TilePoP:

Tile-type Pop-up Prop for Virtual Reality

Shan-Yuan Teng[1,3], Cheng-Lung Lin[2], Chi-huan Chiang[1], Tzu-Sheng Kuo[1,4], Liwei Chan[2], Da-Yuan Huang[2], Bing-Yu Chen[1]

1 National Taiwan University
2 National Chiao Tung University
3 The University of Chicago
4 Stanford University

20x

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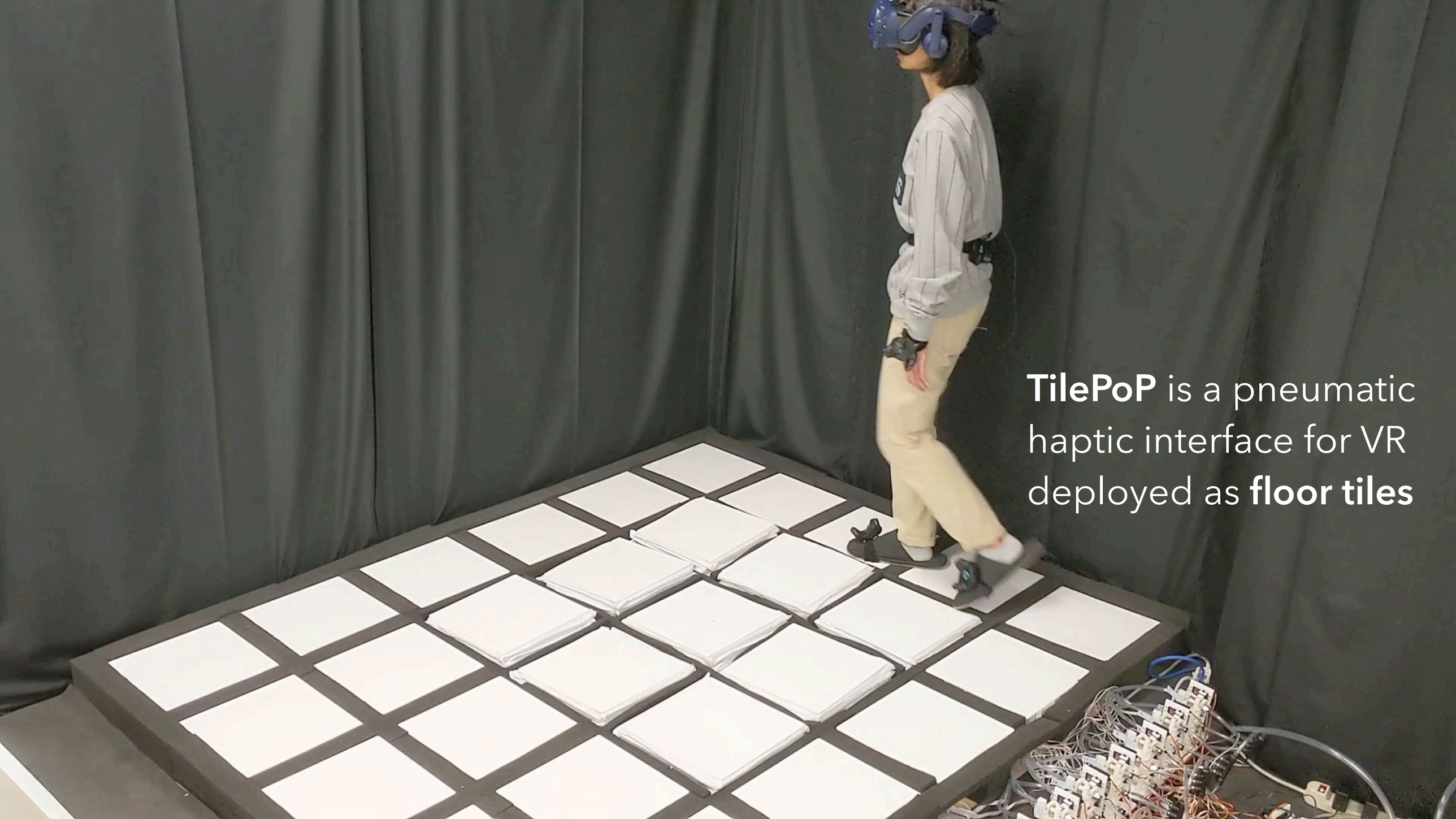
20x


TilePoP is a pneumatic haptic interface for VR deployed as **floor tiles**

related work

VR haptic feedback

wearable

Grabity
Choi et al. [UIST ’17]

PuPoP
Teng et al. [UIST ’18]

SPIDAR-W
Nagai et al. [SIGGRAPH Asia ’15]

EMS
Lopes et al. [CHI ’17]

wearable

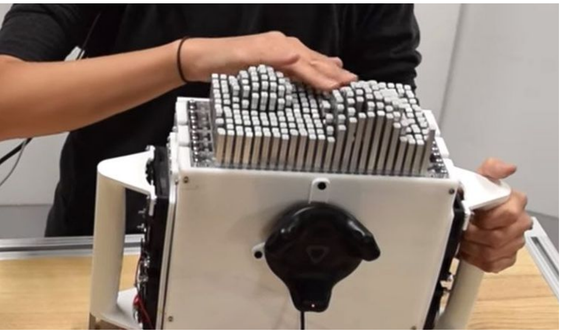
Grabity
Choi et al. [UIST ’17]

PuPoP
Teng et al. [UIST ’18]

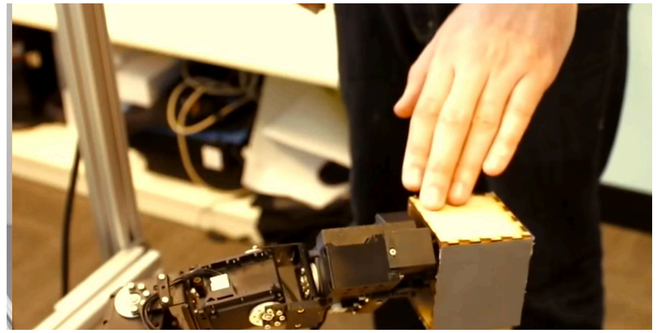
SPIDAR-W
Nagai et al. [SIGGRAPH Asia ’15]

EMS
Lopes et al. [CHI ’17]

tabletop

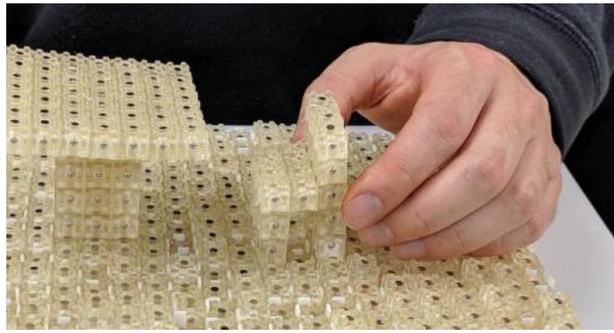


shapeShift
Siu et al. [CHI ’18]



Snake Charmer
Araujo et al. [TEI ’16]

Robotic Assembly
Zhao et al. [ISS ’17]



Dynablock
Suzuki et al. [UIST ’18]

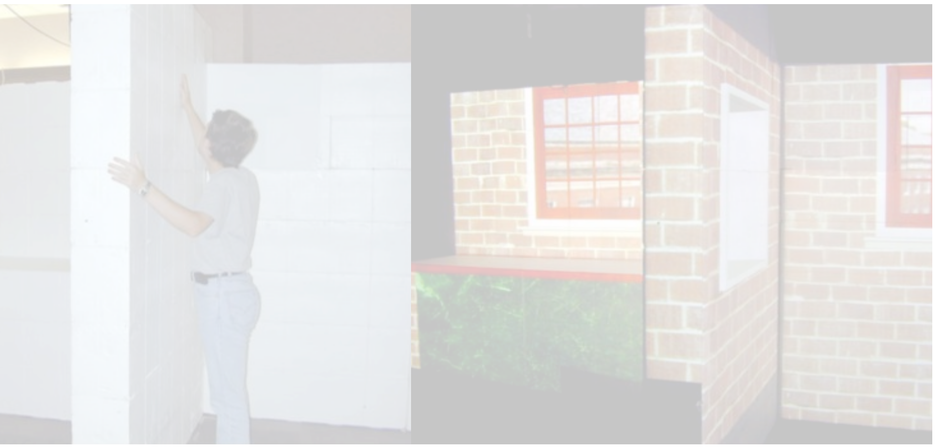
body-scale interaction

body-scale interaction

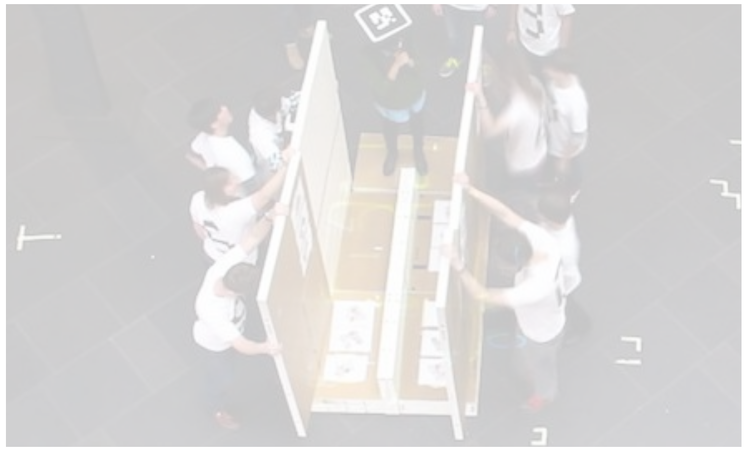
Life-Sized Projector-Based Dioramas
Low et al. [VRST ’01]

TurkDeck
Cheng et al. [UIST ’15]

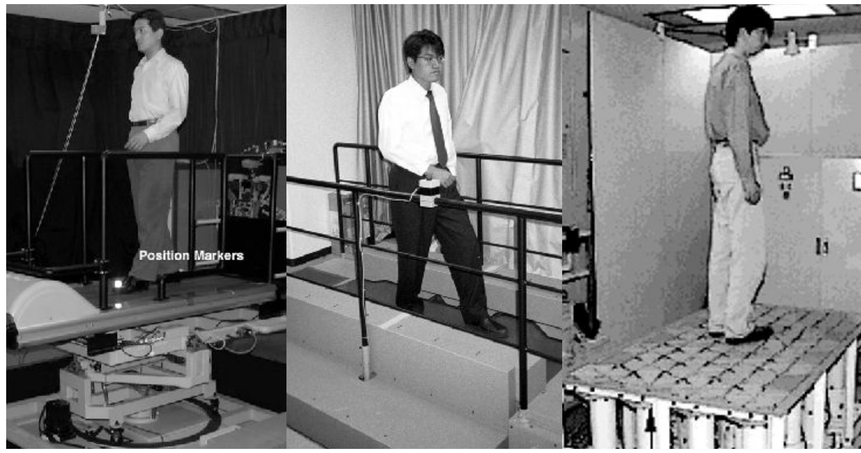
body-scale interaction



Life-Sized Projector-Based Dioramas
Low et al. [VRST ’01]



TurkDeck
Cheng et al. [UIST ’15]



Ground Surface Simulator
Noma et al. [IEEE VR ’00]

body-scale interaction

body-scale dynamic shapes
for whole-body interactions

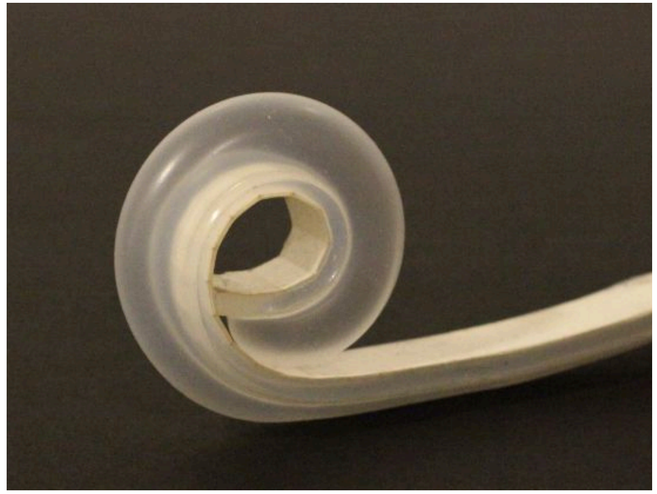
Life-Sized Projector-Based Dioramas
Low et al. [VRST ’01]

TurkDeck
Cheng et al. [UIST ’15]

Ground Surface Simulator
Noma et al. [IEEE VR ’00]

pneumatic shape-changing interfaces

Dynamic Buttons
Harrison and Hudson.
[CHI ’09]



PneUI
Yao et al. [UIST ’13]

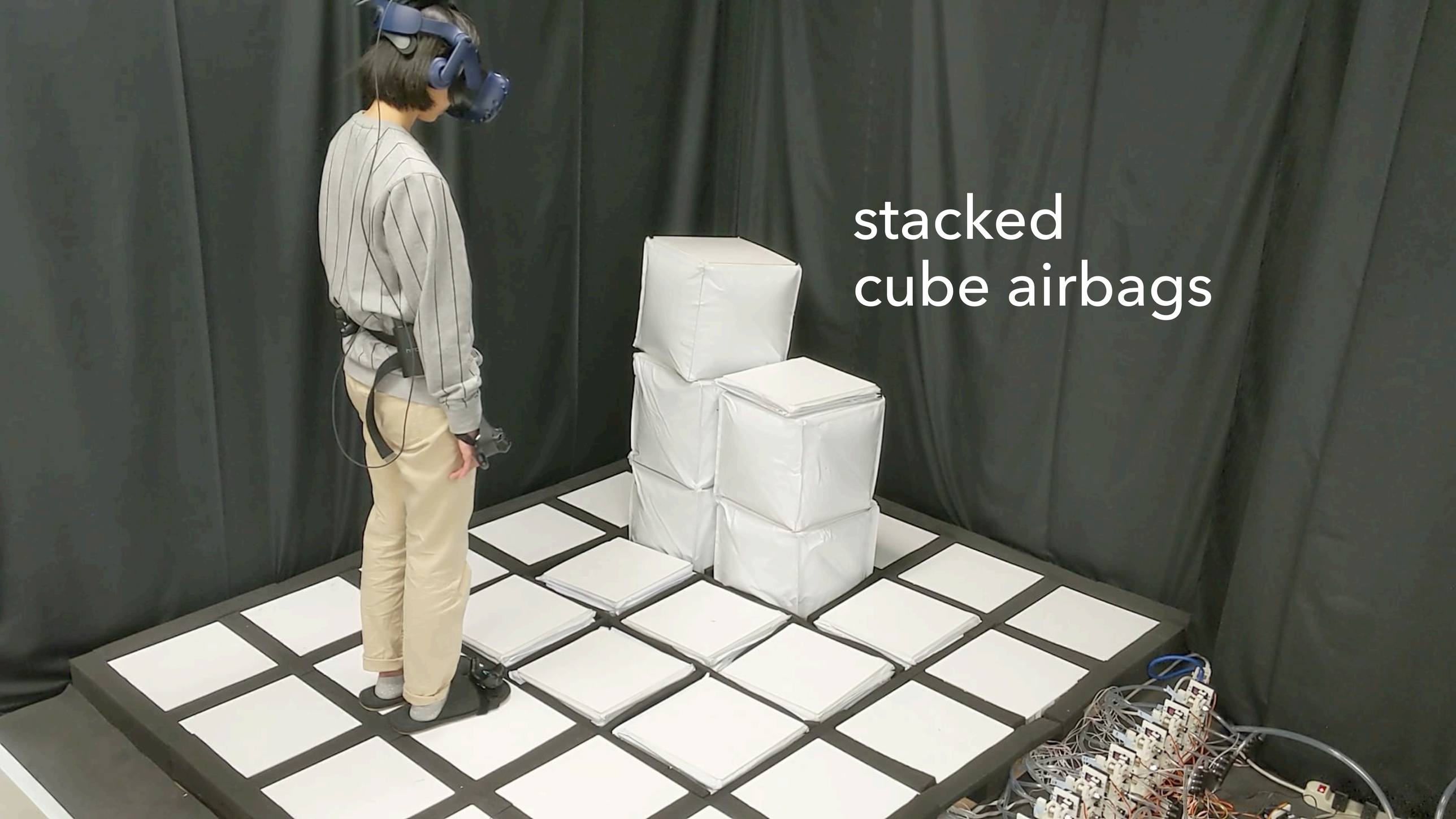
aeroMorph
Ou et al. [UIST ’16]

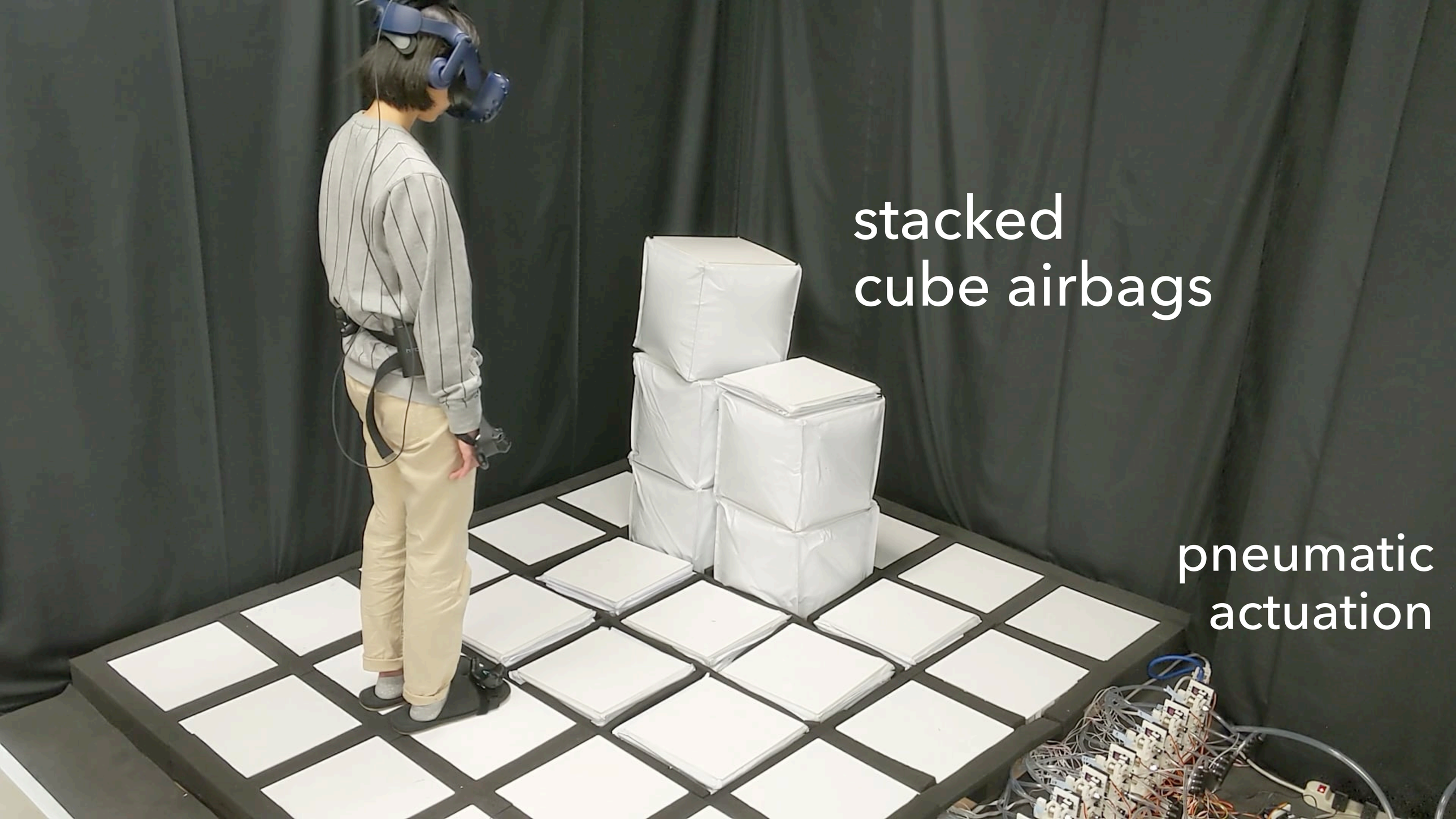
Printflatable
Sareen et al. [CHI ’17]

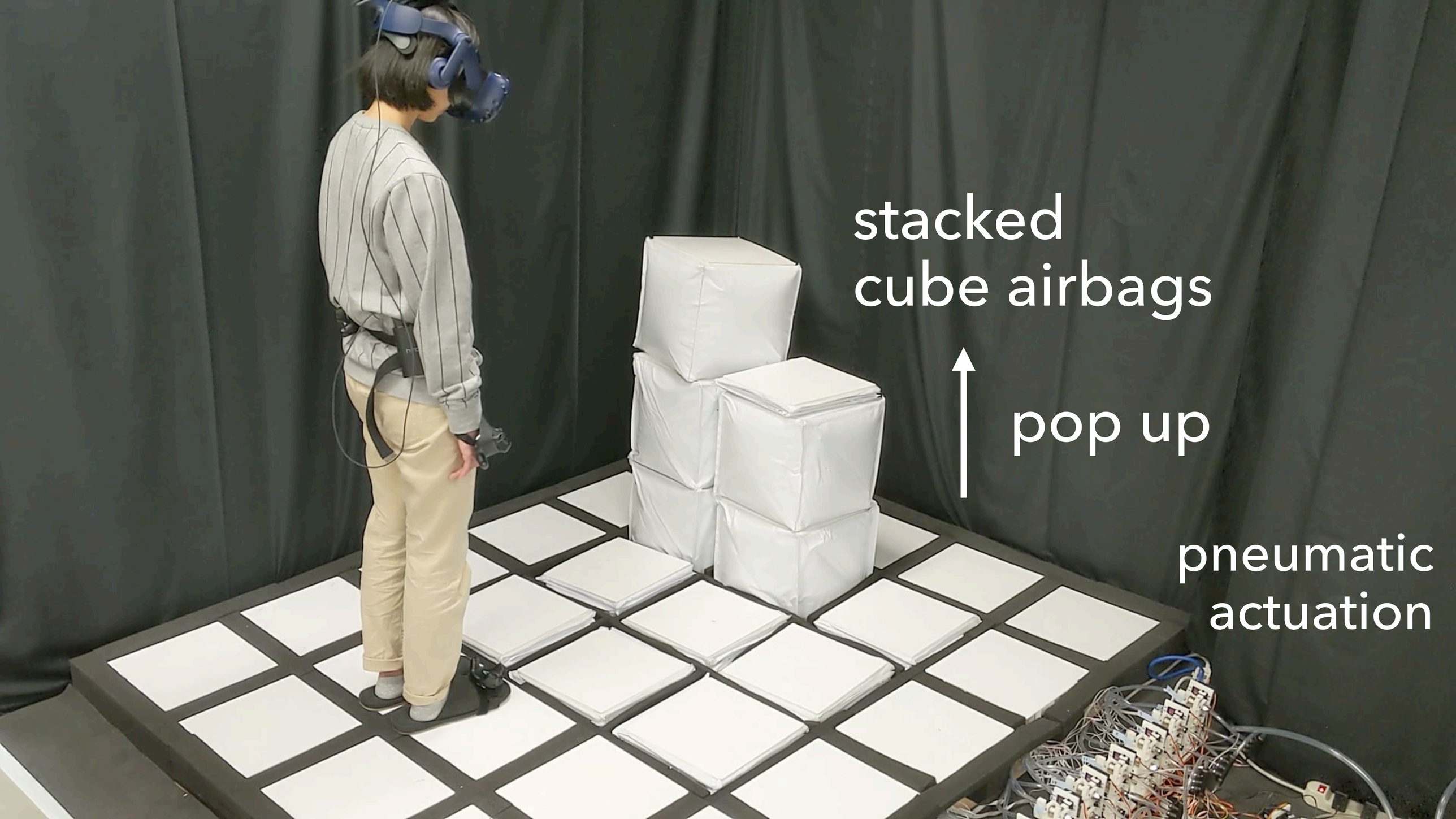
TilePoP

TilePoP

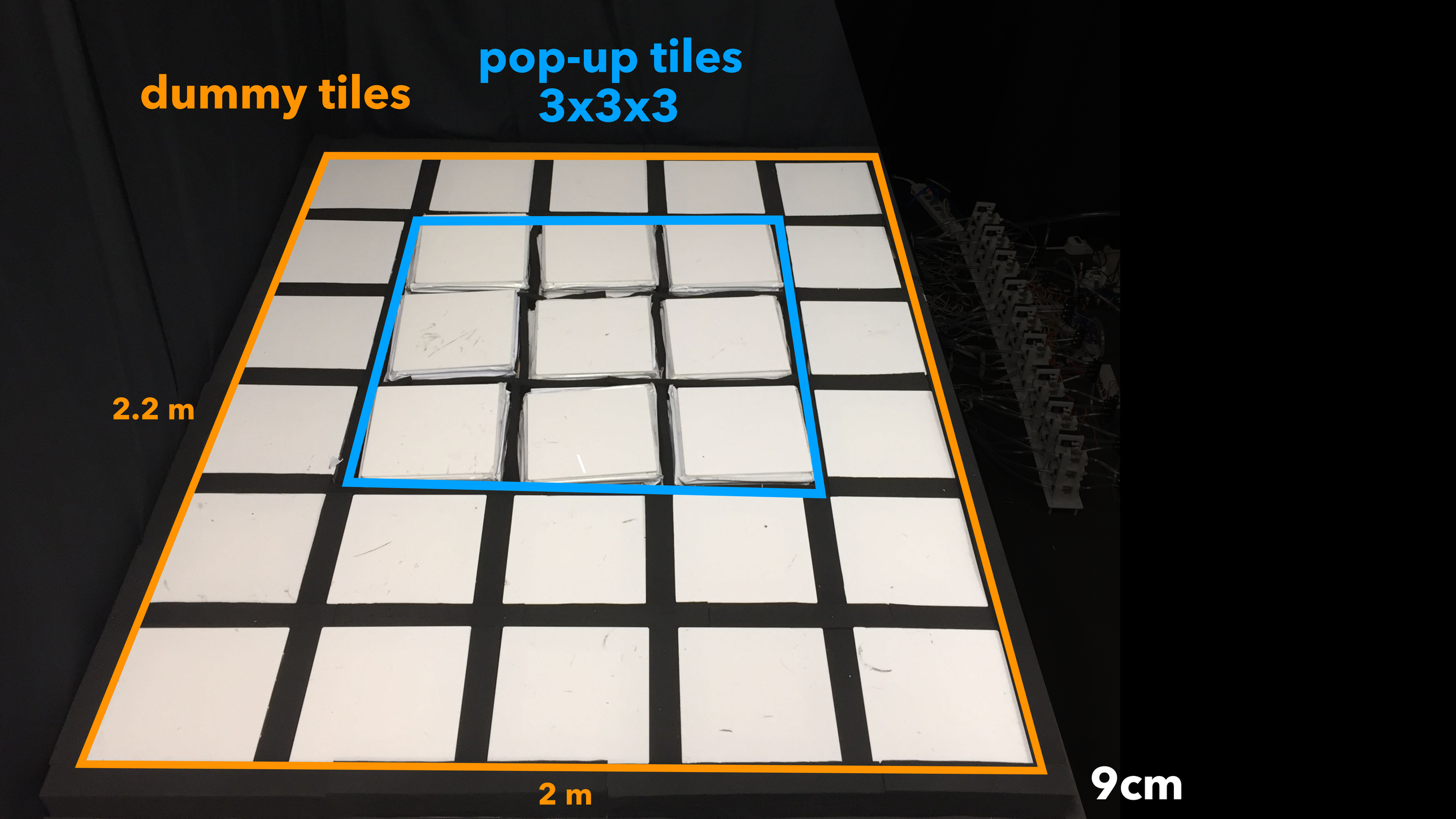
implementation

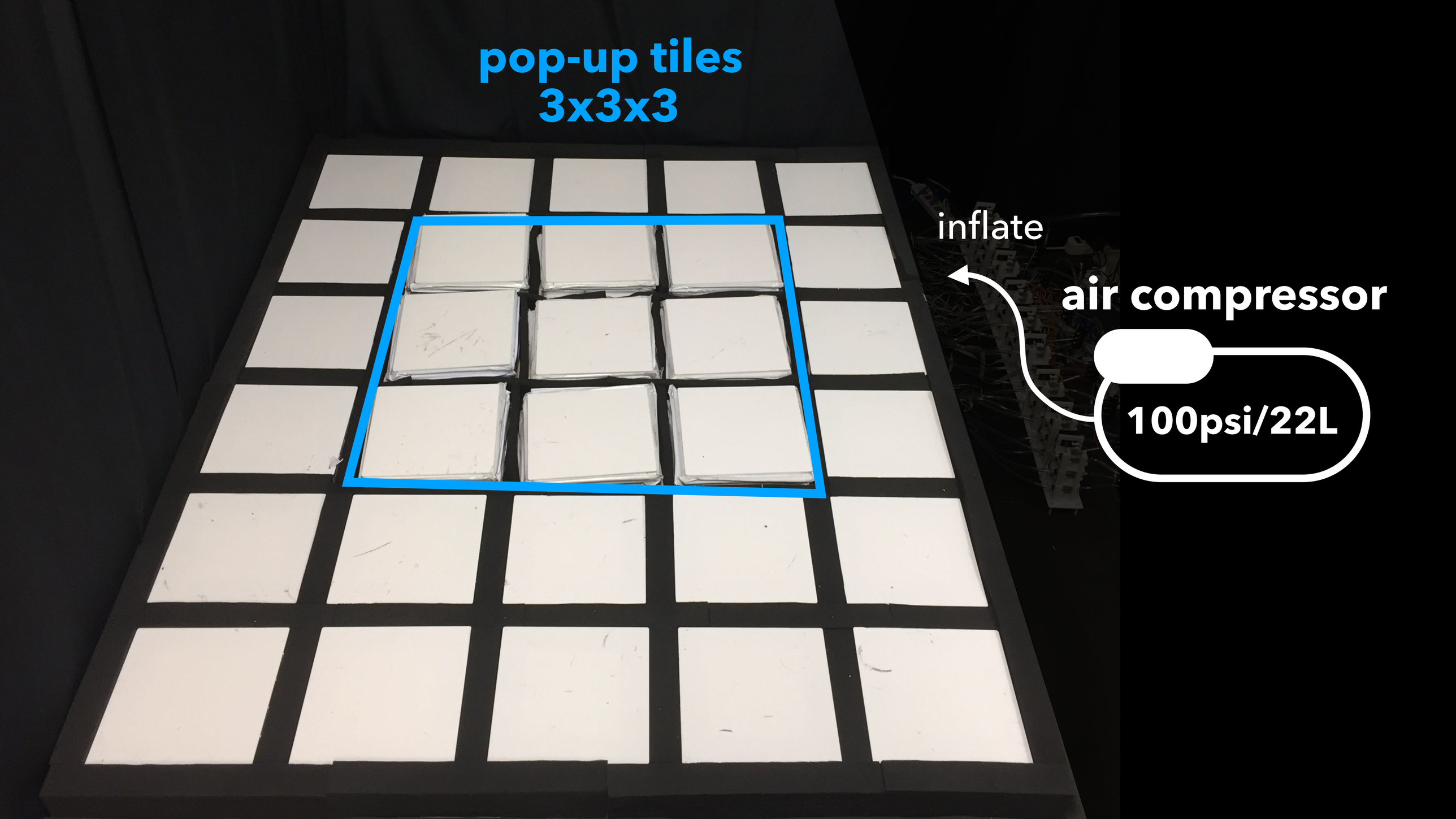

stacked
cube airbags

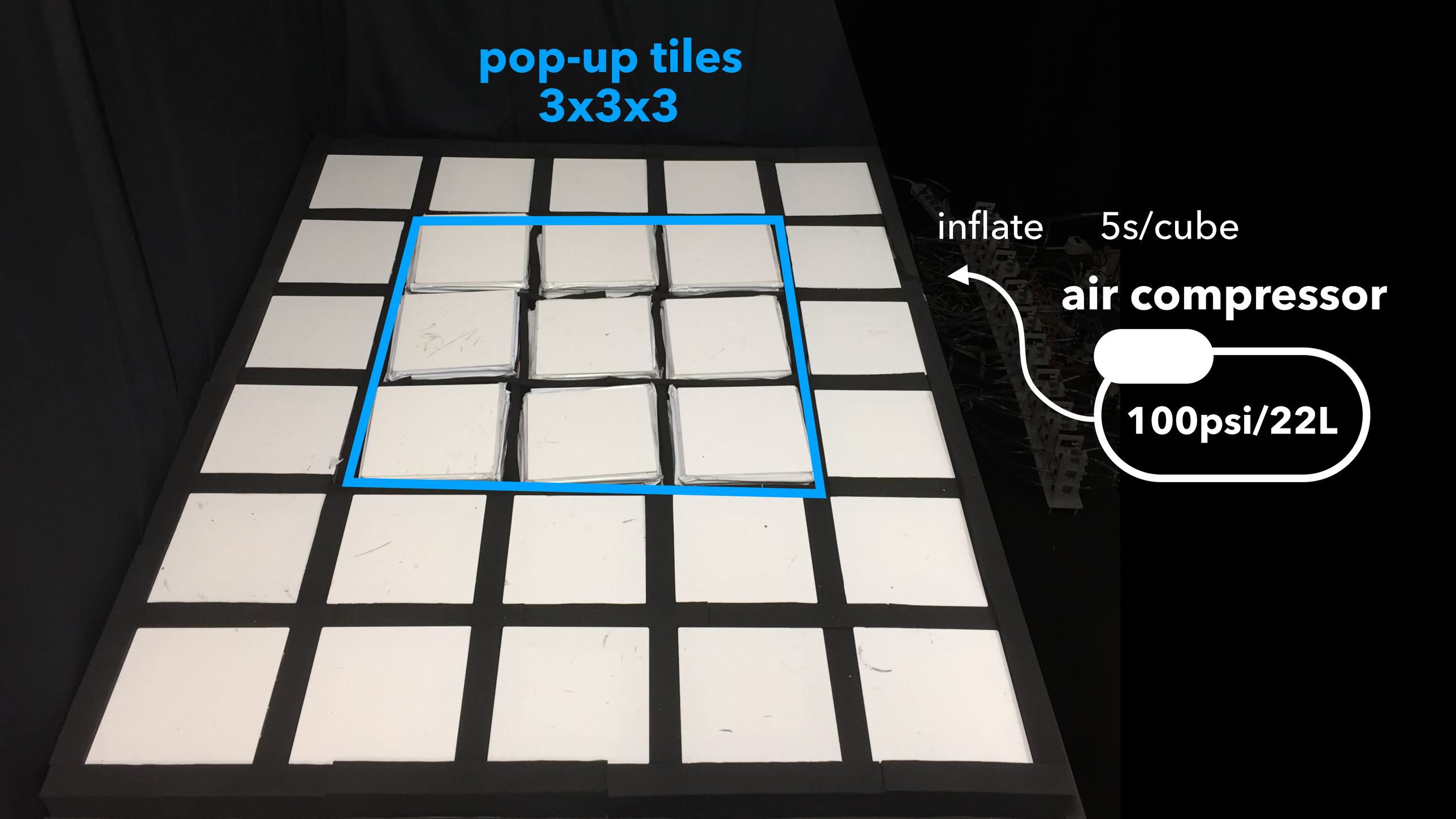

stacked
cube airbags
pneumatic
actuation

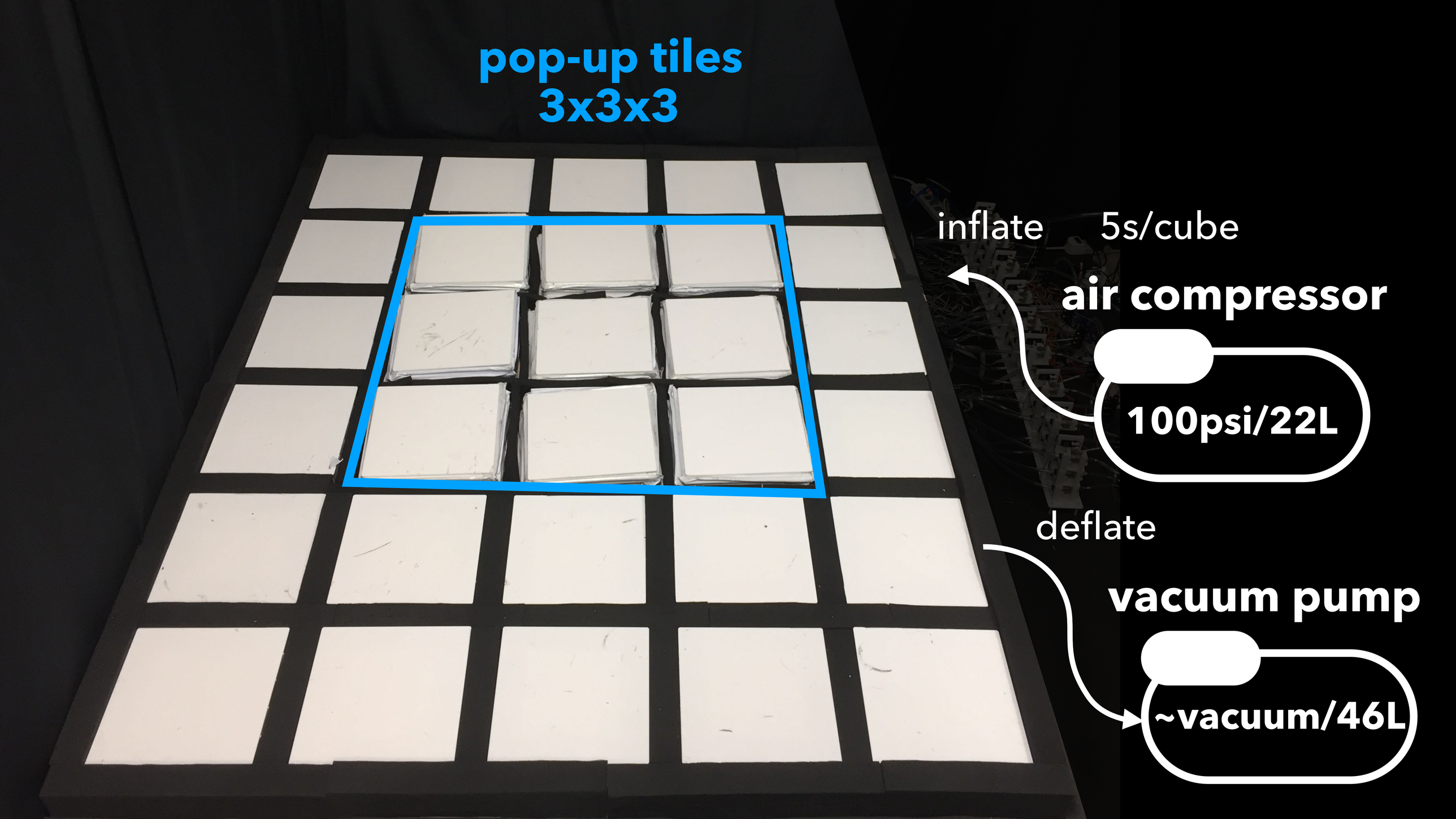

stacked
cube airbags
pop up
pneumatic
actuation

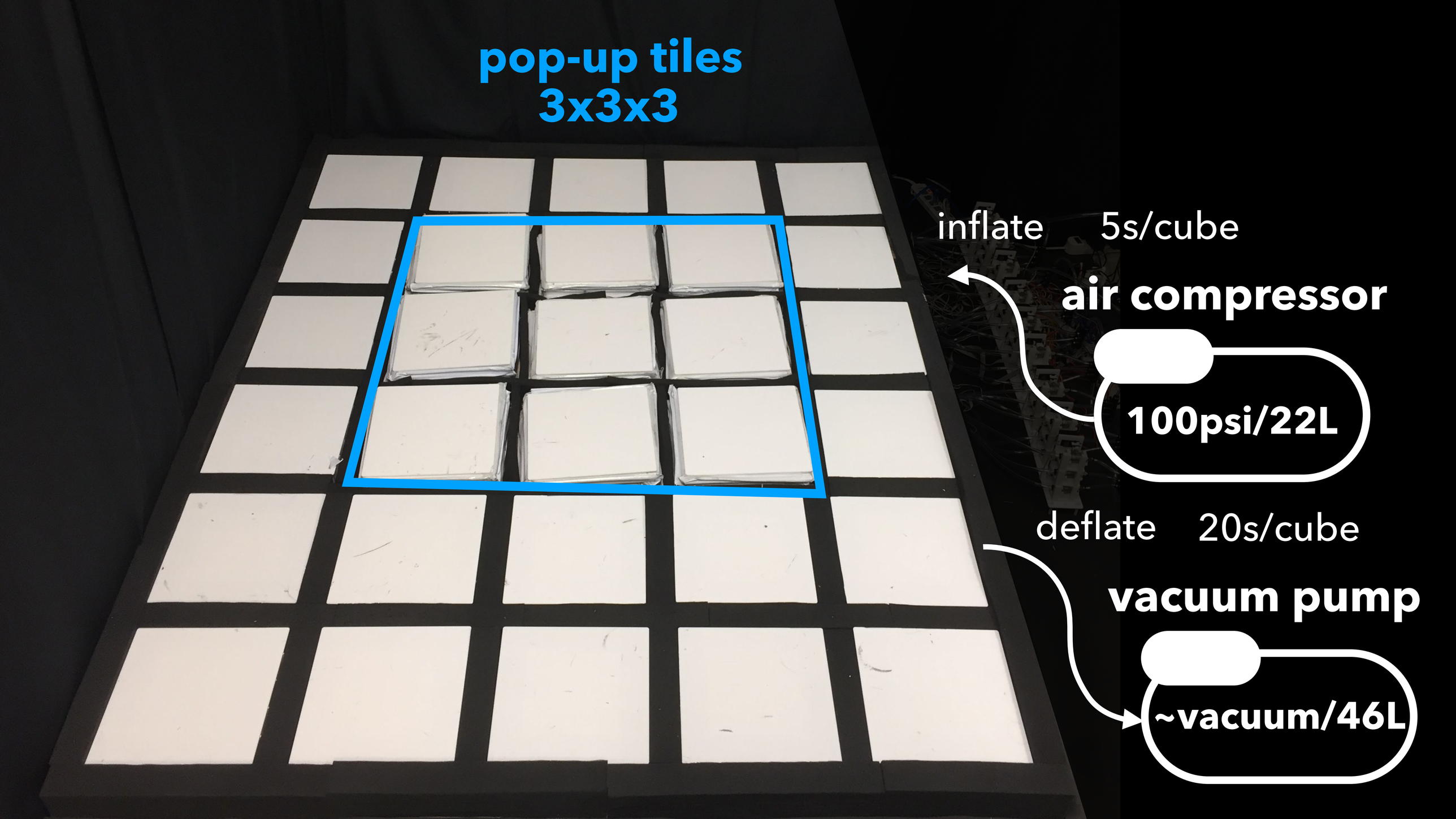

pop-up tiles
3x3x3

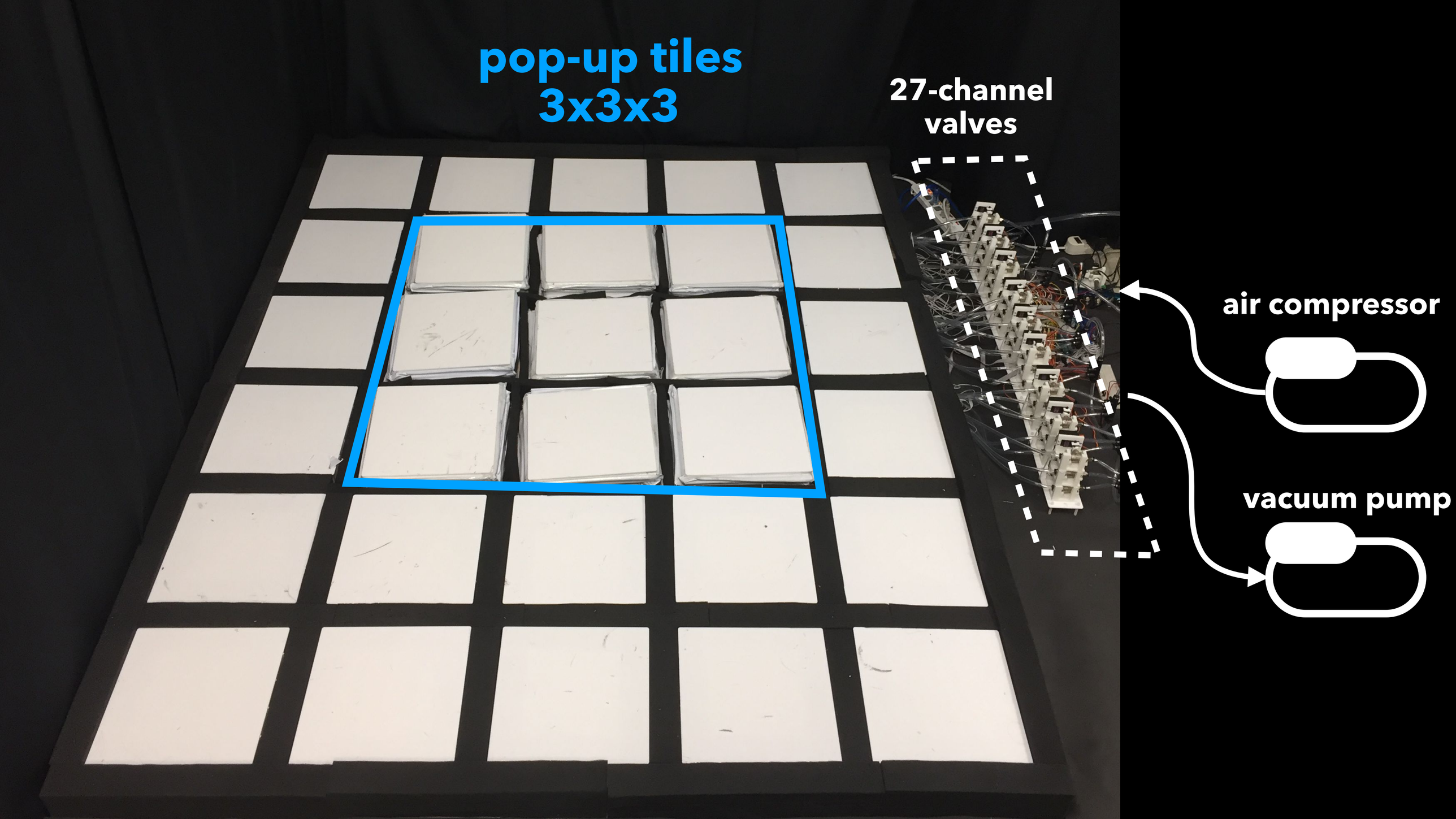

dummy tiles
pop-up tiles
3x3x3
2.2 m
2 m
9cm

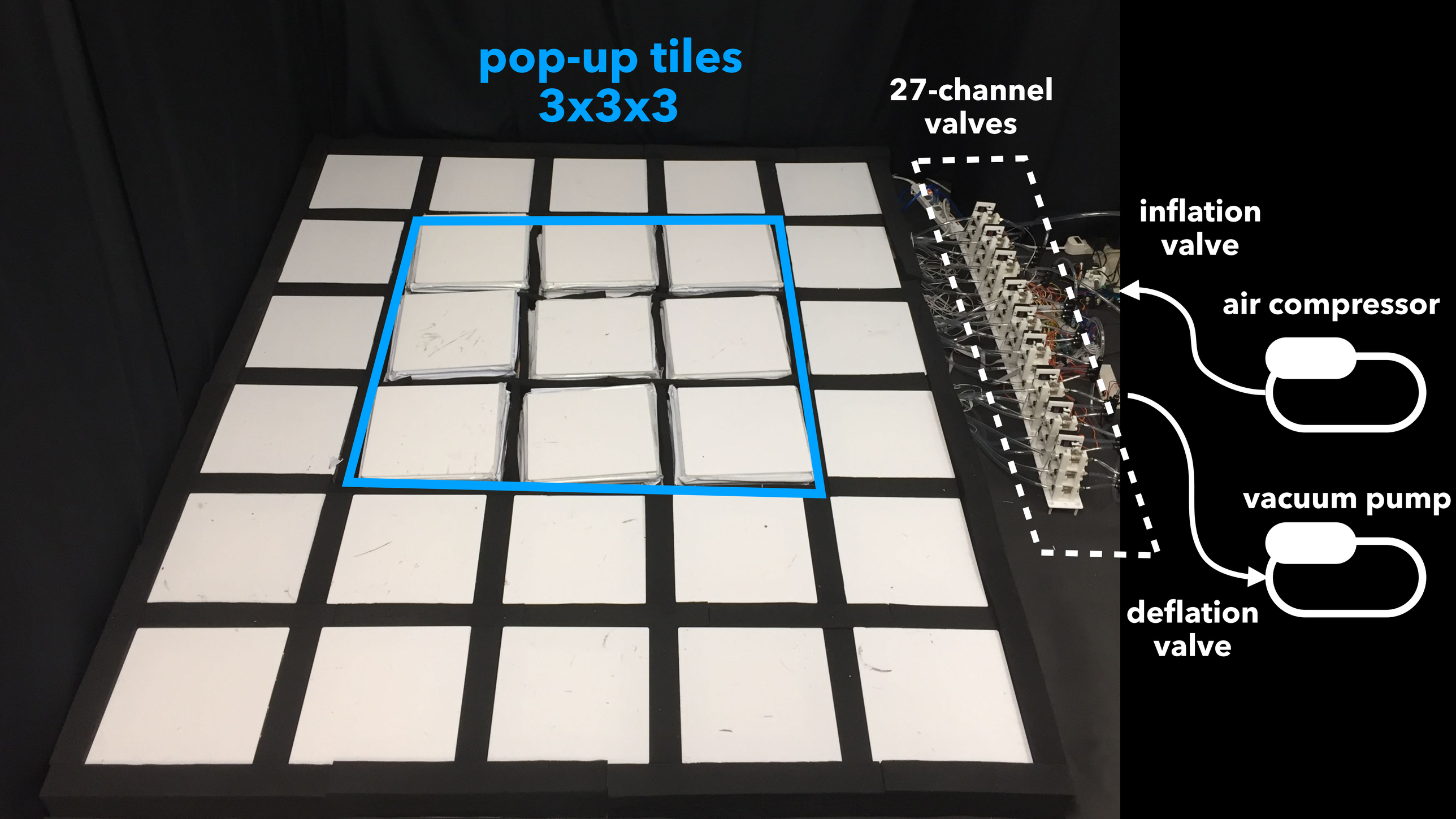

pop-up tiles
3x3x3
inflate
air compressor
100psi/22L

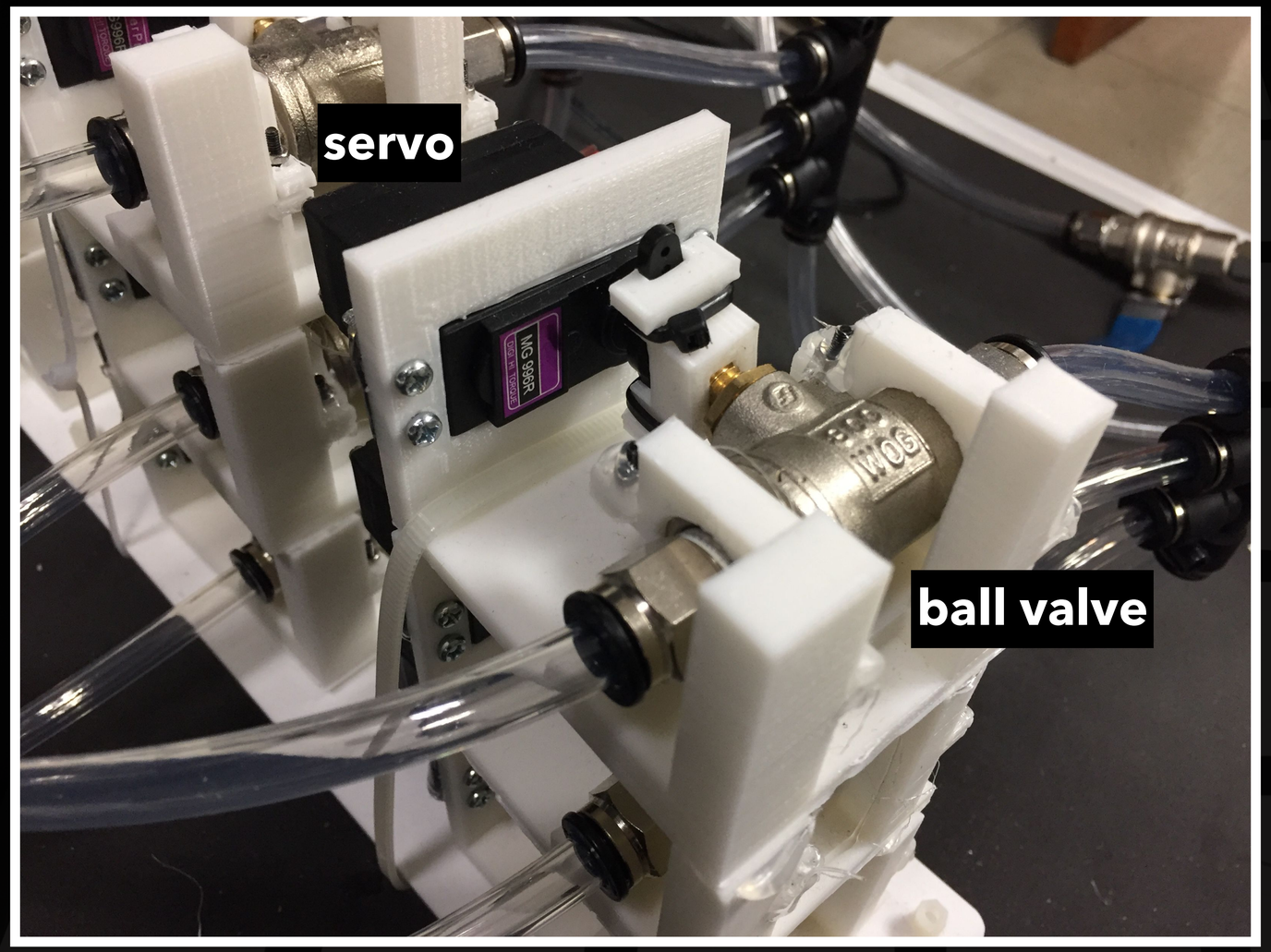

pop-up tiles
3x3x3
inflate
5s/cube
air compressor
100psi/22L

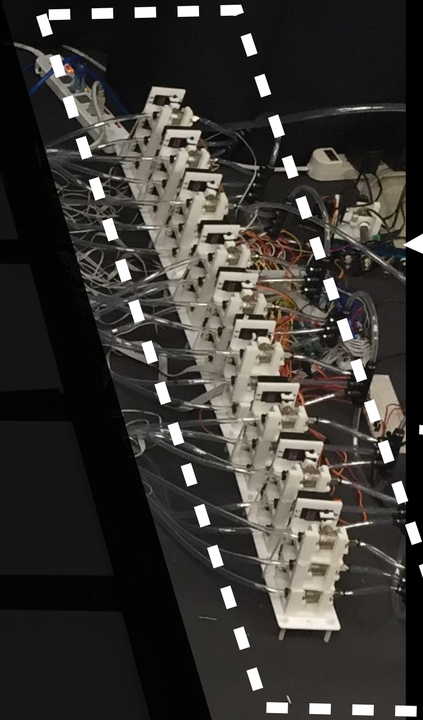

pop-up tiles
3x3x3
inflate
5s/cube
air compressor
100psi/22L
deflate
vacuum pump
~vacuum/46L


pop-up tiles
3x3x3
inflate 5s/cube
air compressor
100psi/22L
deflate 20s/cube
vacuum pump
~vacuum/46L


pop-up tiles
3x3x3
27-channel
valves
air compressor
vacuum pump


pop-up tiles
3x3x3
27-channel
valves
inflation
valve
air compressor
vacuum pump
deflation
valve



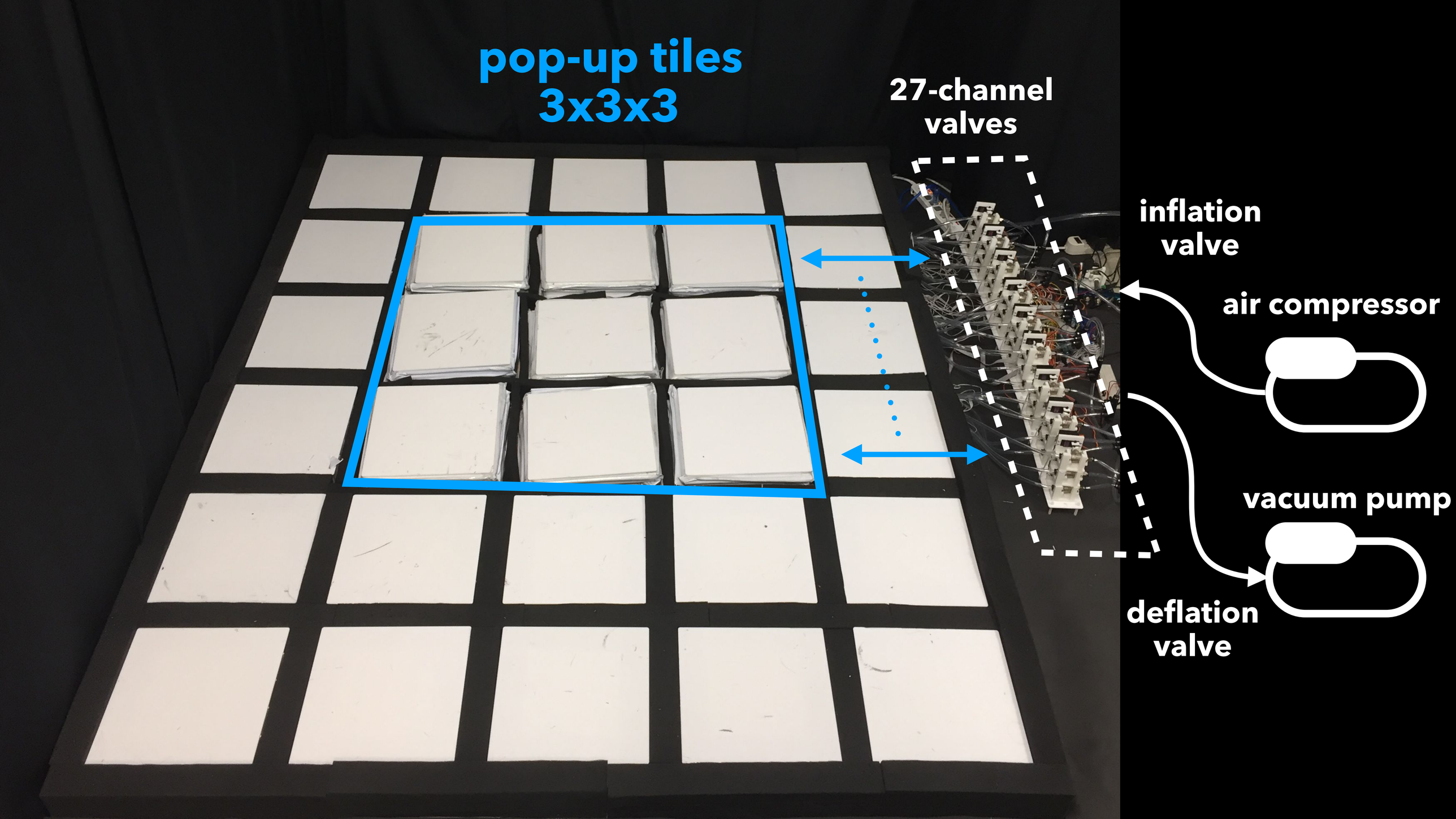


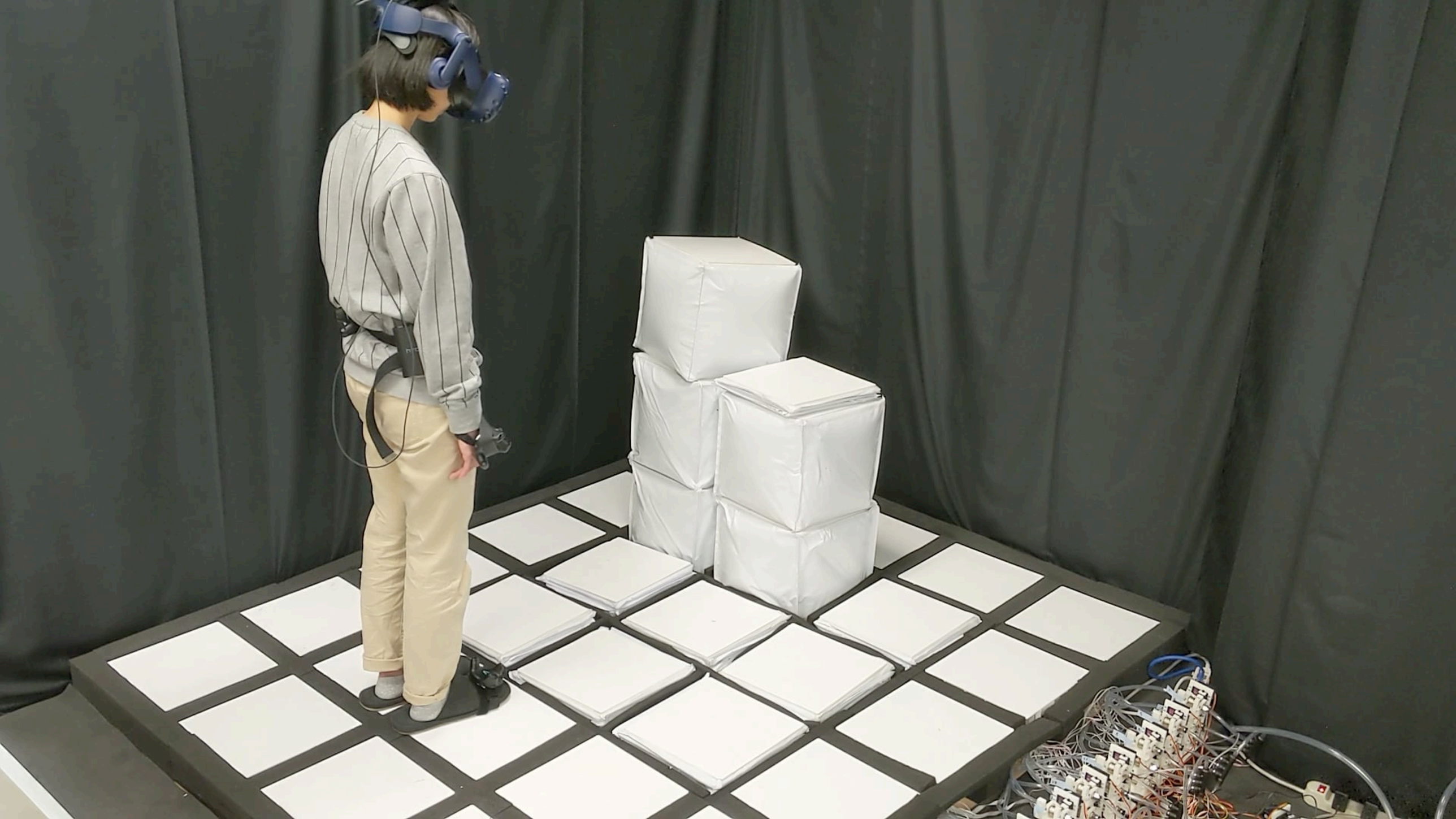
inflation
valve

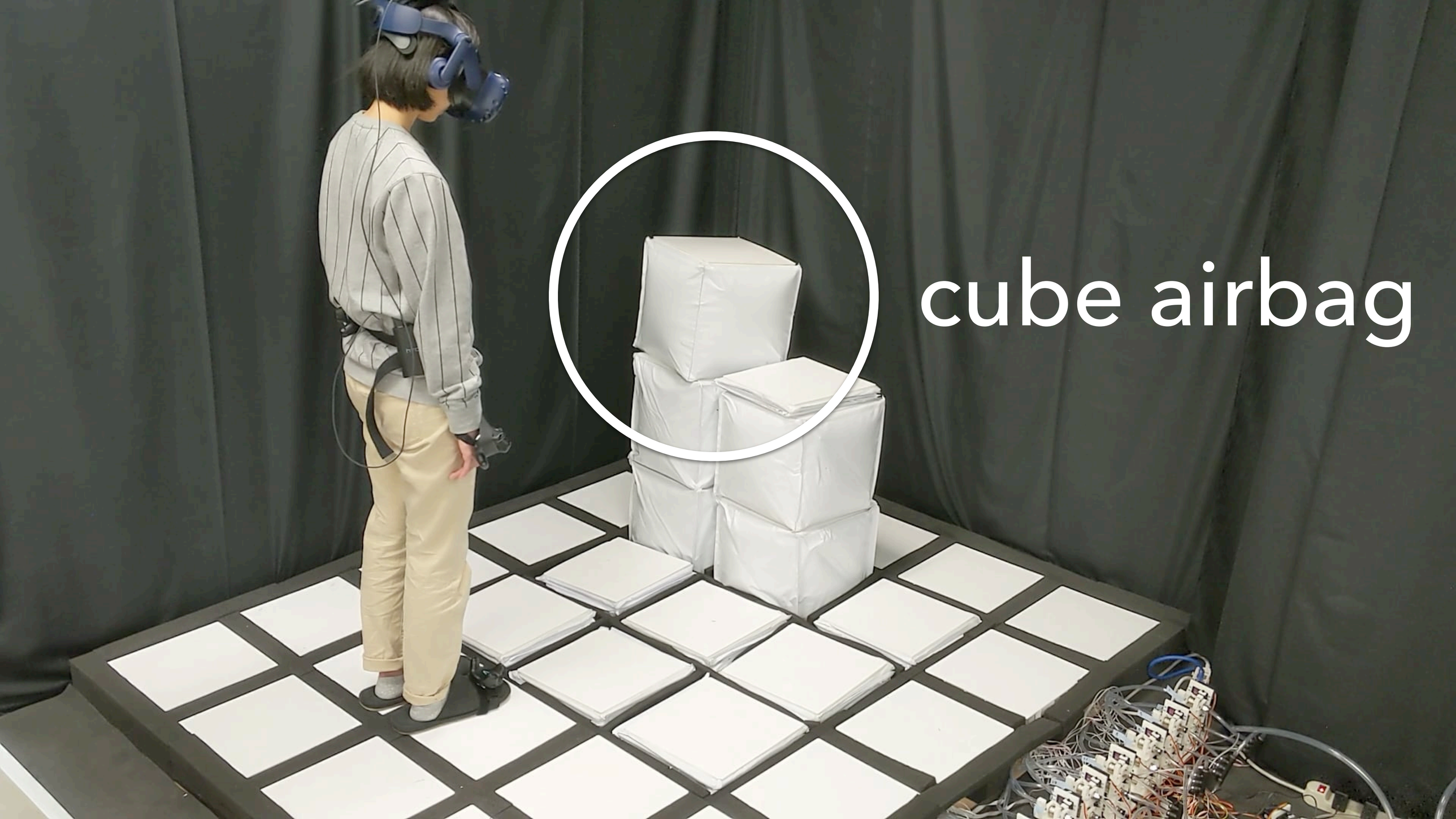
air compressor

vacuum pump

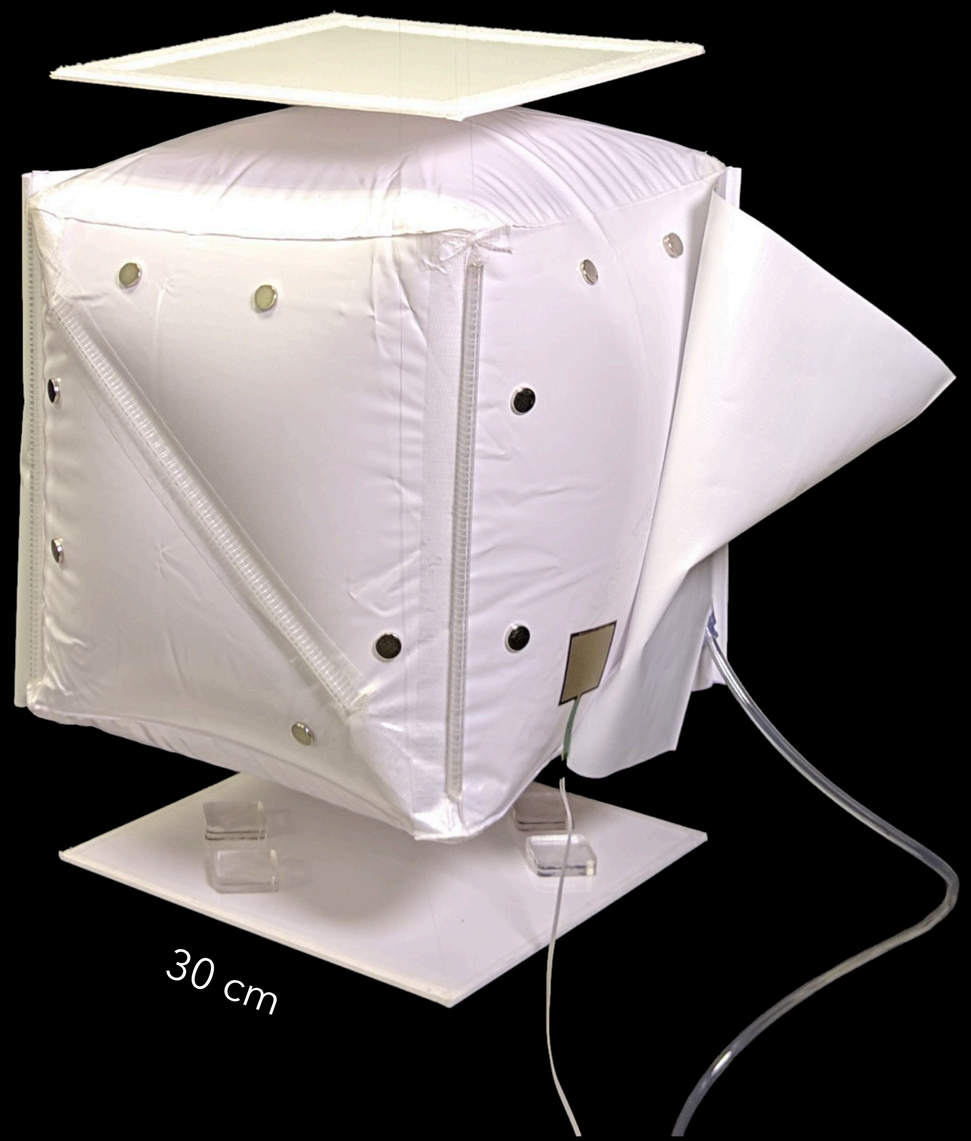
deflation
valve

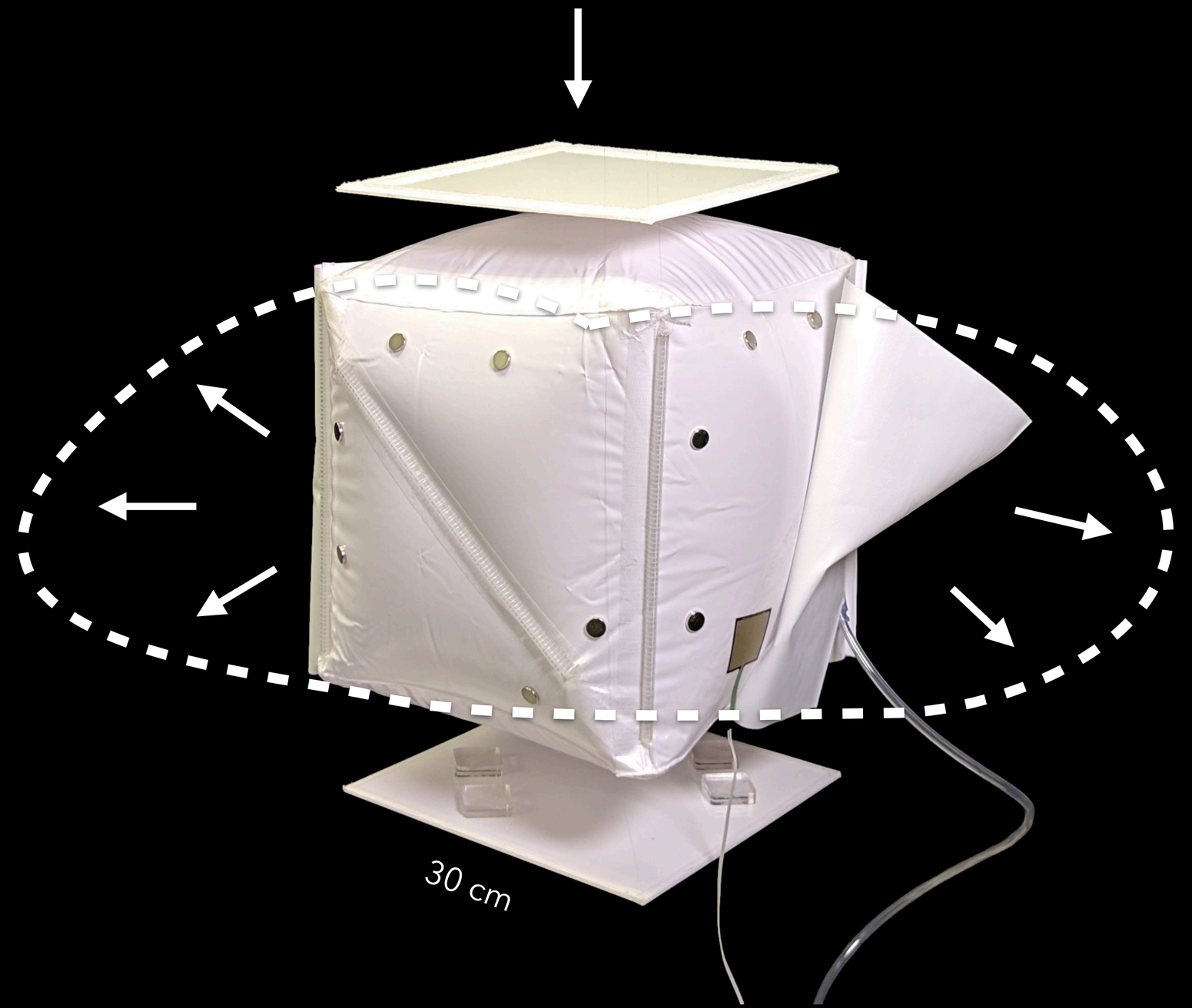

pop-up tiles
3x3x3
27-channel
valves
inflation
valve
air compressor
vacuum pump
deflation
valve




cube airbag

inflatable cube




30 cm

support body weight*

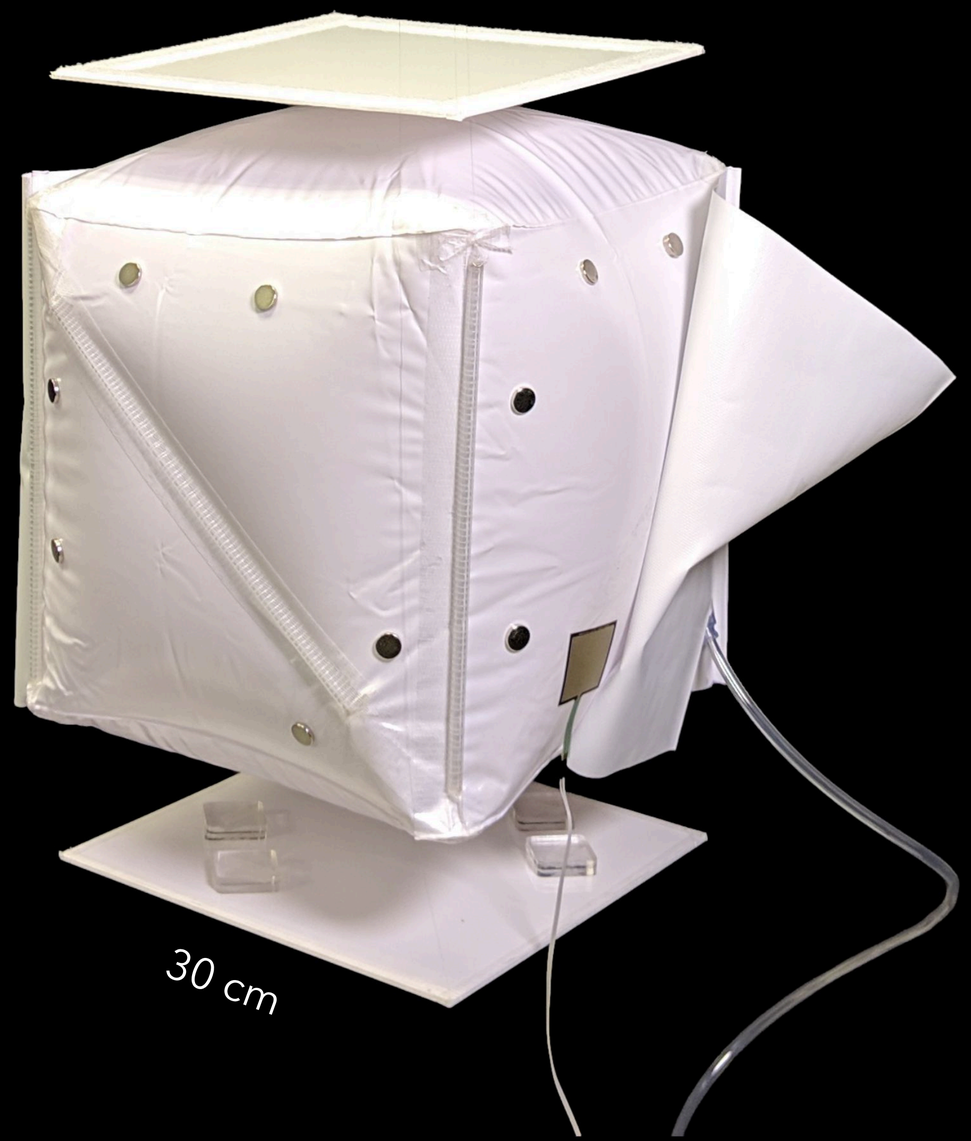
PVC wrapping fabric

***only when fully inflated**

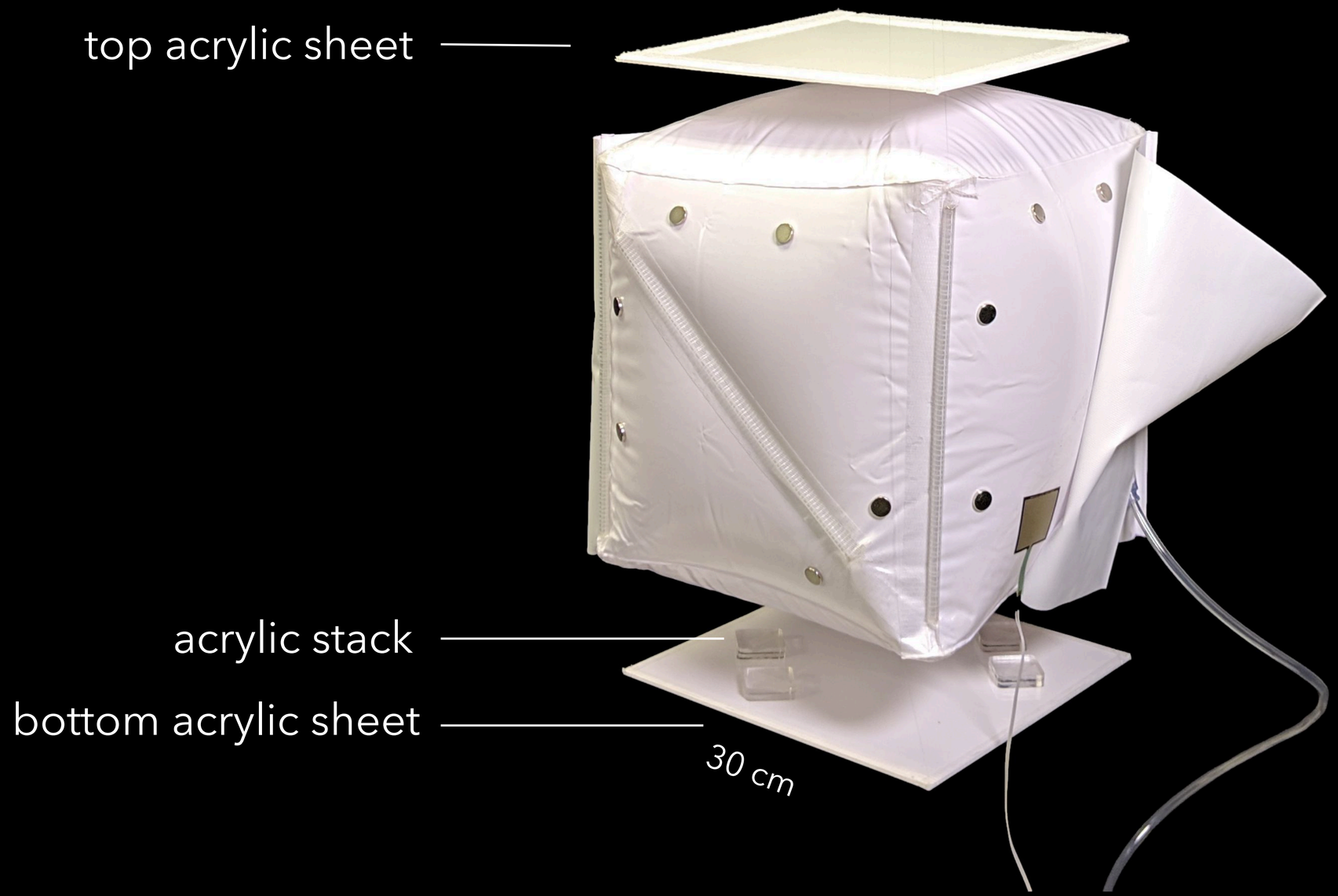
folding guides

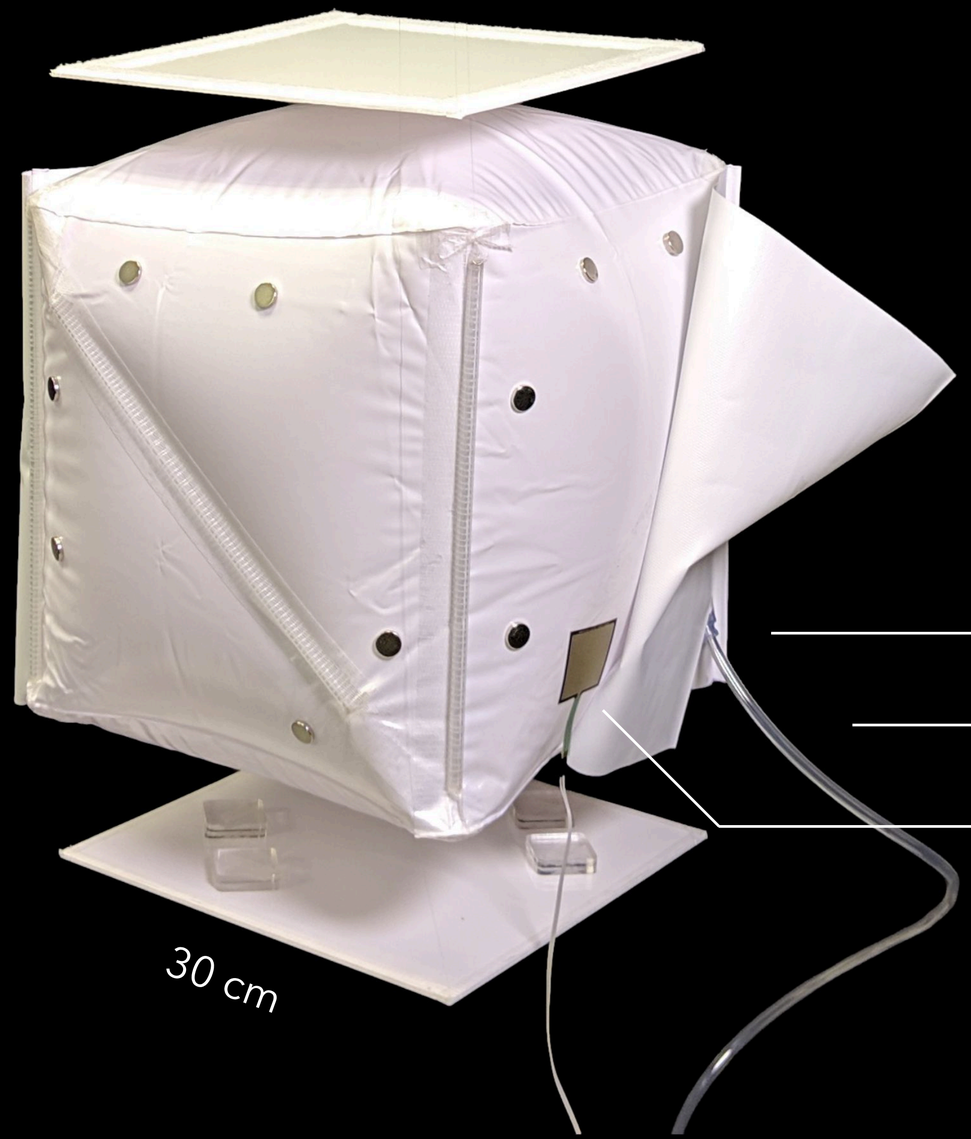
acrylic tube

magnet



stability





pneumatic control

outlet

PE tube

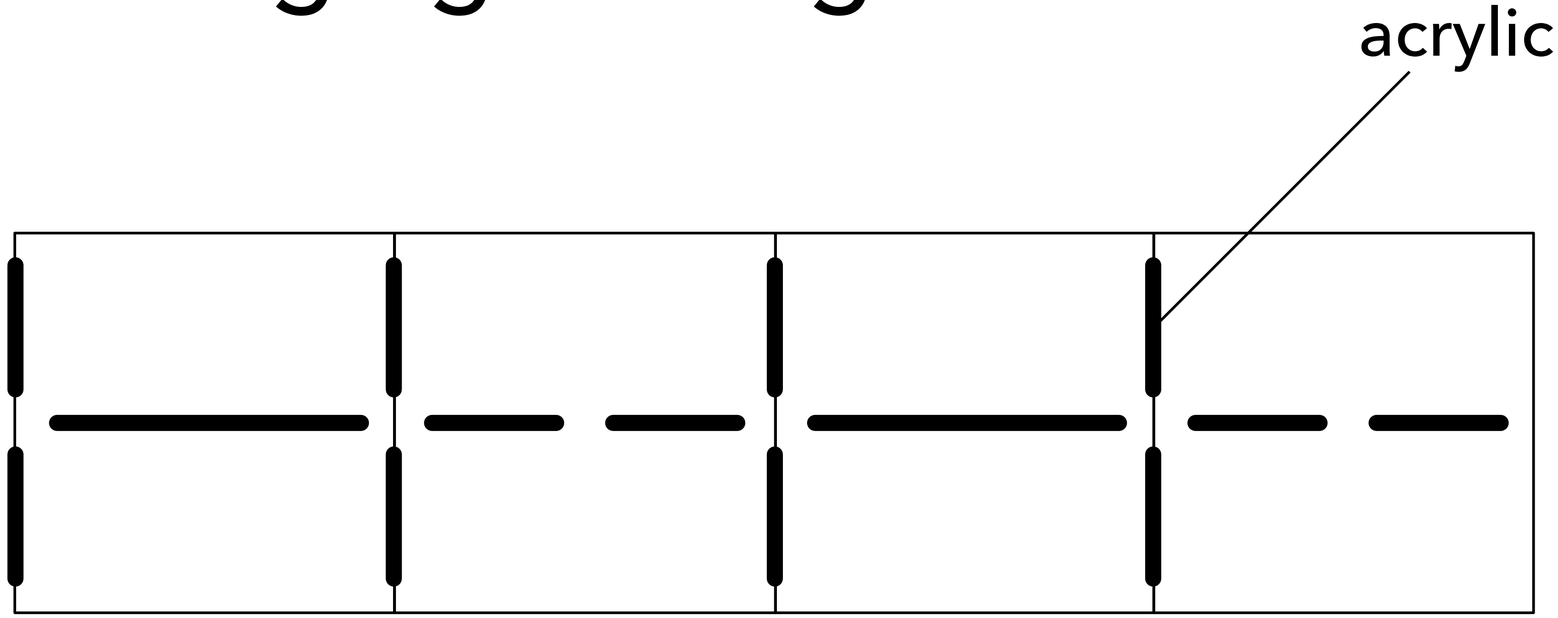
force sensor

TilePoP

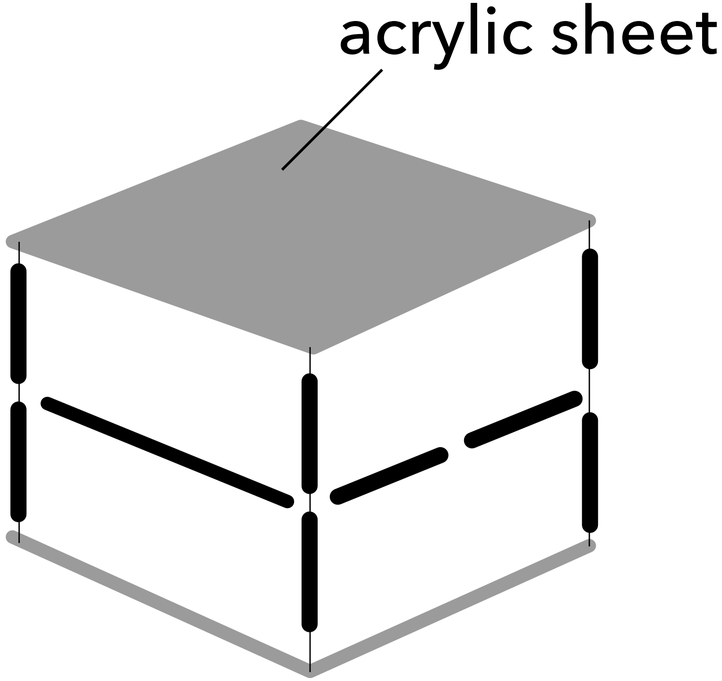
implementation

challenge #1: folding

packaging folding



side expansion view

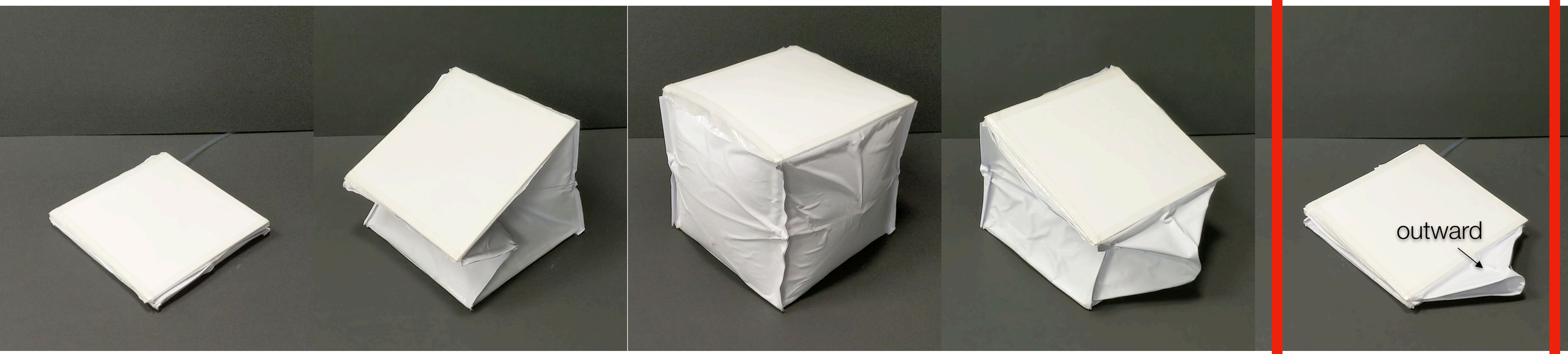


3D view

packaging folding

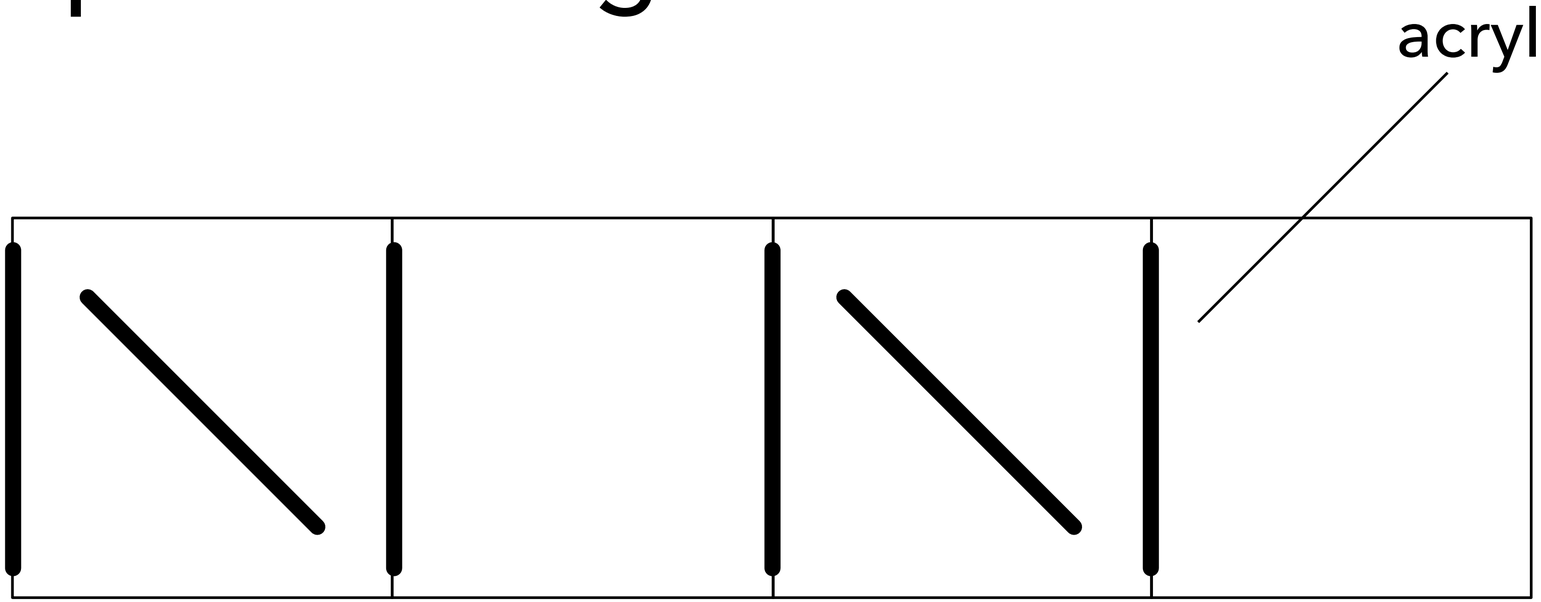
flat ⟶ inflating ⟶ full ⟶ deflating ⟶ flat

packaging folding

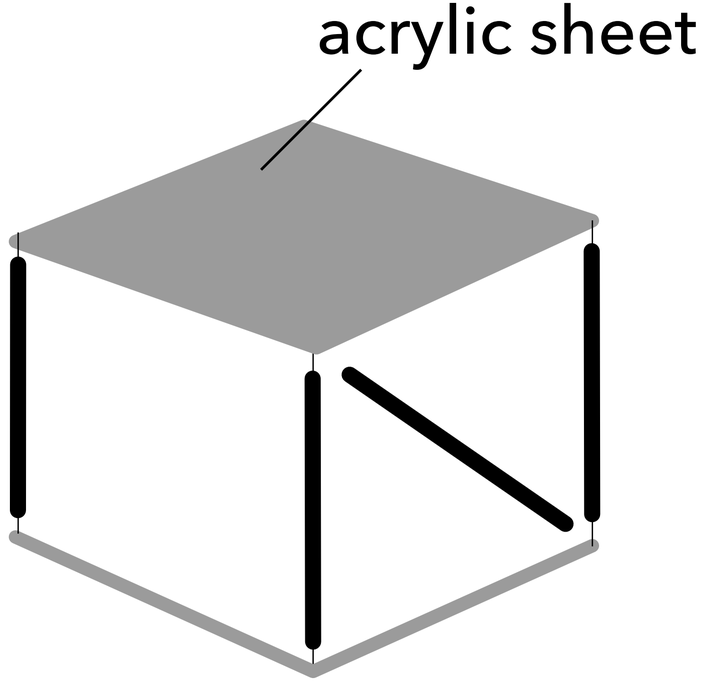


flat → inflating → full → deflating → flat

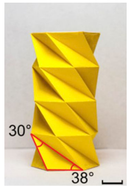
spiral folding



side expansion view

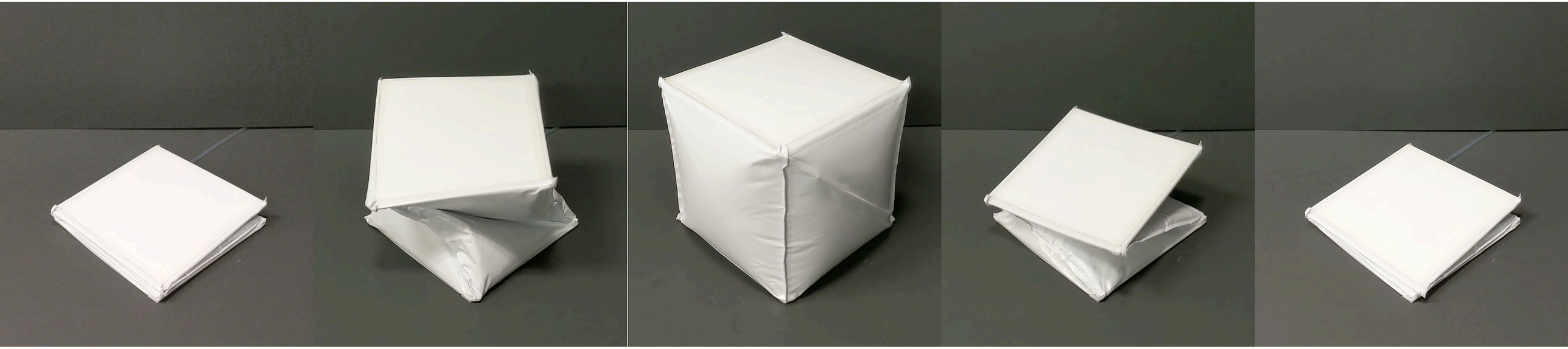


3D view



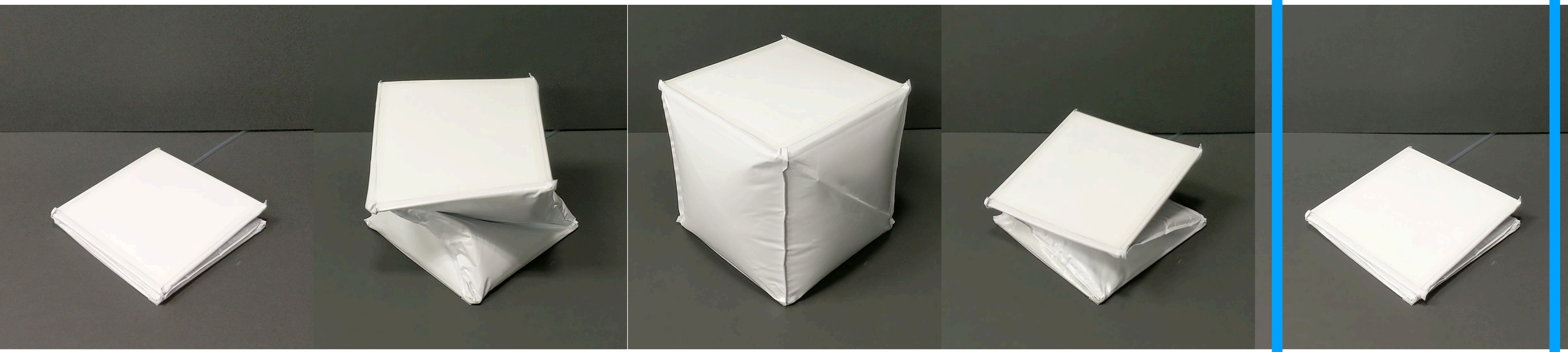
Zhai et al.
[PNAS ’18]

spiral folding



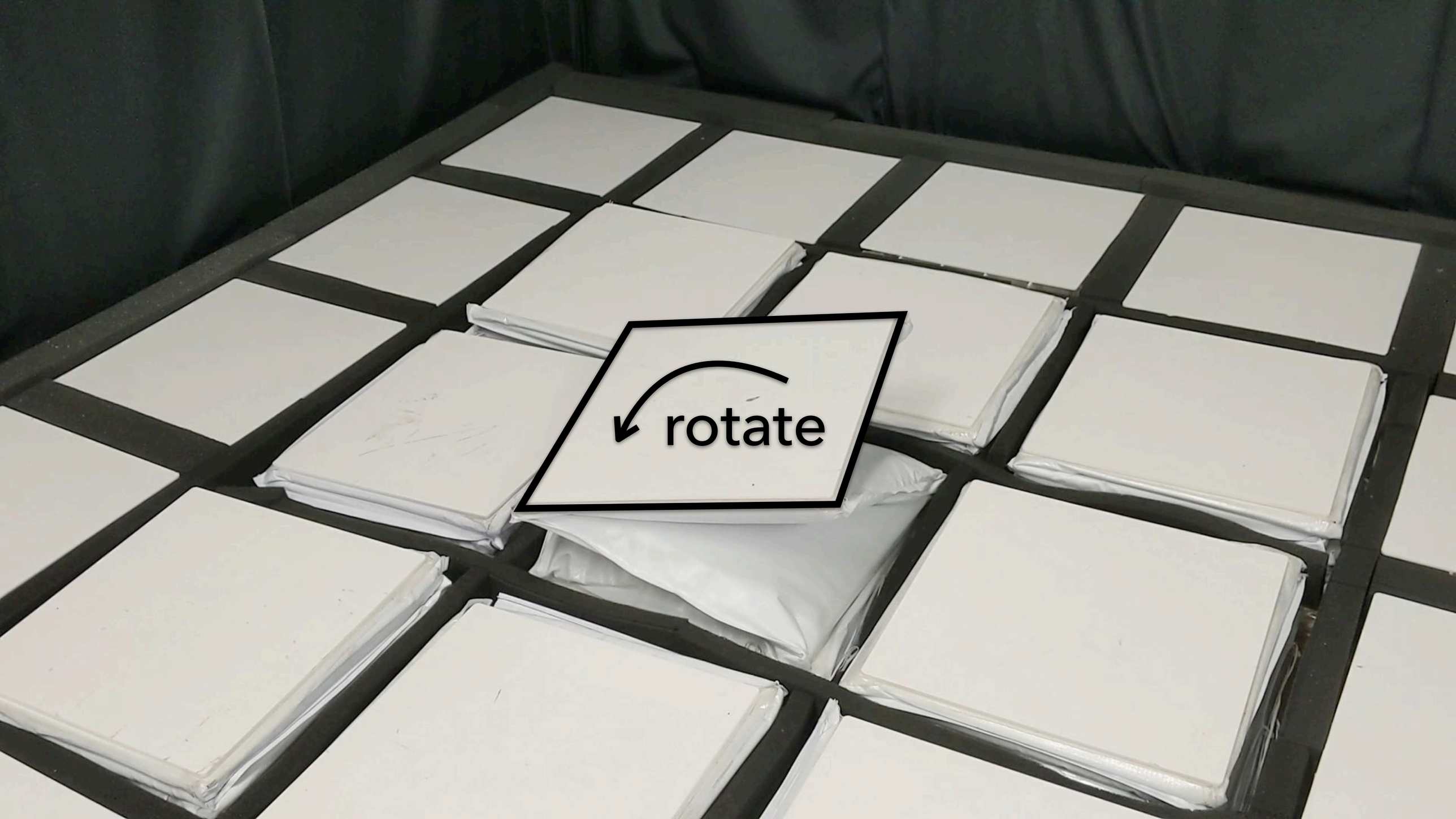
flat → inflating → full → deflating → flat

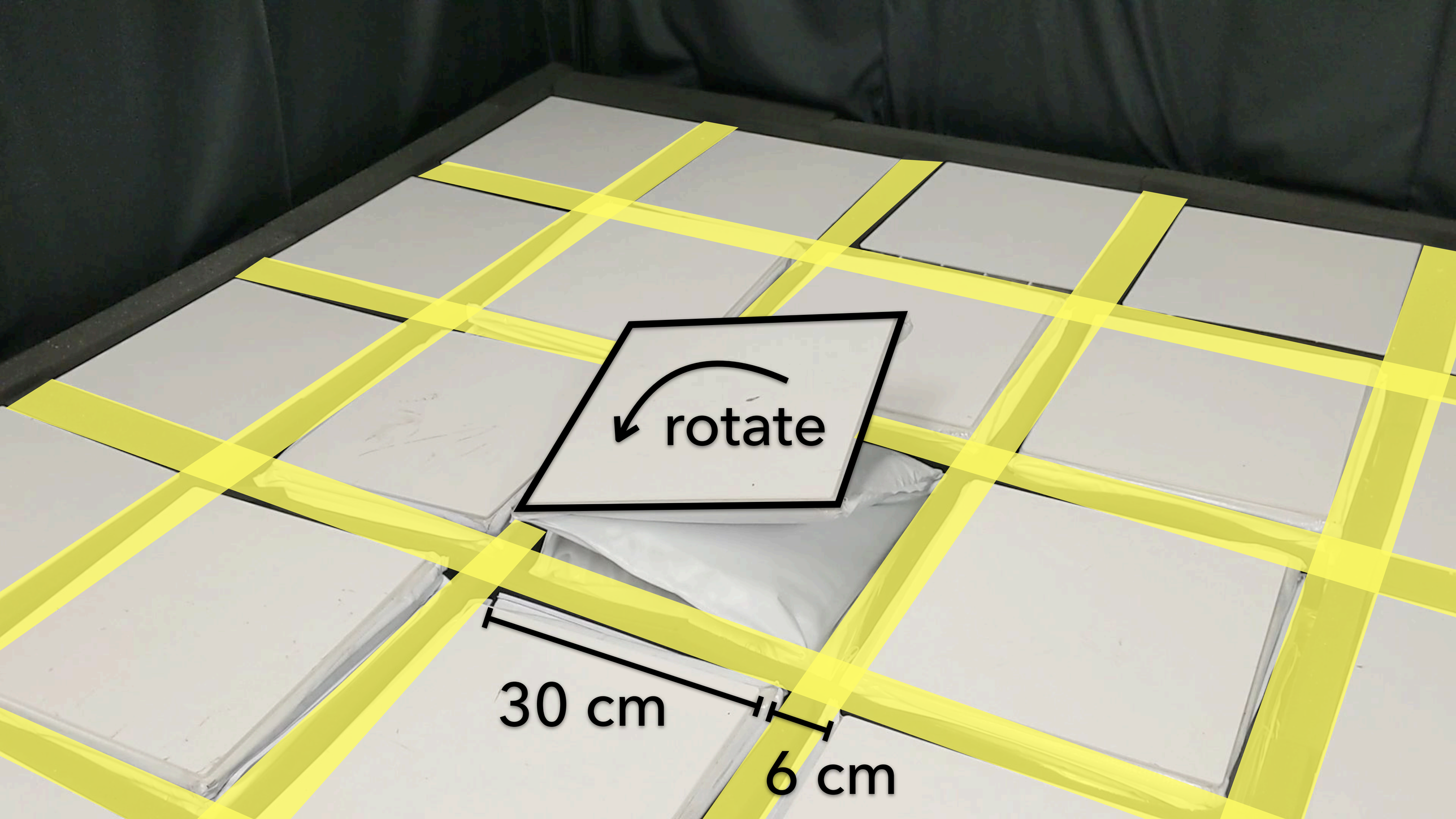
spiral folding



flat → inflating → full → deflating → flat


Each tile is made with
a **spiral folding structure.**

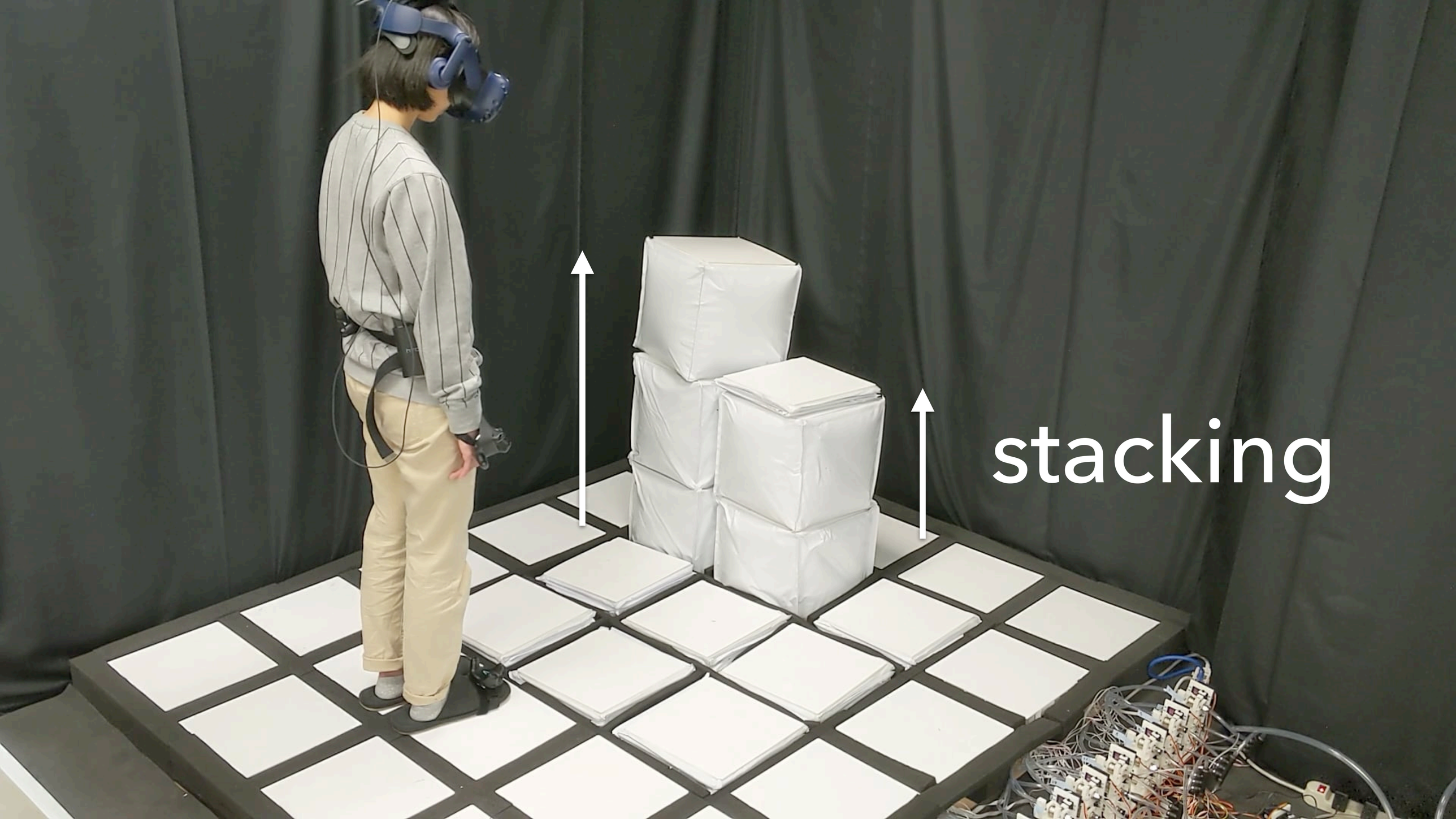

rotate


rotate
30 cm
6 cm

TilePoP

implementation

challenge #2: stacking

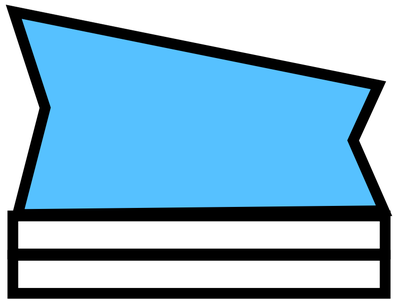

stacking

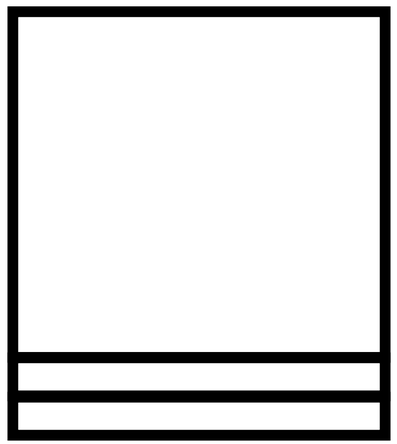
3 stacked airbags folded

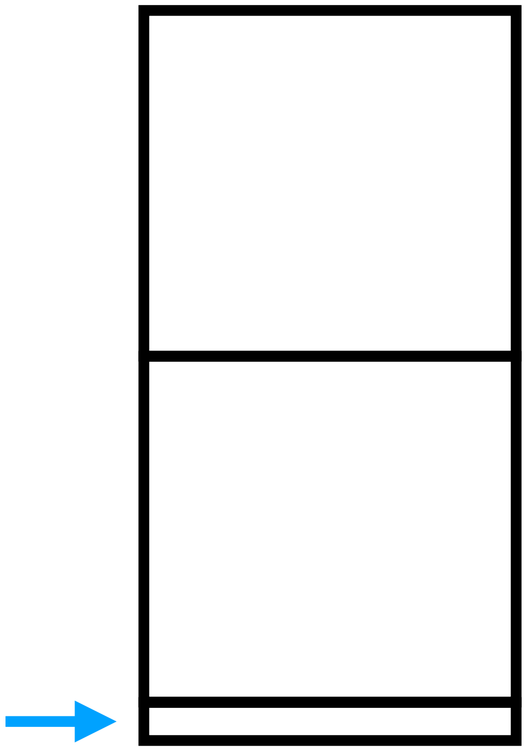
side view

inflate from the top one

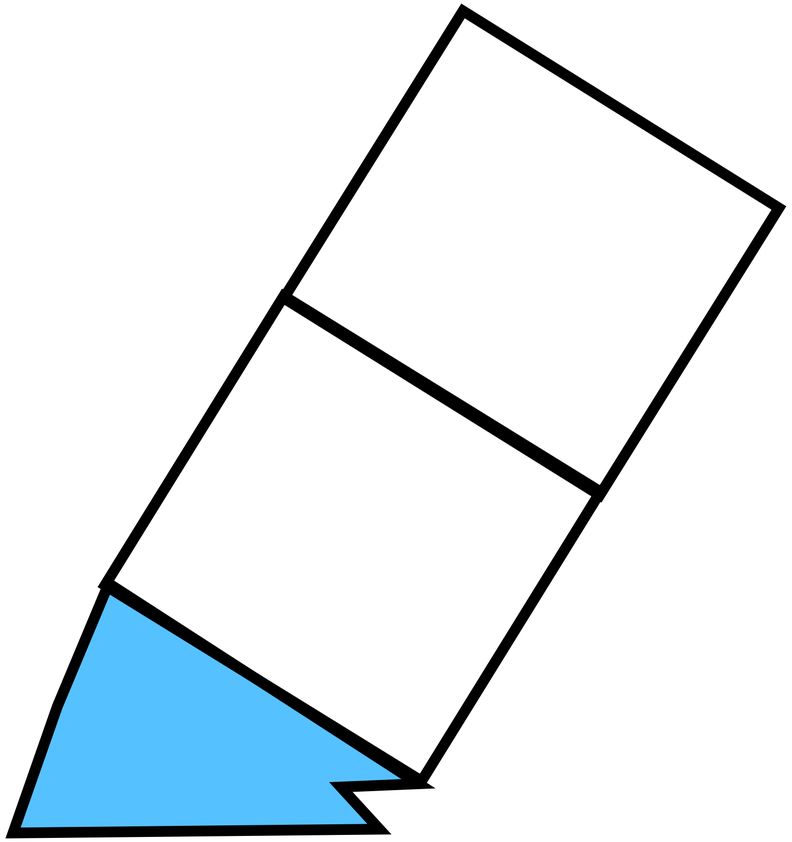
inflating



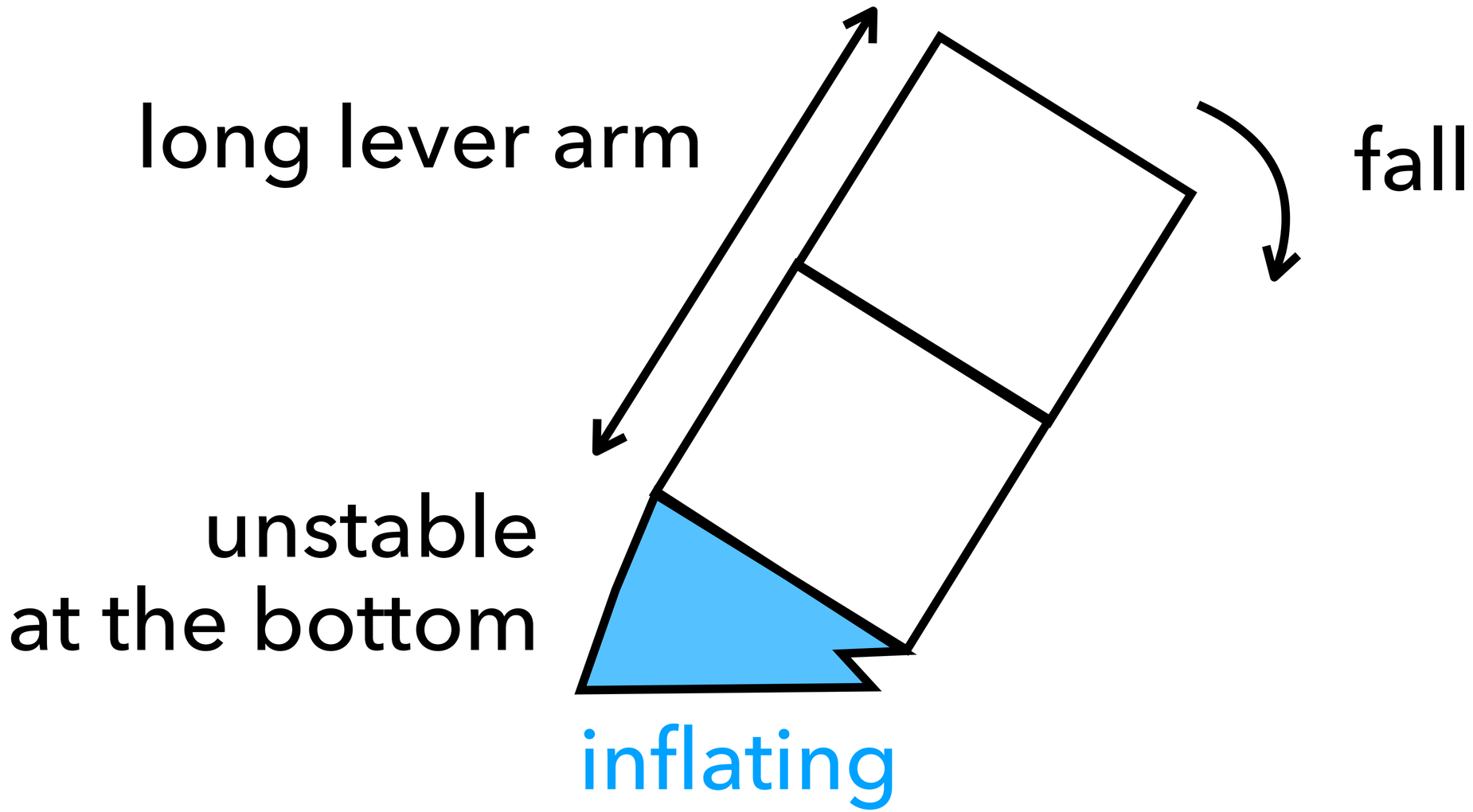




unstable
at the bottom



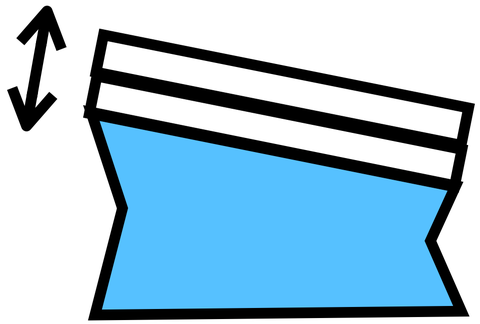
inflating

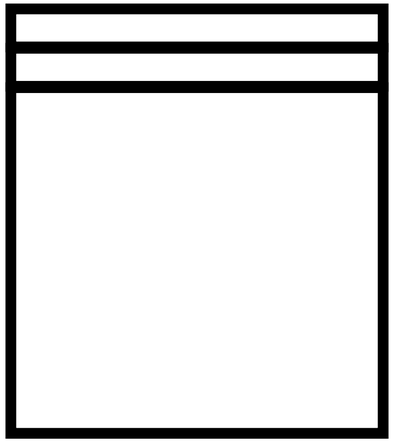

long lever arm
fall
unstable
at the bottom
inflating

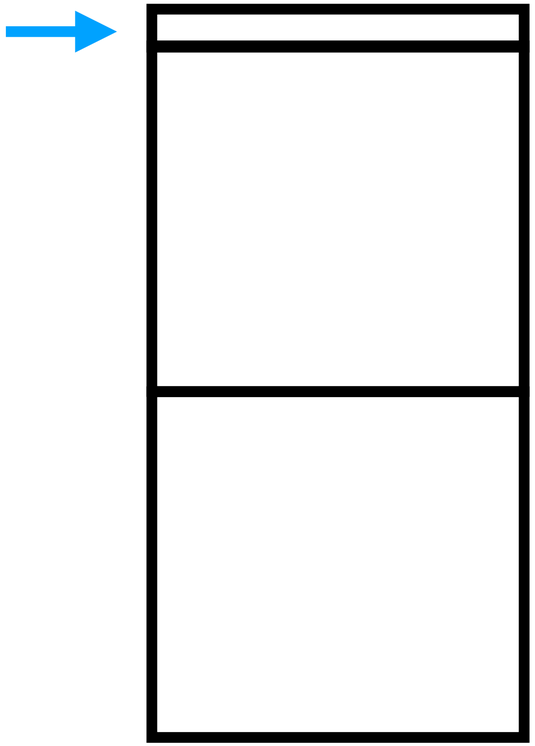
inflate from the bottom one

short lever arm

inflating

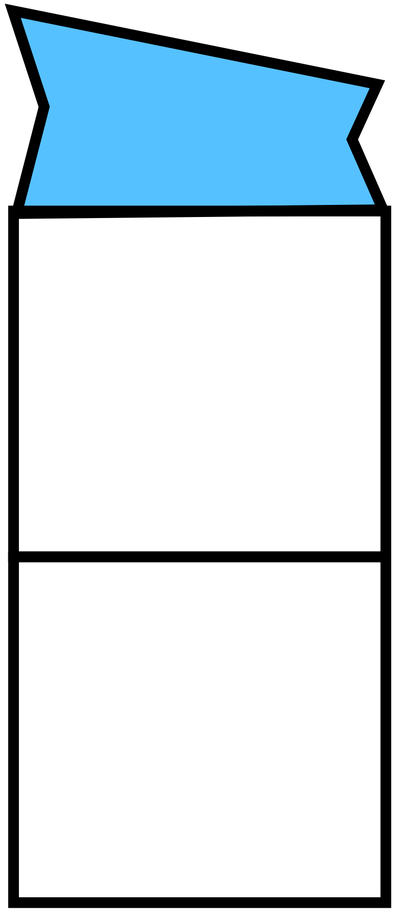


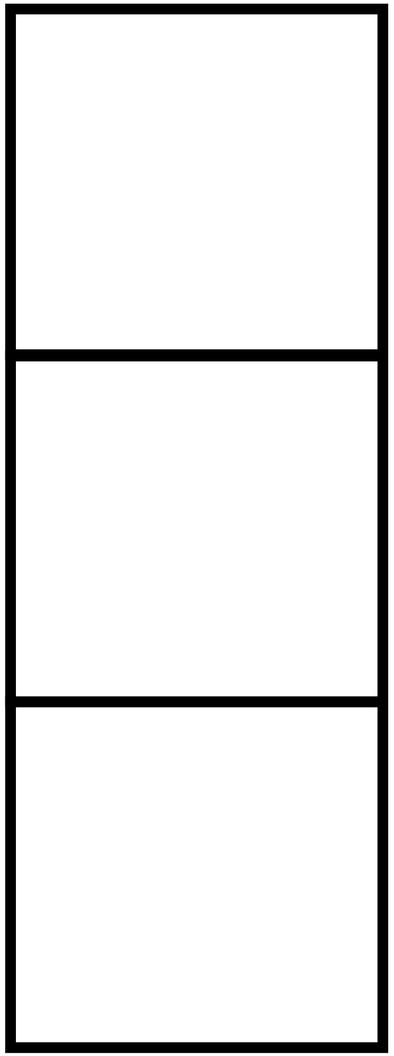


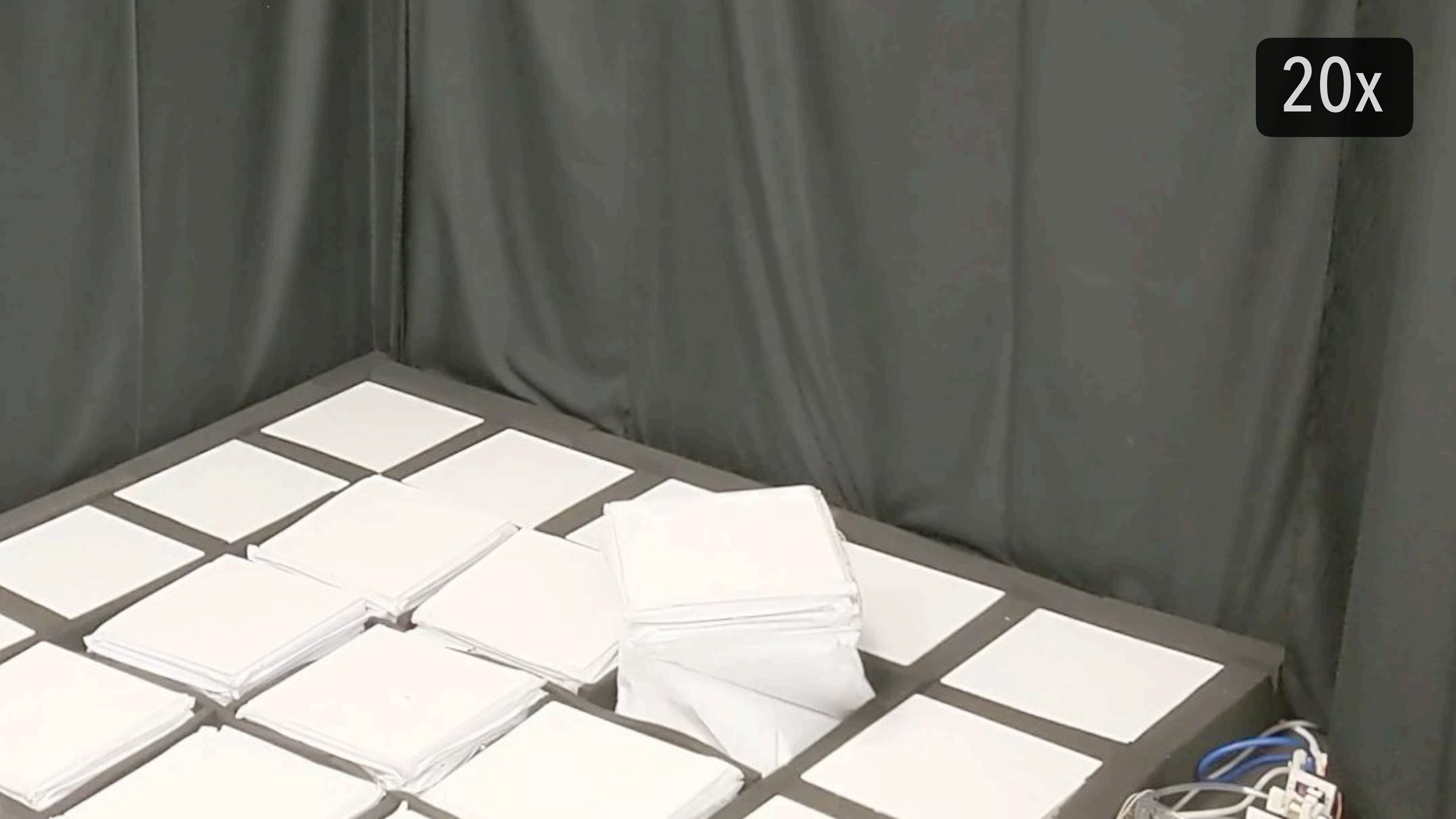


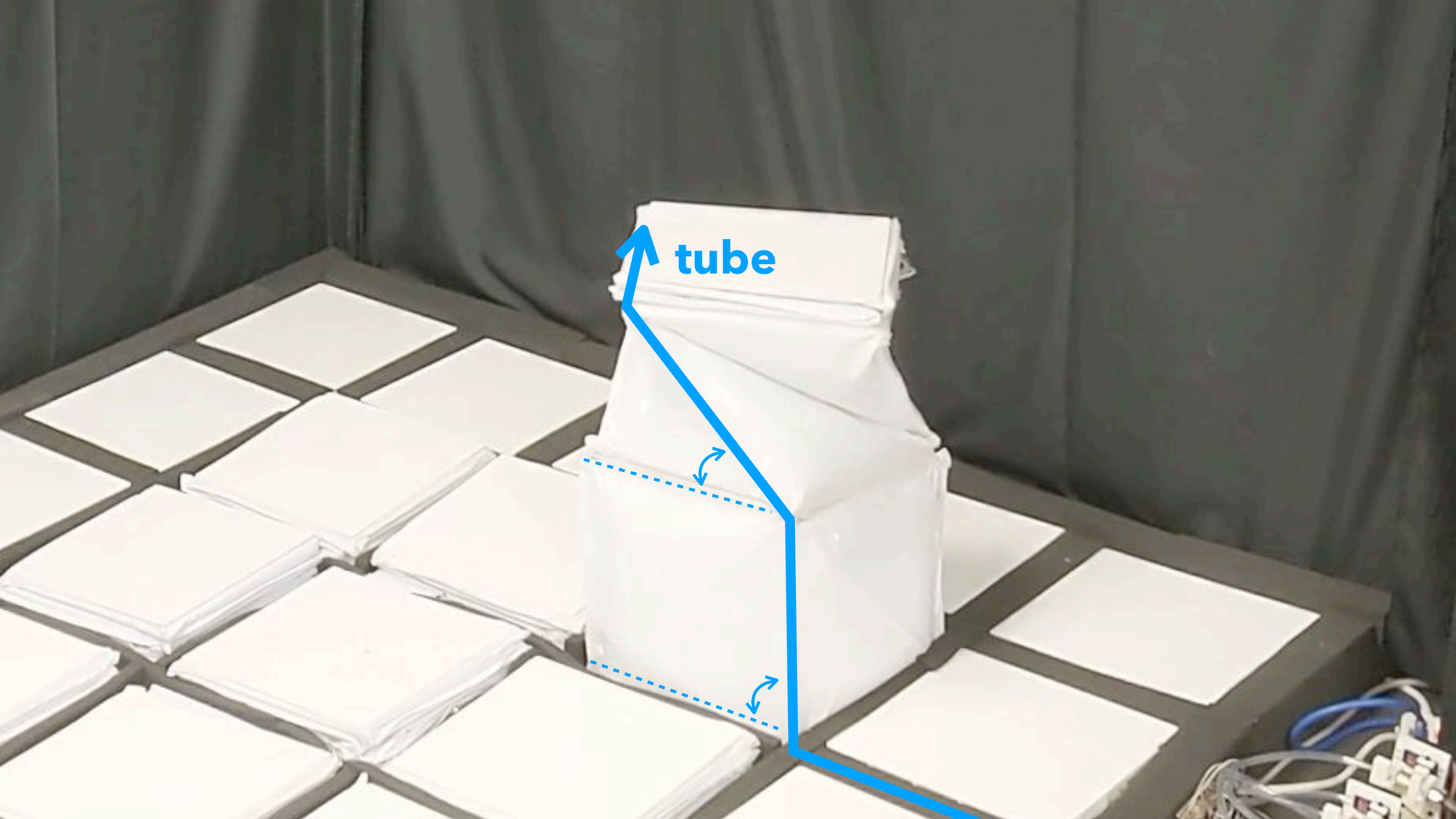
inflating

stable
at the bottom






20x


tube

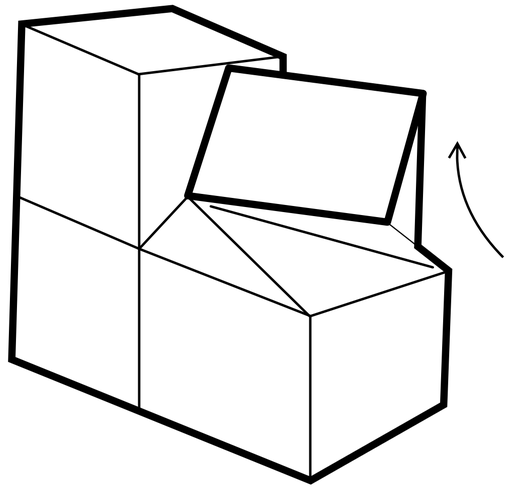
TilePoP

implementation

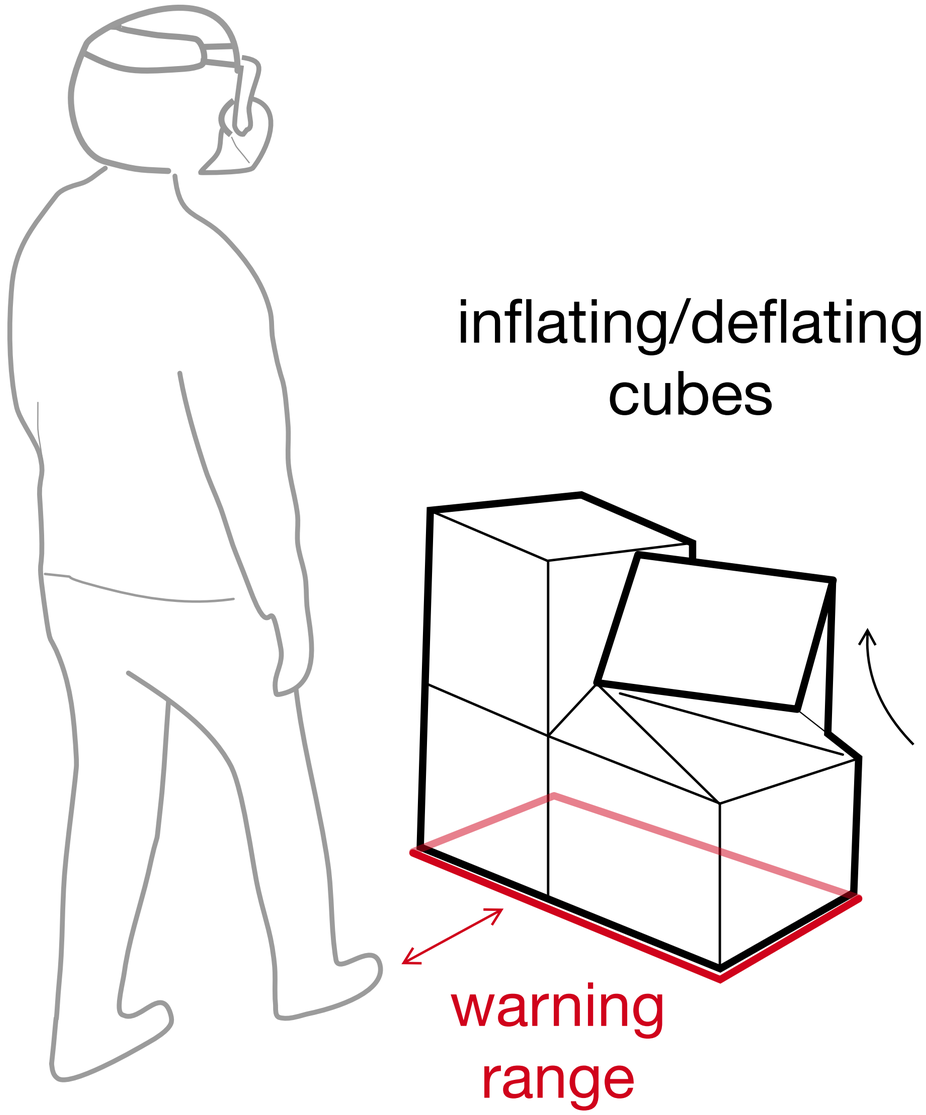
challenge #3: transformation time

1. add indicator

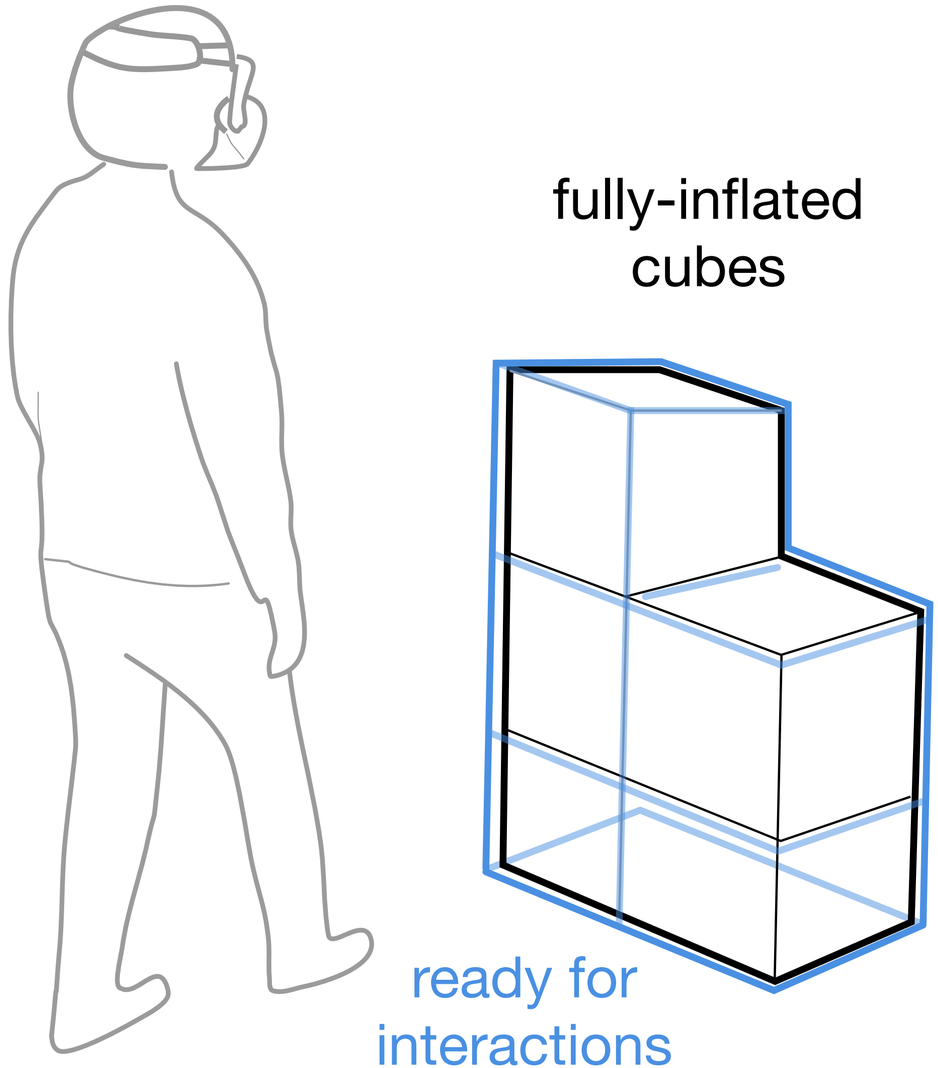
inflating/deflating
cubes

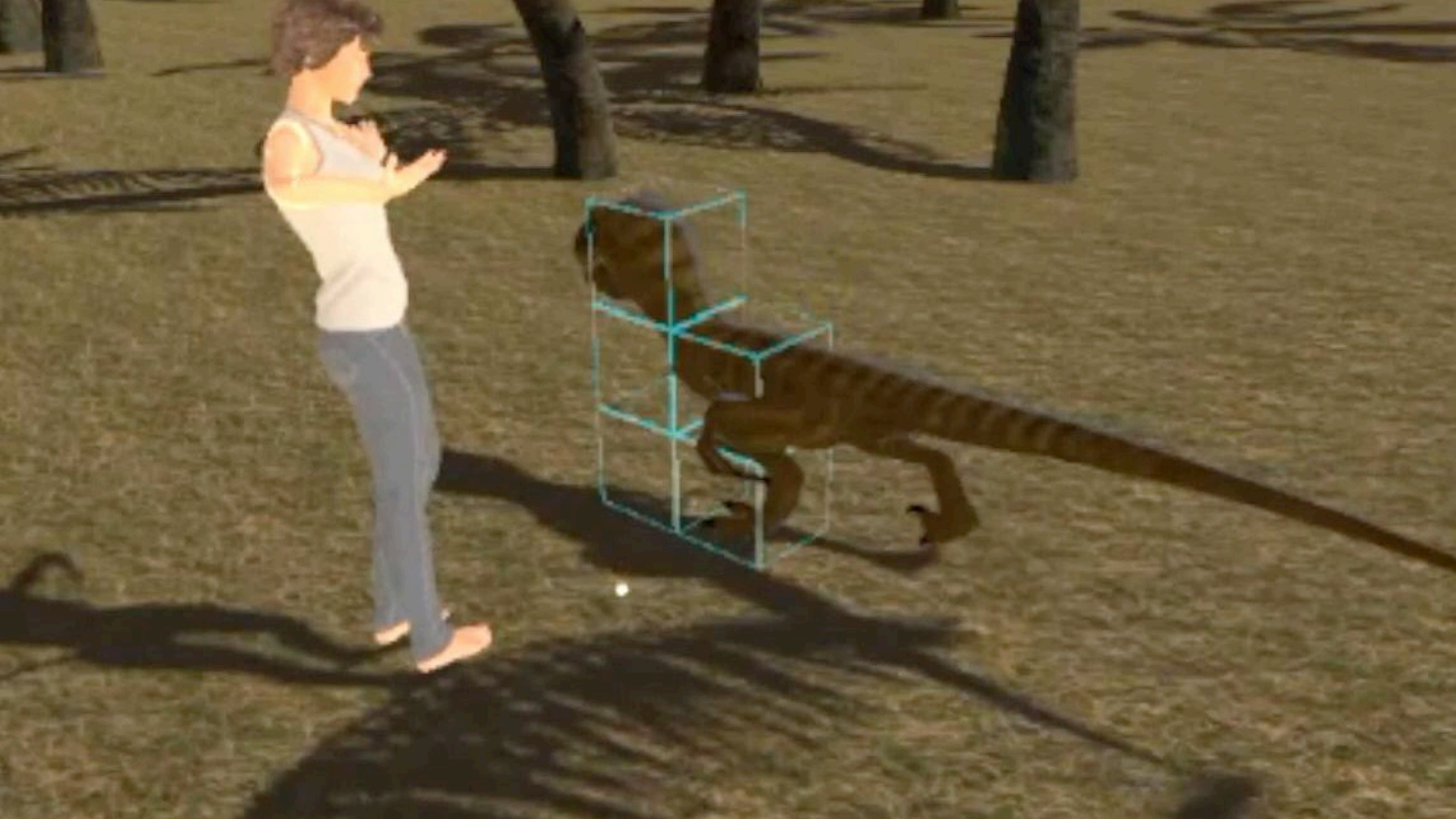


1. add indicator

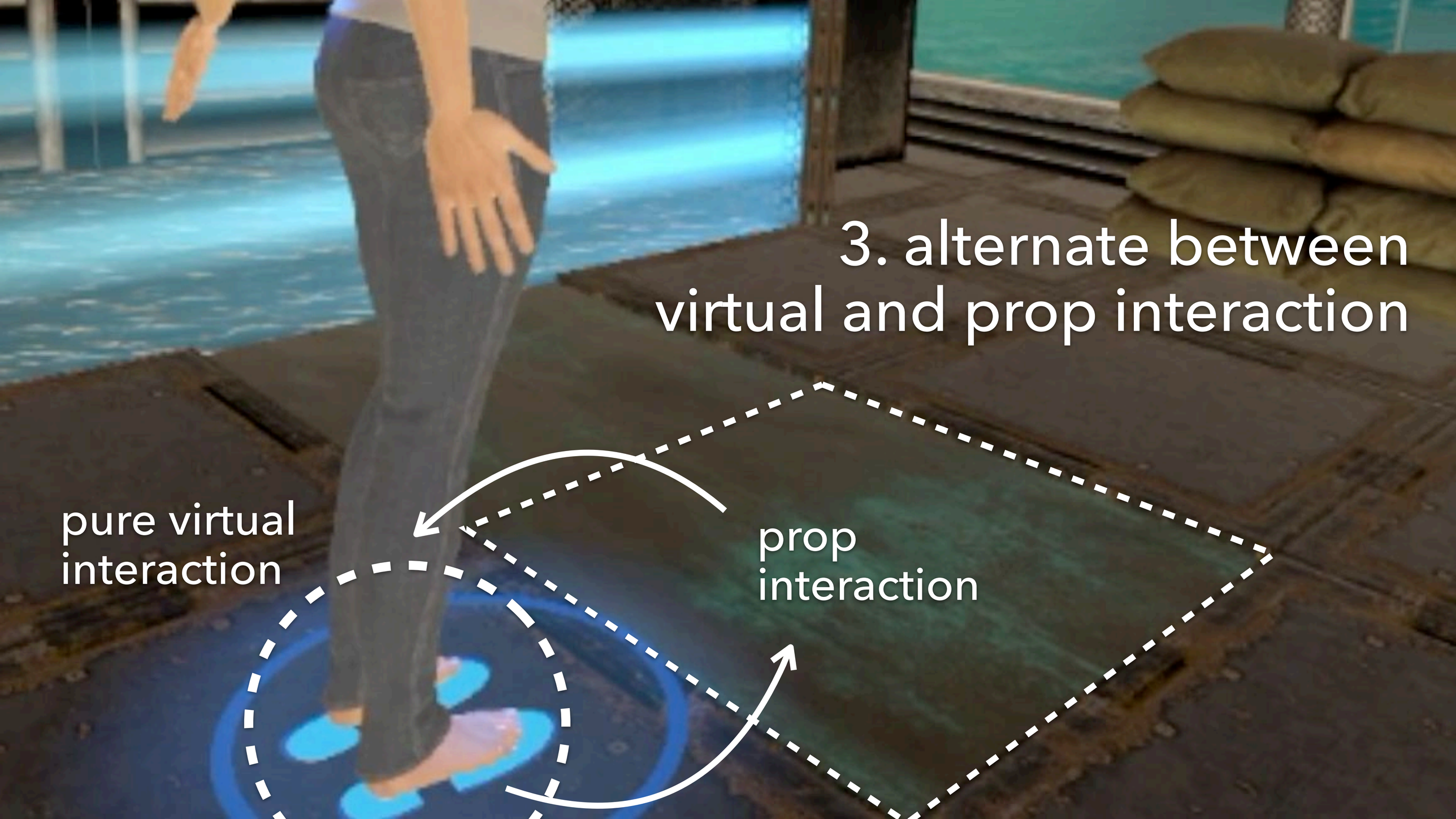


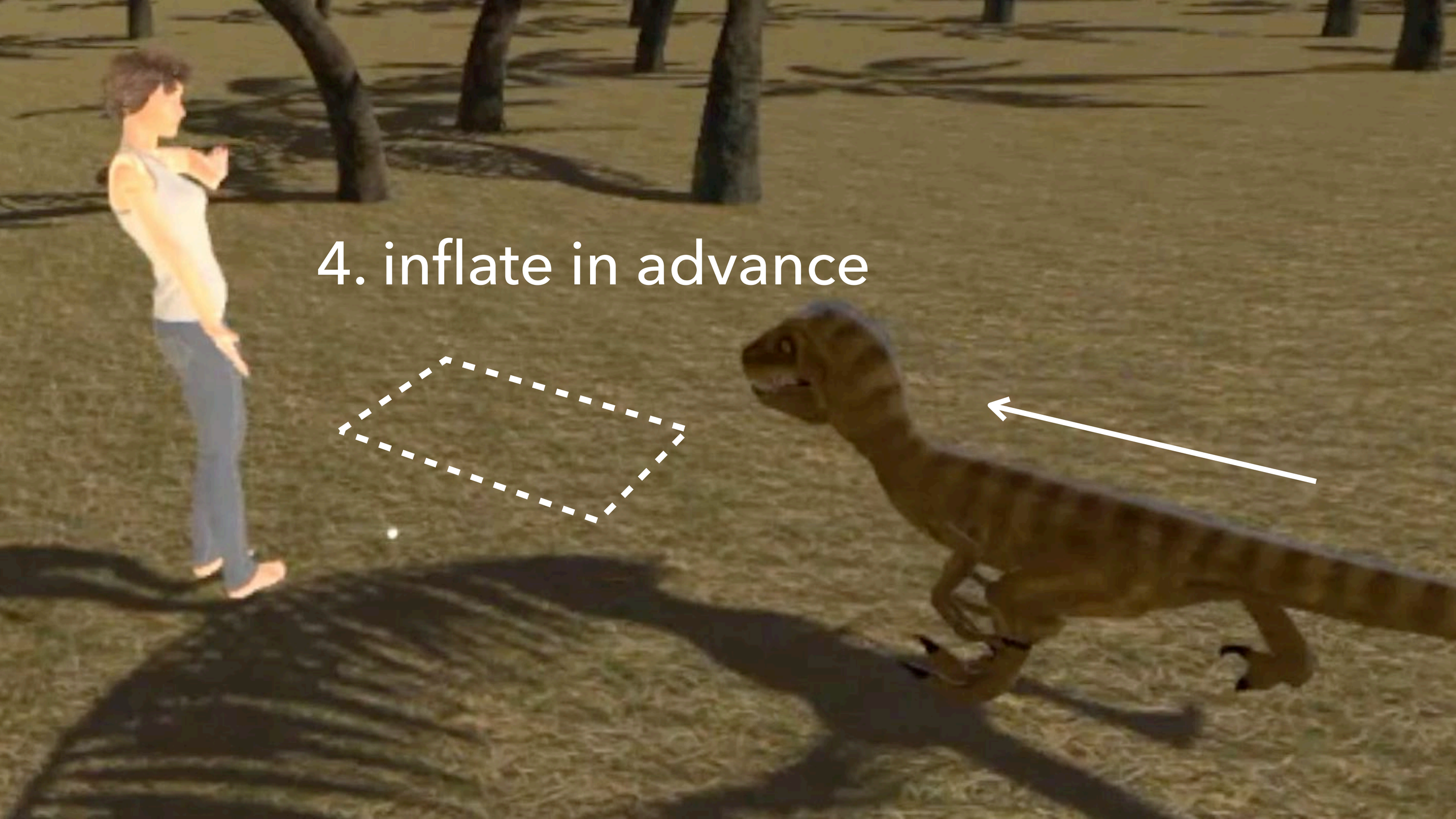
1. add indicator

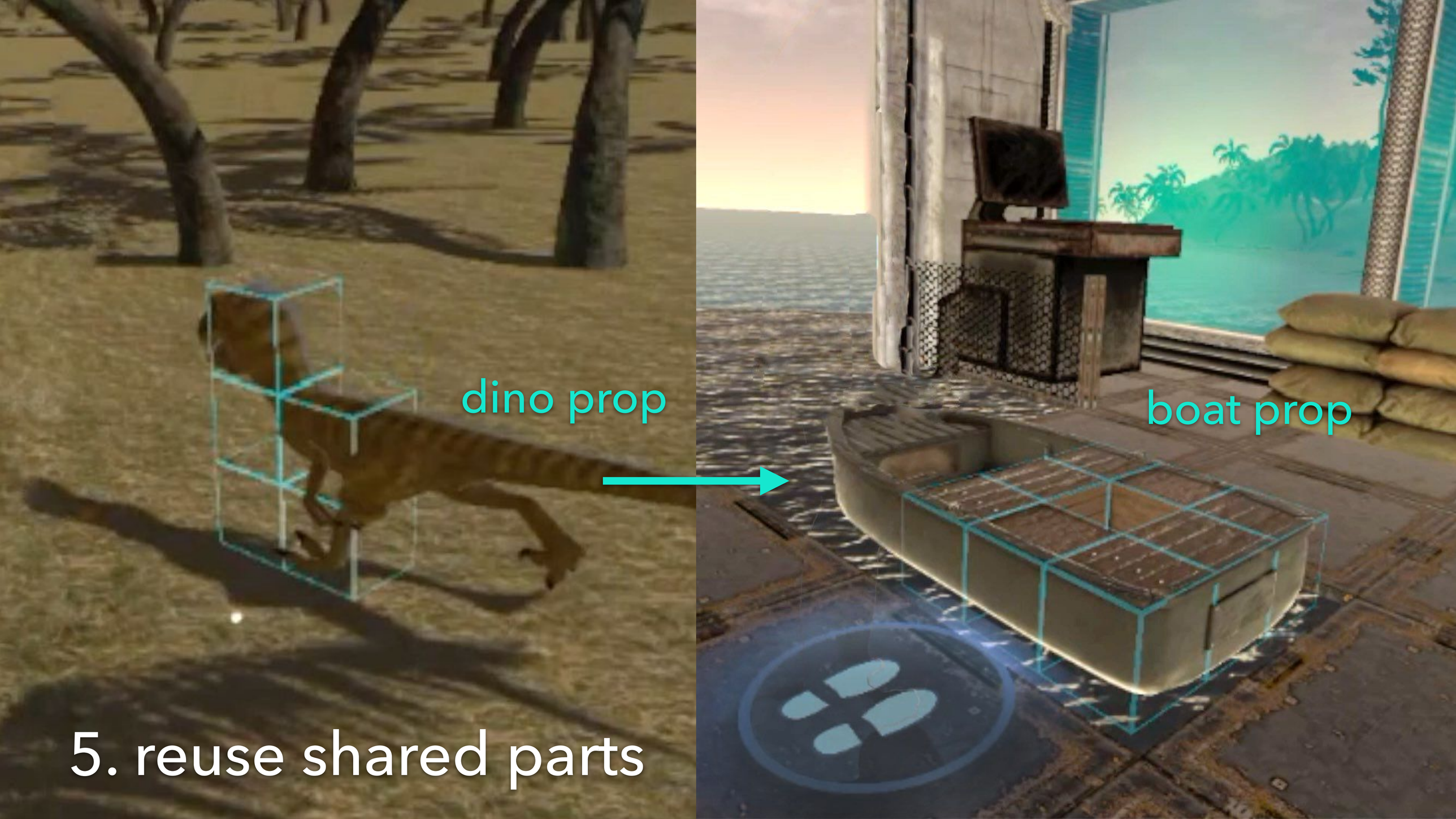




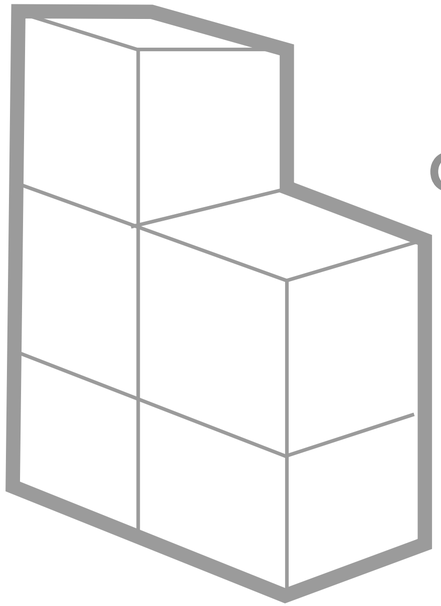

2. add visual effect
during transformation


3. alternate between
virtual and prop interaction
pure virtual
interaction
prop
interaction


4. inflate in advance

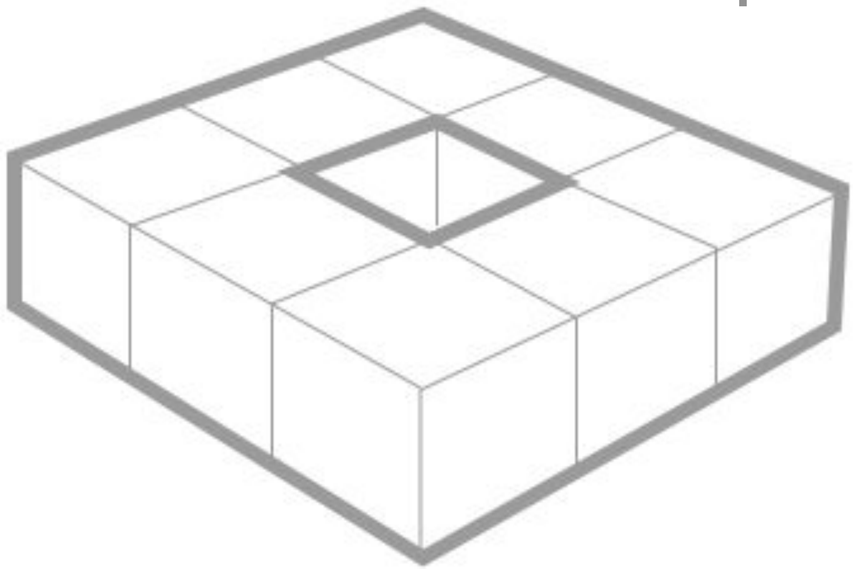


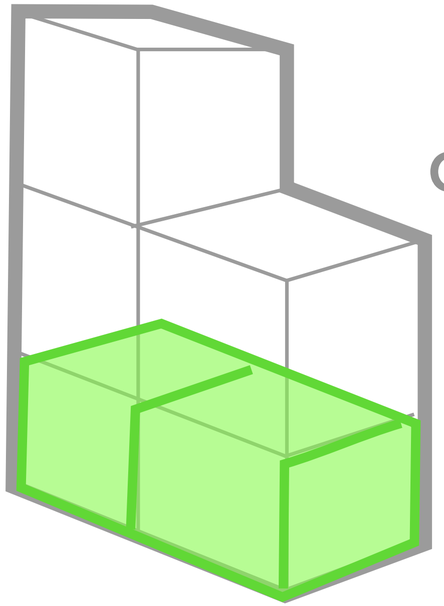
5. reuse shared parts



dino prop

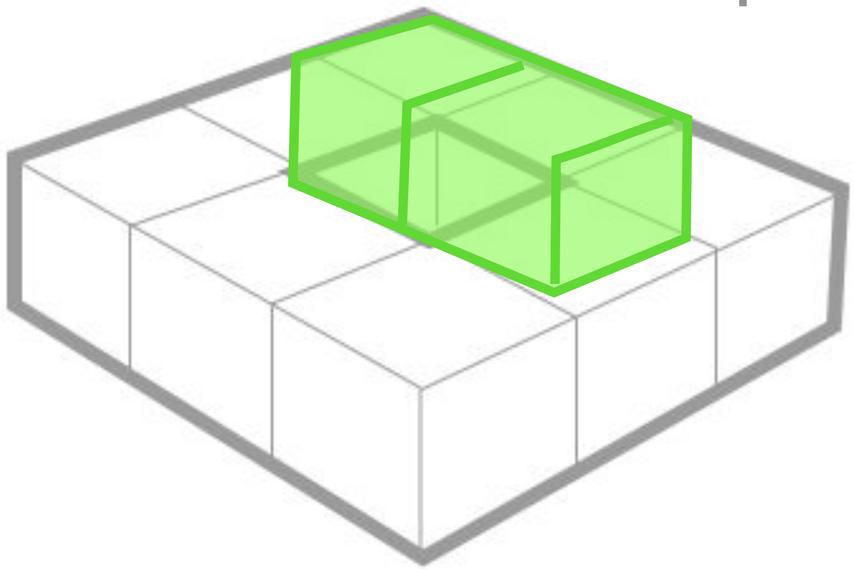
boat prop



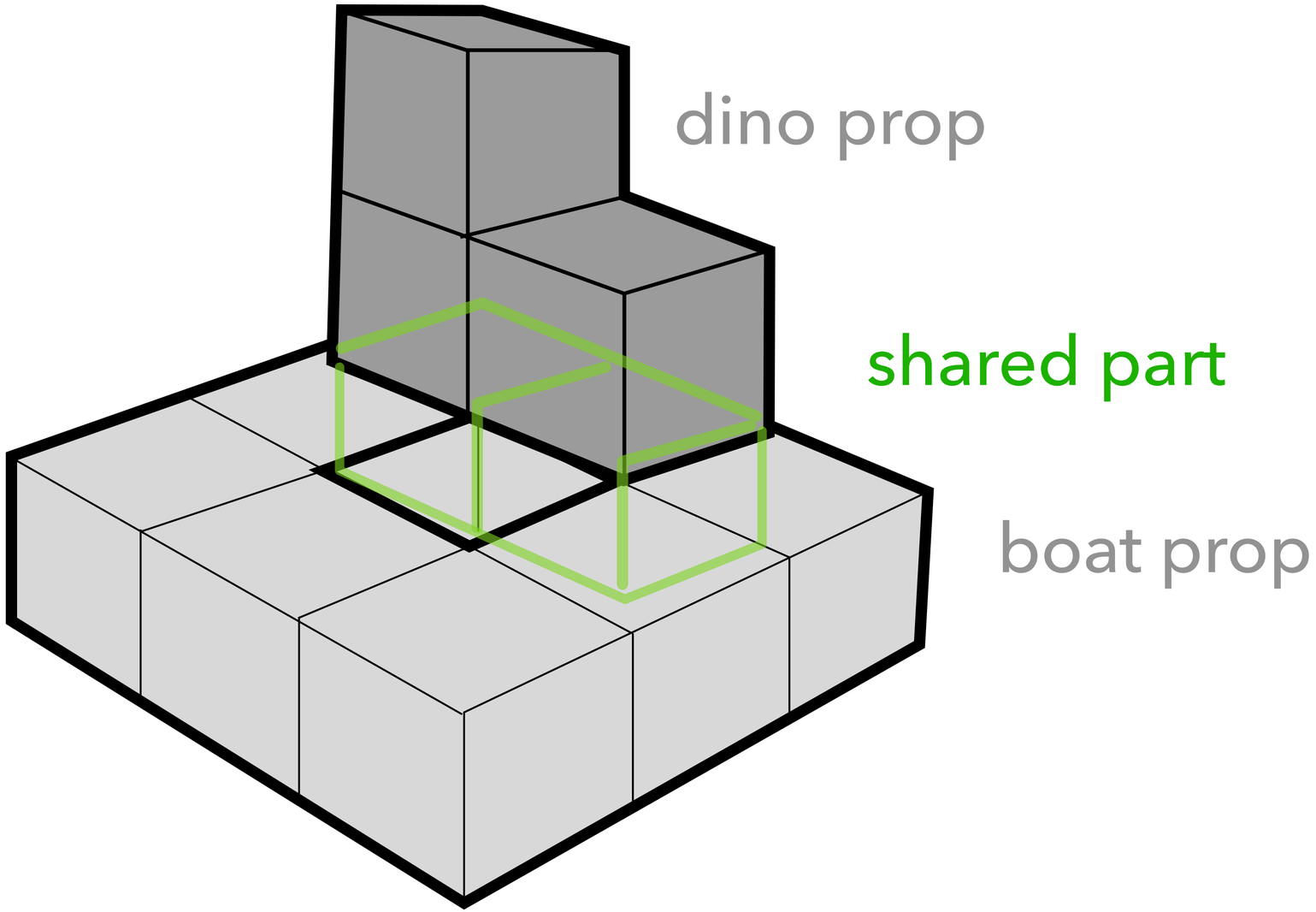


dino prop

boat prop



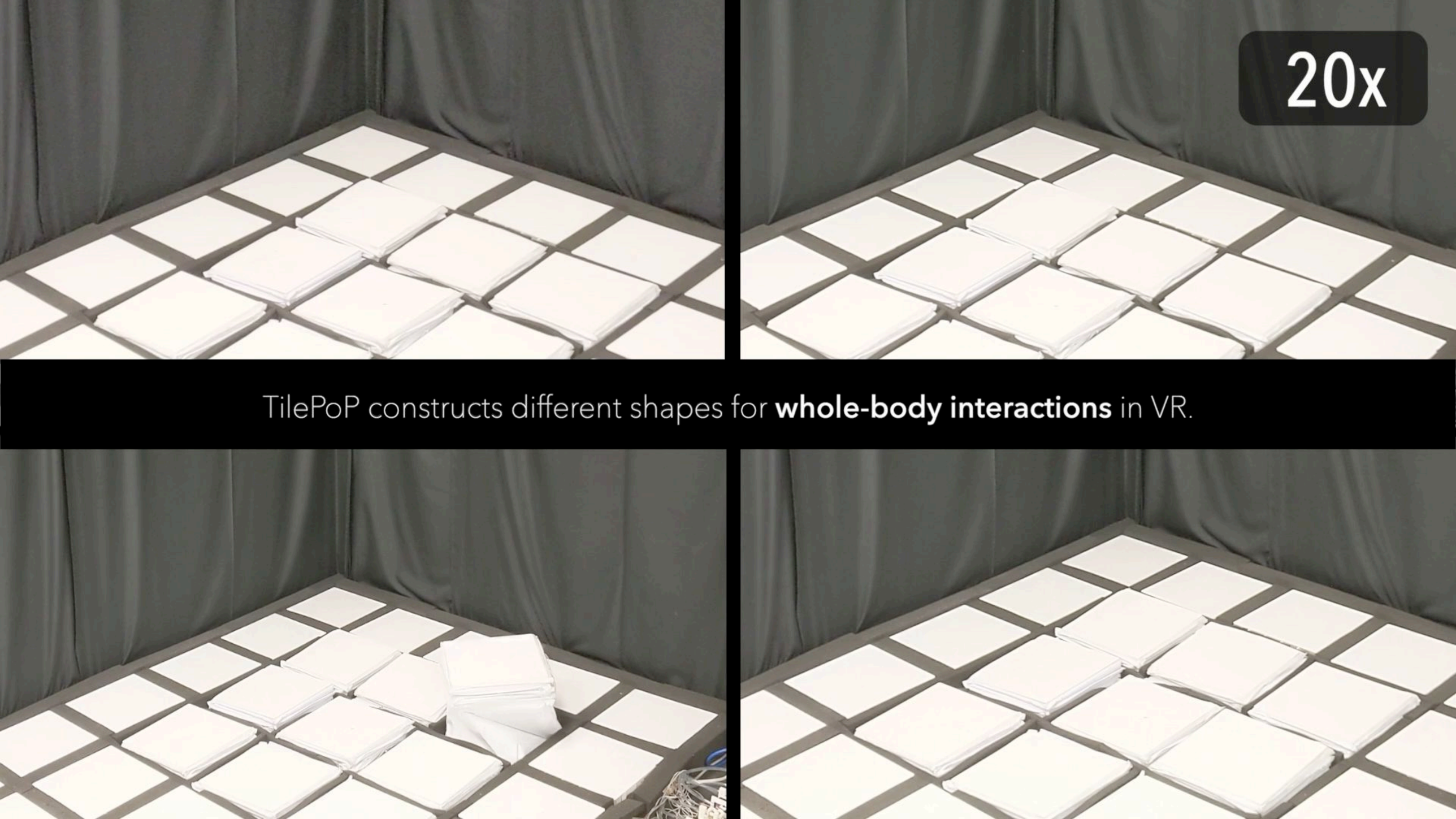
shared part


dino prop
shared part
boat prop

interactions using TilePoP

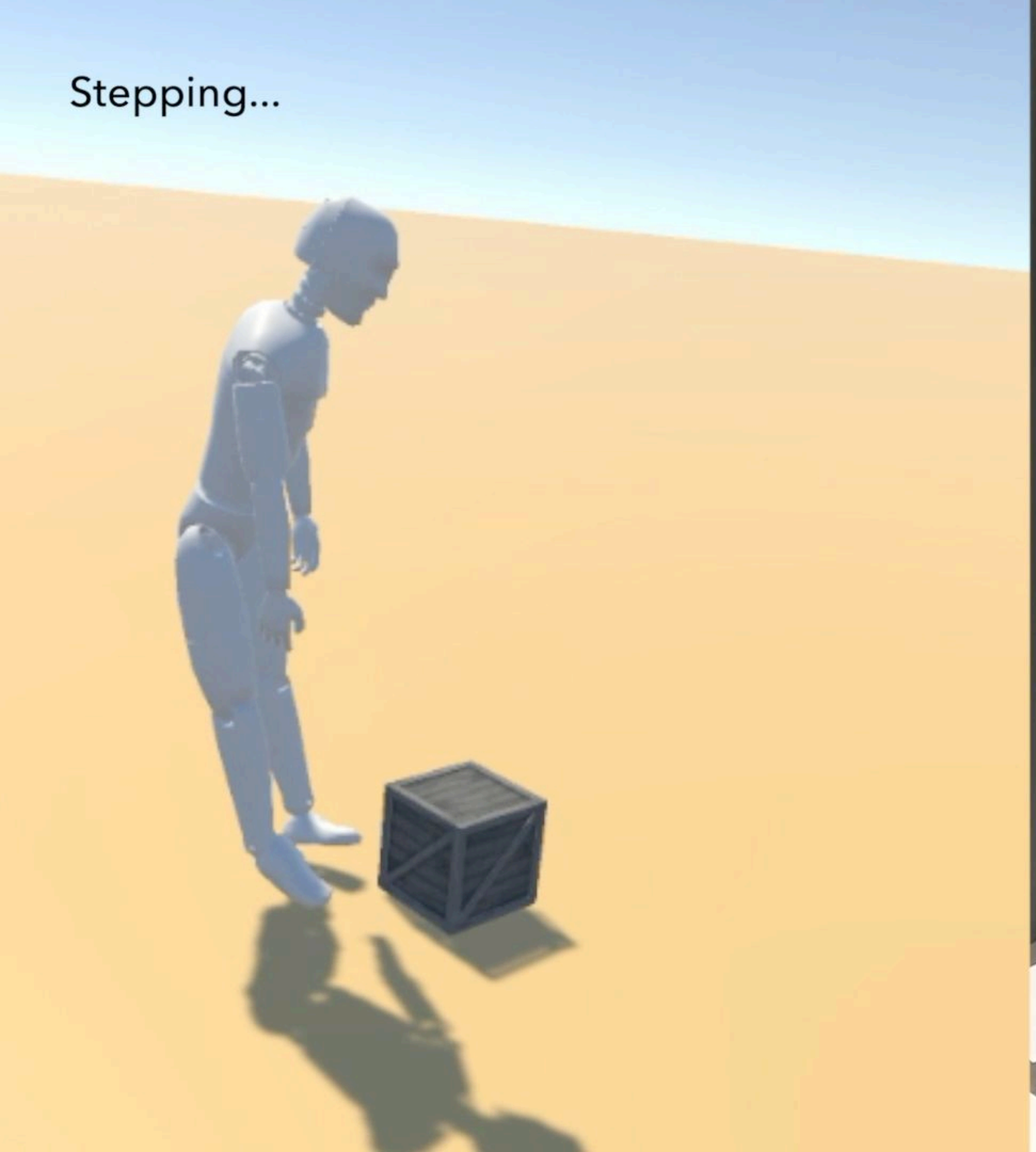
interactions using TilePoP

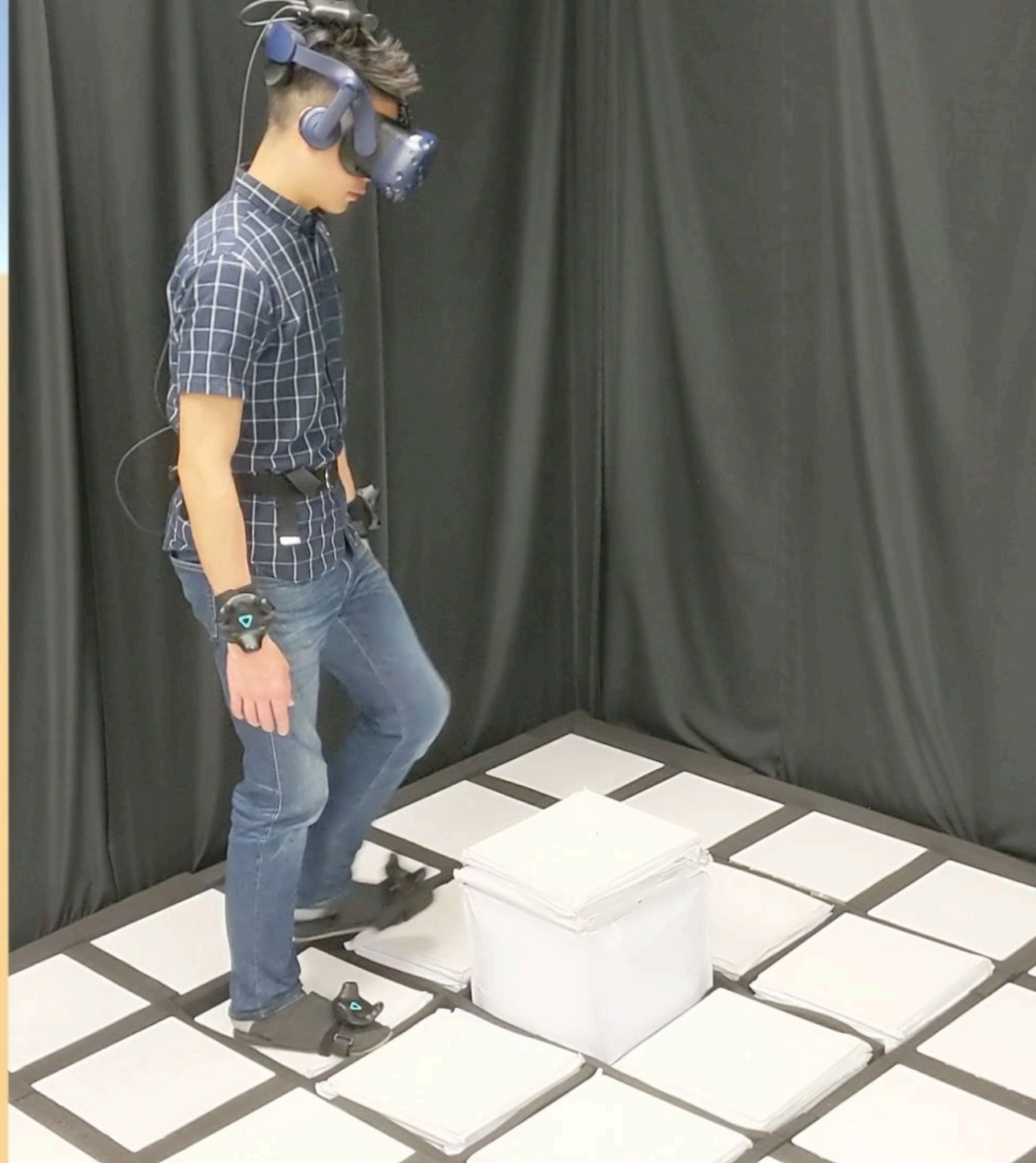
on-demand shapes for the whole body



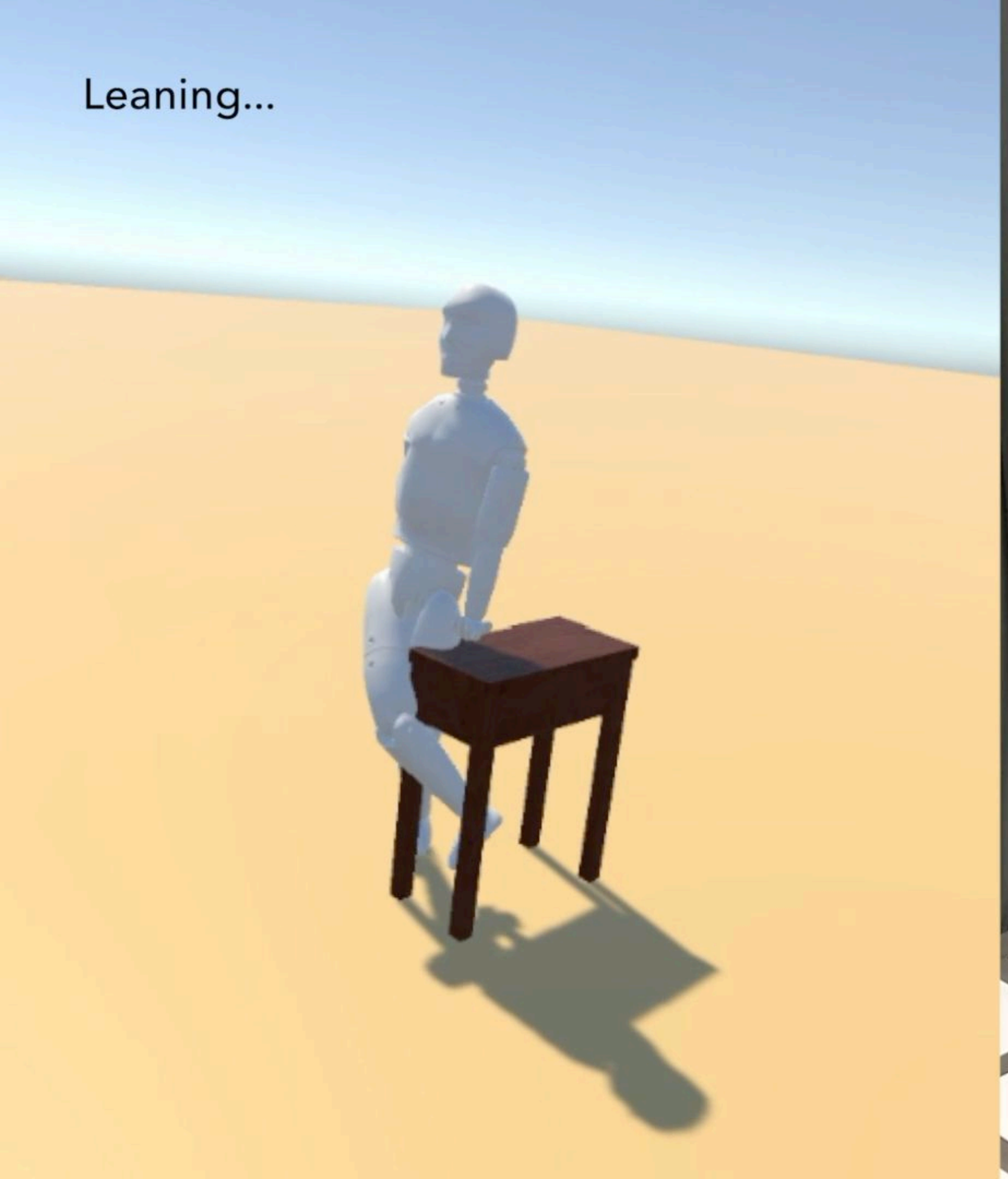
TilePoP constructs different shapes for **whole-body interactions** in VR.

Stepping...





Sitting...

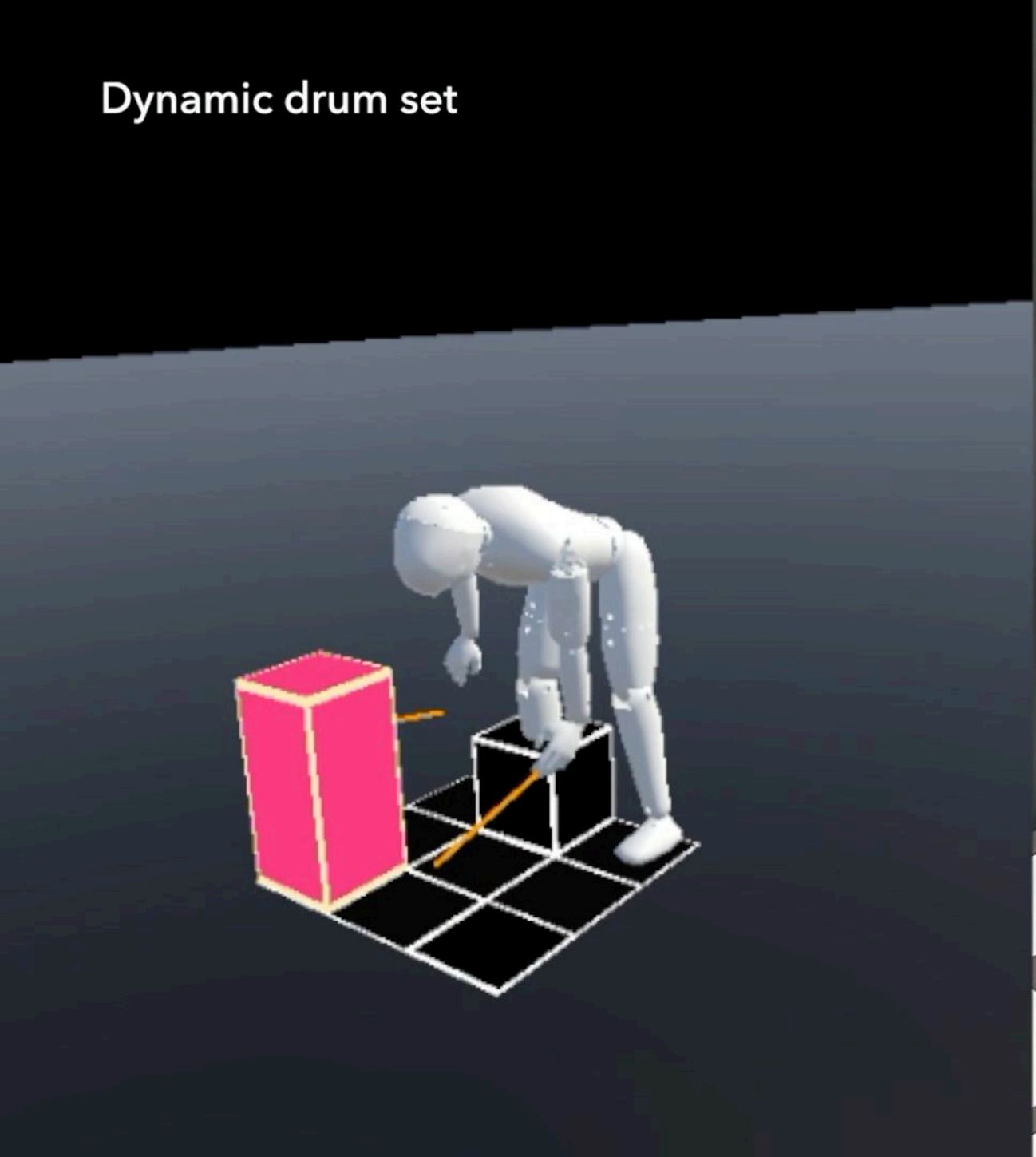

Leaning...

Lying down...

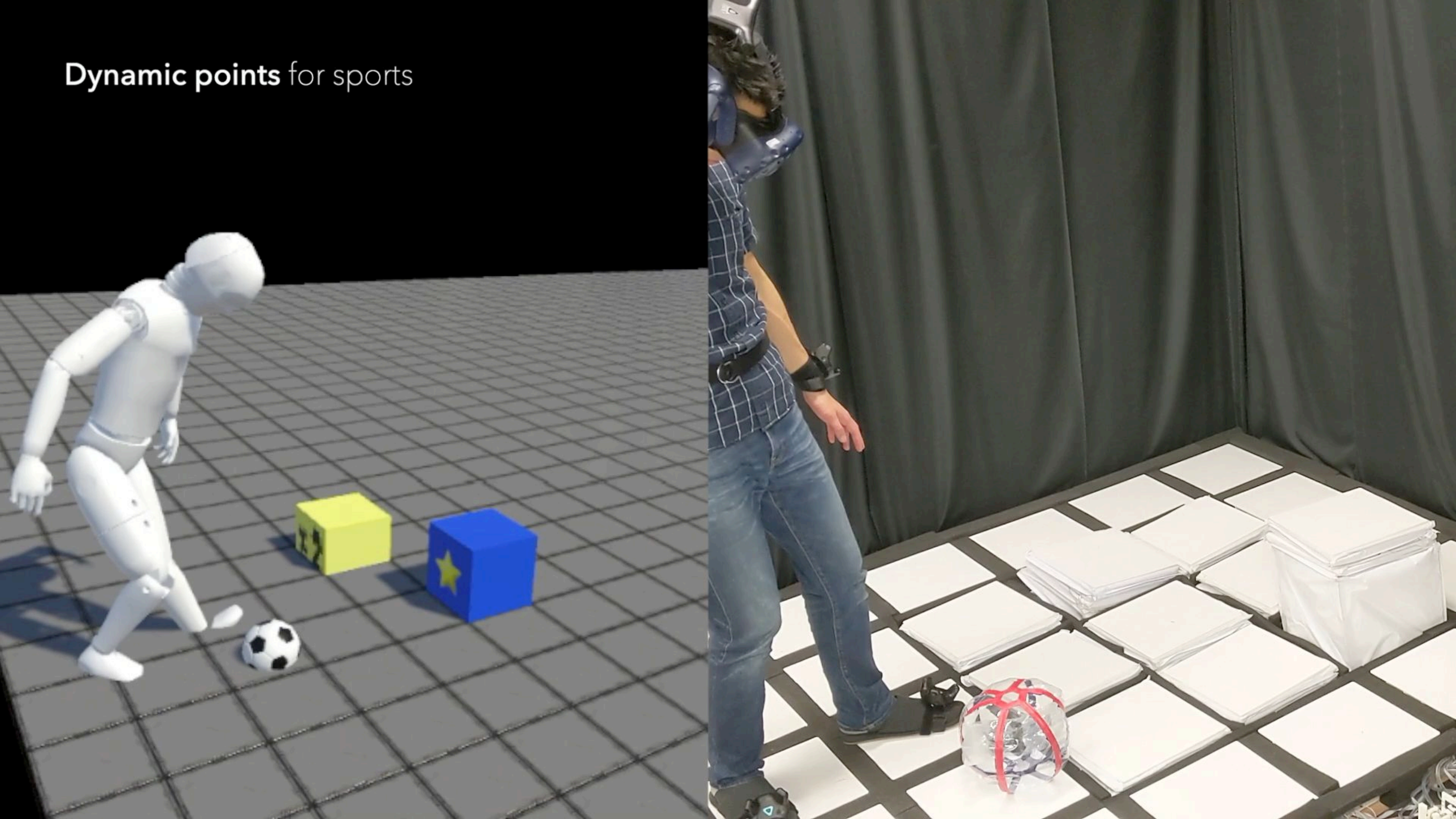
interactions using TilePoP

interacting with additional props

Dynamic drum set



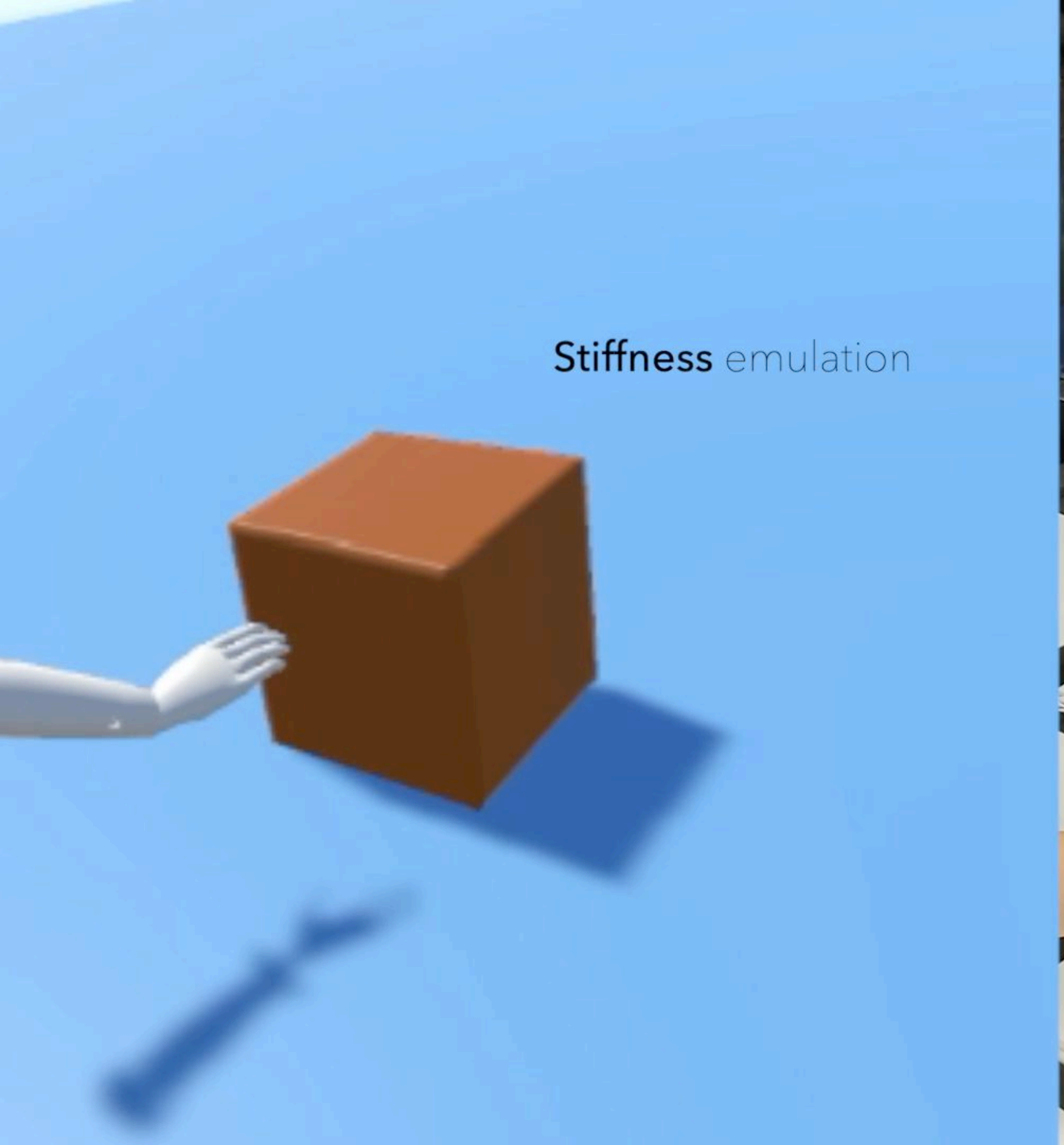
Dynamic points for sports

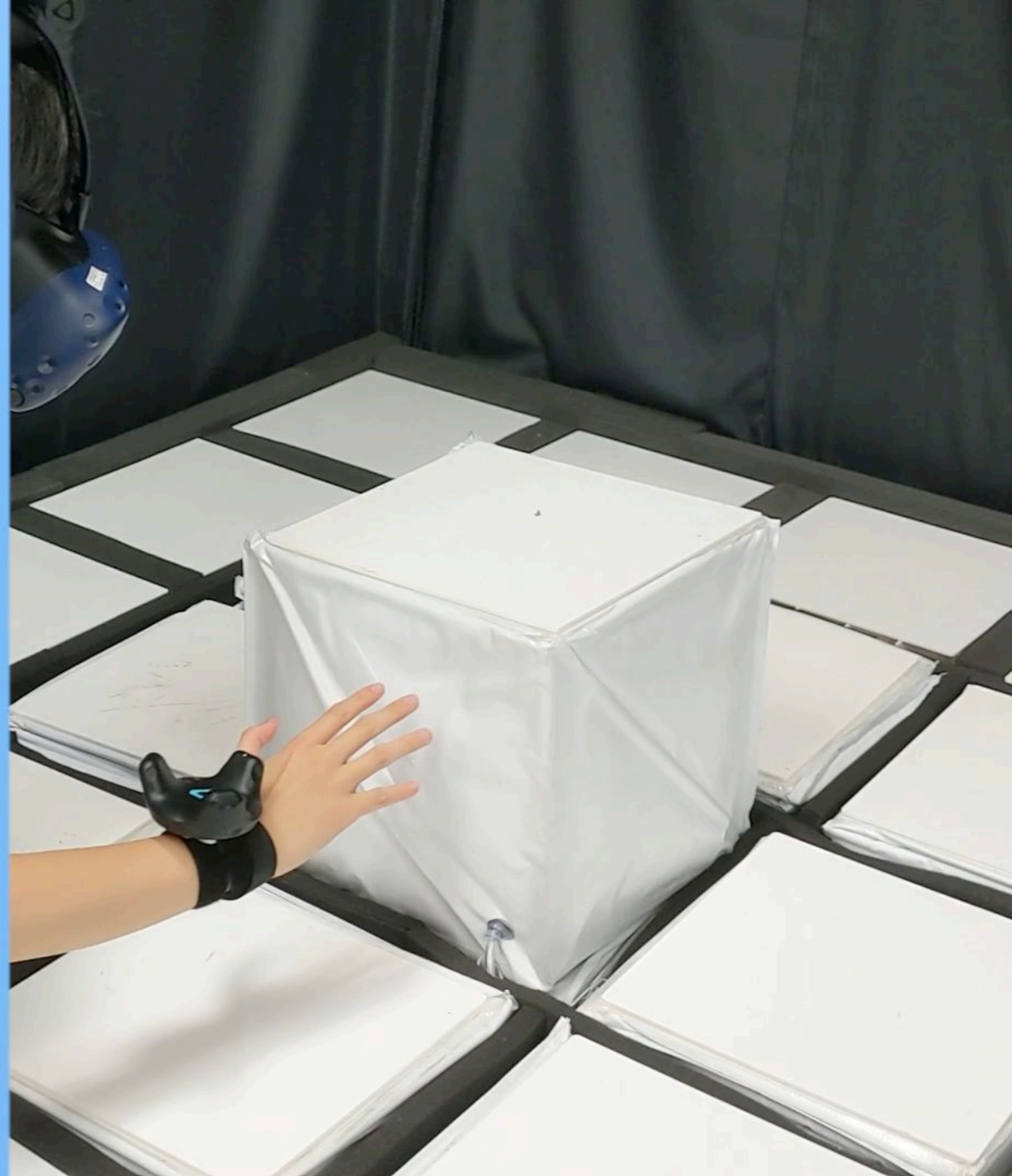


interactions using TilePoP

emulation of material properties

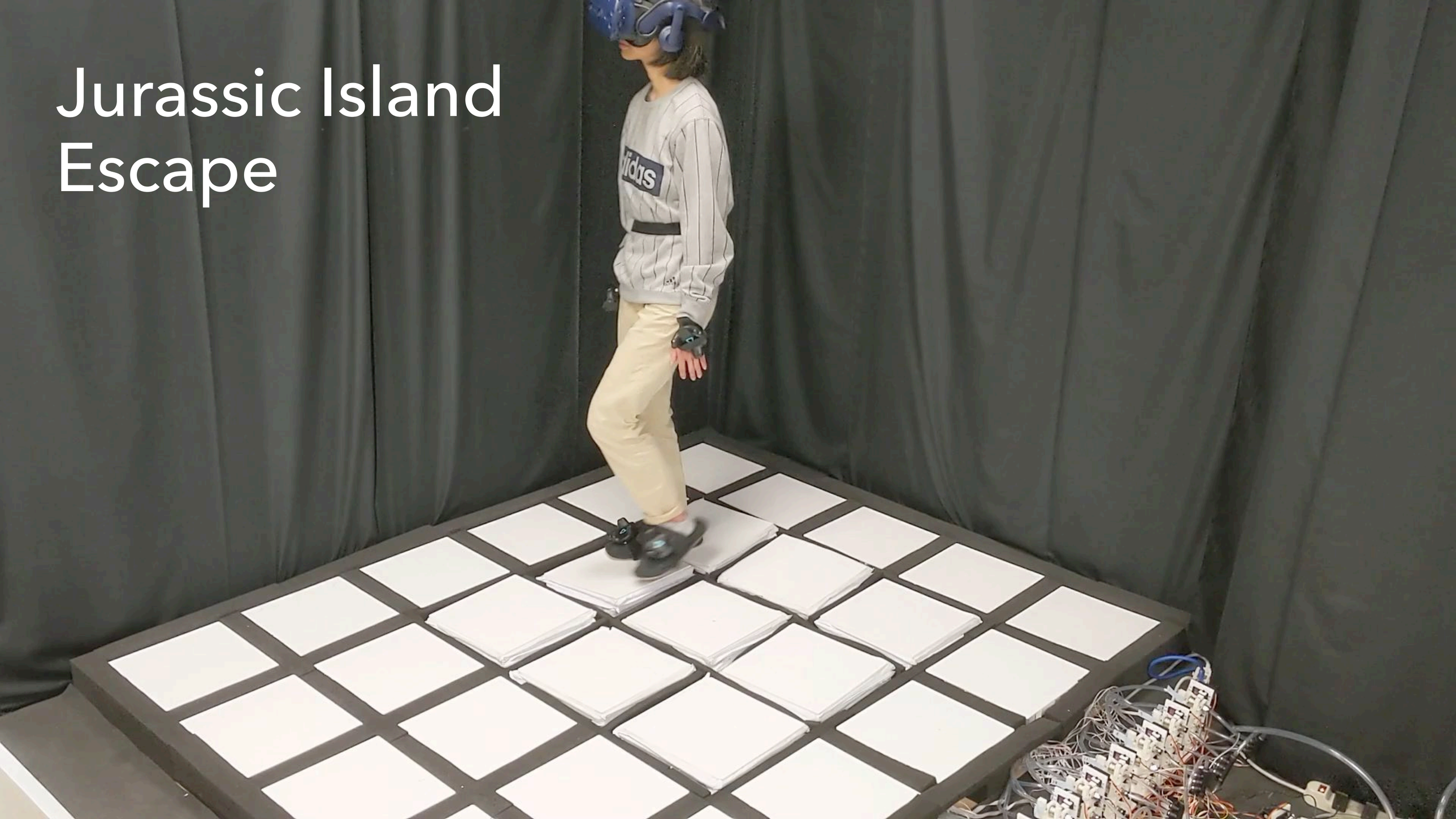
Stiffness emulation

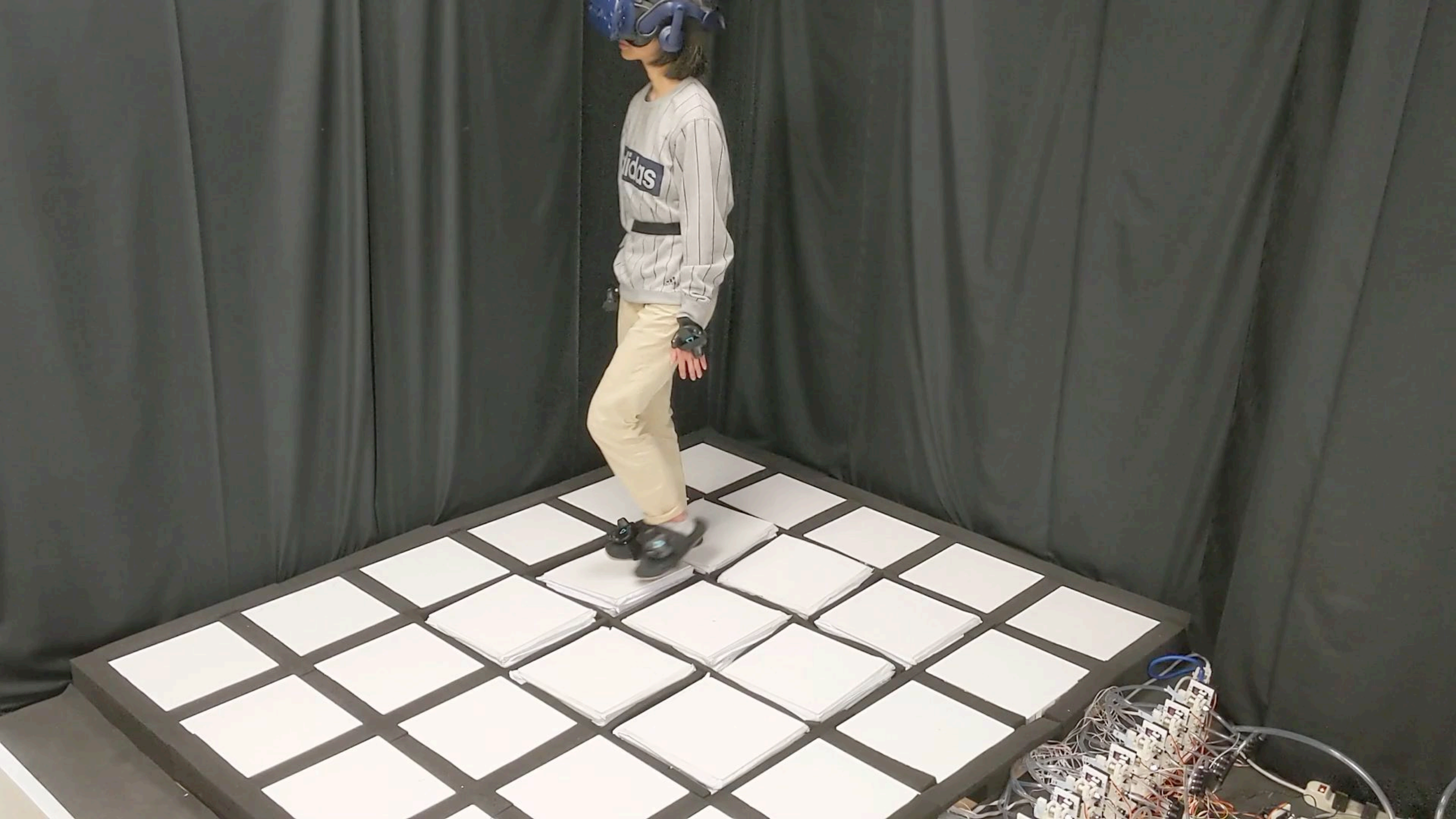




Breathing emulation

Jurassic Island Escape





Block World Builder

preliminary user evaluation


“it’s like a real”
“it’s like a real”

limitations

limitations

Shape changing speed is slow.

limitations

Shape changing speed is slow.

Inflated airbags are not stable for standing.

limitations

Shape changing speed is slow.

Inflated airbags are not stable for standing.

Shapes are limited to 2.5D blocks.

future work

future work

To increase speed:

Consider developing internal tube structures.

future work

To increase speed:
Consider developing internal tube structures.

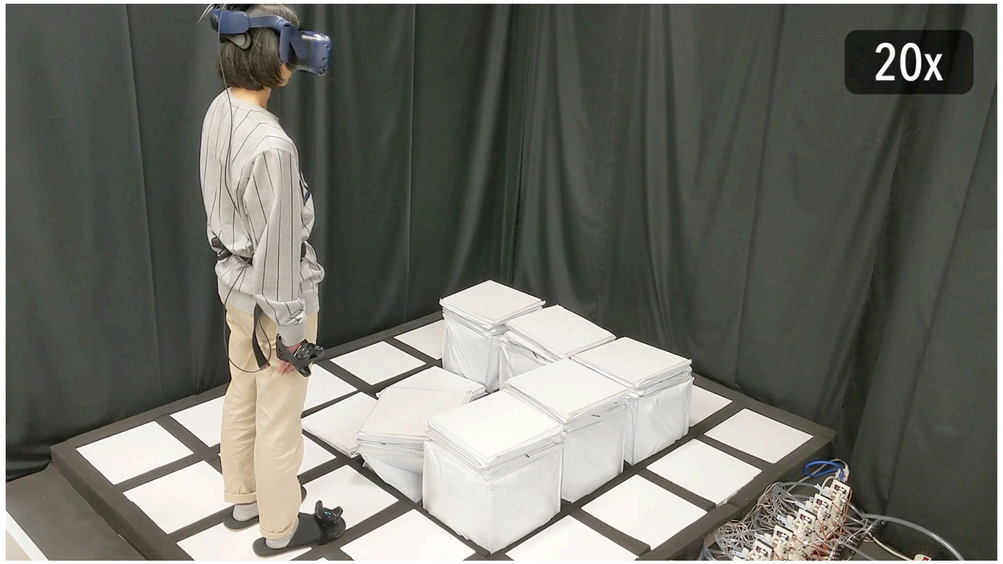
To provide finer shapes:
Consider developing external structure.

work in progress

conclusion

conclusion

We introduced TilePoP, a floor-mounted shape display for VR.



conclusion

We introduced TilePoP, a floor-mounted shape display for VR.

TilePoP provides large physical shapes on demand, allowing users to walk and sit on.


hand-scale
PuPoP [UIST '18]
body-scale
TilePoP [UIST '19]
pop-up prop

thank you!

UIST 2019

TilePoP:

Tile-type Pop-up Prop for Virtual Reality

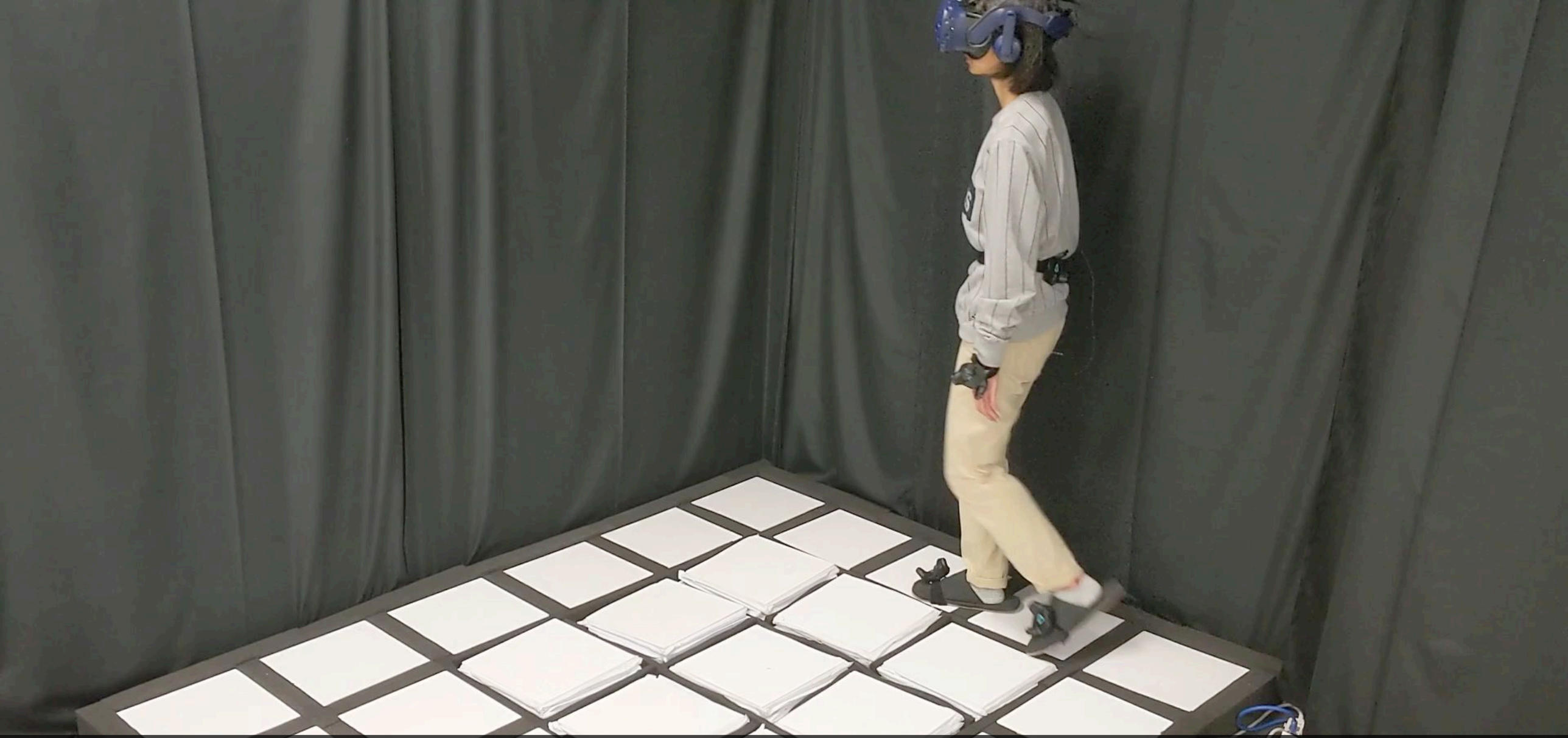
Shan-Yuan Teng[1,3], Cheng-Lung Lin[2], Chi-huan Chiang[1], Tzu-Sheng Kuo[1,4], Liwei Chan[2], Da-Yuan Huang[2], Bing-Yu Chen[1]

1 National Taiwan University

2 National Chiao Tung University

3 The University of Chicago

4 Stanford University



TilePoP: Tile-type Pop-up Prop for Virtual Reality

Shan-Yuan Teng, Cheng-Lung Lin, Chi-huan Chiang, Tzu-Sheng Kuo, Liwei Chan, Da-Yuan Huang, Bing-Yu Chen