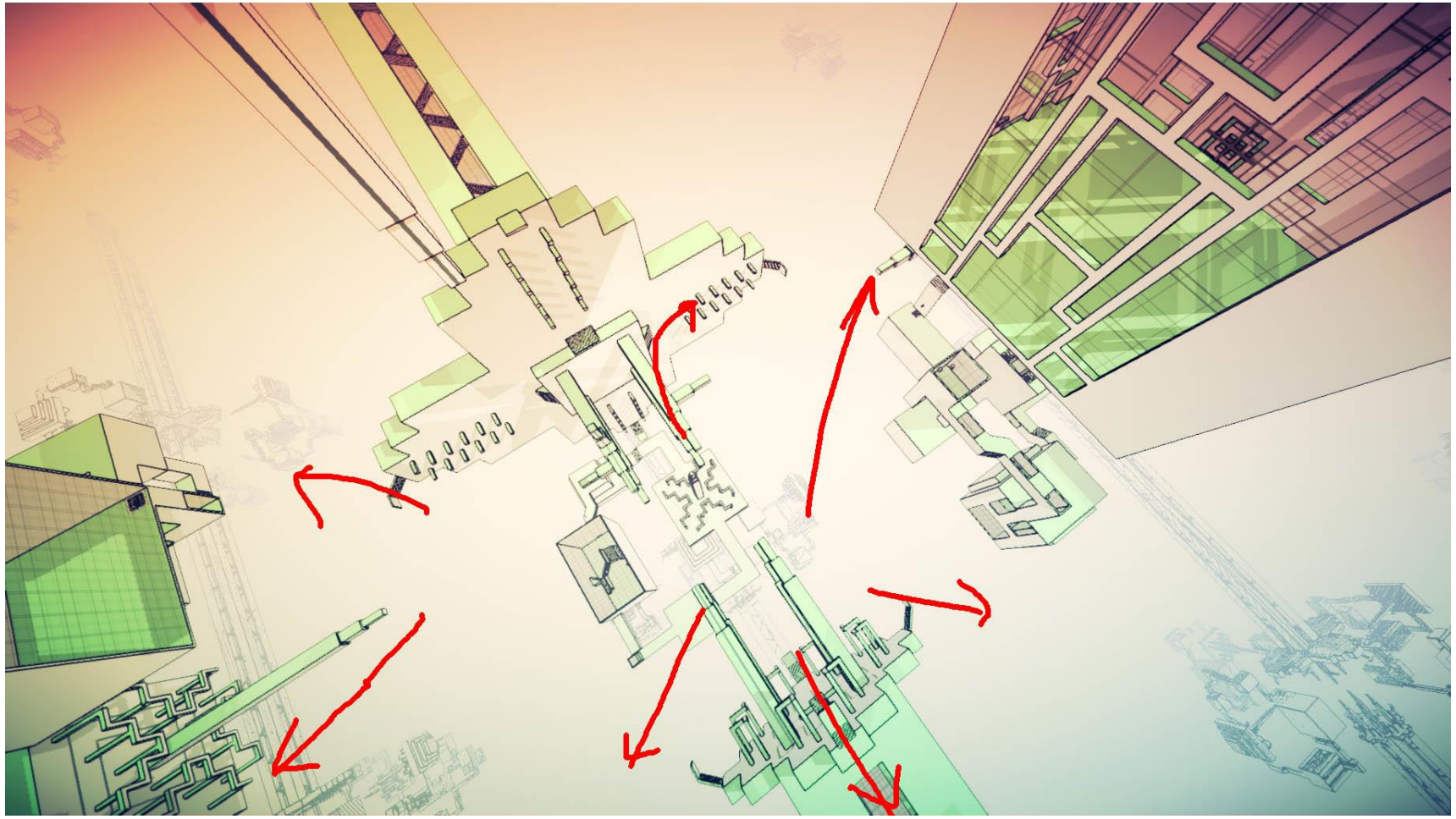




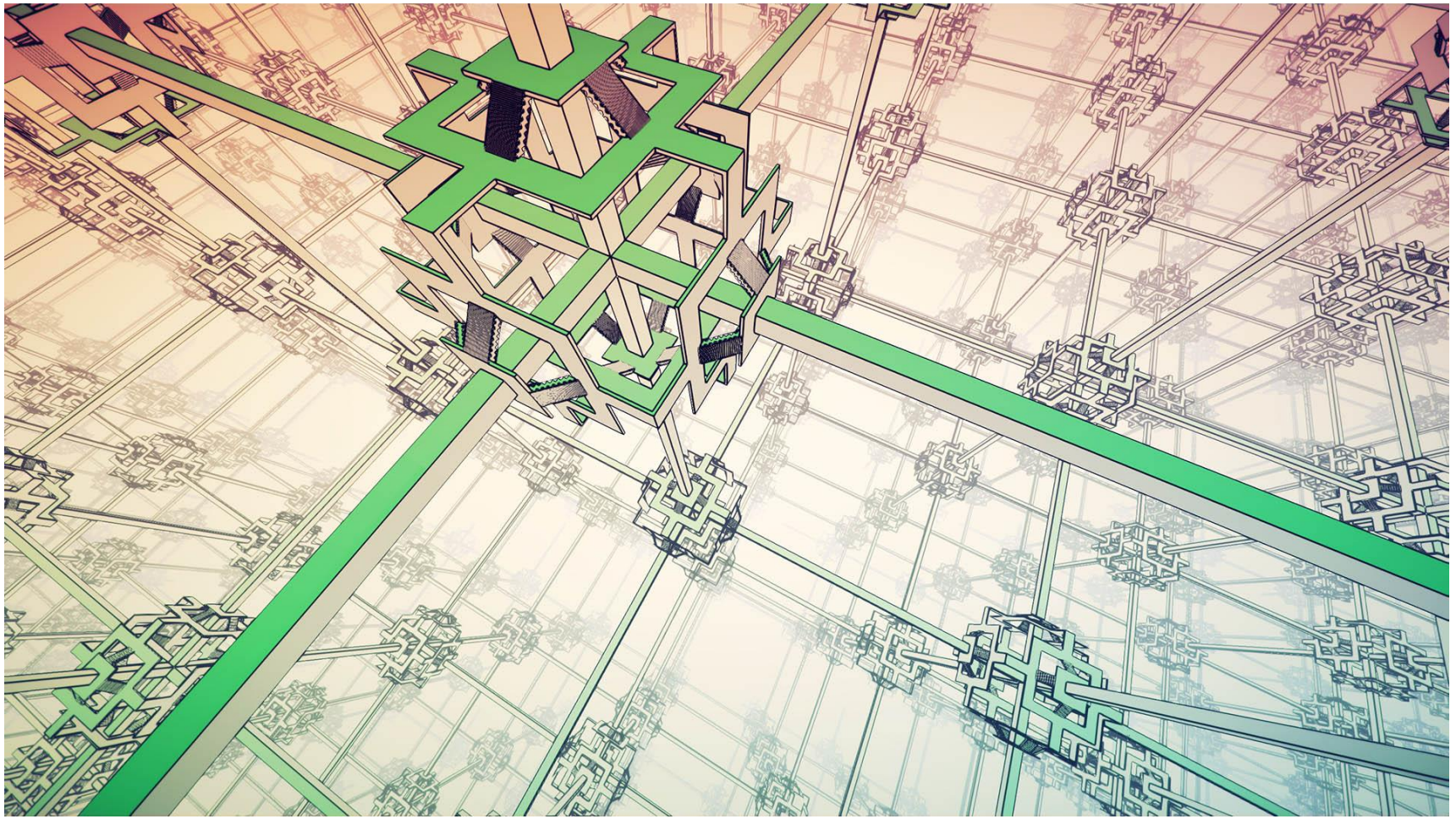


# Summary

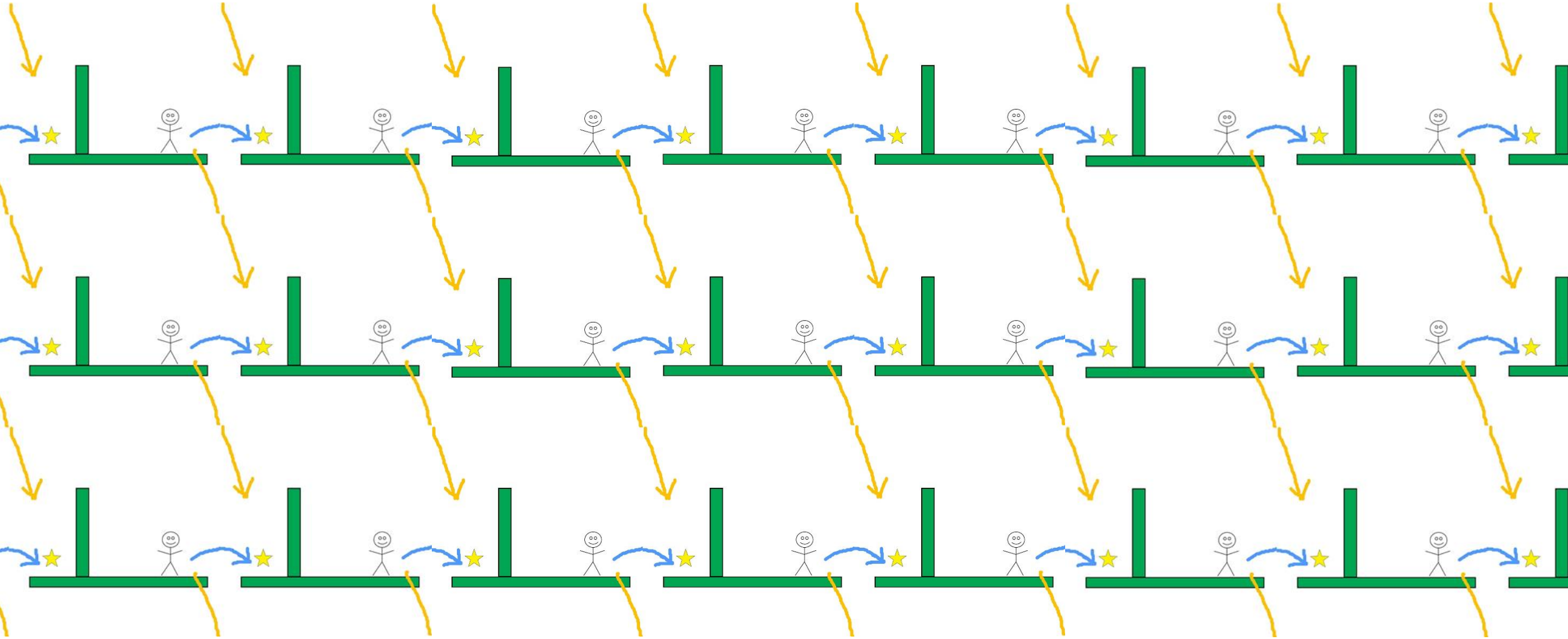
# Embrace the geometry. Don’t work against it.



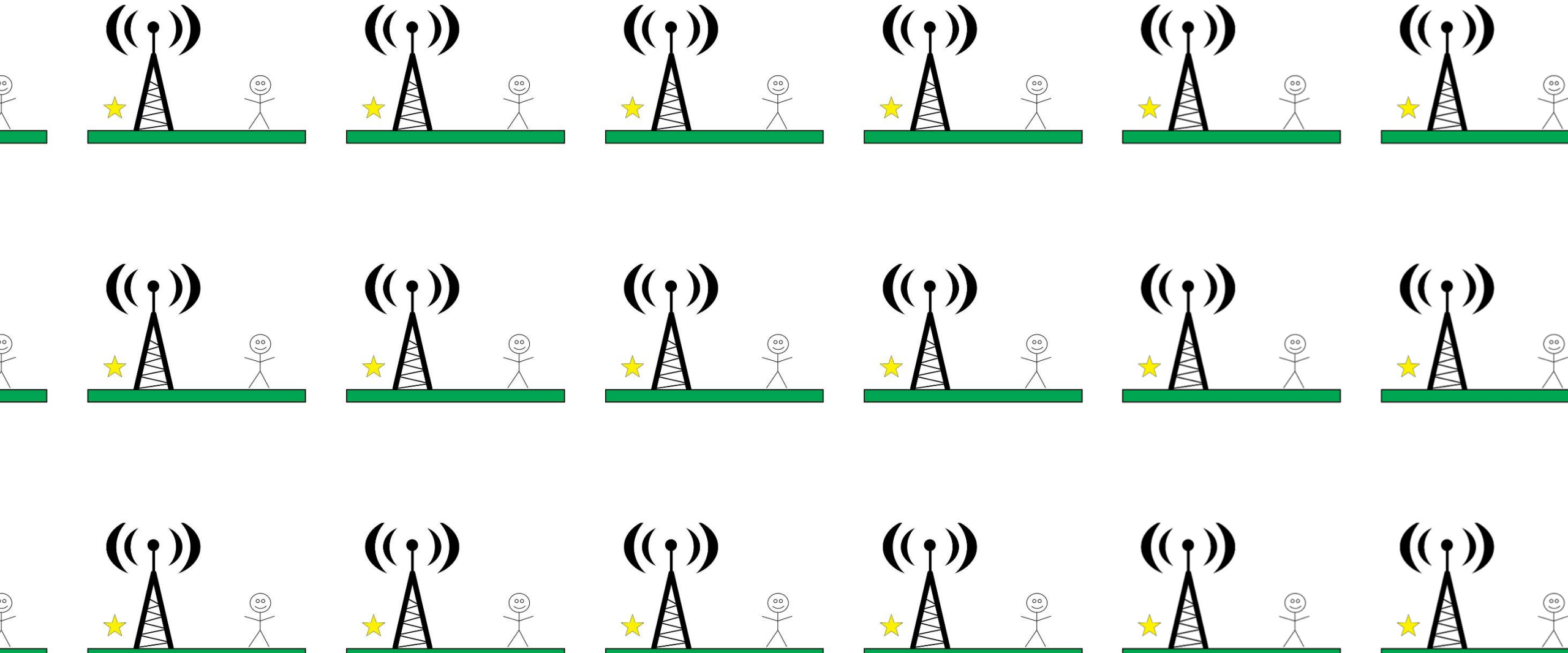
# Unexpected Solutions to Previous Problems



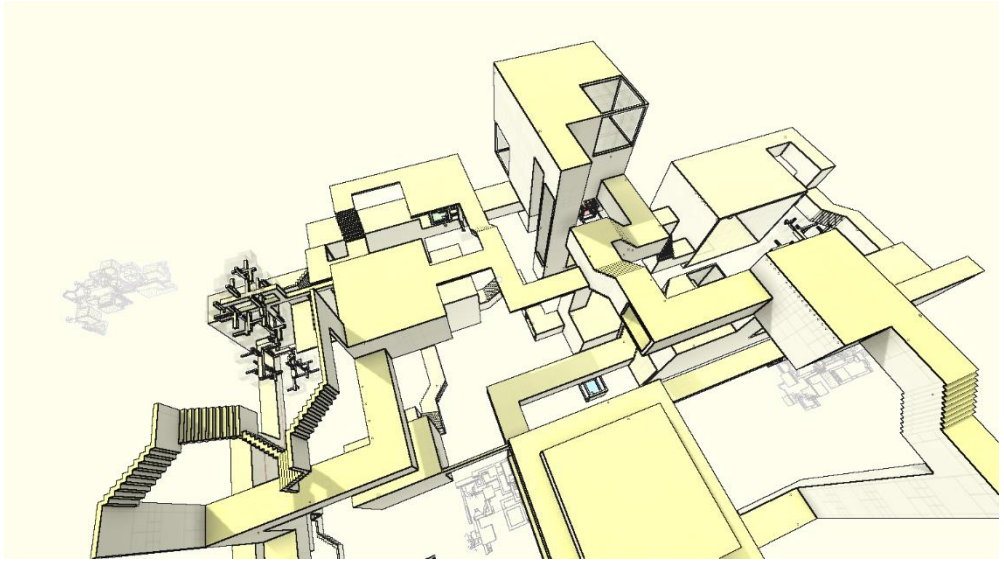
# Rethink Gating

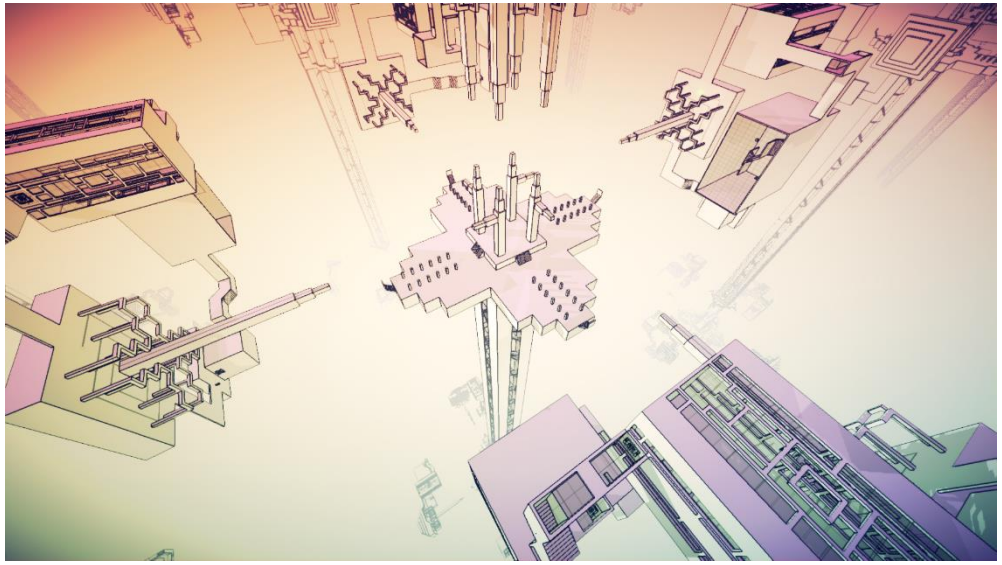


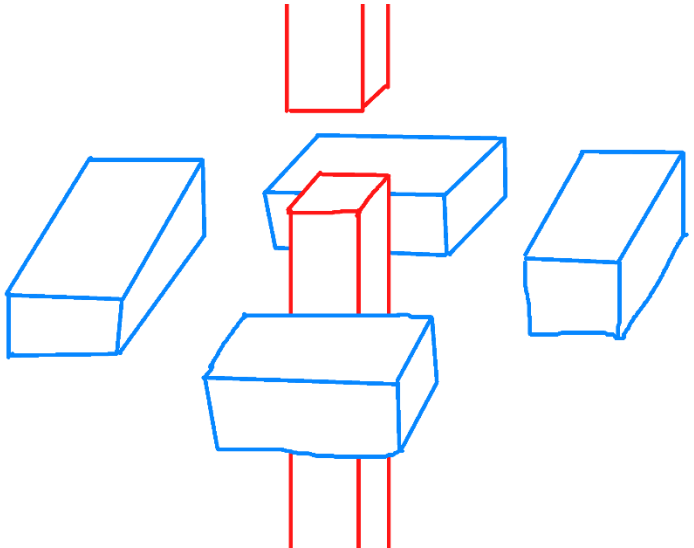
# Rethink Direction



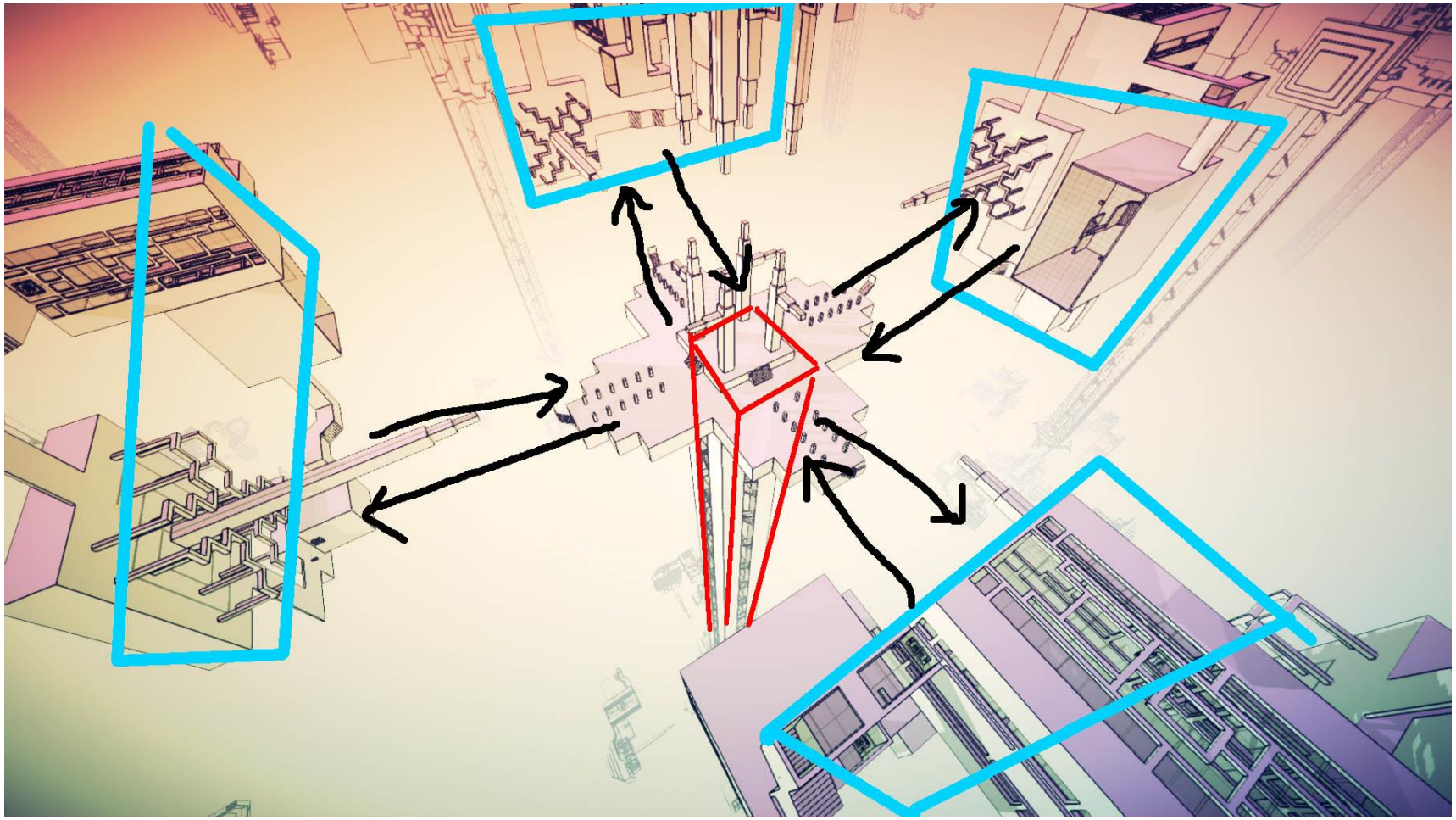
# Macro - Iconic Parti



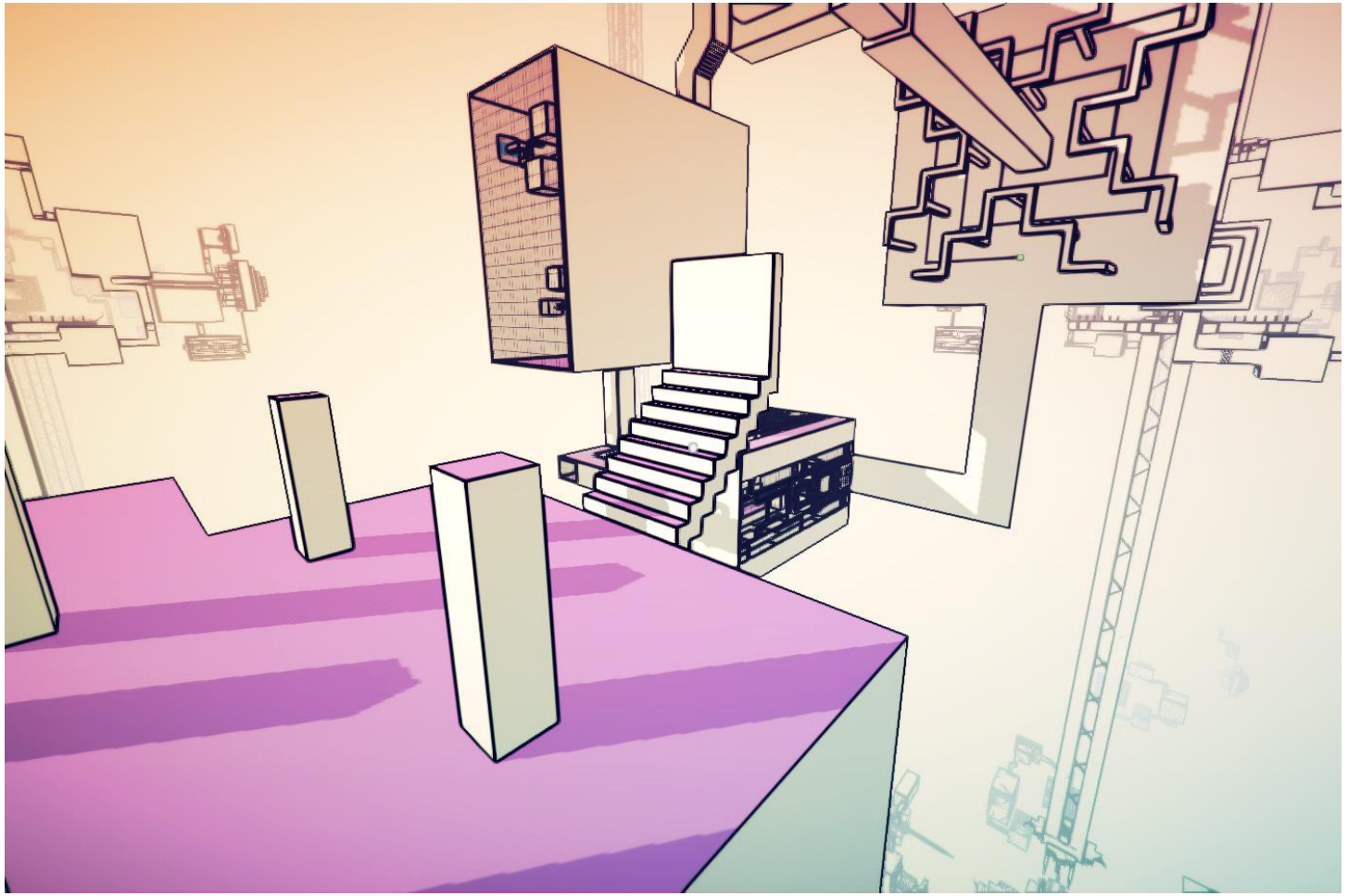




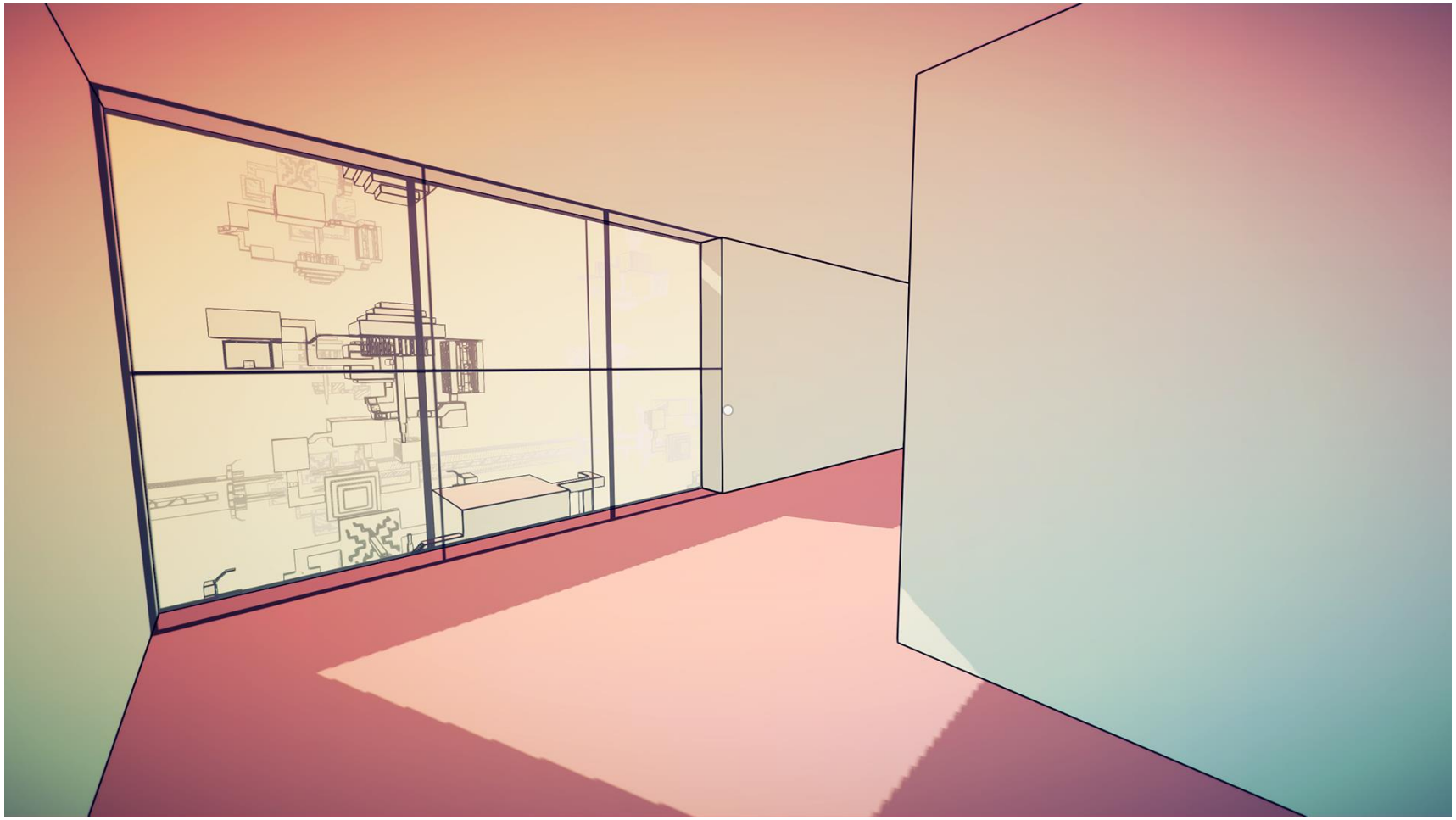
# Macro - Logic in Level

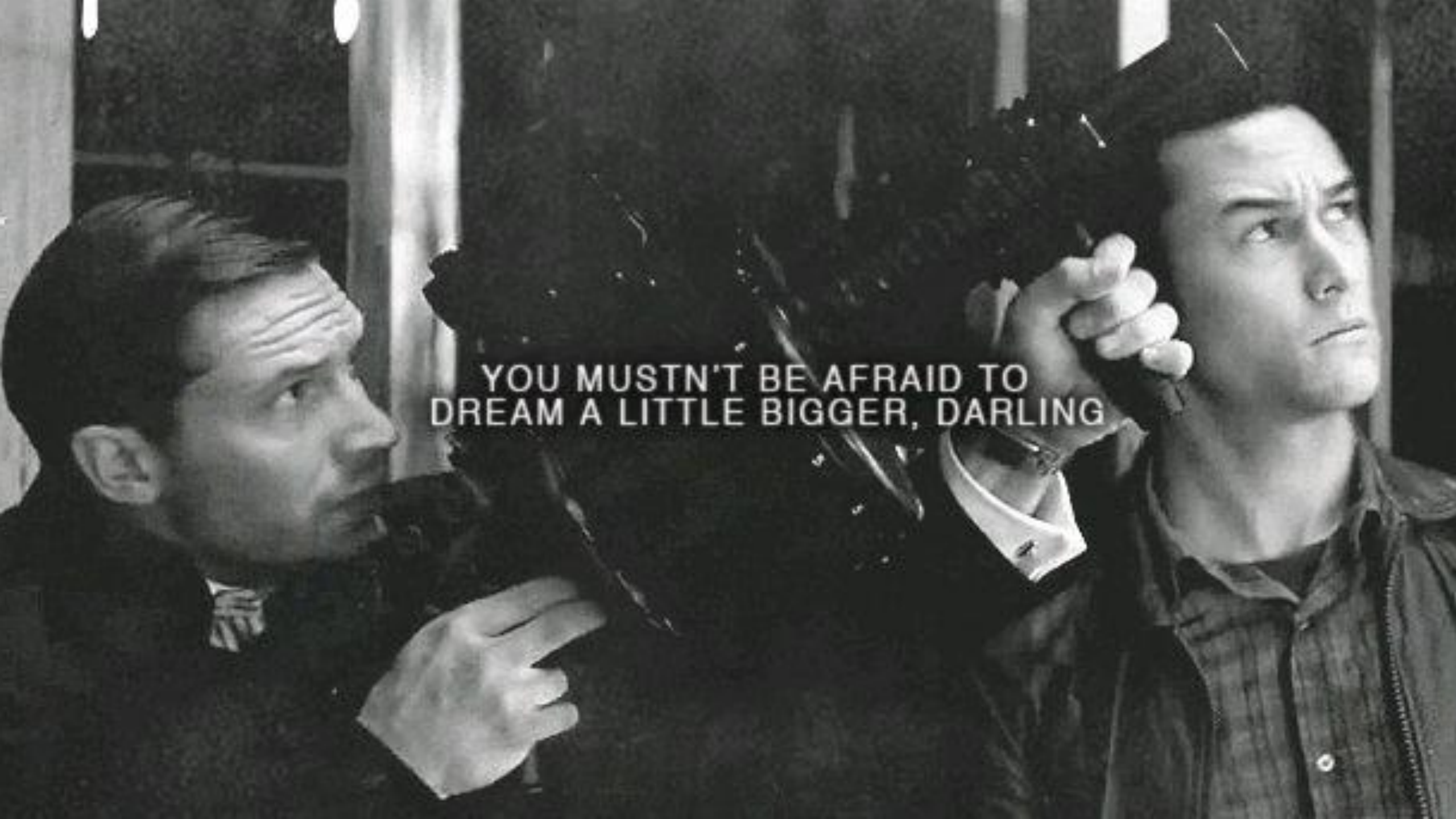


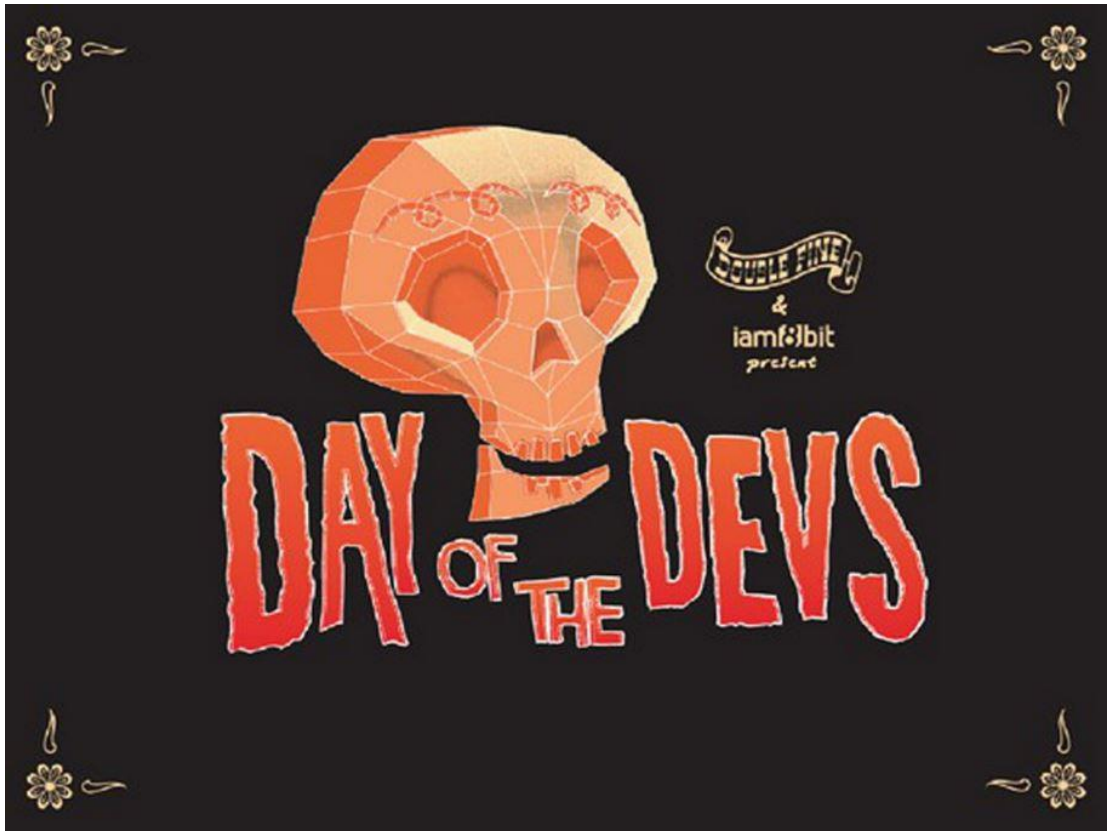
# Micro – Intentional Architecture



# Micro – Patterns in Architectural Elements



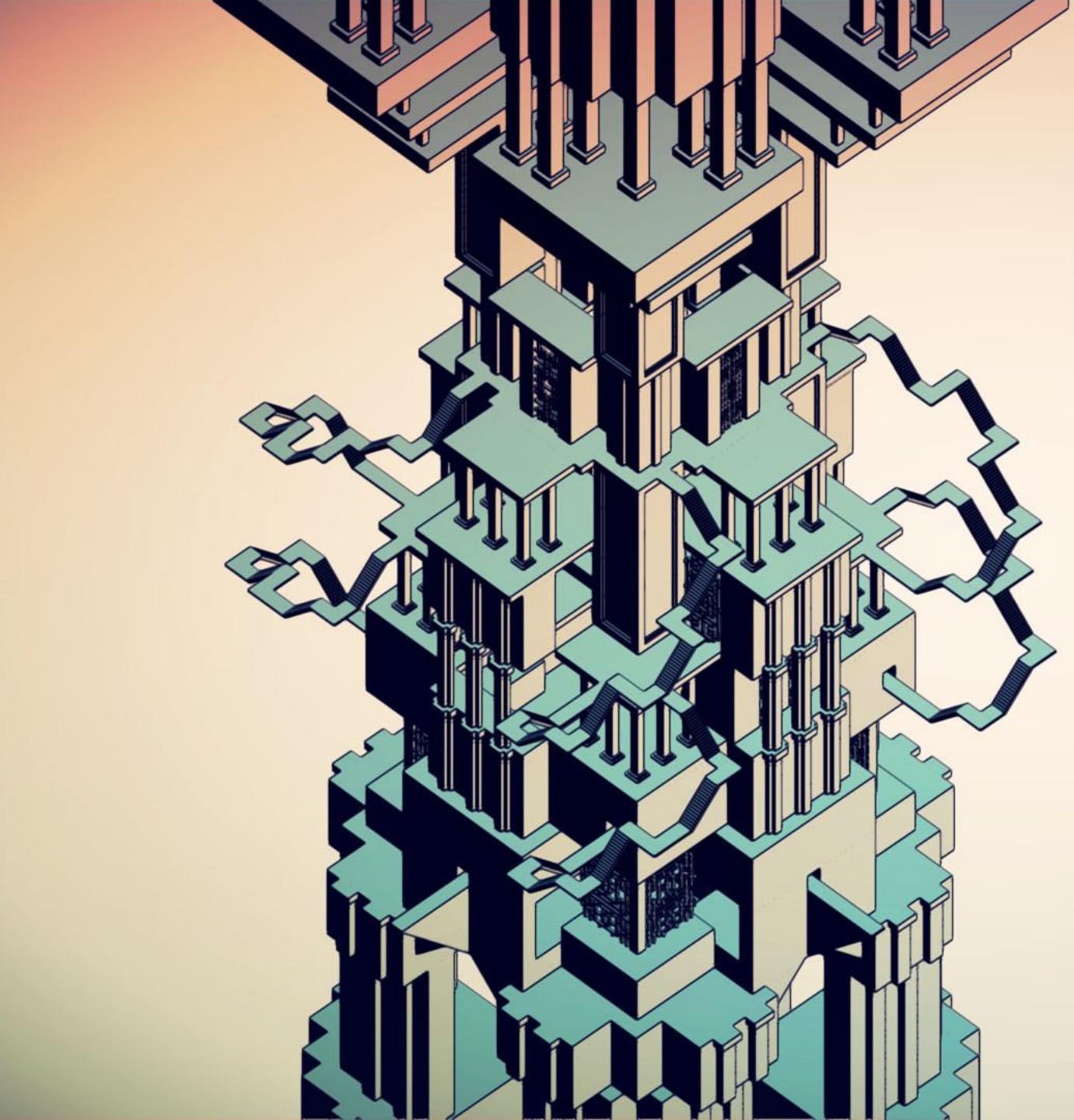

YOU MUSTN'T BE AFRAID TO
DREAM A LITTLE BIGGER, DARLING




Manifold Garden is playable here at GDC!

**Moscone NORTH** – Lower Lobby

**Monday to Thursday:** 10am – 5pm
**Friday:** 10am – 1pm

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