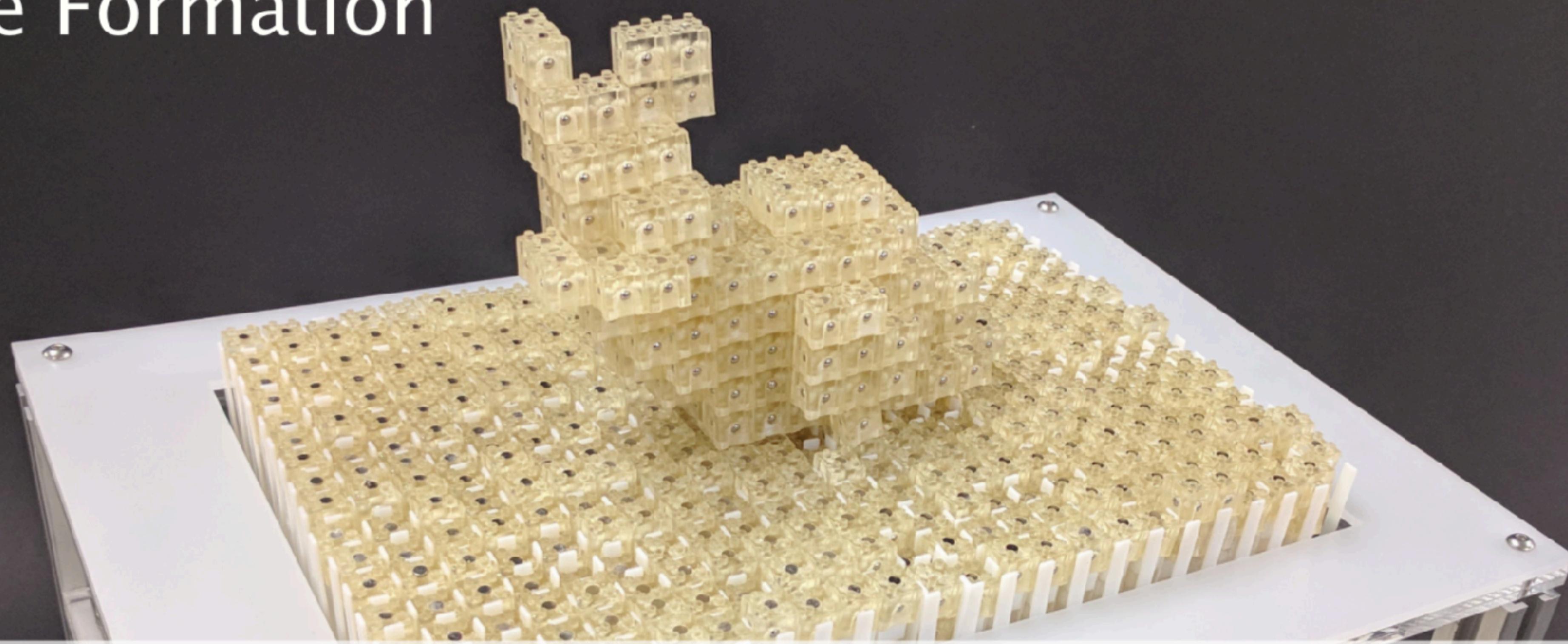




# Dynablock

## Dynamic 3D Printing for Instant and Reconstructable Shape Formation



Ryo Suzuki<sup>1</sup>, Junichi Yamaoka<sup>2</sup>, Daniel Leithinger<sup>1</sup>, Tom Yeh<sup>1</sup>, Mark D. Gross<sup>1</sup>, Yoshihiro Kawahara<sup>2</sup>, Yasuaki Kakehi<sup>2</sup>

University of Colorado Boulder<sup>1</sup>, University of Tokyo<sup>2</sup>



University of Colorado  
Boulder



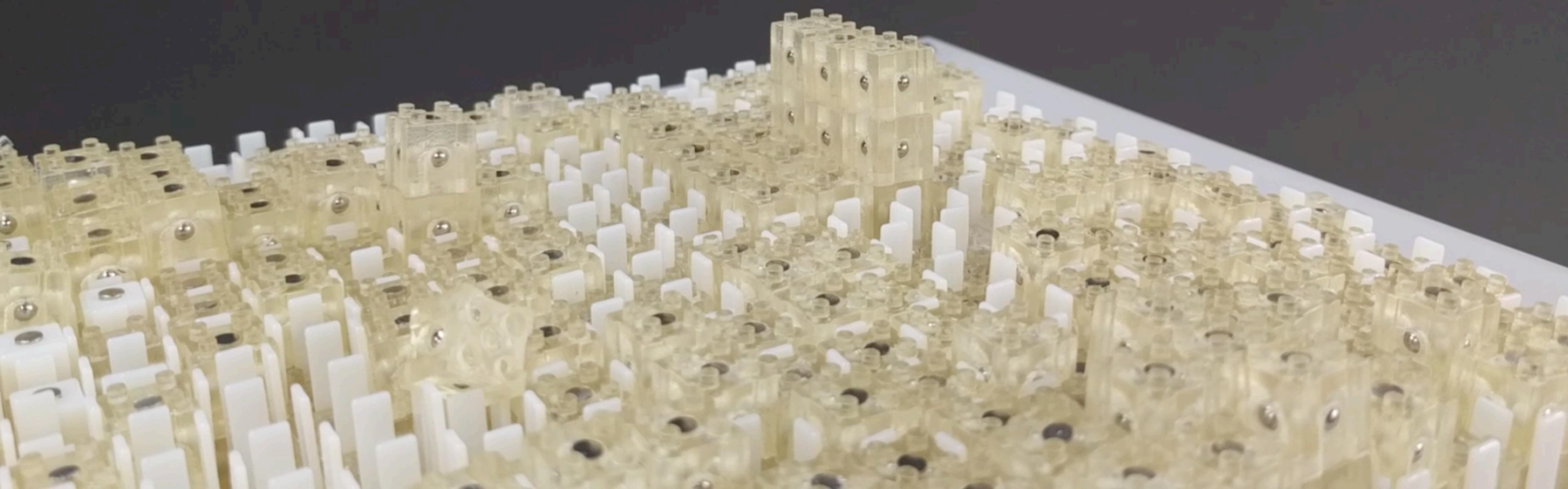
THE UNIVERSITY  
OF TOKYO

What if 3D printers could print  
a physical object **in seconds**?

What if the object could be  
disassembled and **reconstructed**  
as a new object like clay?



3D printinter as  
**an Interactive medium,**  
not a fabrication device



1. Summary

## 2. Related Work

3. Dynamic 3D Printing: Design Architecture

4. Dynablock: System and Implementation

5. Limitations and Future Work



*“The **Ultimate Display** would, of course, be a room within which  
the computer can control the existence of matter.”*

*“The Ultimate Display” by Ivan Sutherland, 1965*

# PERFECT RED PERFECT SPHERE

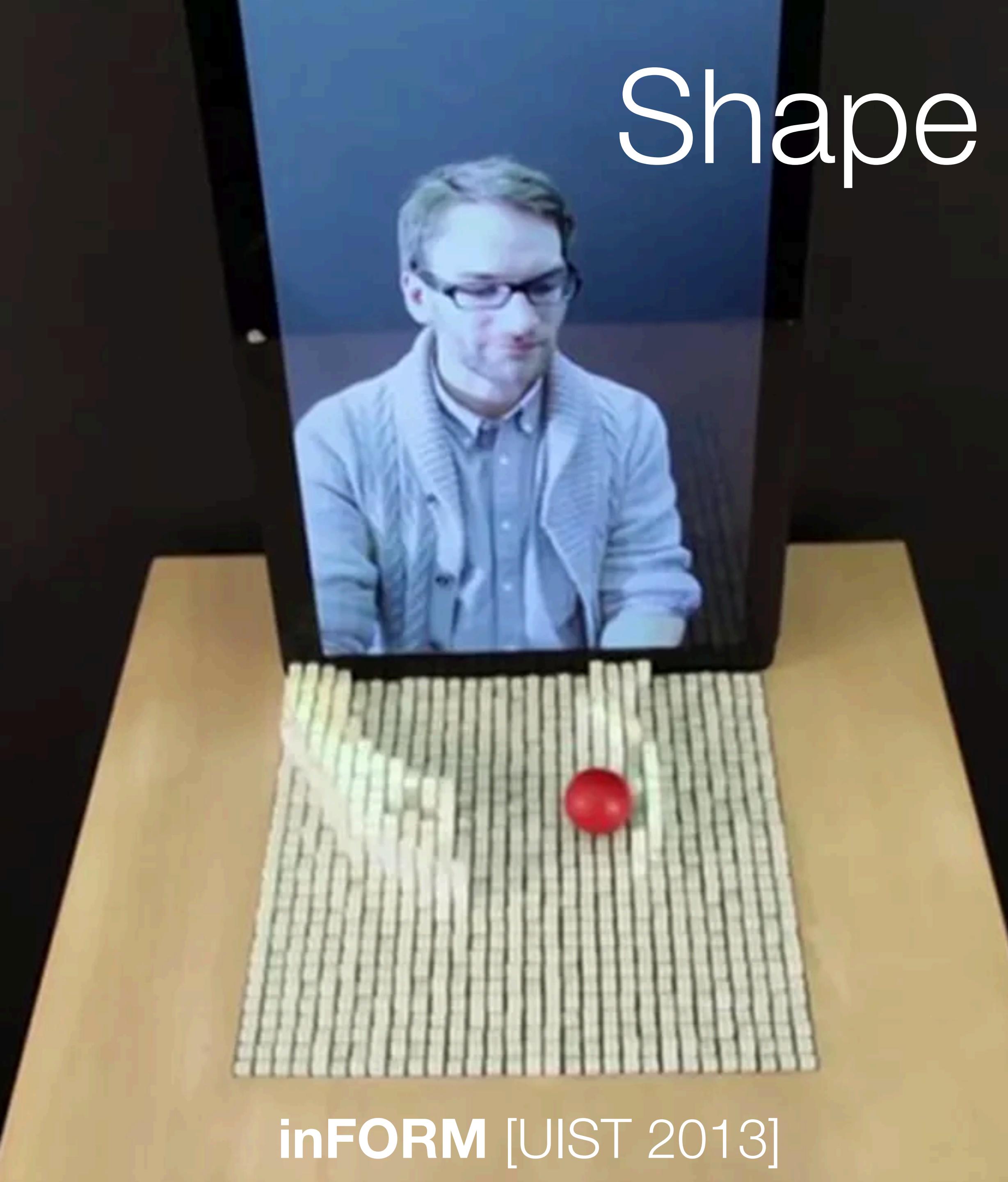


A grayscale photograph showing a person's hand reaching towards a glowing red sphere. The sphere is centered in the frame, with a bright white glow emanating from its surface. A thin white line points from the word "SPHERE" in the title down to the sphere. The background is dark and textured.

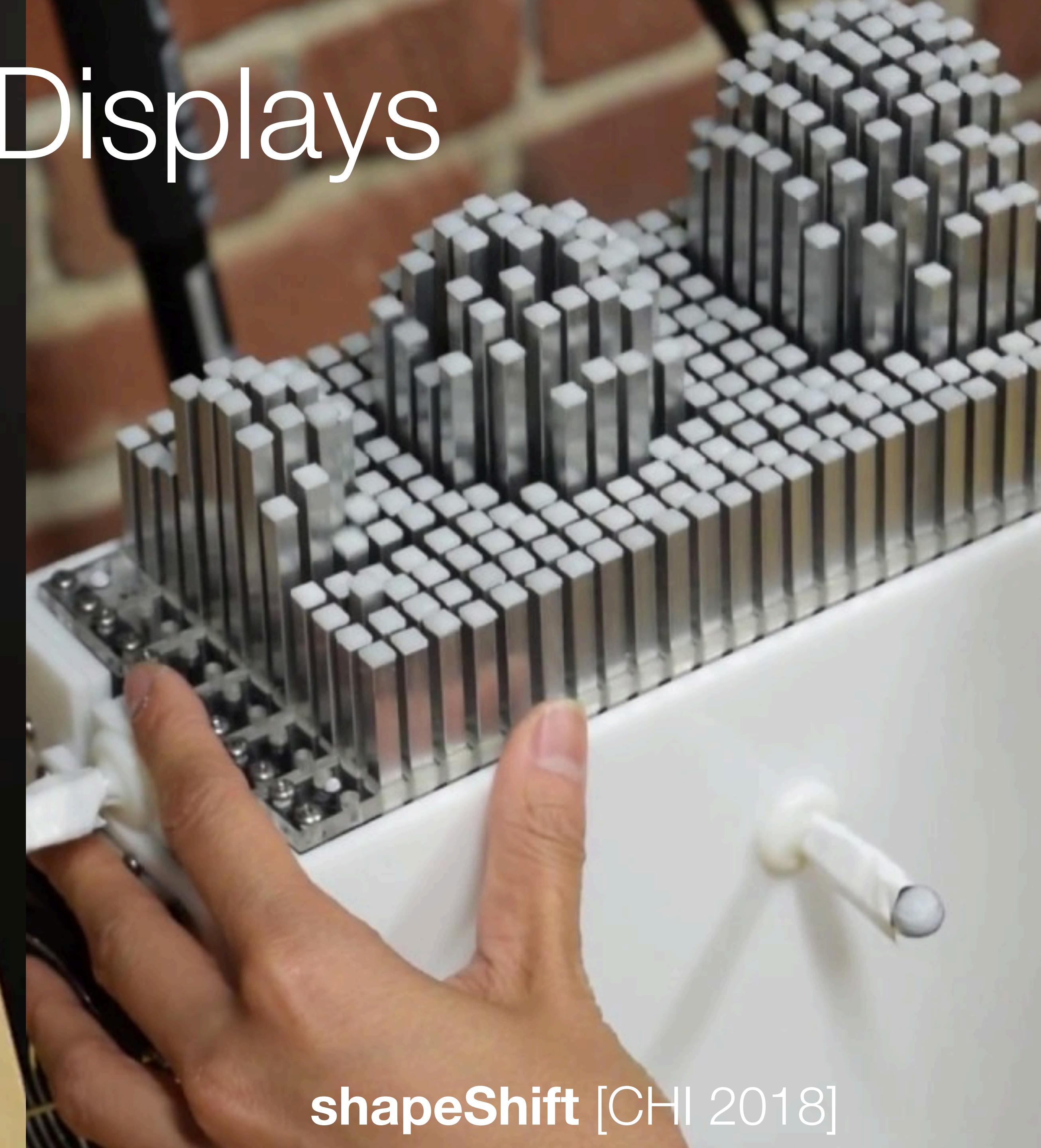
*“Radical Atoms is our vision of human interactions with dynamic physical materials that can transform their shape.”*

*“Radical Atoms ” by Hiroshi Ishii et al, 2012*

# Shape Displays



**inFORM** [UIST 2013]



**shapeShift** [CHI 2018]

# Shape Displays

**Only 2.5D shape + Not graspable**

# Constructive Assembly

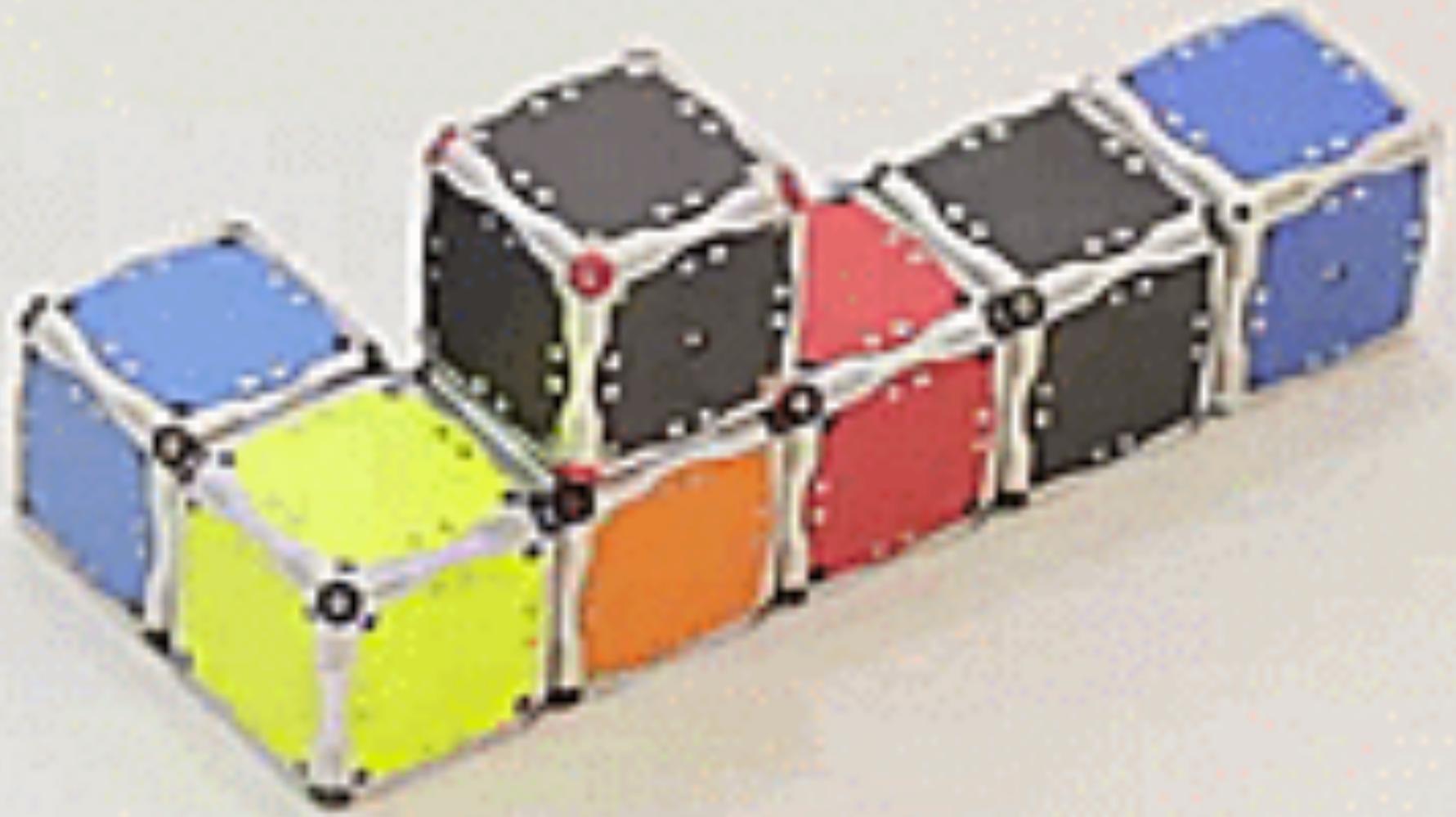


**Kinetic Blocks** [UIST 2015]

# Constructive Assembly

**Limited block size + resolution**

# Self-Reconfigurable Modular Robots



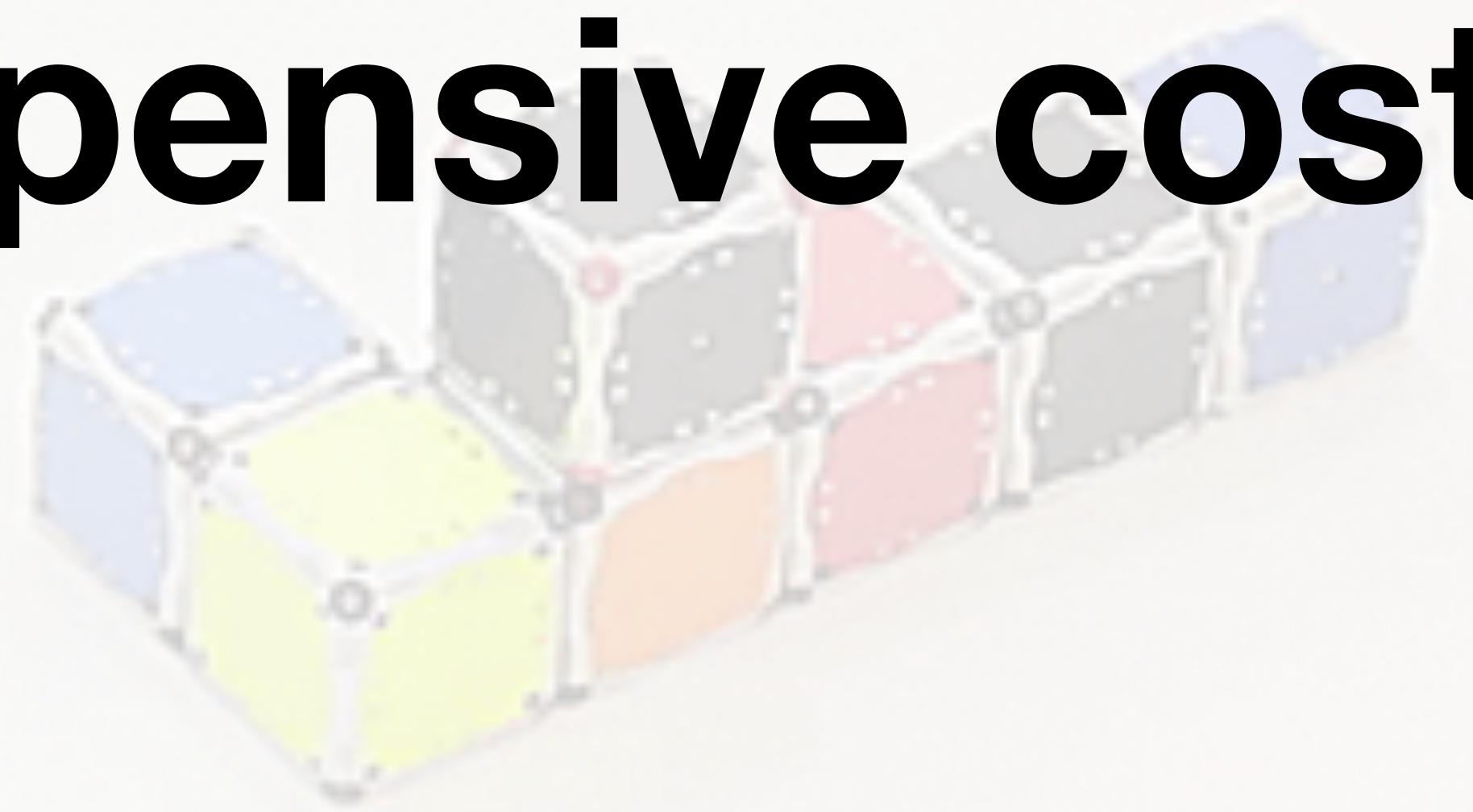
**M-Blocks** [IROS 2013]



**Robotic Assembly** [ISS 2017]

# Self-Reconfigurable Modular Robots

**Expensive cost / Scalability issue**

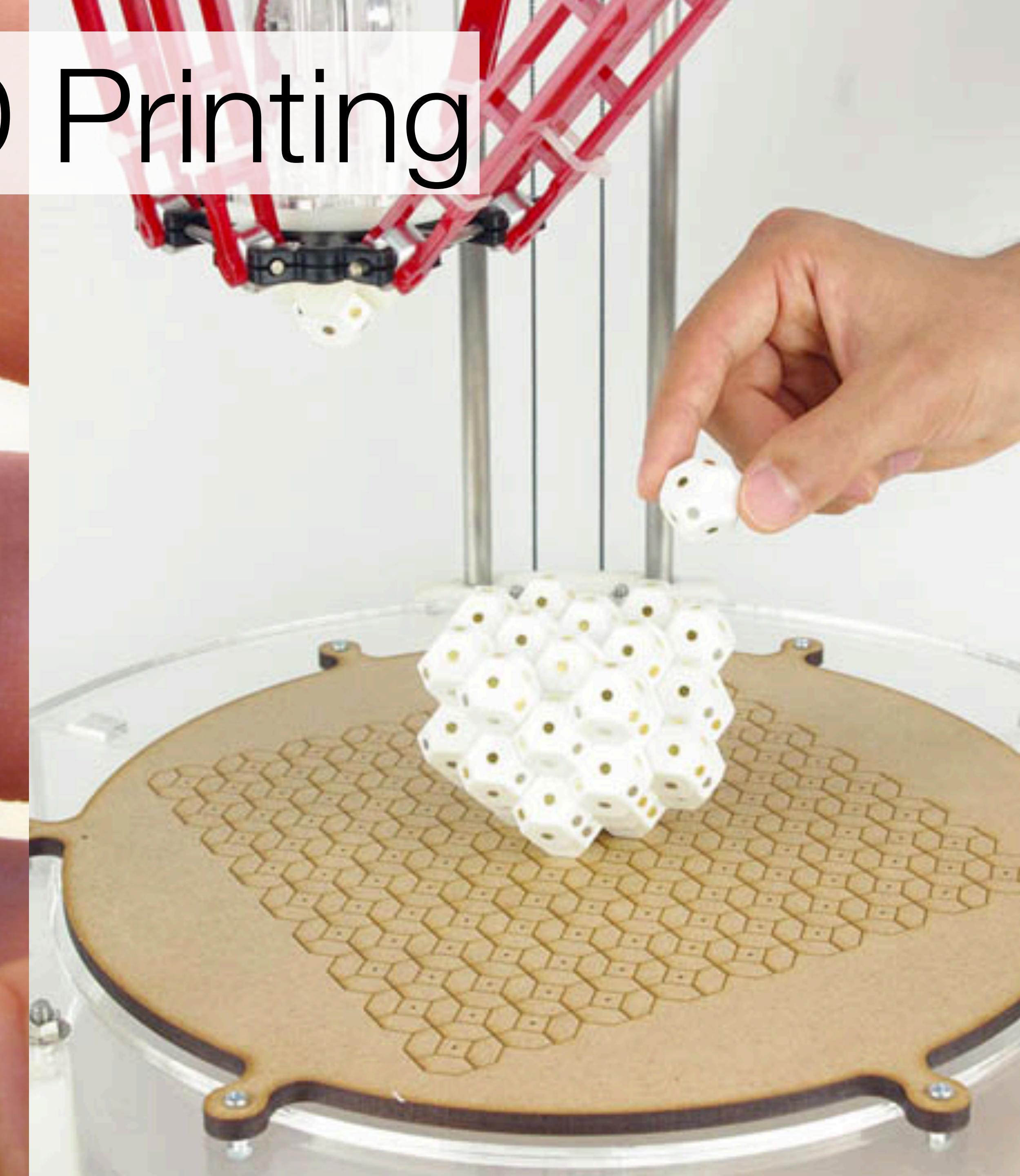


M-Blocks [IROS 2013]



Robotic Assembly [ISS 2017]

# Digital 3D Printing



# Digital 3D Printing

## Slow Printing Speed

1. Summary
2. Related Work
3. Dynamic 3D Printing
4. Dynablock: System and Implementation
5. Limitations and Future Work

# **Graspable**

Object

# **Instant**

Printing Time

# **Arbitrary**

3D Shape

# **Reconstructable**

Materials

**Graspable**  
Object

**Instant**  
Printing Time

**Arbitrary**  
3D Shape

**Reconstructable**  
Materials

**Graspable**  
Object

**Instant**  
Printing Time

**Arbitrary**  
3D Shape

**Reconstructable**  
Materials

# Graspable

Object

Instant  
Printing Time

Arbitrary  
3D Shape

# Reconstructable

Materials

# Graspable

Object

## Instant

Printing Time

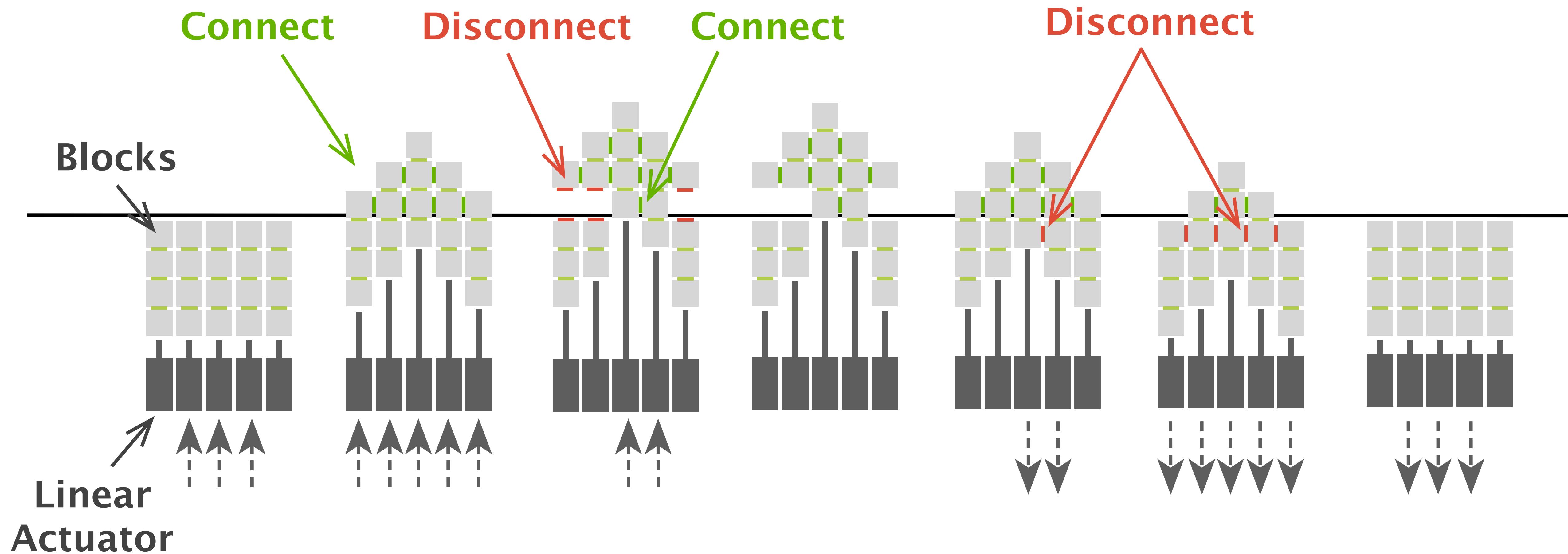
## Arbitrary

3D Objects

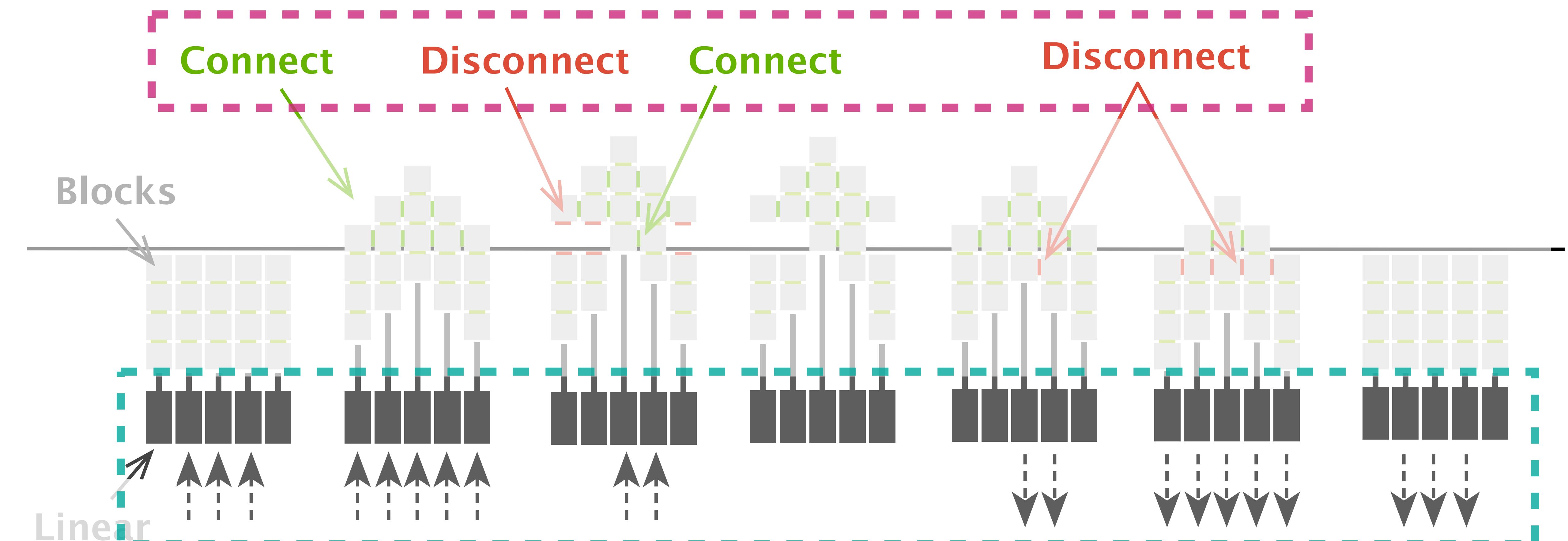
# Dynamic 3D Printing

## Reconstructable

Materials

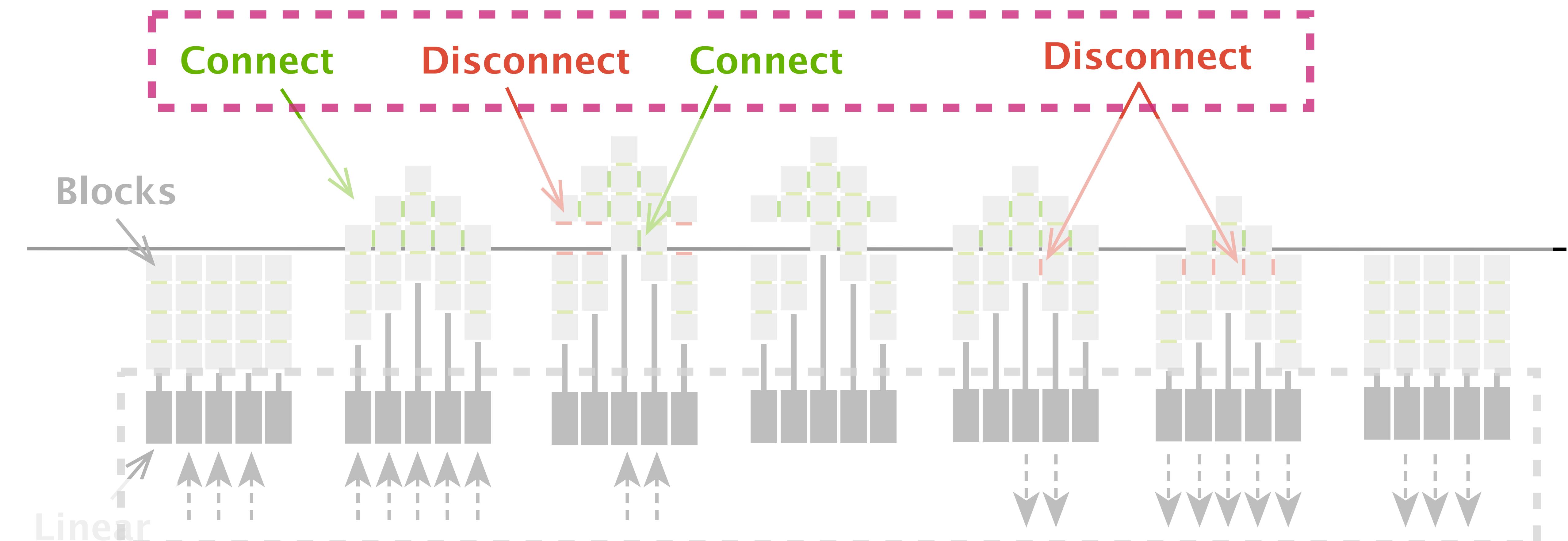


# Switchable Connector



Parallel Assembler

# Switchable Connector

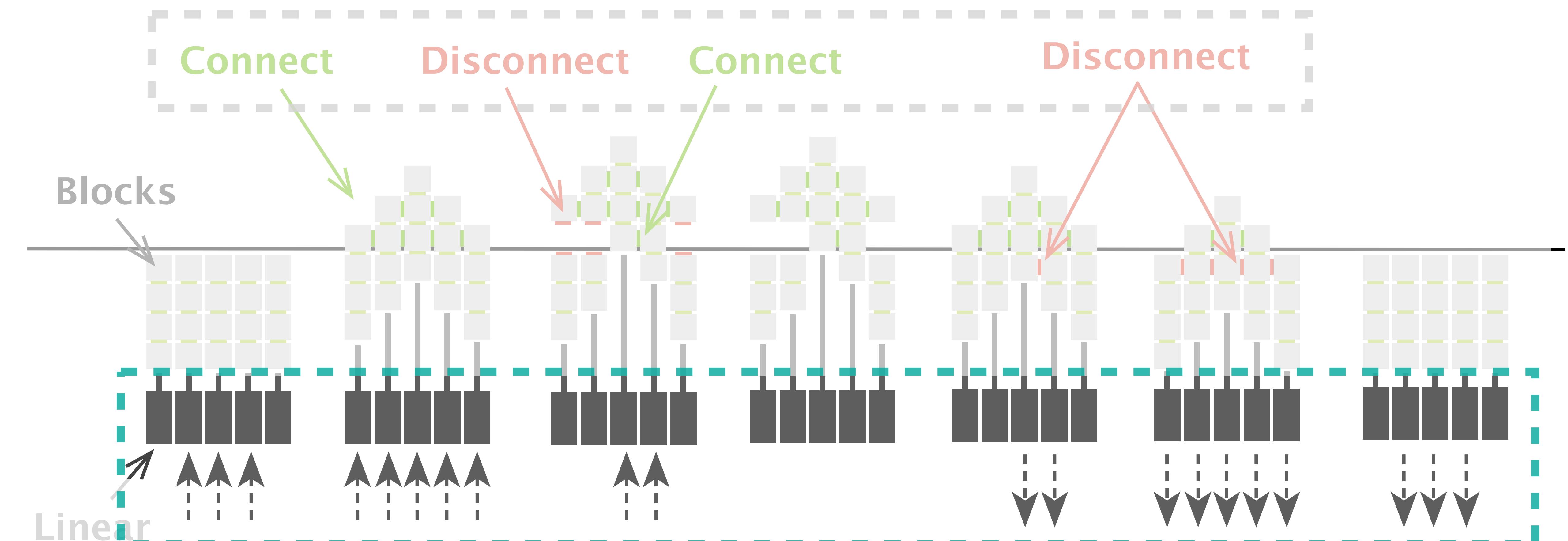


Parallel Assembler

# Switchable Connector

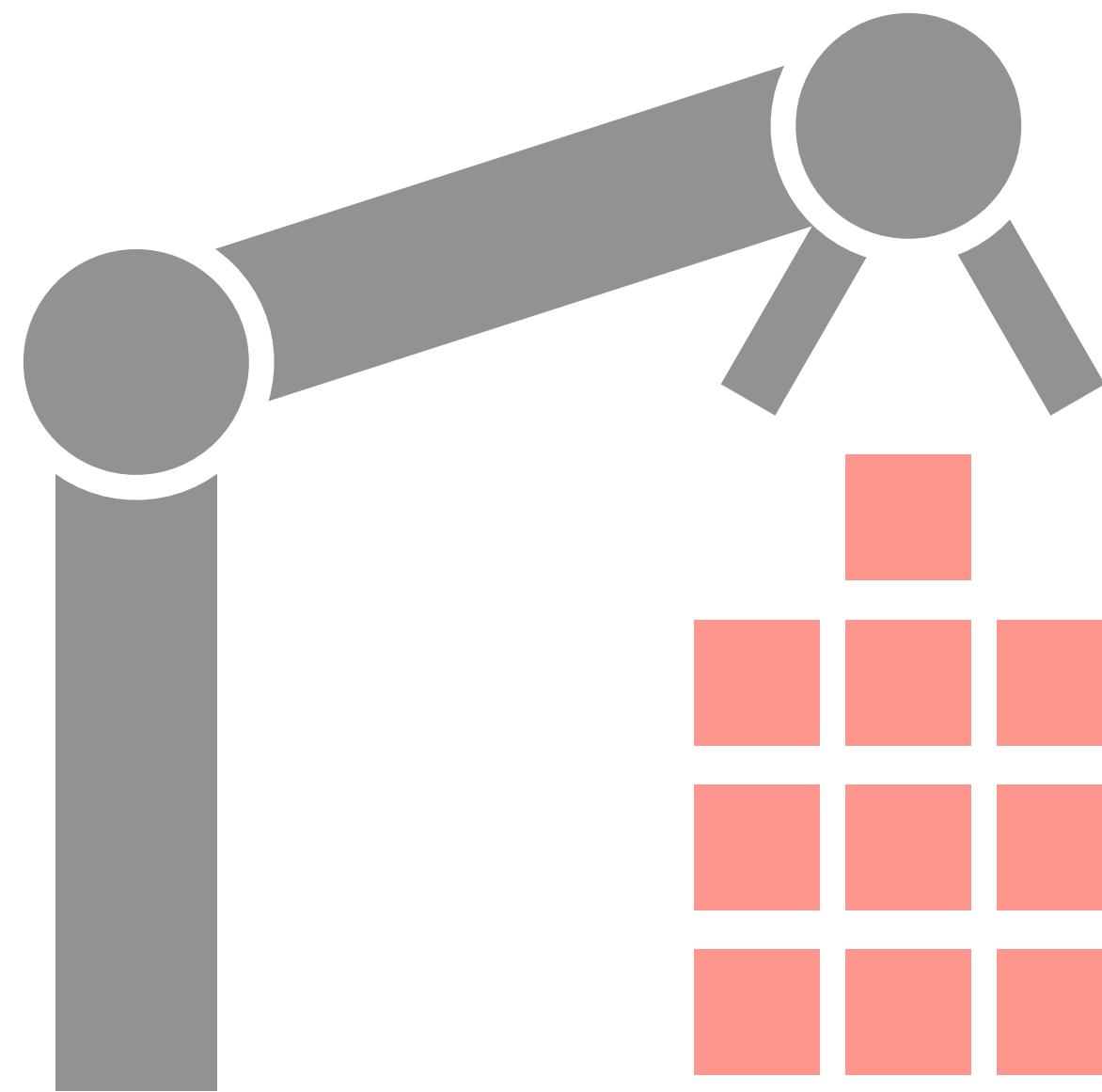
Type	Connection	Disconnection	Time
Mechanical Latching	Push / Rotate	Pull / Rotate	1 - 10s
Permanent Magnet	None	Push / Rotate	0.1 - 1s
Electromagnet	Run Current	Turn off Current	0 - 0.1s
Electrostatic	Apply Voltage	Turn off Voltage	0 - 0.1s
Electro-permanent magnet	Run Pulse Current	Pulse Current	0 - 0.1s
Thermal bonding	Heat and Cool	Heat	1 - 30s
Photochromic bonding	Expose Visible Light	Expose UV Light / Heat	1 - 10s
Dry Adhesion	Surface Contact	Reduce the Contact Area	1 - 10s

# Switchable Connector



Parallel Assembler

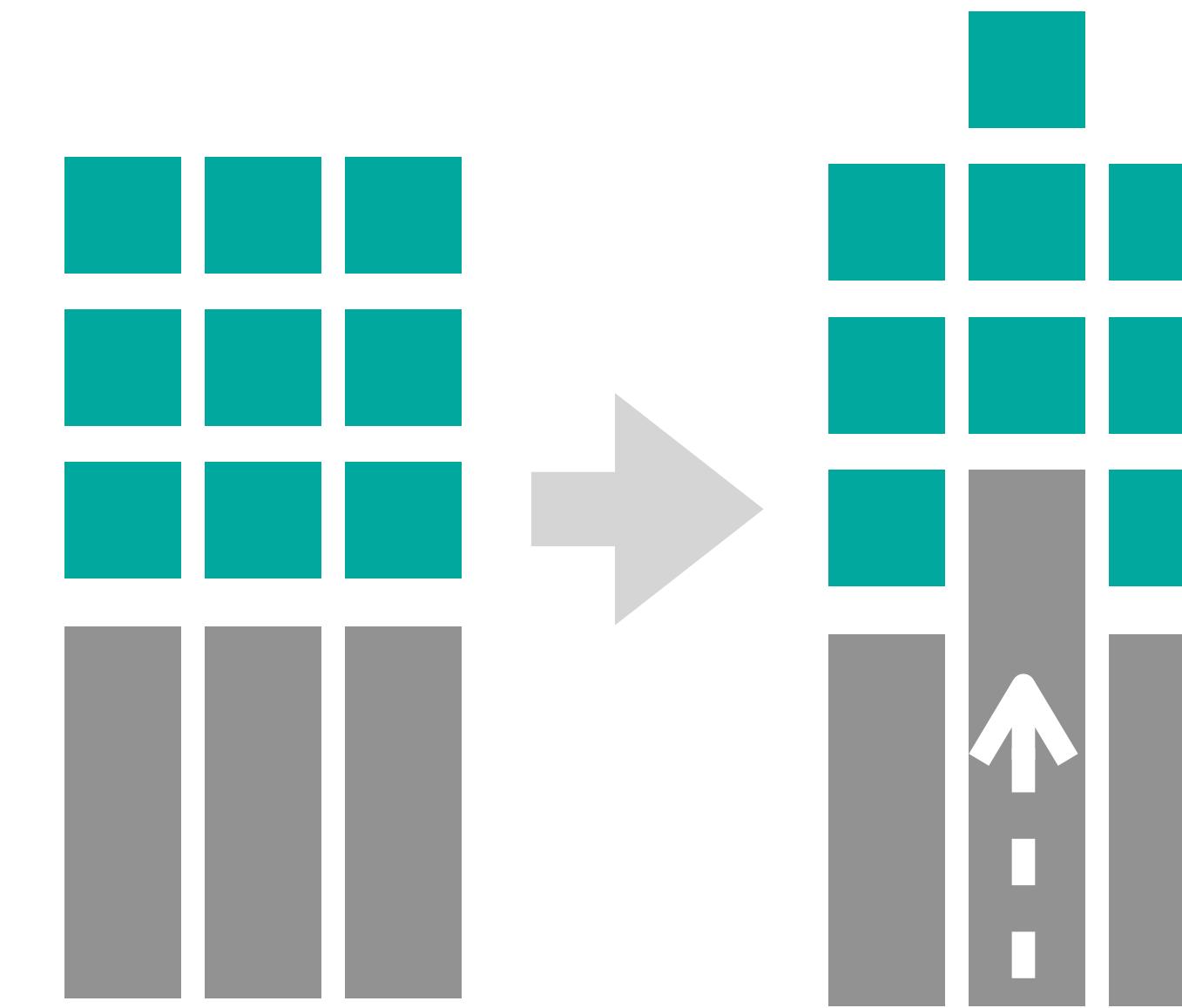
# Linear Assembler



$O(N^2)$

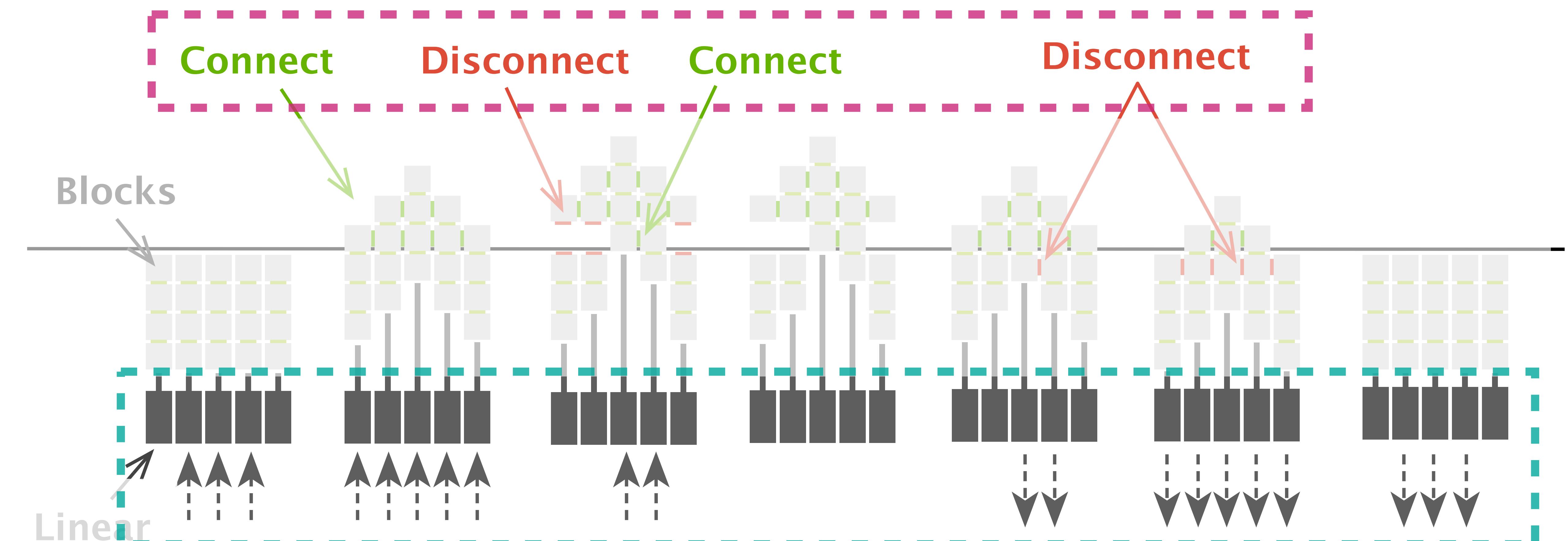
Building Time  
One Layer  
 $(N \times N)$

# Parallel Assembler



$O(1)$

# Switchable Connector



Parallel Assembler

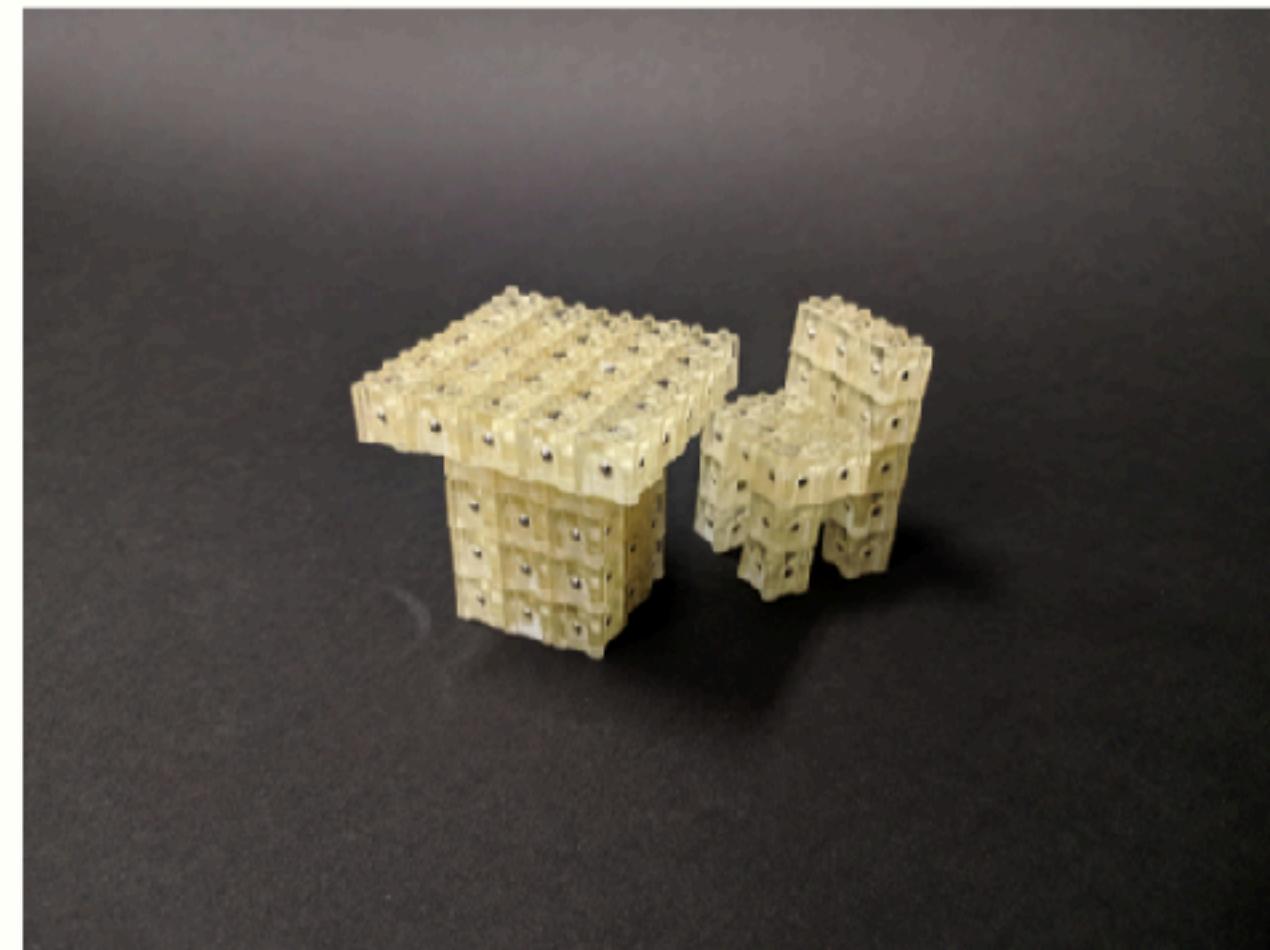
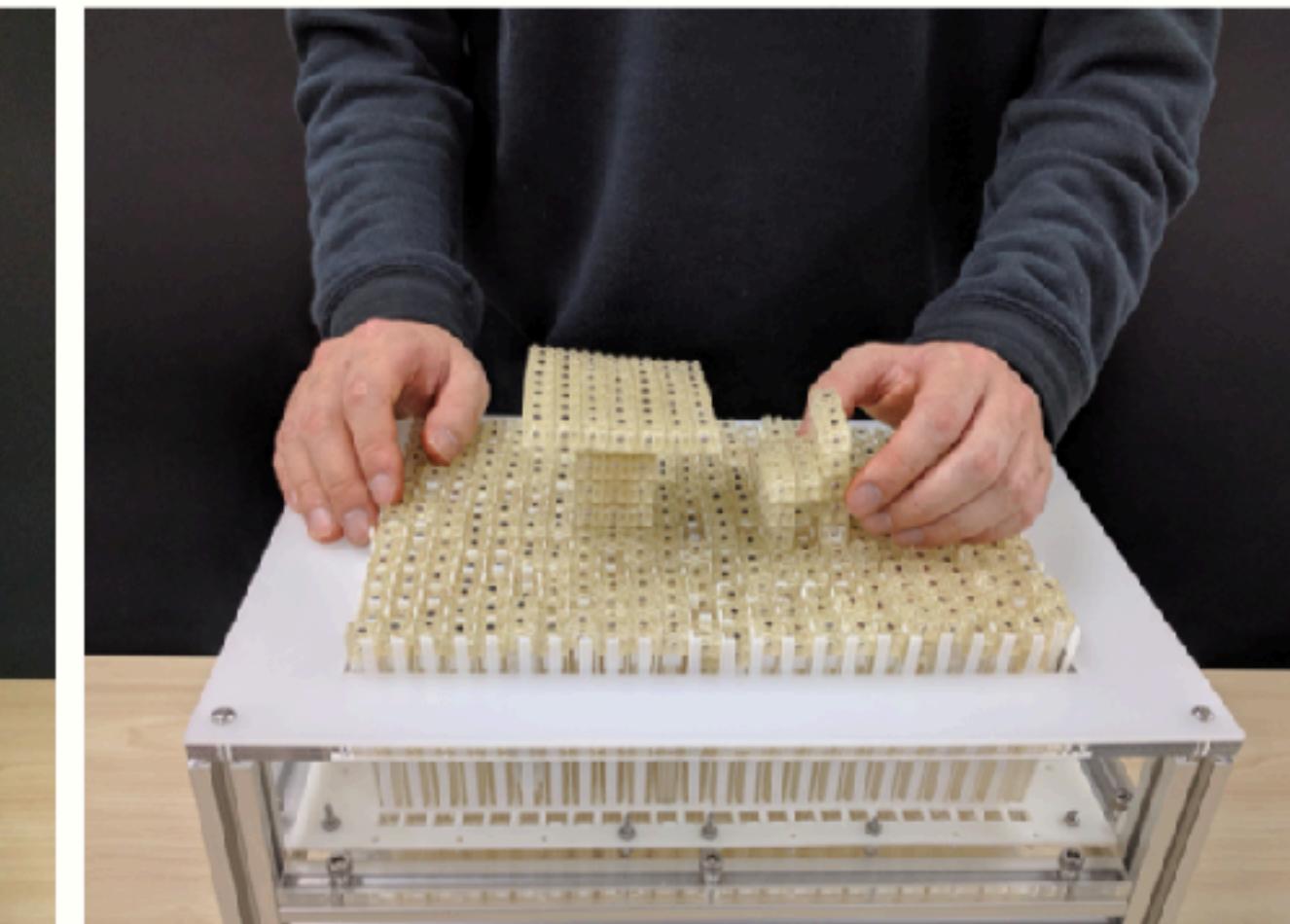
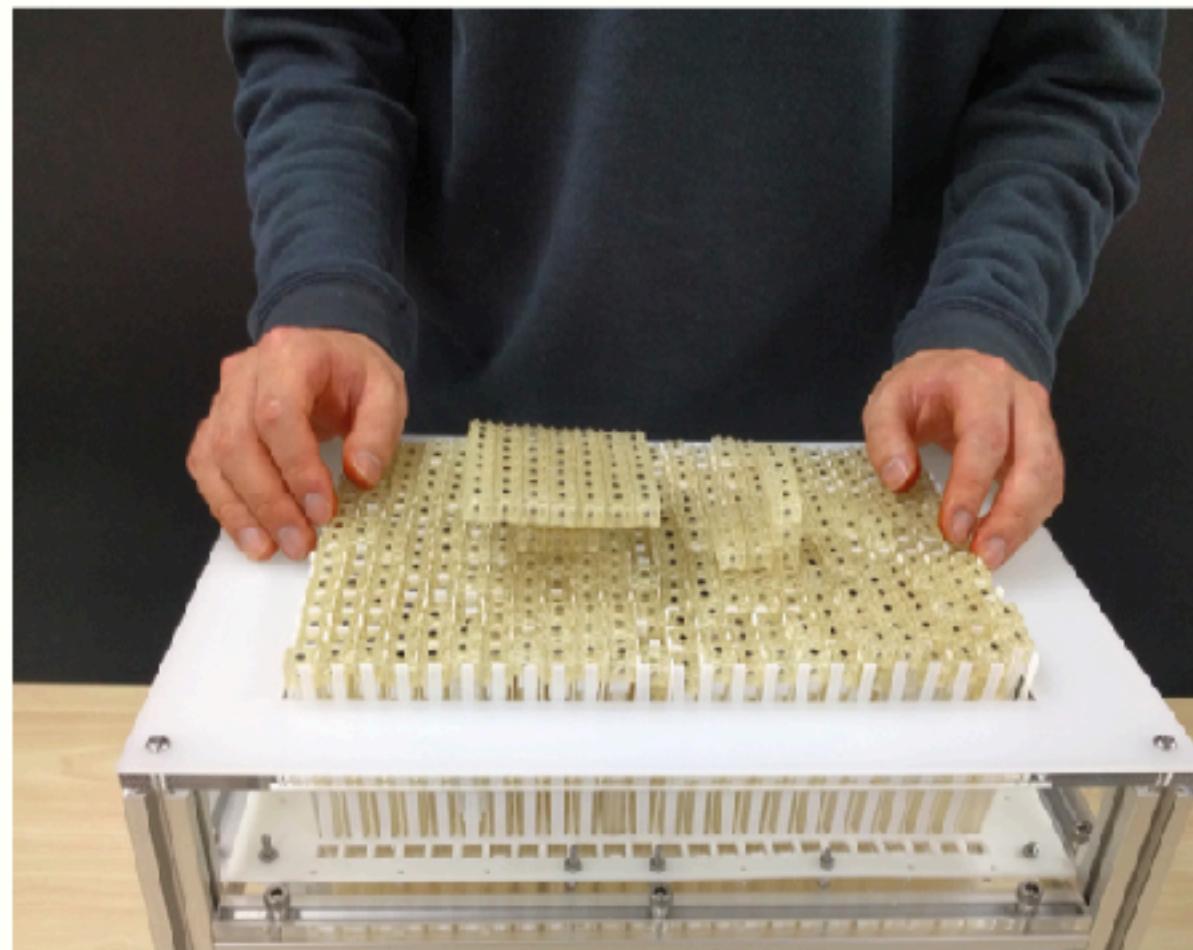
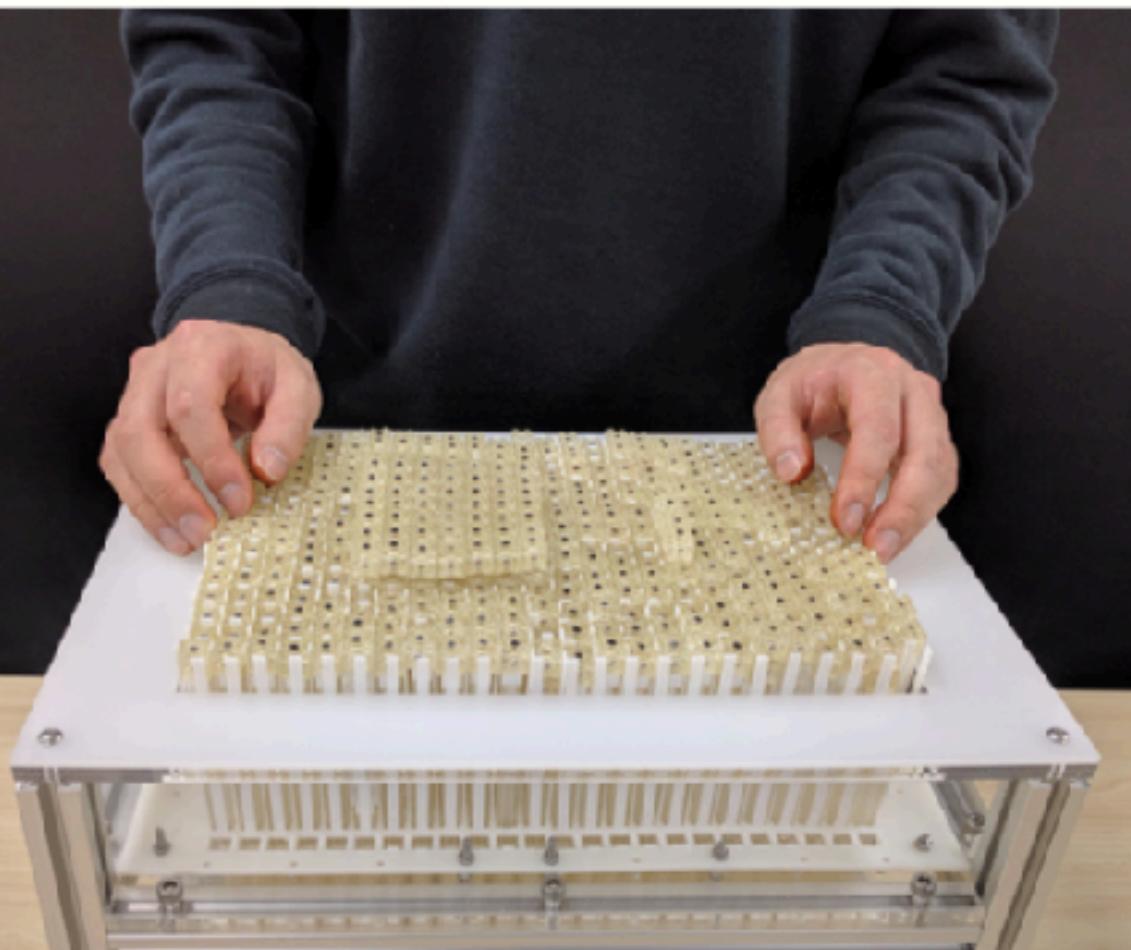
1. Summary
2. Related Work
3. Dynamic 3D Printing: Design Architecture

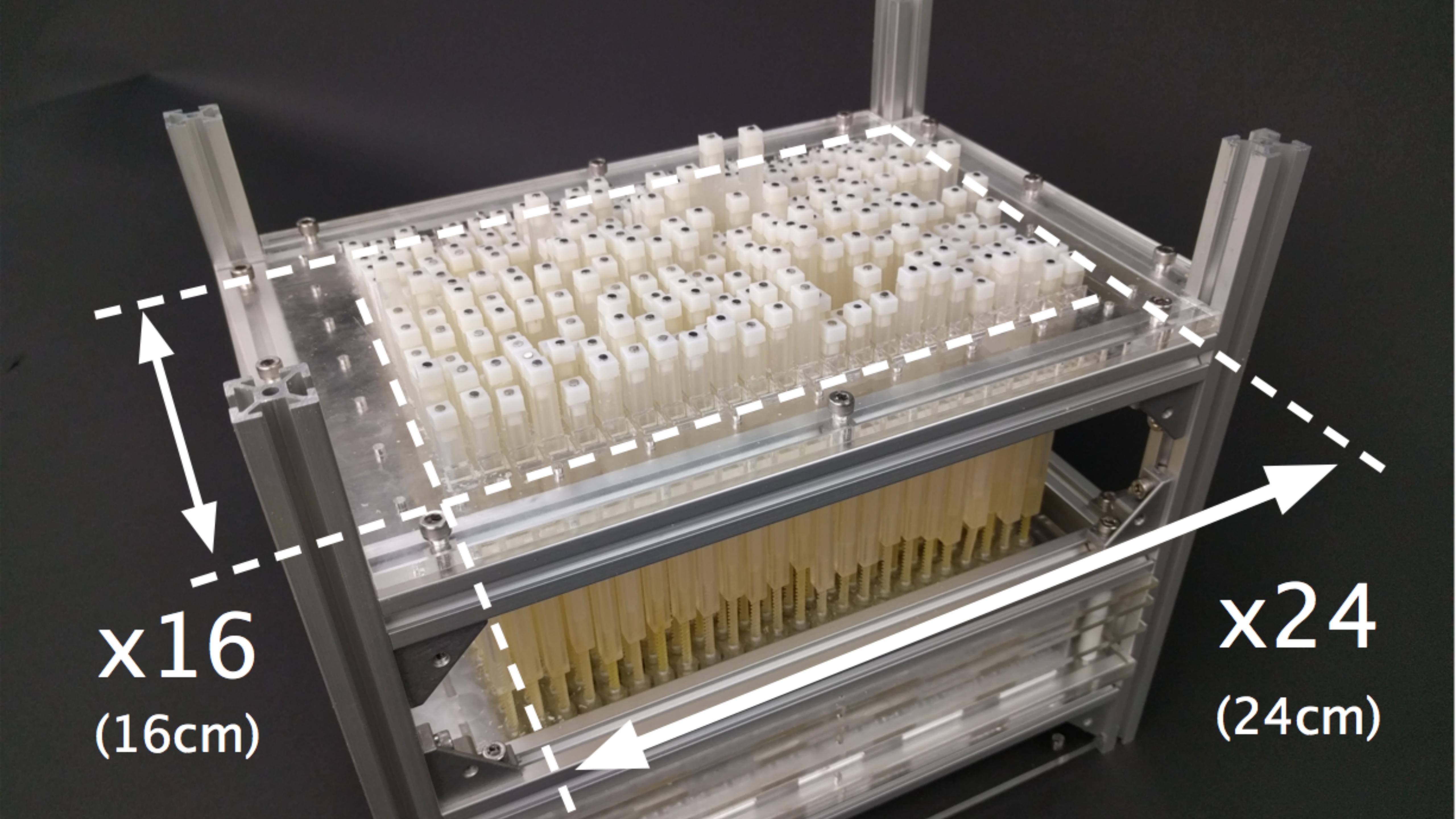
## 4. Dynablock

5. Limitations and Future Work

# Dynablock

A proof-of-concept prototype for dynamic 3D printing



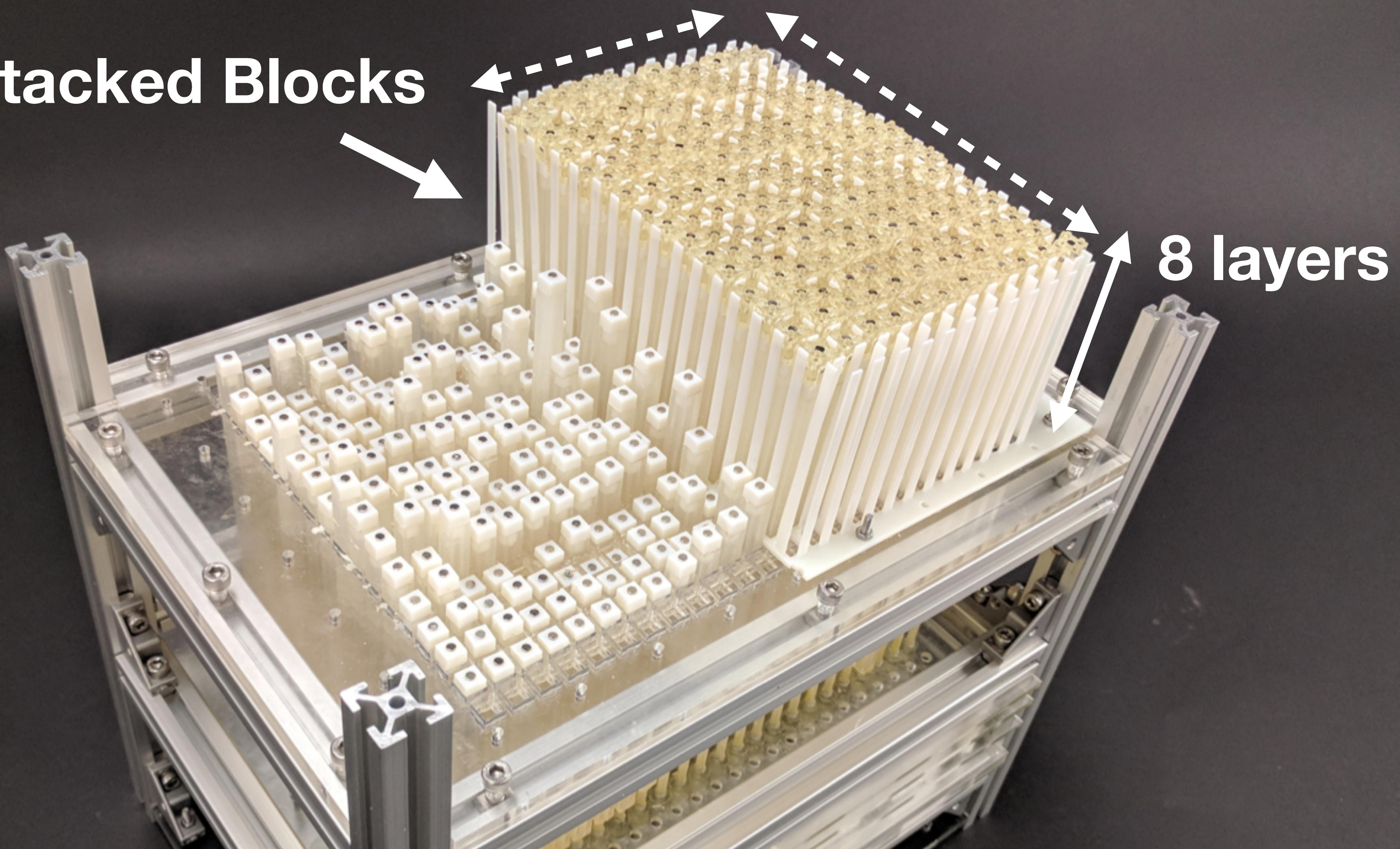


x16  
(16cm)

x16  
(16cm)

x24  
(24cm)

**Stacked Blocks**

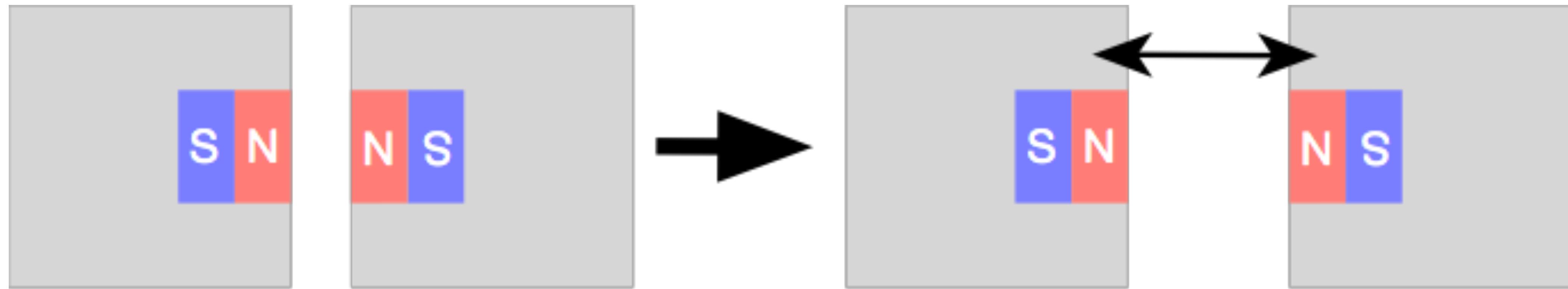


**8 layers**

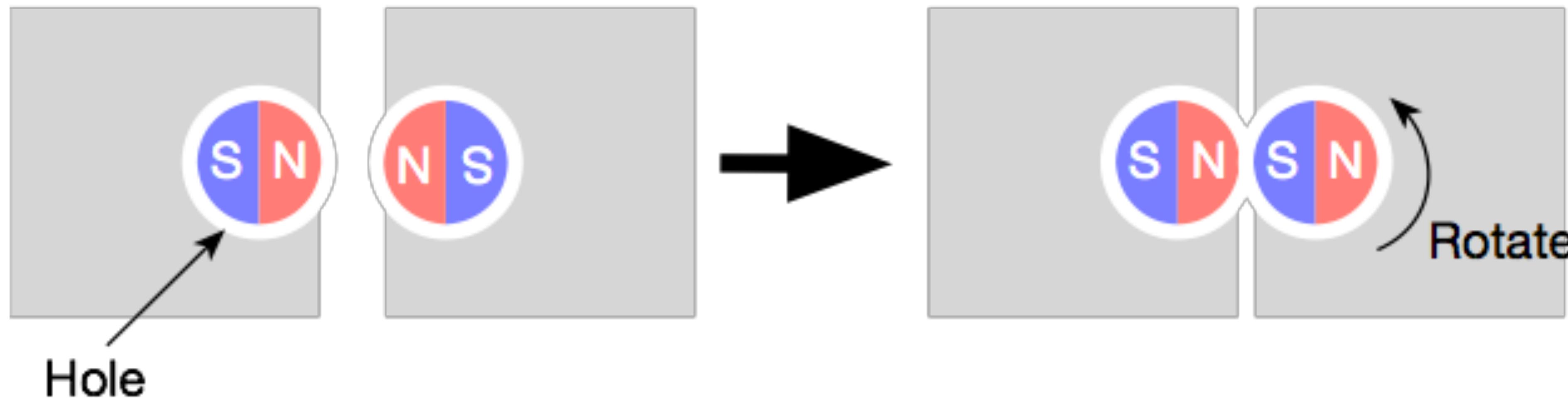
Horizontal  
Connection  
Disconnection

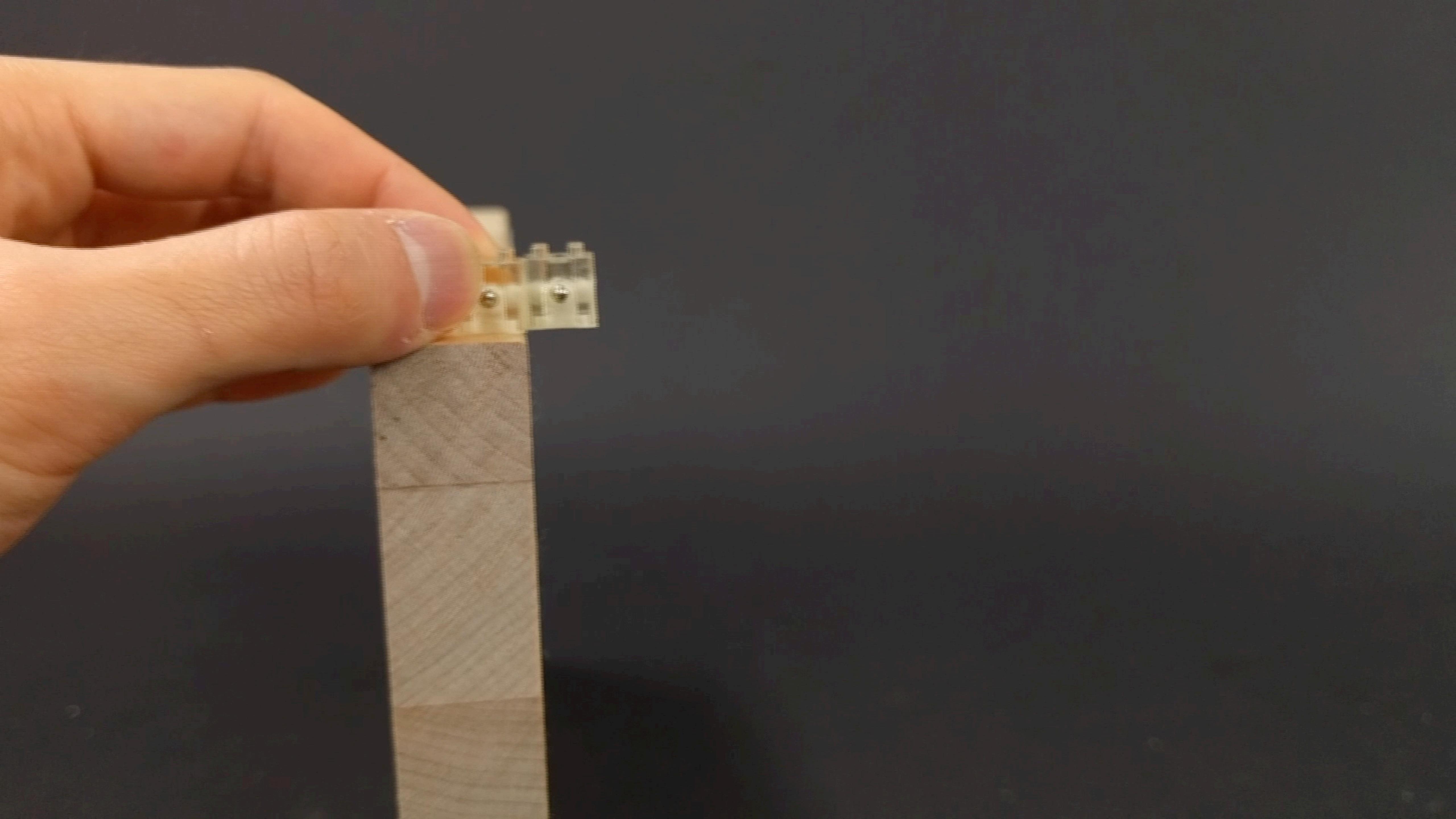
# Horizontal Connection

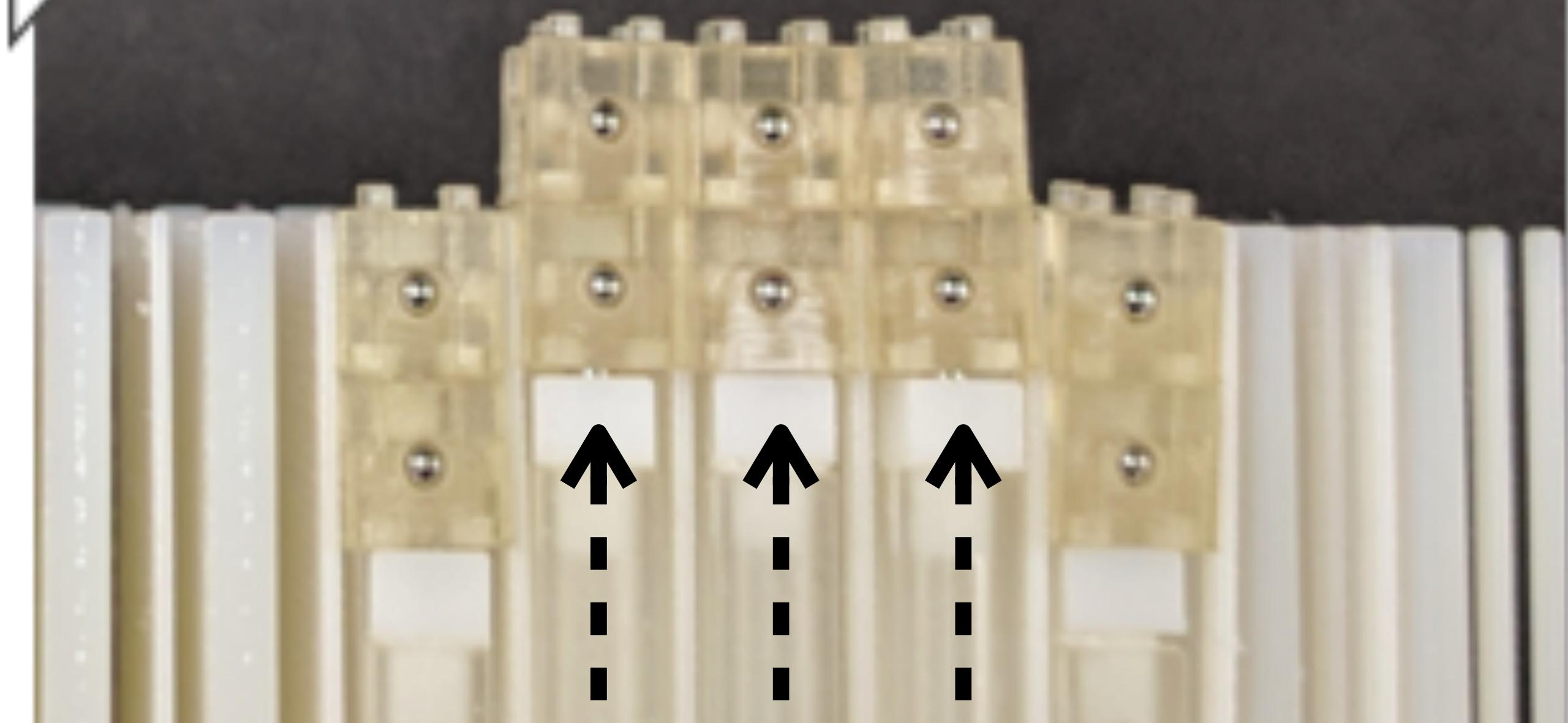
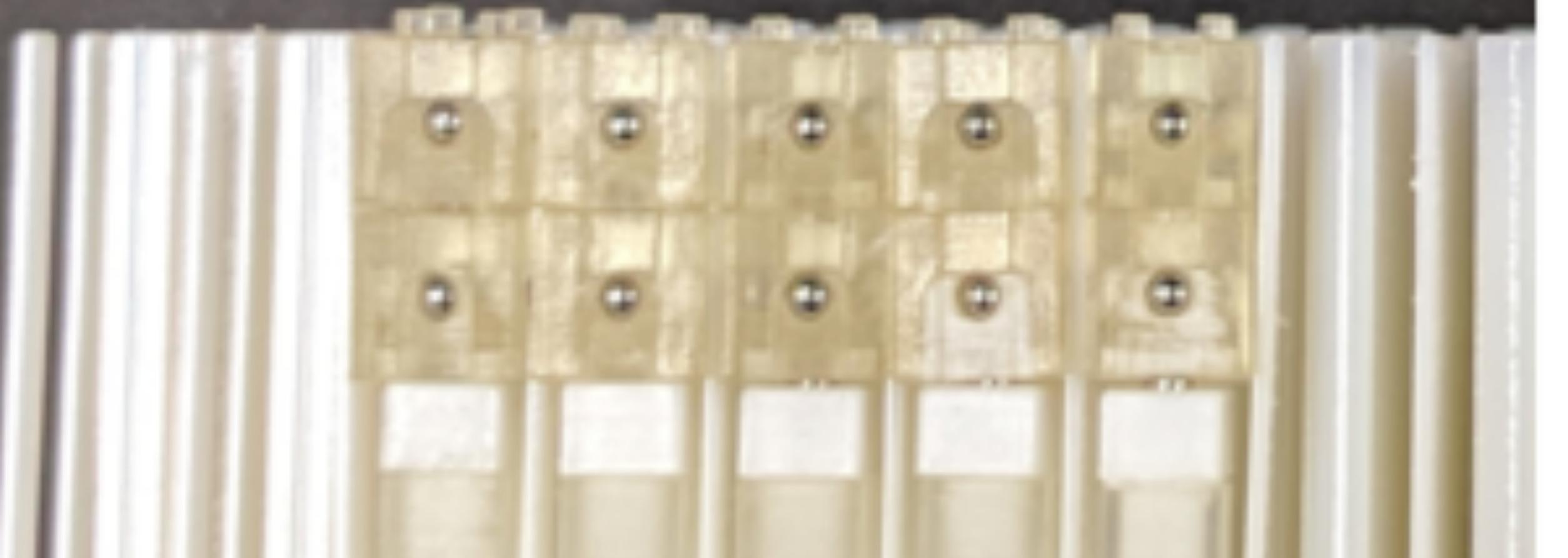
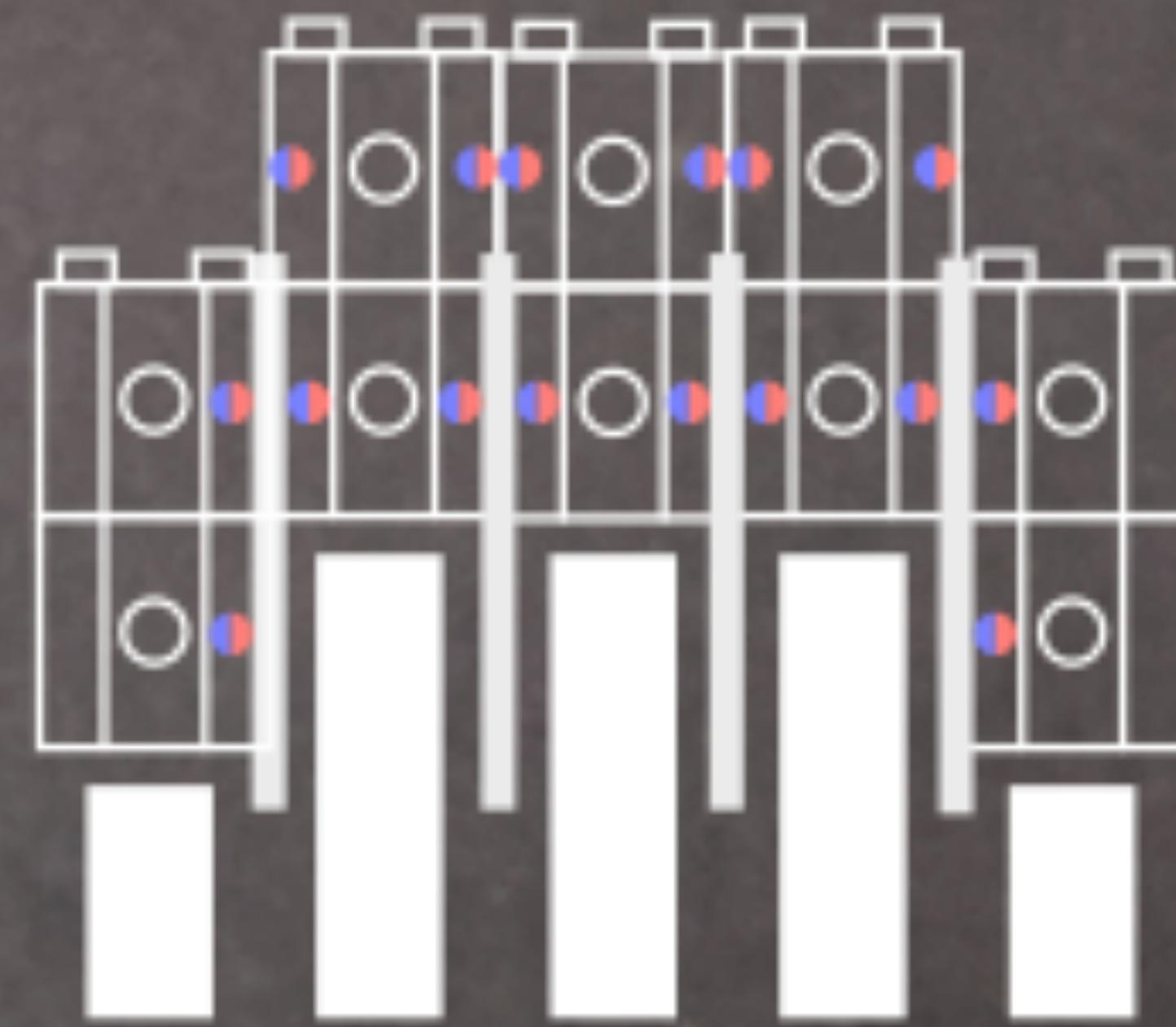
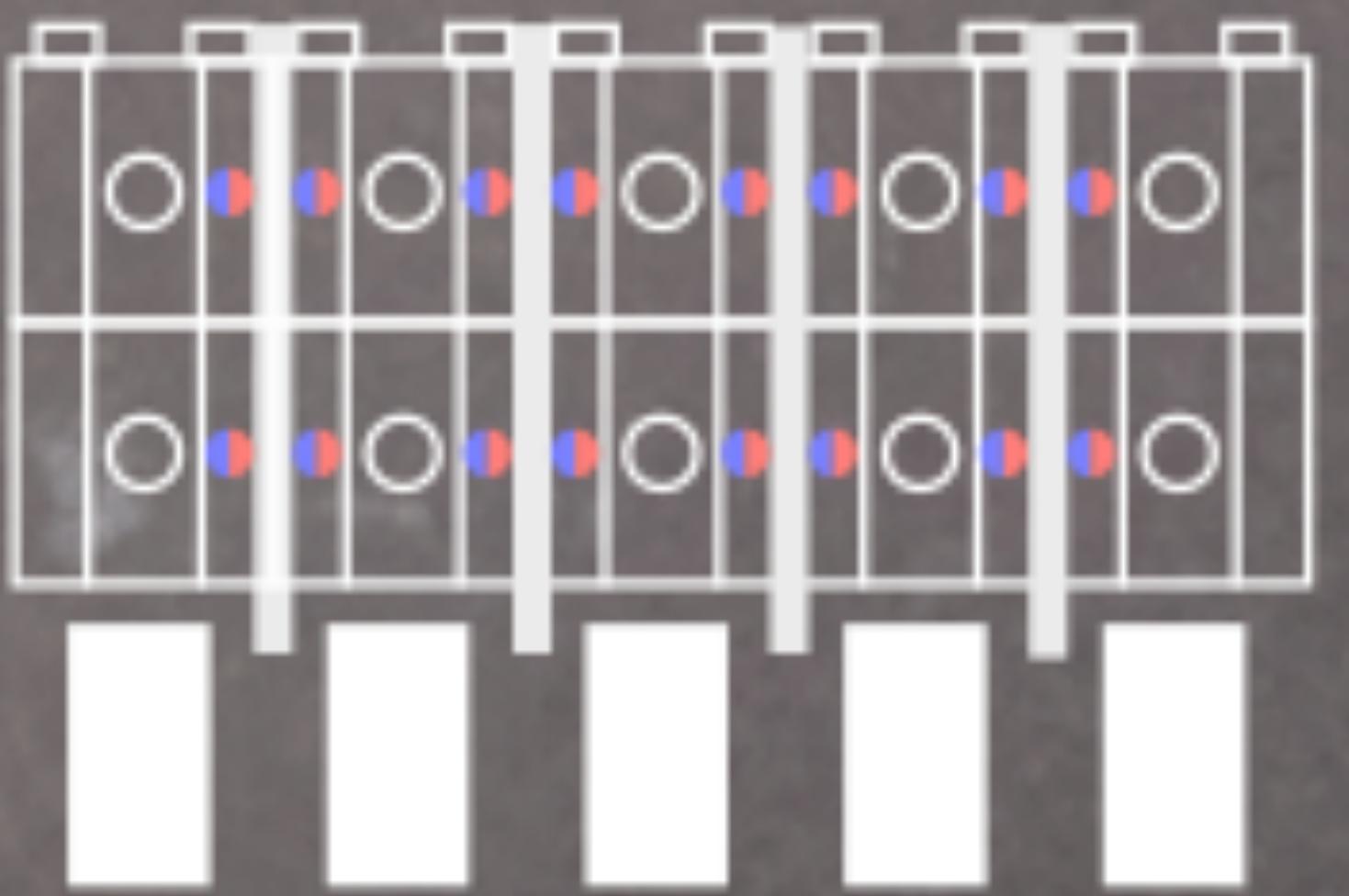
✗



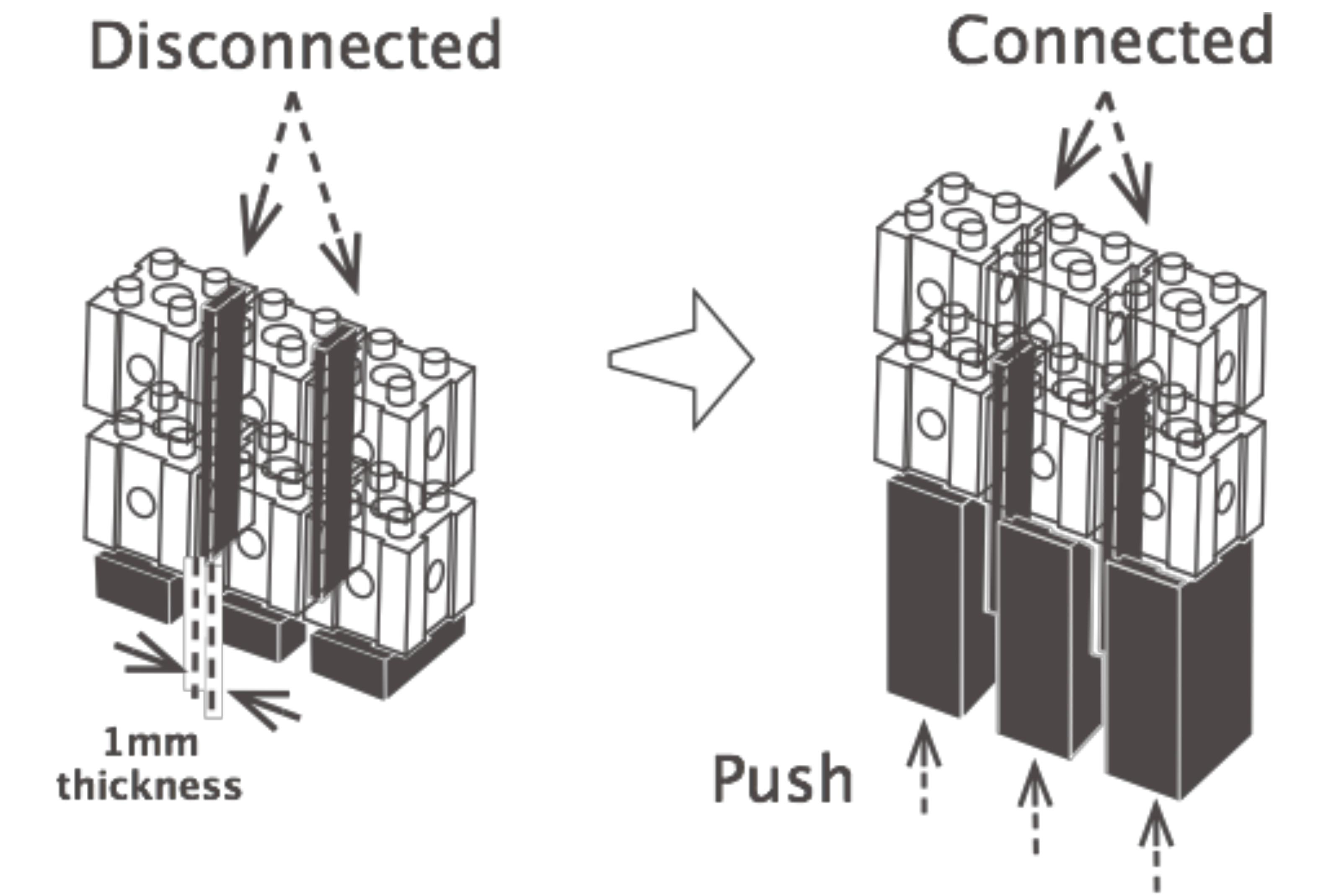
○



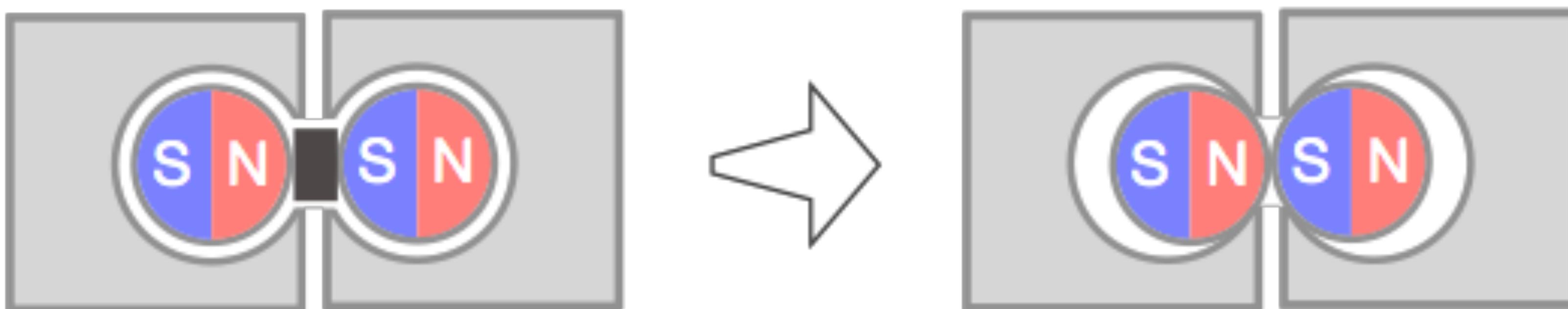




**3D View**

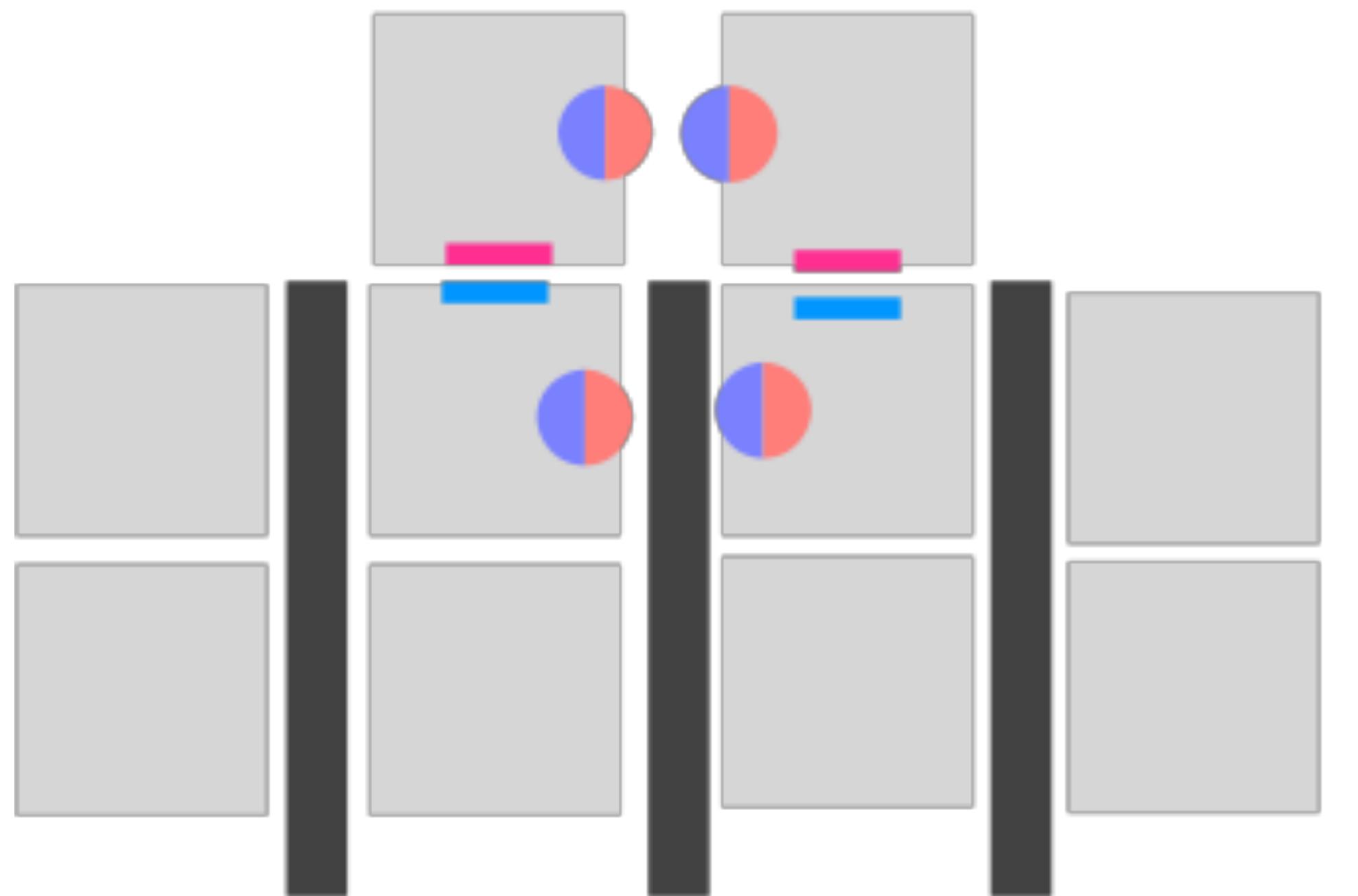


**Top View**

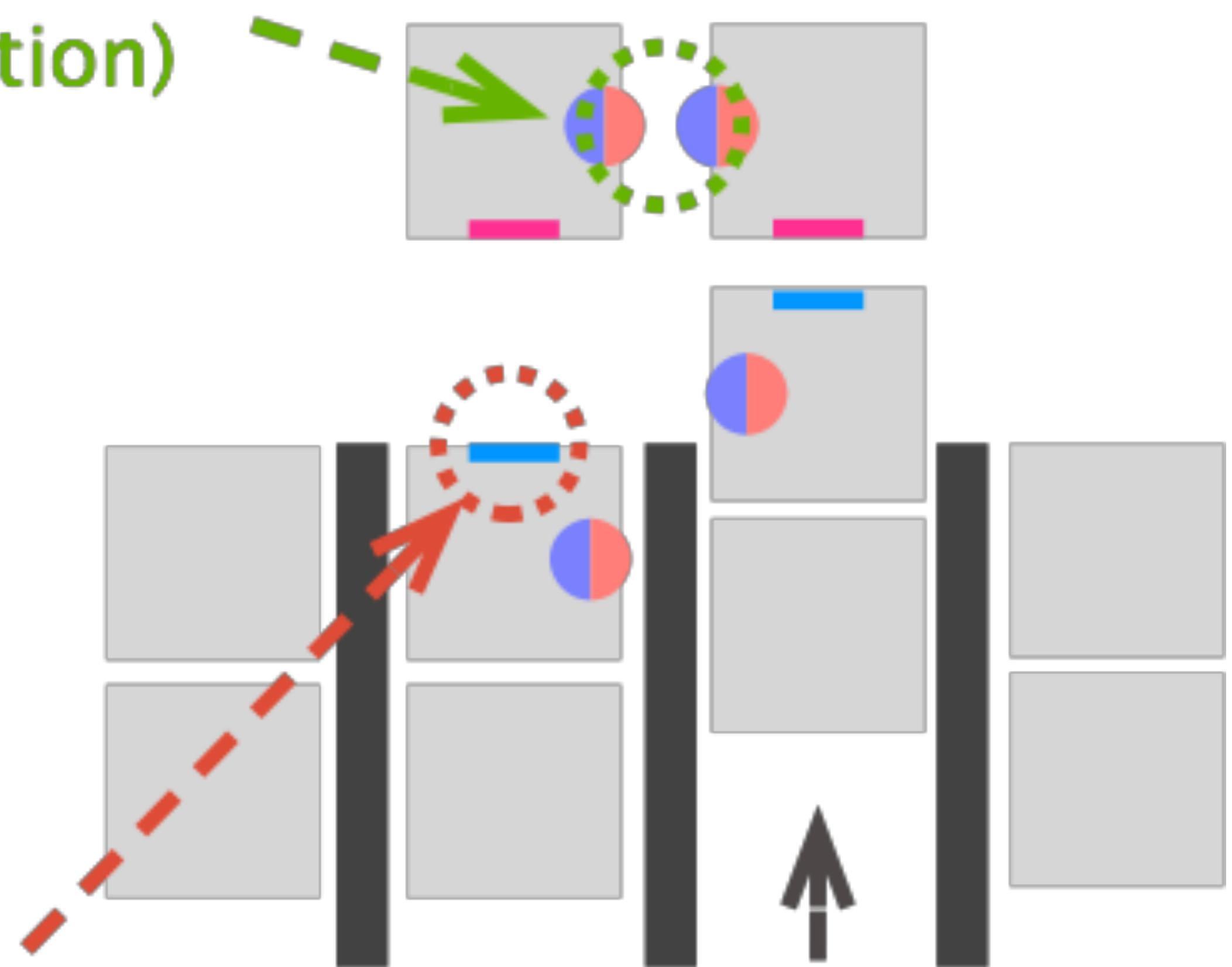


Vertical  
Connection  
Disconnection

# **Stay Connected** (Strong Connection)

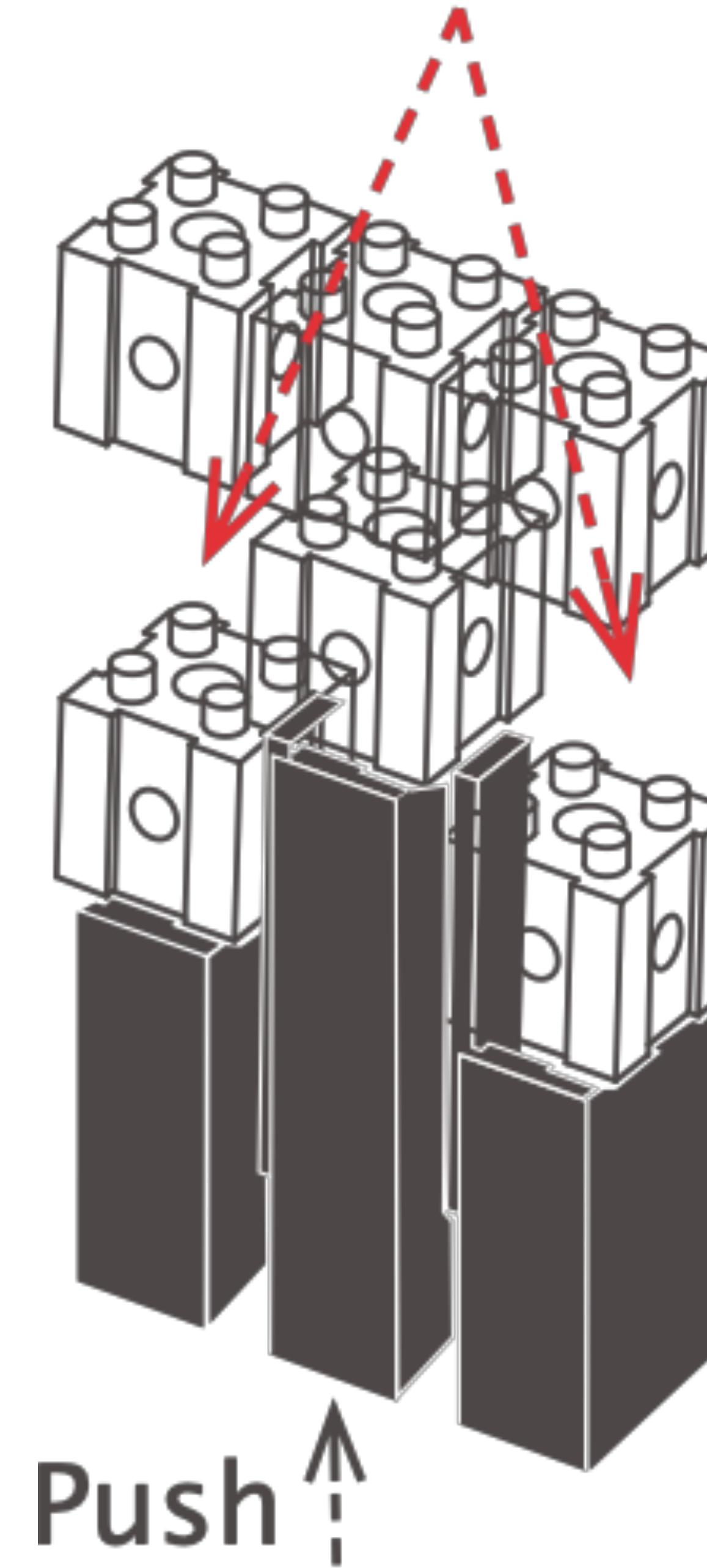


# **Disconnected** (Weak Connection)

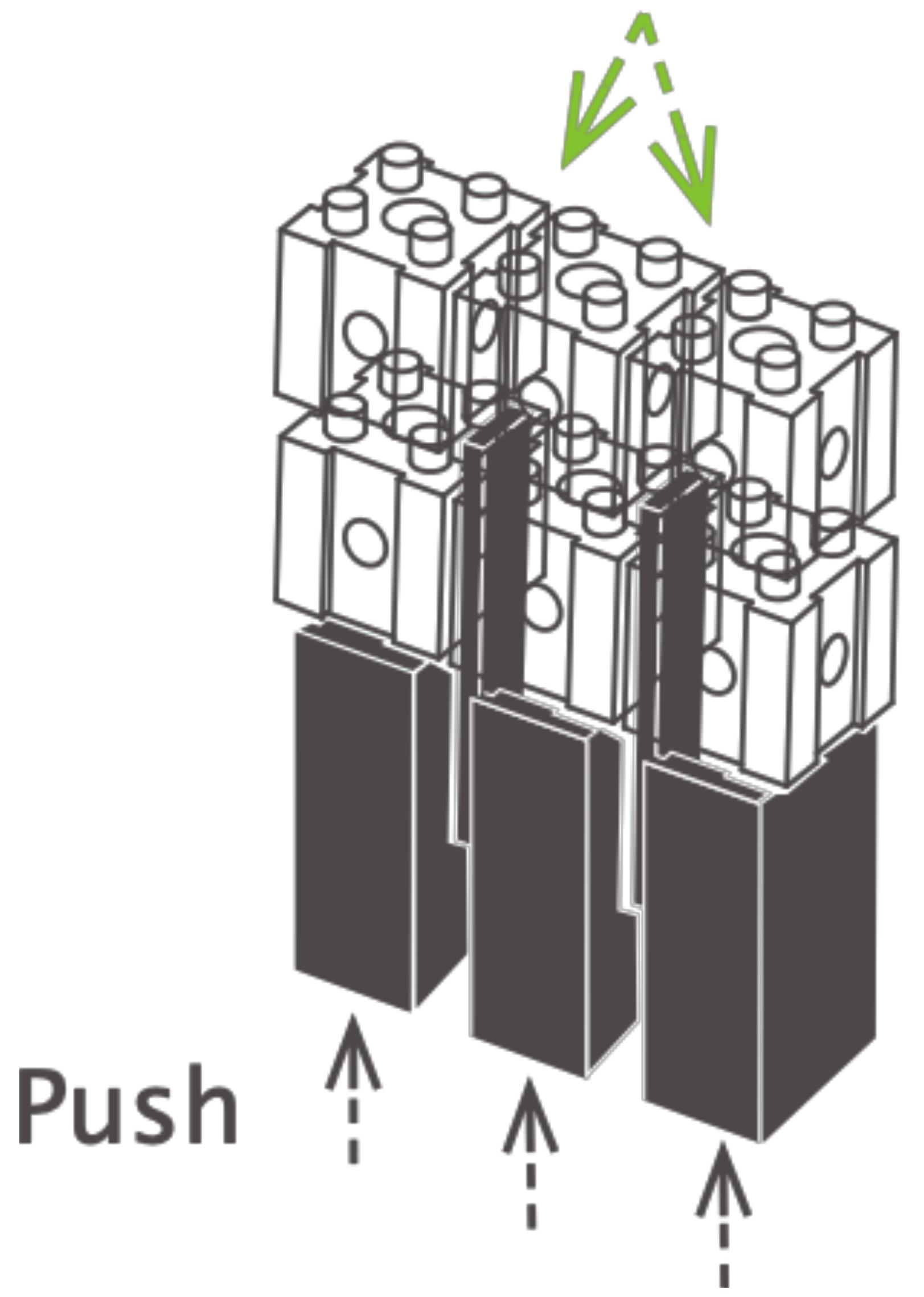


Push

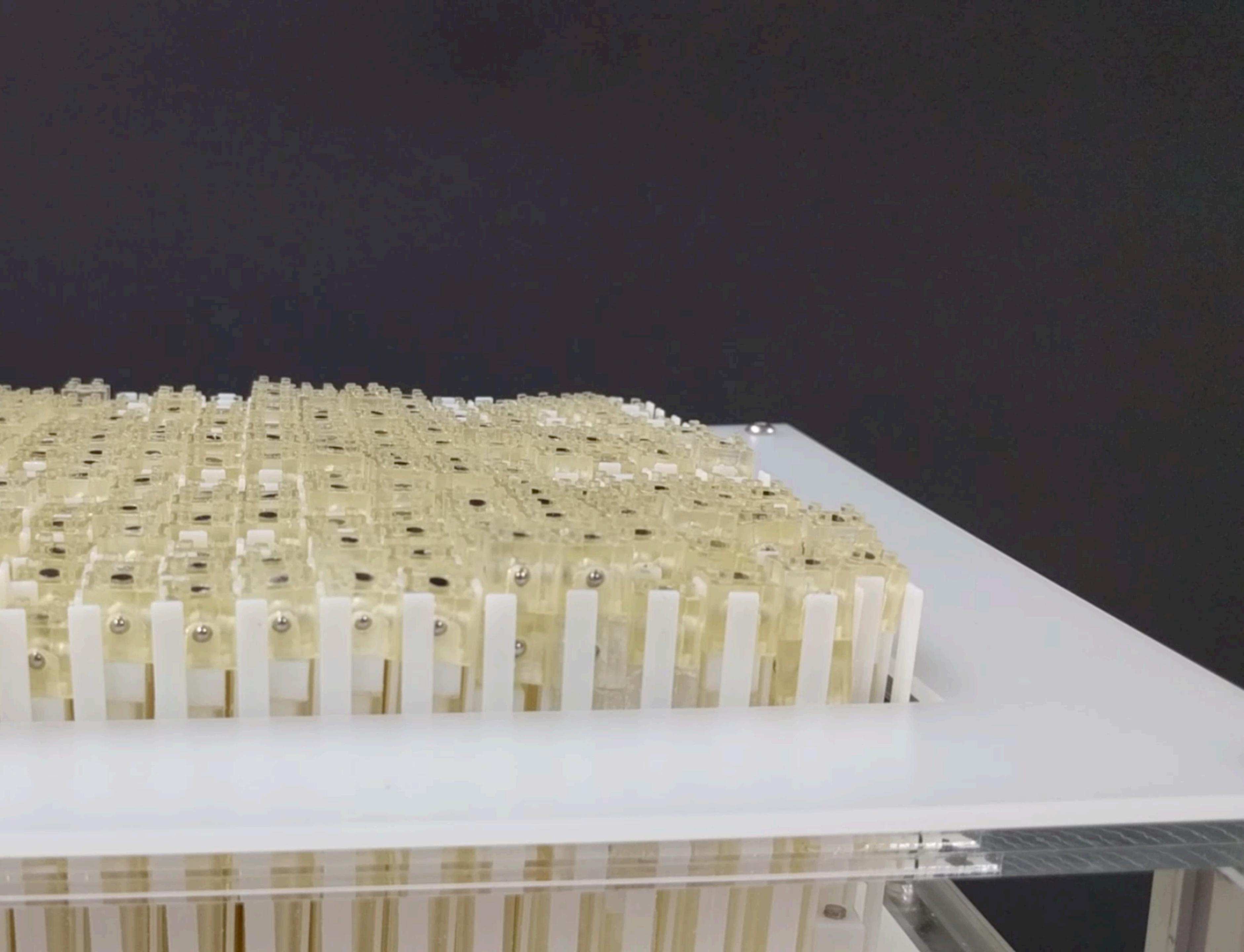
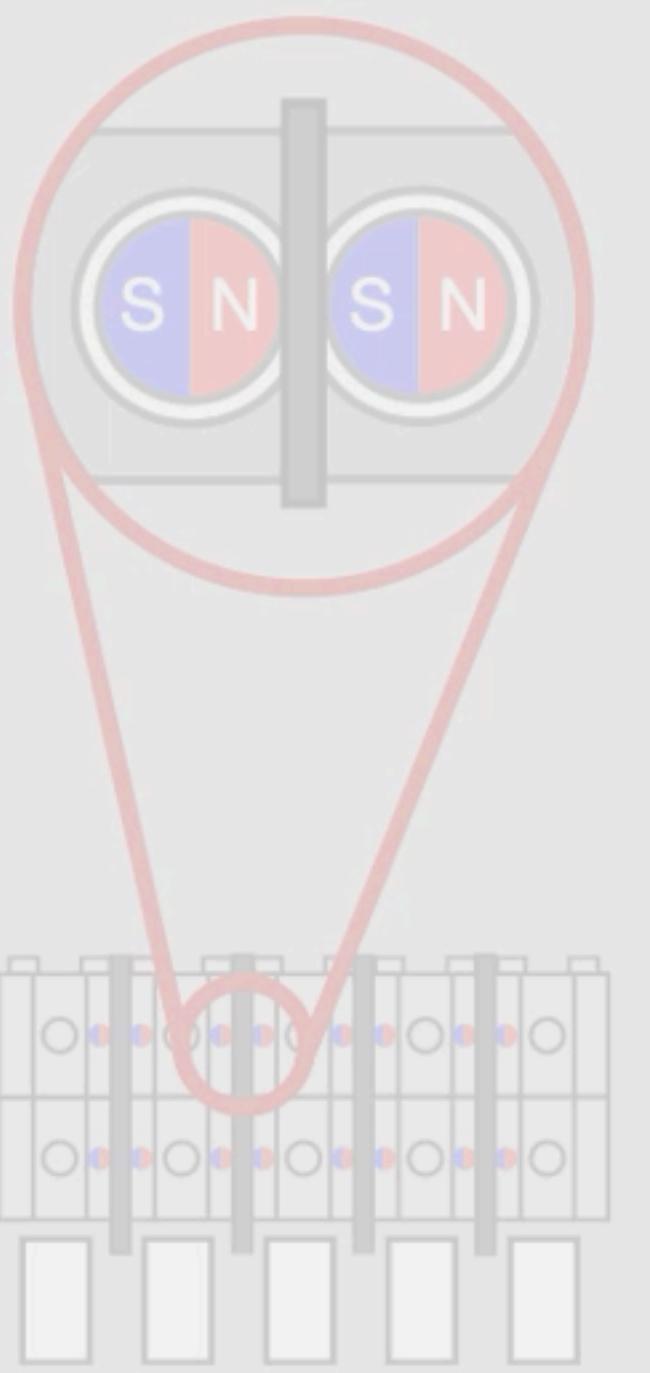
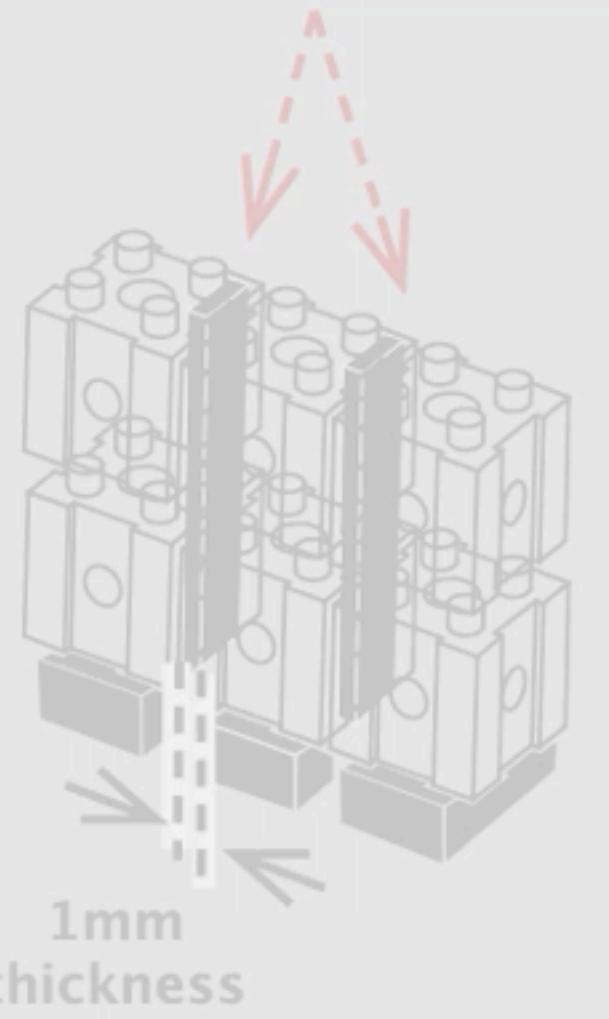
**Disconnected**

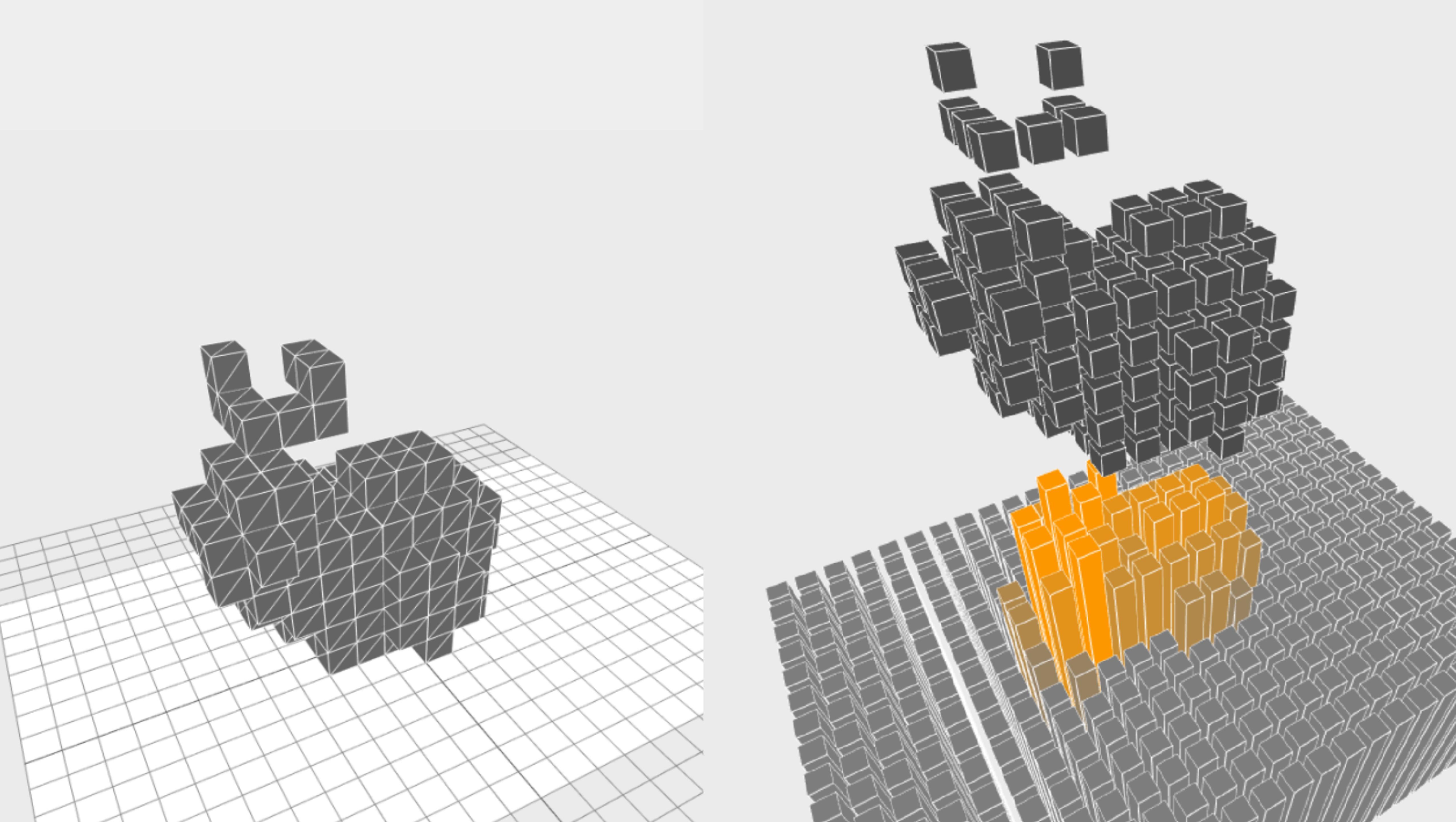


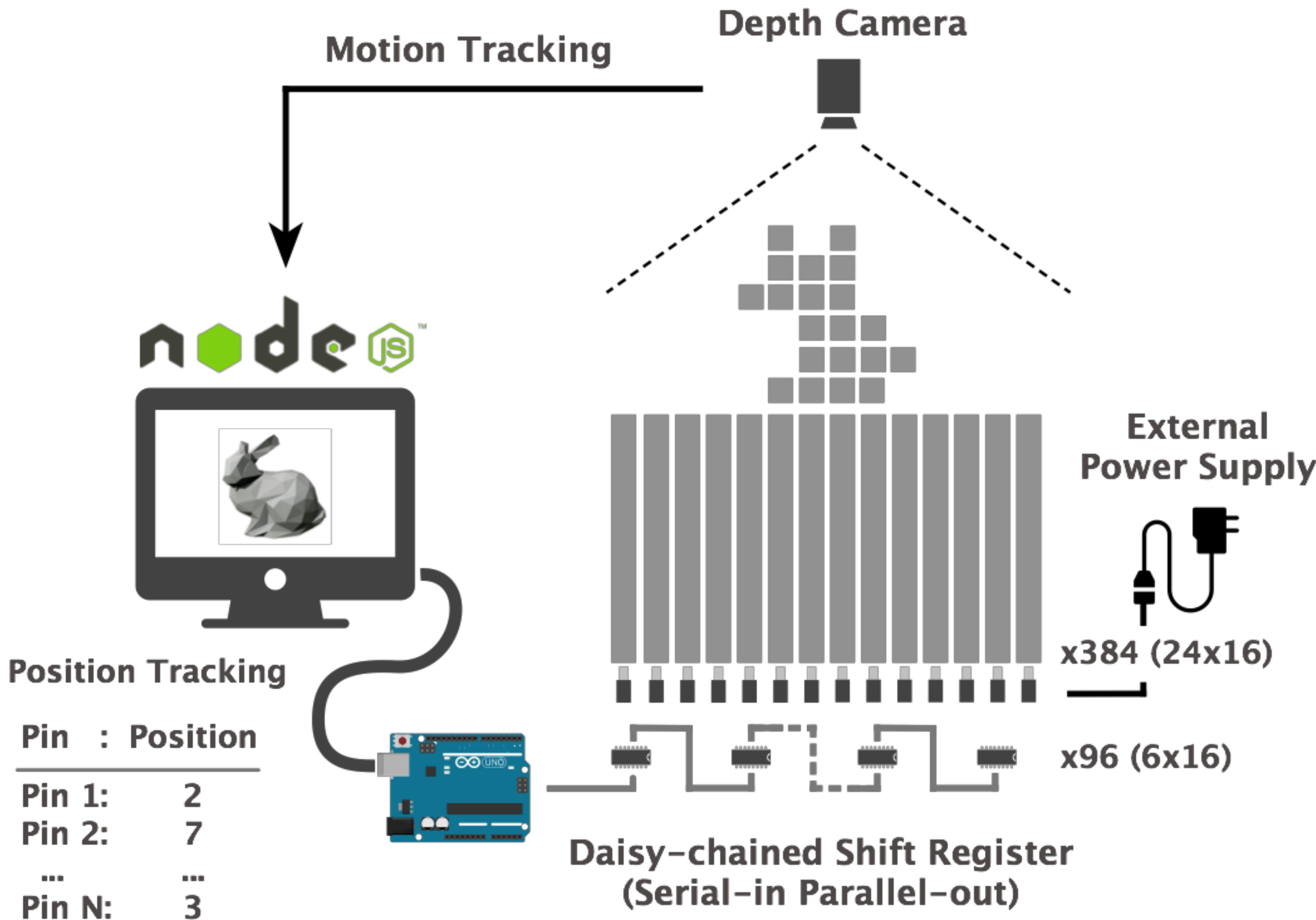
**Connected**



Disconnected







1. Summary
2. Related Work
3. Dynamic 3D Printing: Design Architecture
4. Dynablock: System and Implementation

## 5. Limitations and Future Work

# Limitation 1:

## Error Handling and Correction

# Limitation 2:

## Stability of the Object

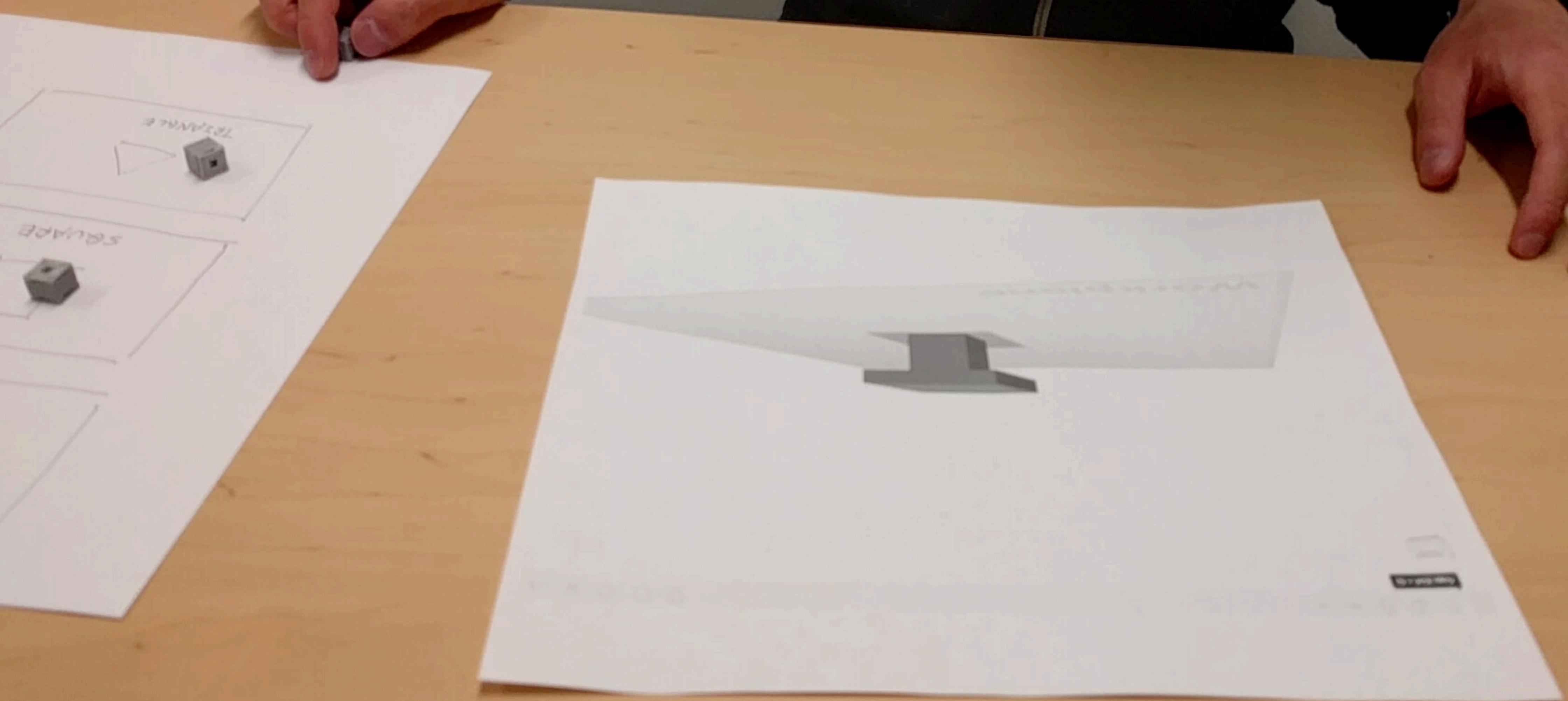
# Limitation 3:

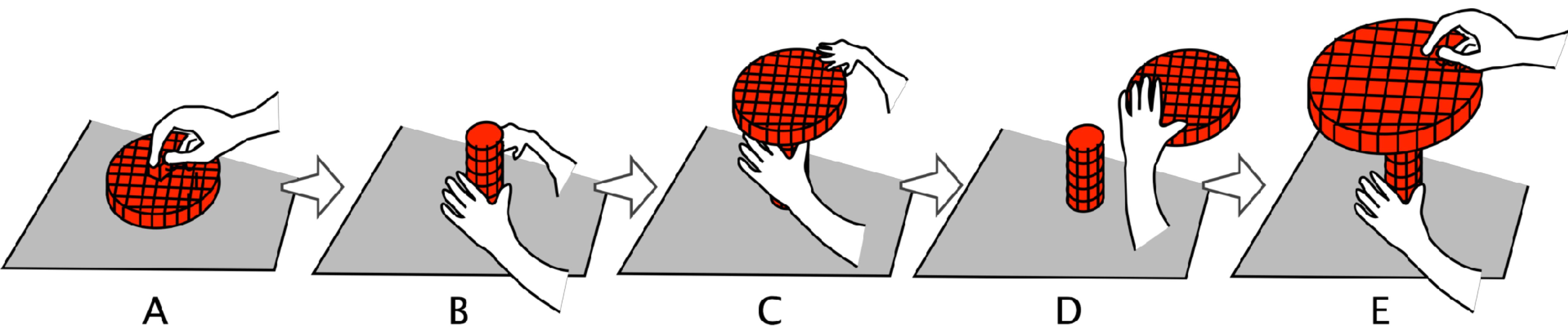
## Process for Reconstruction

# Vision



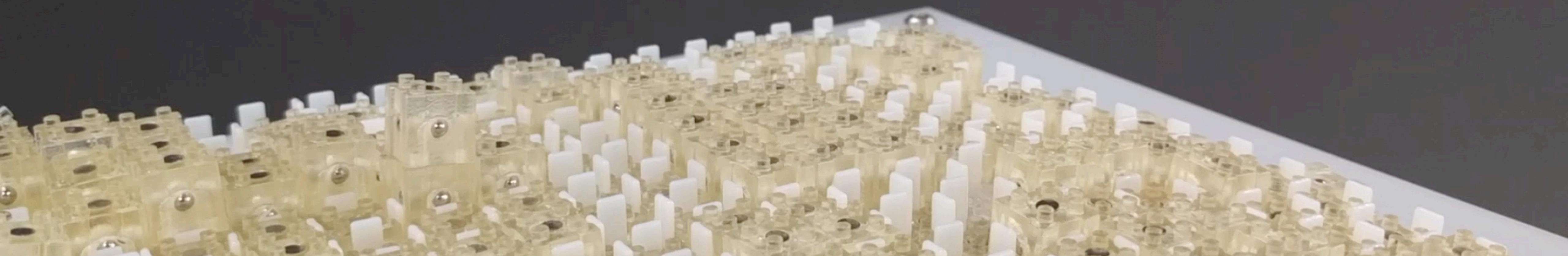
**Claytronics** (CMU 2006)





# Dynablock

## Dynamic 3D Printing for Instant and Reconstructable Shape Formation



**Ryo Suzuki, Junichi Yamaoka, Daniel Leithinger, Tom Yeh, Mark D. Gross,  
Yoshihiro Kawahara, Yasuaki Kakehi**  
University of Colorado Boulder, The University of Tokyo



University of Colorado  
Boulder



THE UNIVERSITY  
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