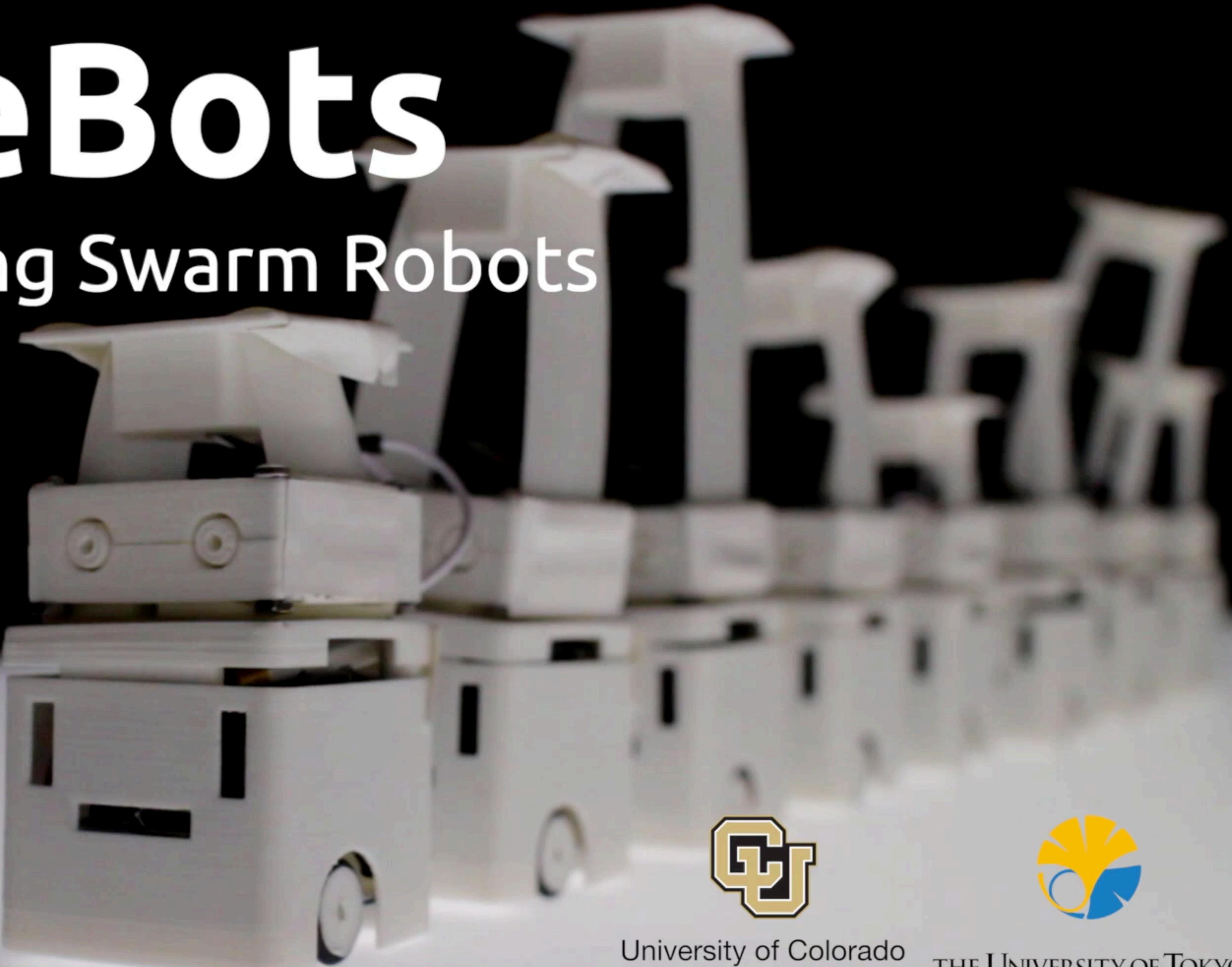


ShapeBots

Shape-changing Swarm Robots

Ryo Suzuki
Clement Zheng
Yasuaki Kakehi
Tom Yeh
Ellen Yi-Luen Do
Mark Gross
Daniel Leithinger

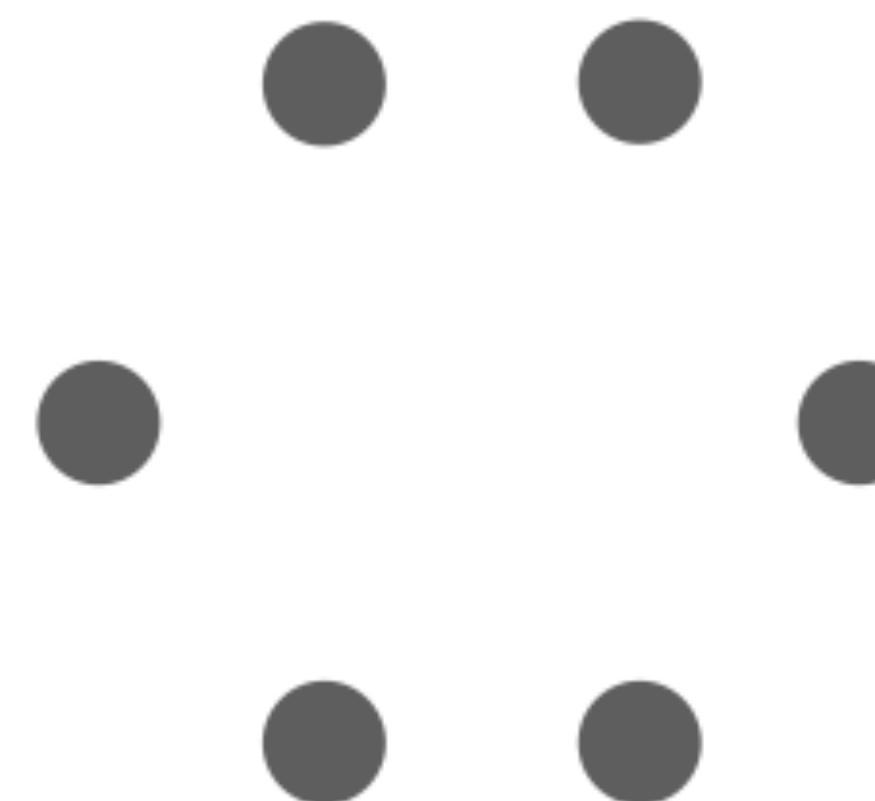


University of Colorado
Boulder



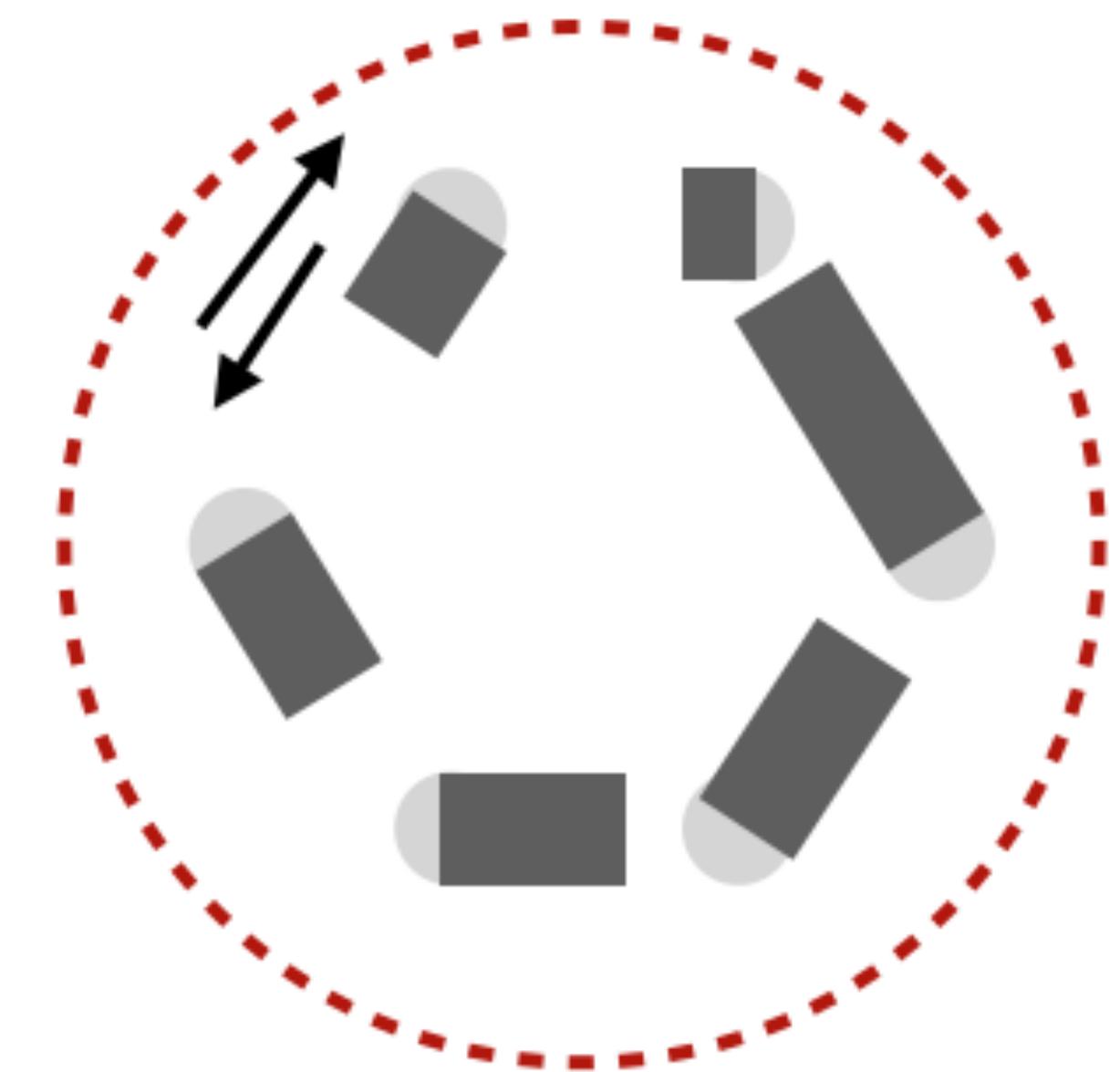
THE UNIVERSITY OF TOKYO

Swarm Robots



Collective
Shape-changing

Shape-changing Swarm Robots



Collective + Individual
Shape-changing

Shape-changing UI

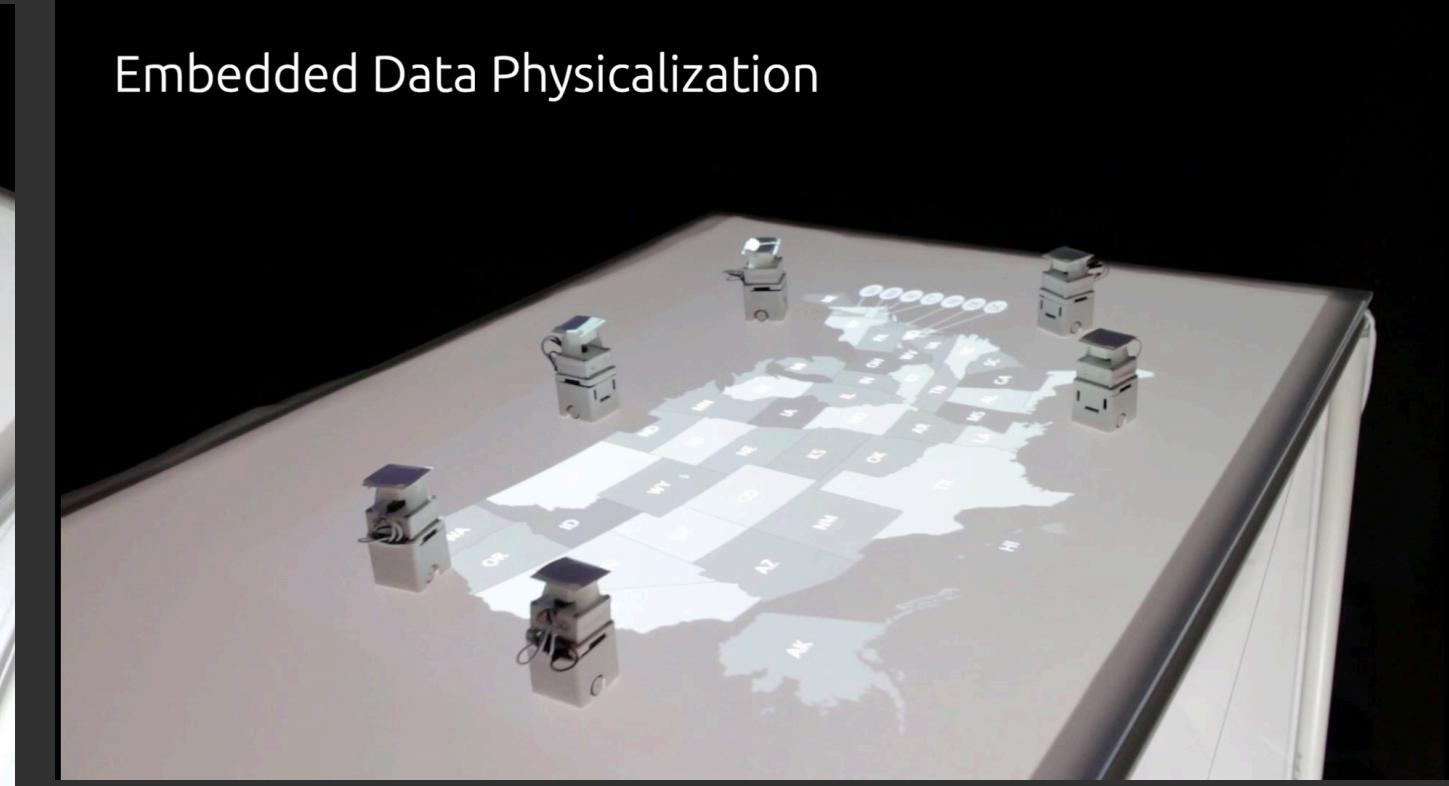
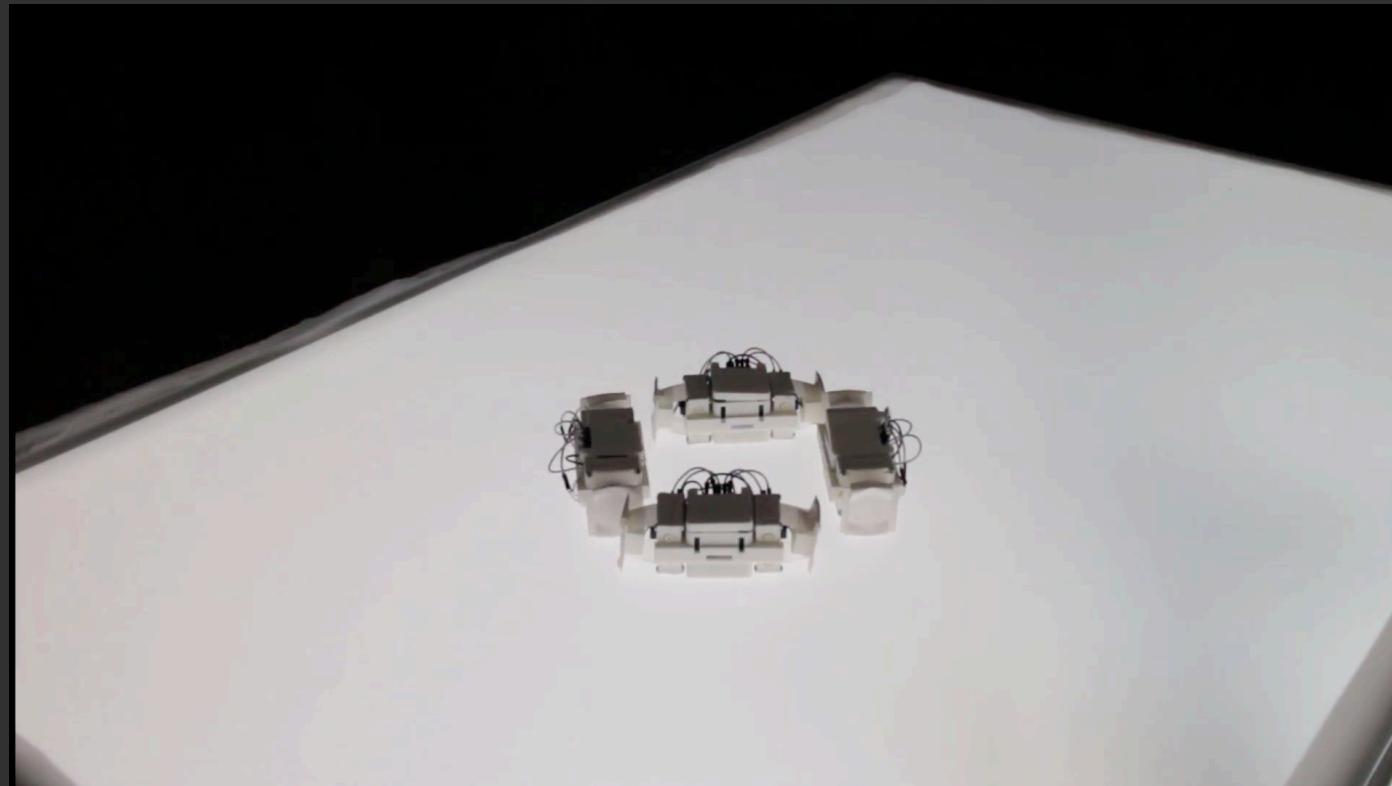


Individual
Shape-changing

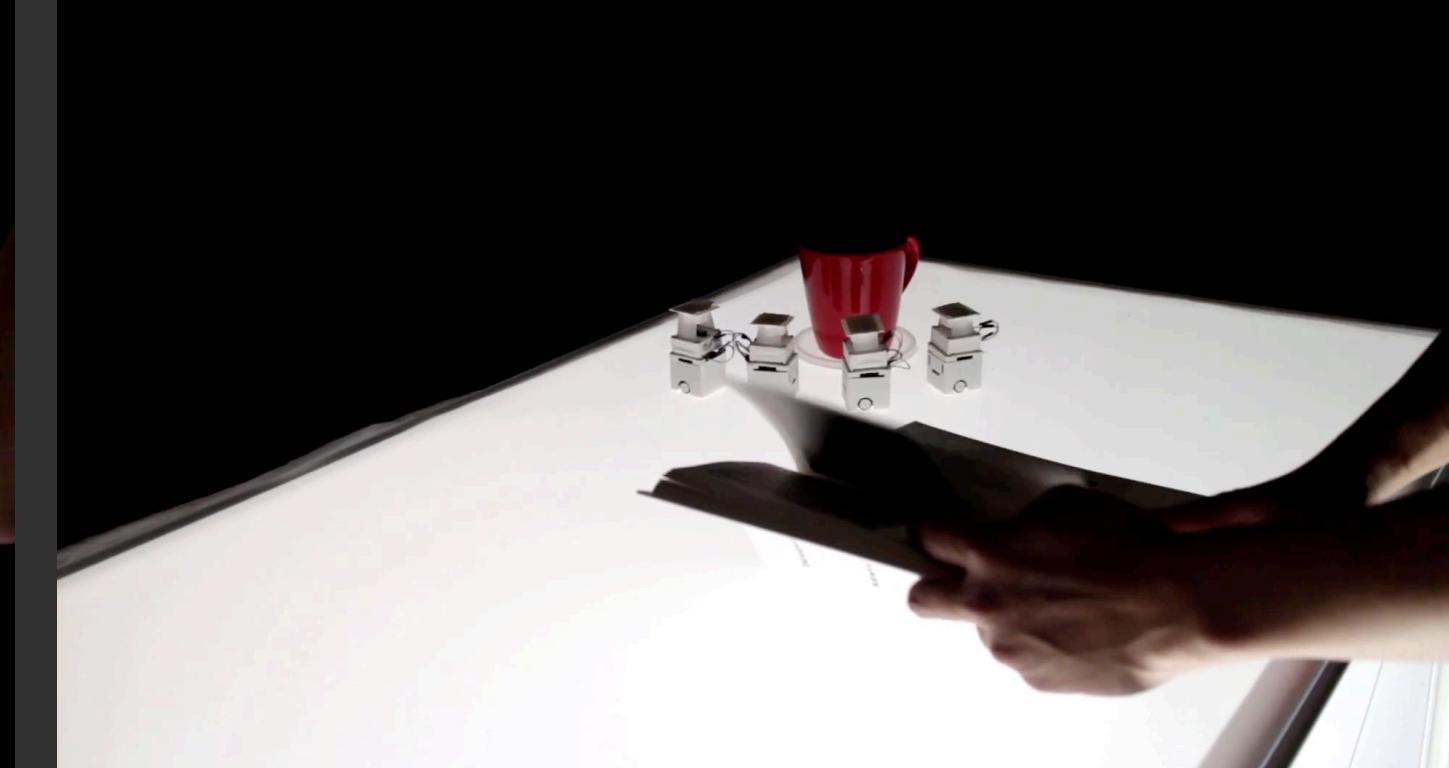
Shape-changing Swarm Robots

a swarm of self-transformable robots that can both **individually** and **collectively** transform their shapes.

Tangible Media



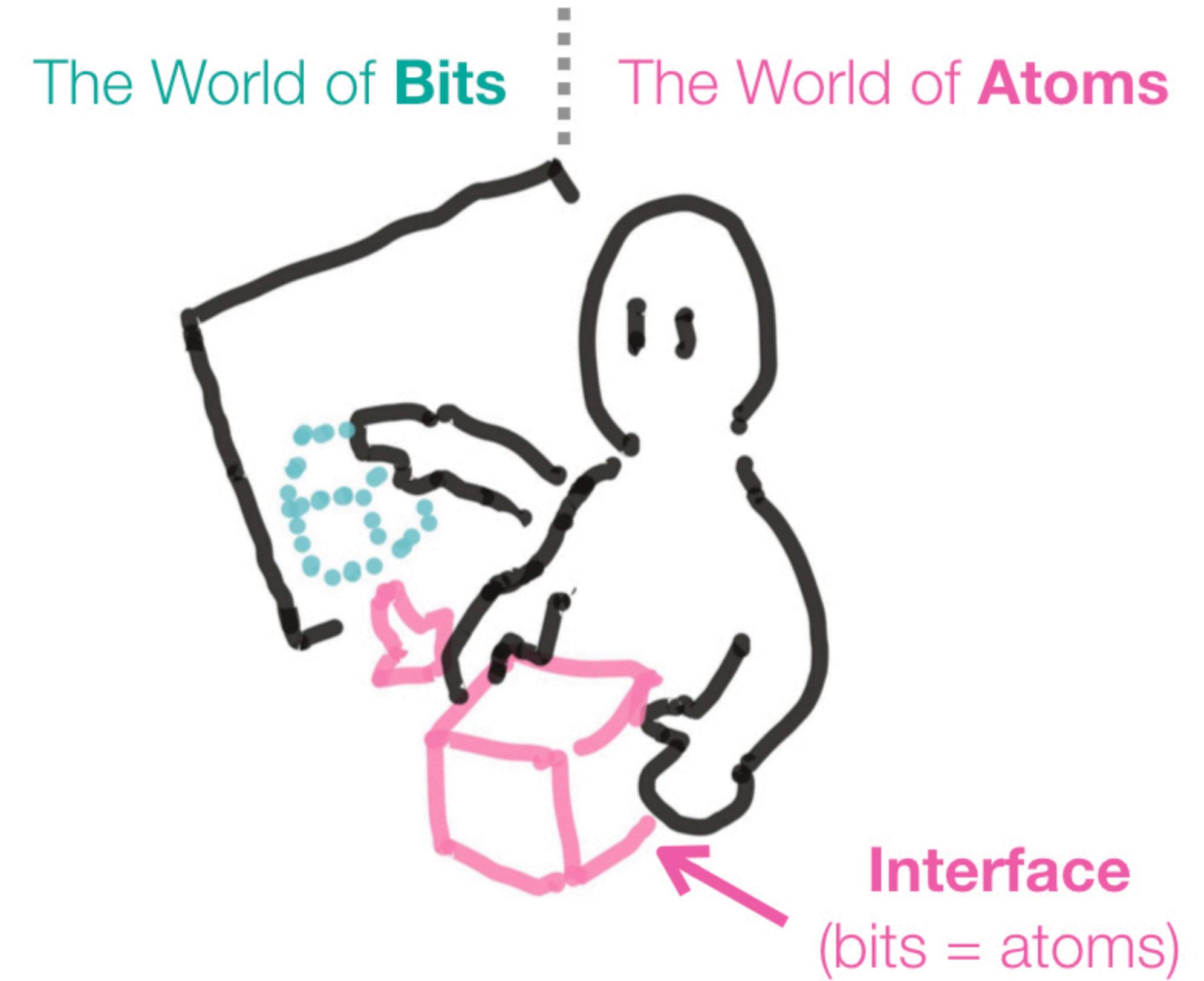
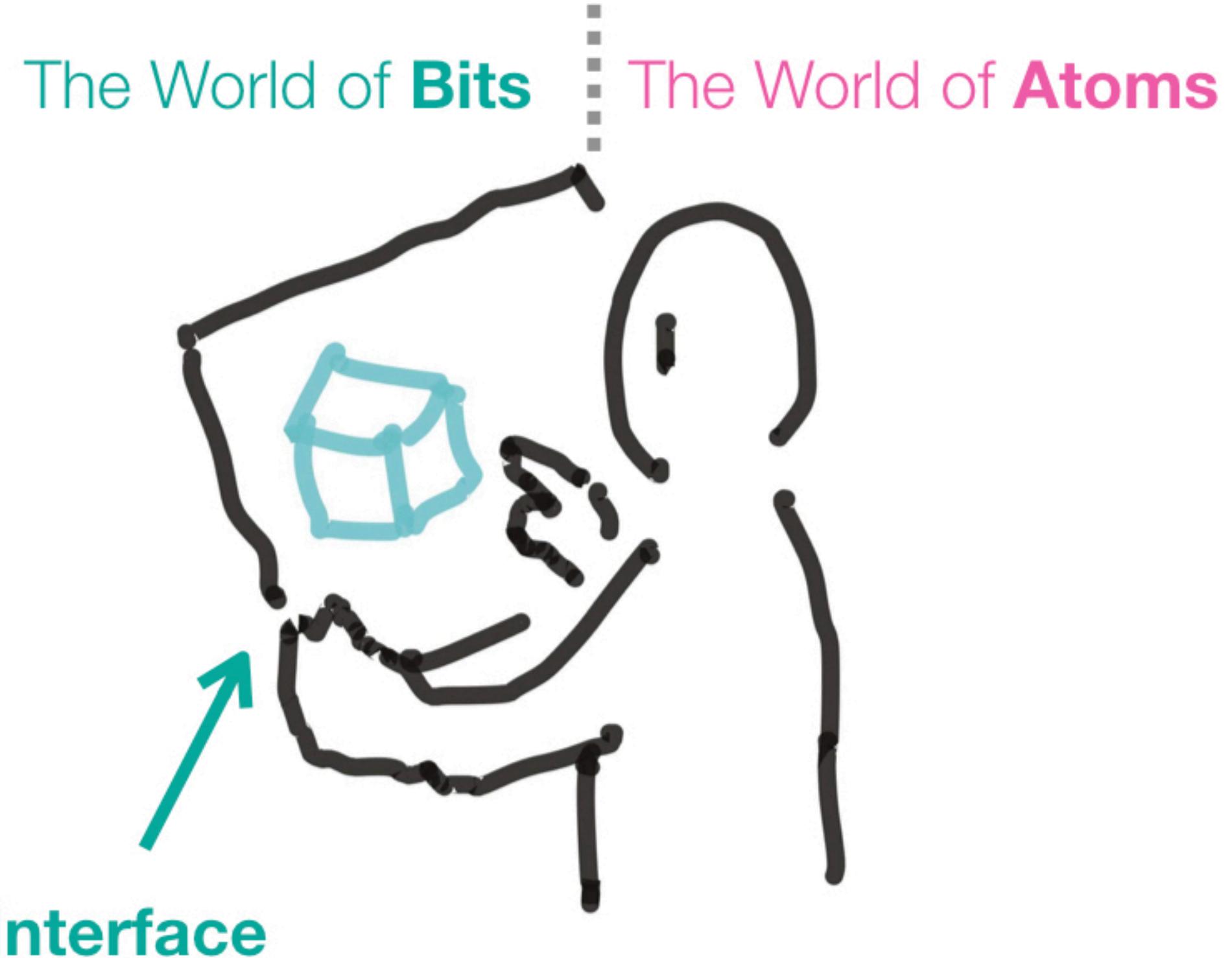
Everyday Assistant



Embedded Data Physicalization

In-situ Physical Assistants

Background

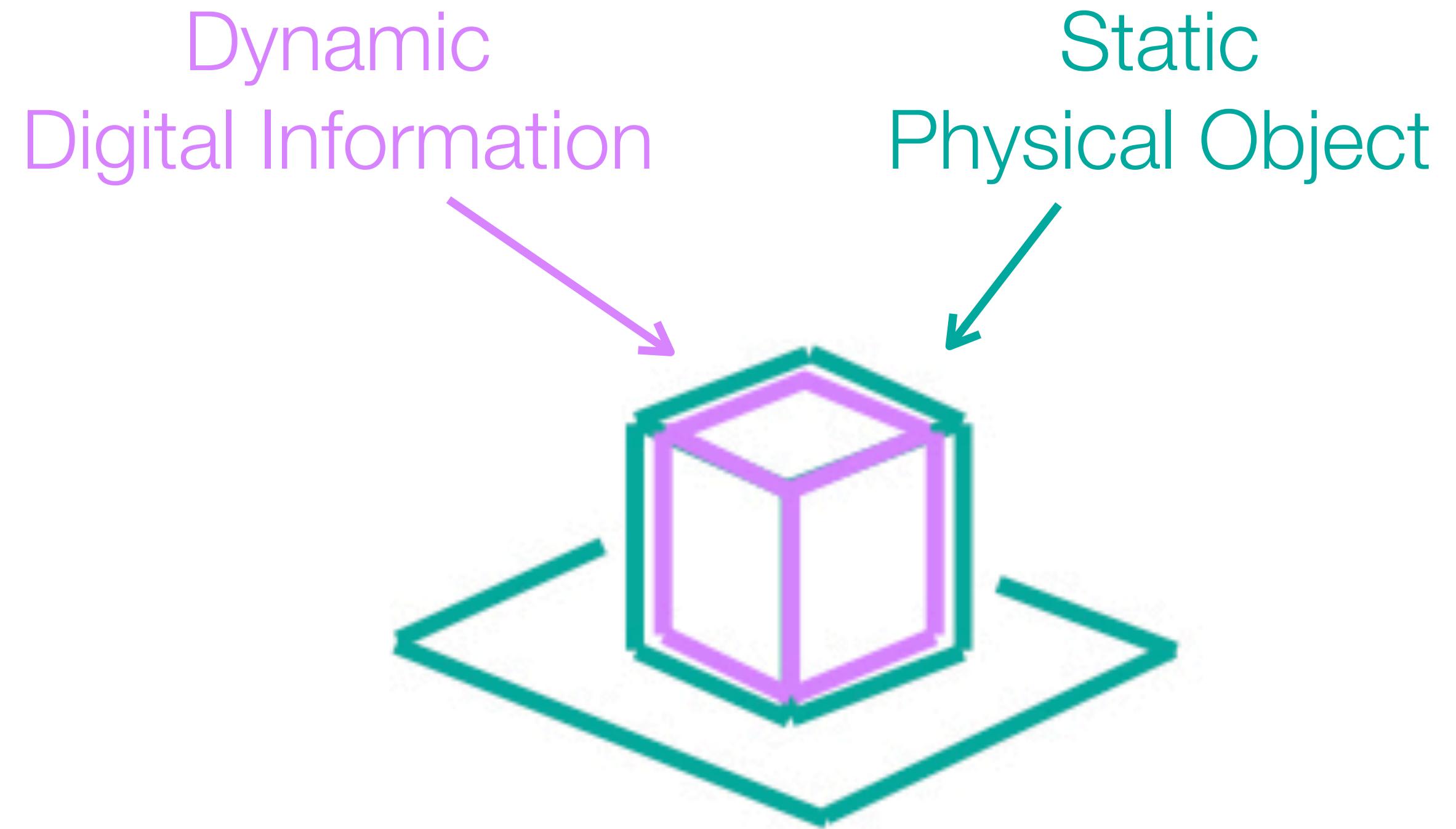


Graphical UI

display as an interface

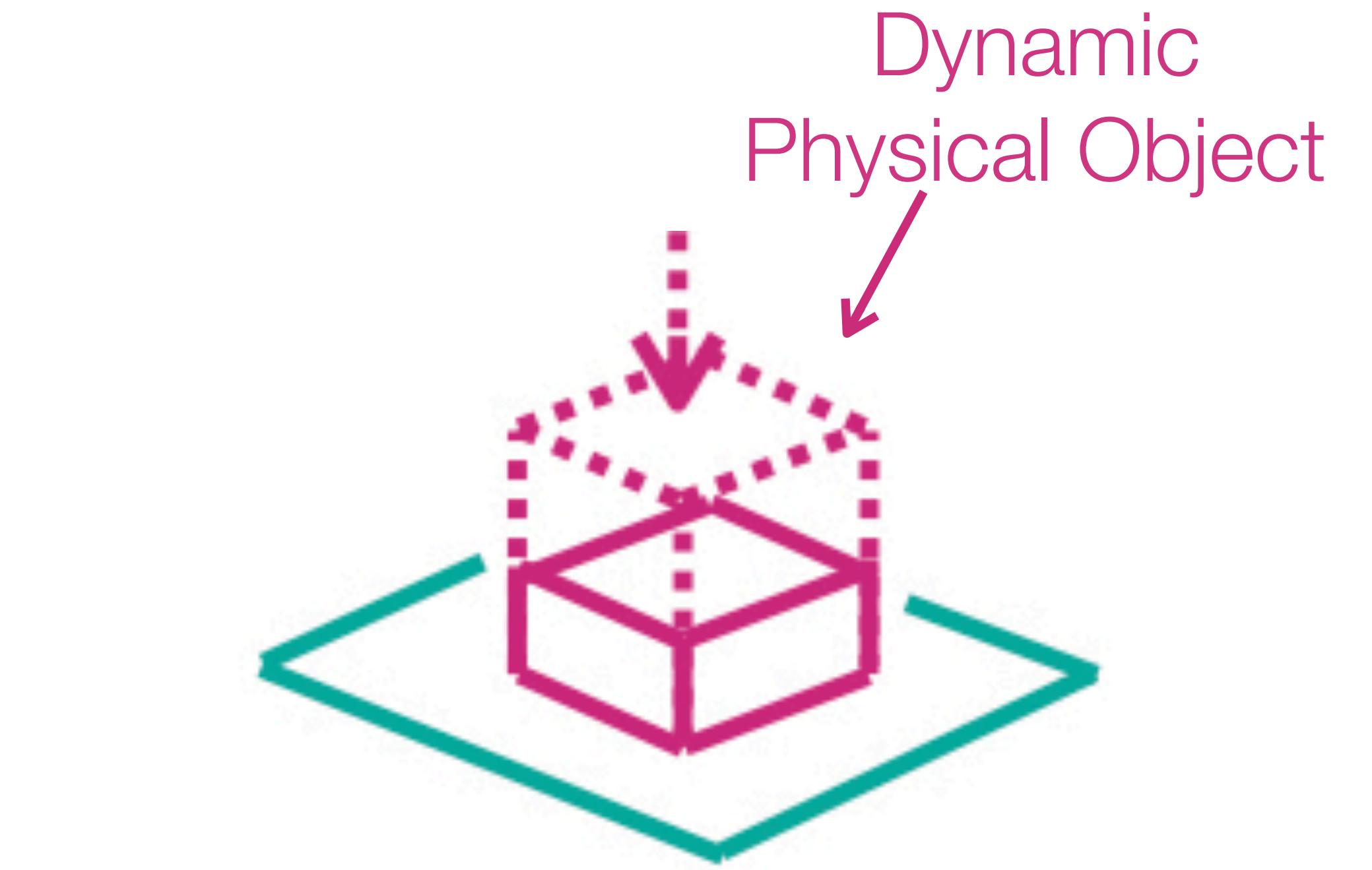
Tangible UI

the physical world as an interface



Static Tangible Interfaces

static tangible objects and overlaid graphics for manipulation and representation



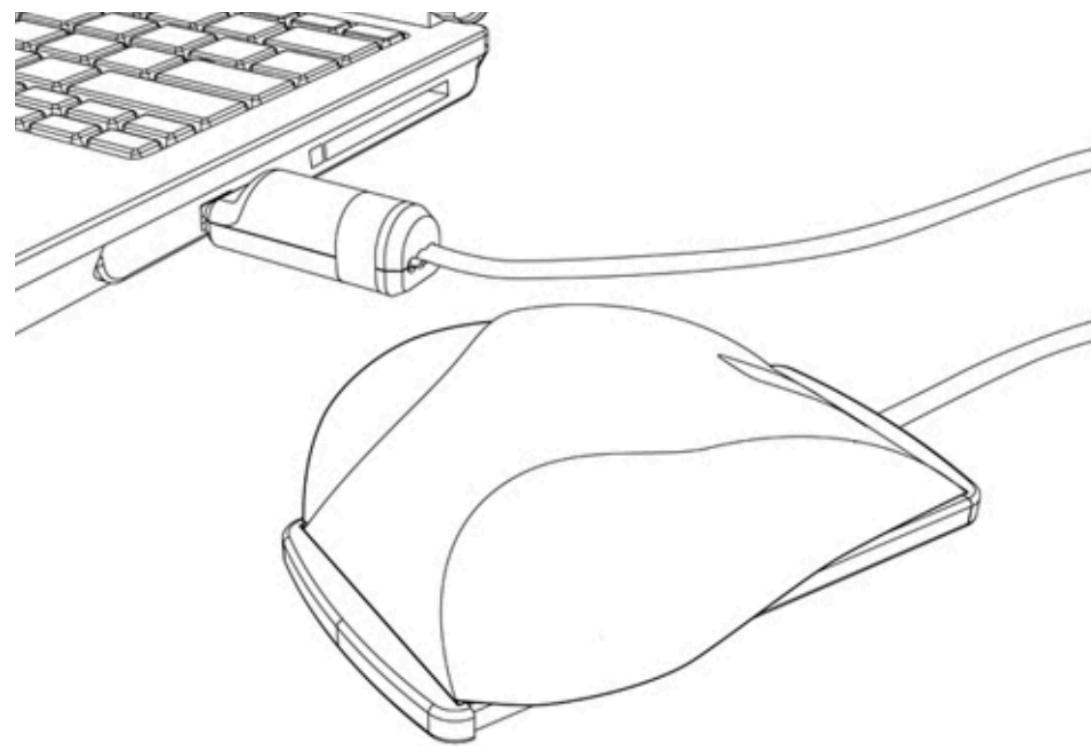
Shape-changing Interfaces

dynamic physical objects to fully represent the fluidity of digital information

Shape-changing Interfaces



PneUI [Yao, UIST'13]



Inflatable Mouse [Kim, CHI'08]



inFORM [Follmer, UIST'13]



BMW Museum [Art+Com '08]



Thrifty Faucet [Togler, TEI'09]



Bendi [Park, CHI'15]



Lumen [Poupyrev '04]

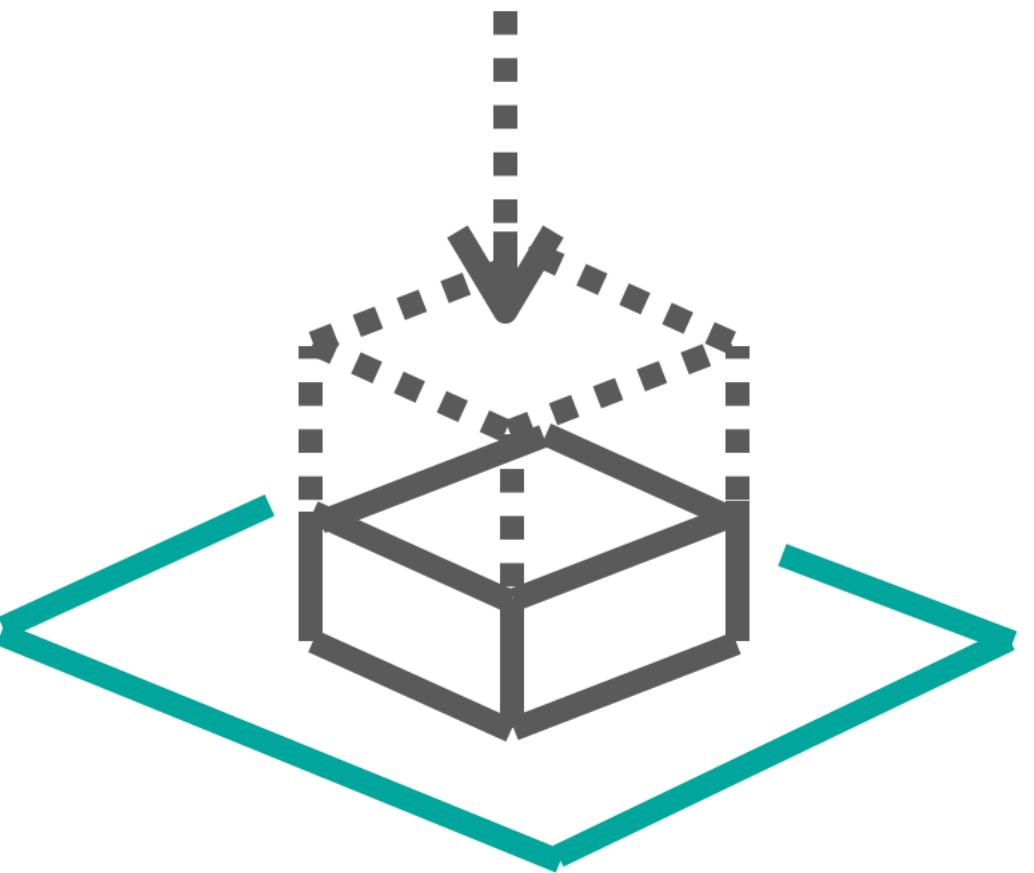


HypoSurface [Goulthorpe '01]

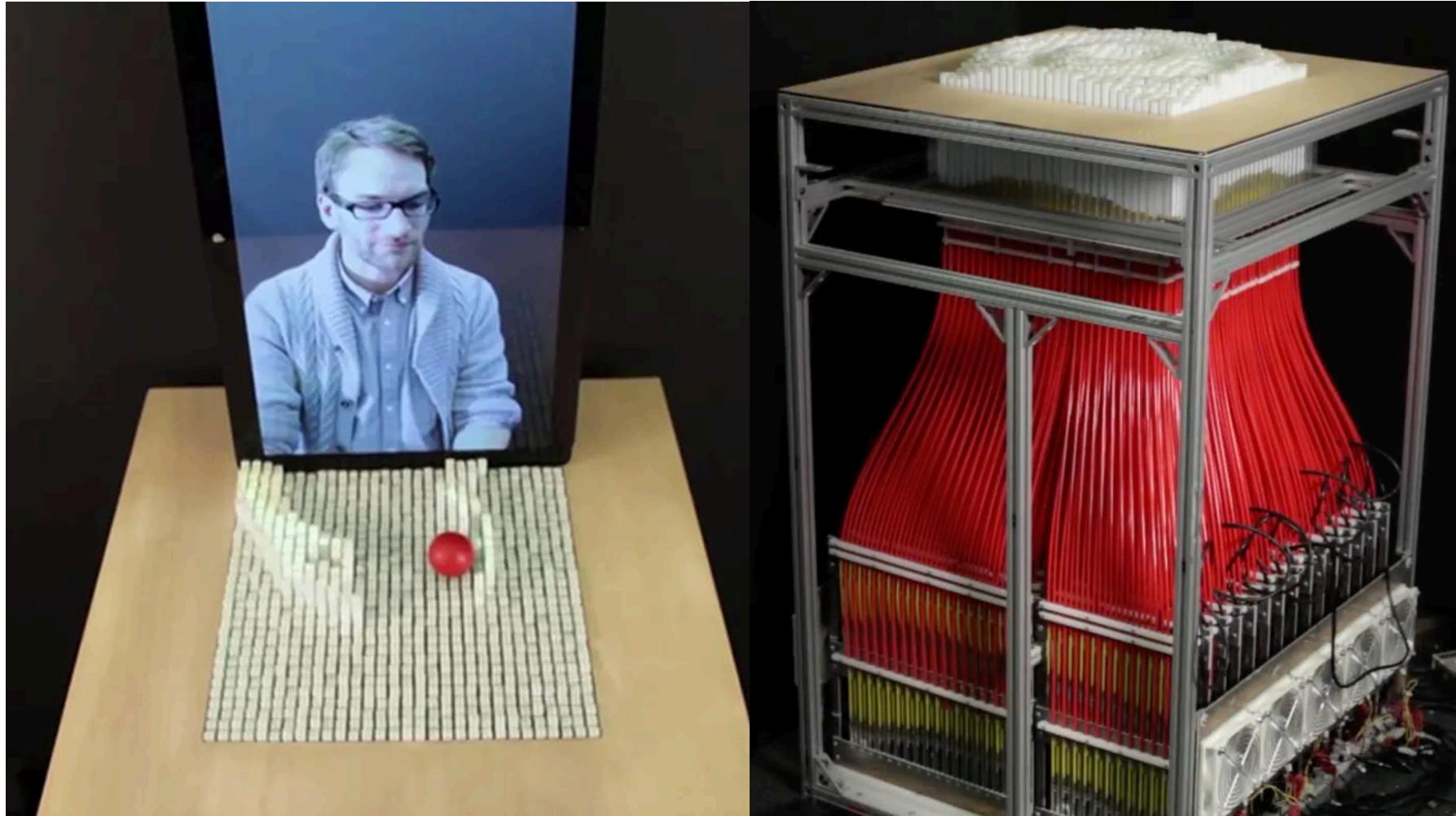
single-purpose



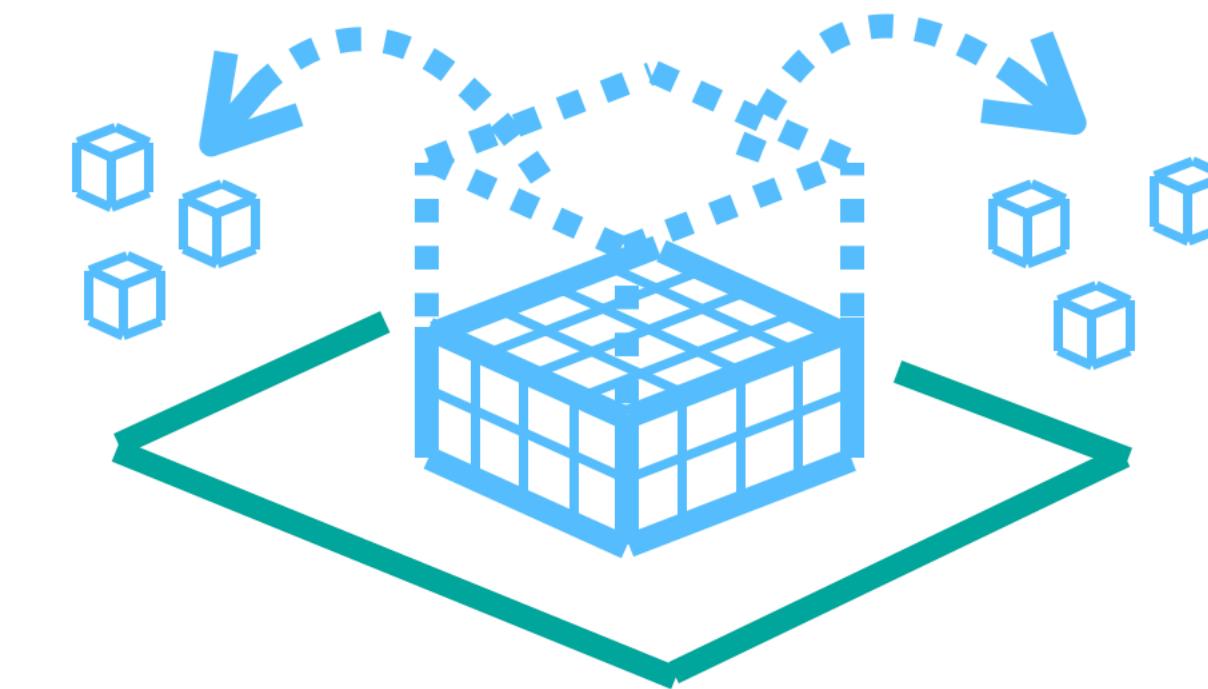
general-purpose



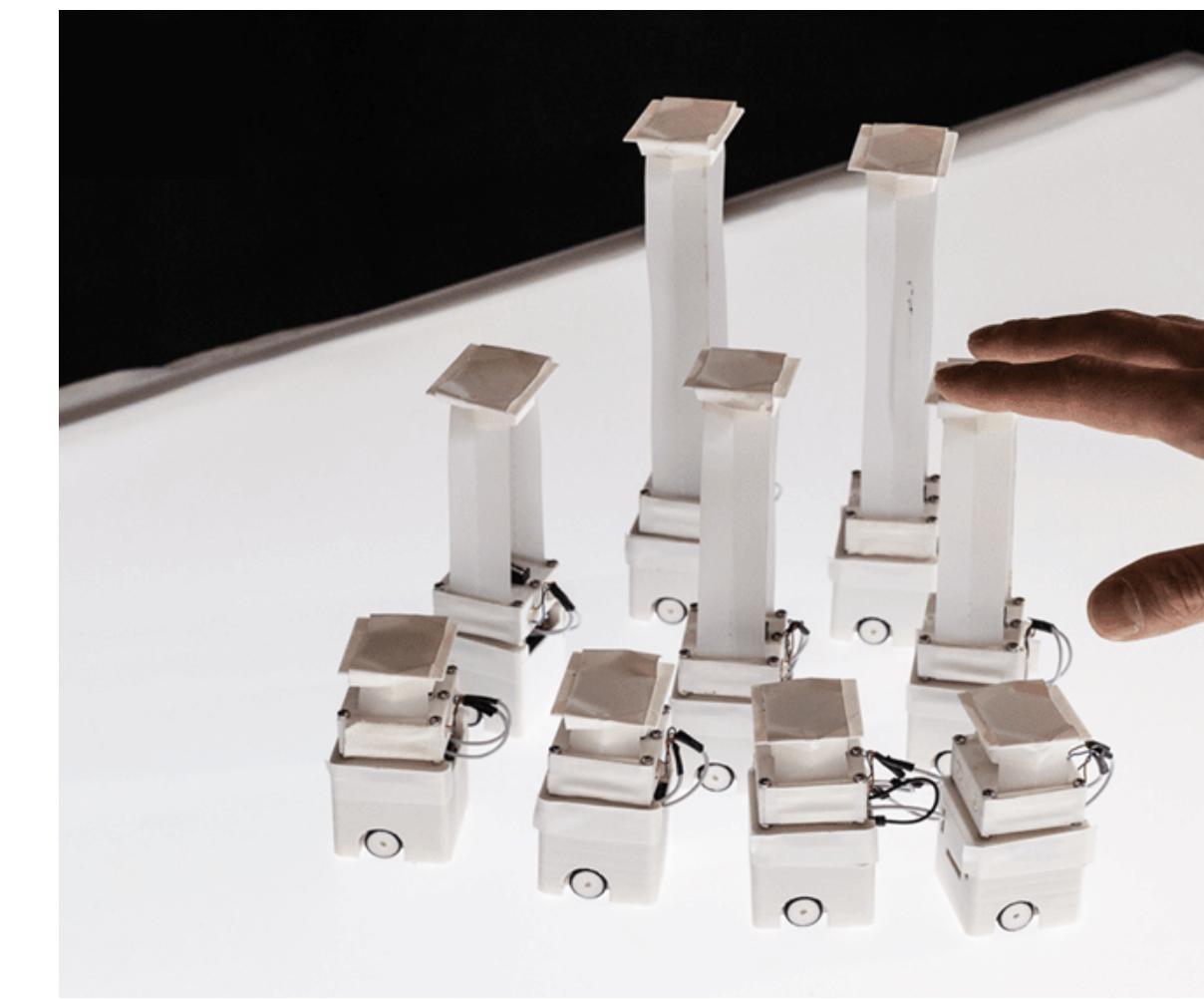
Monolithic



large, heavy, complex



Discrete and Distributed



modular, scalable, deployable

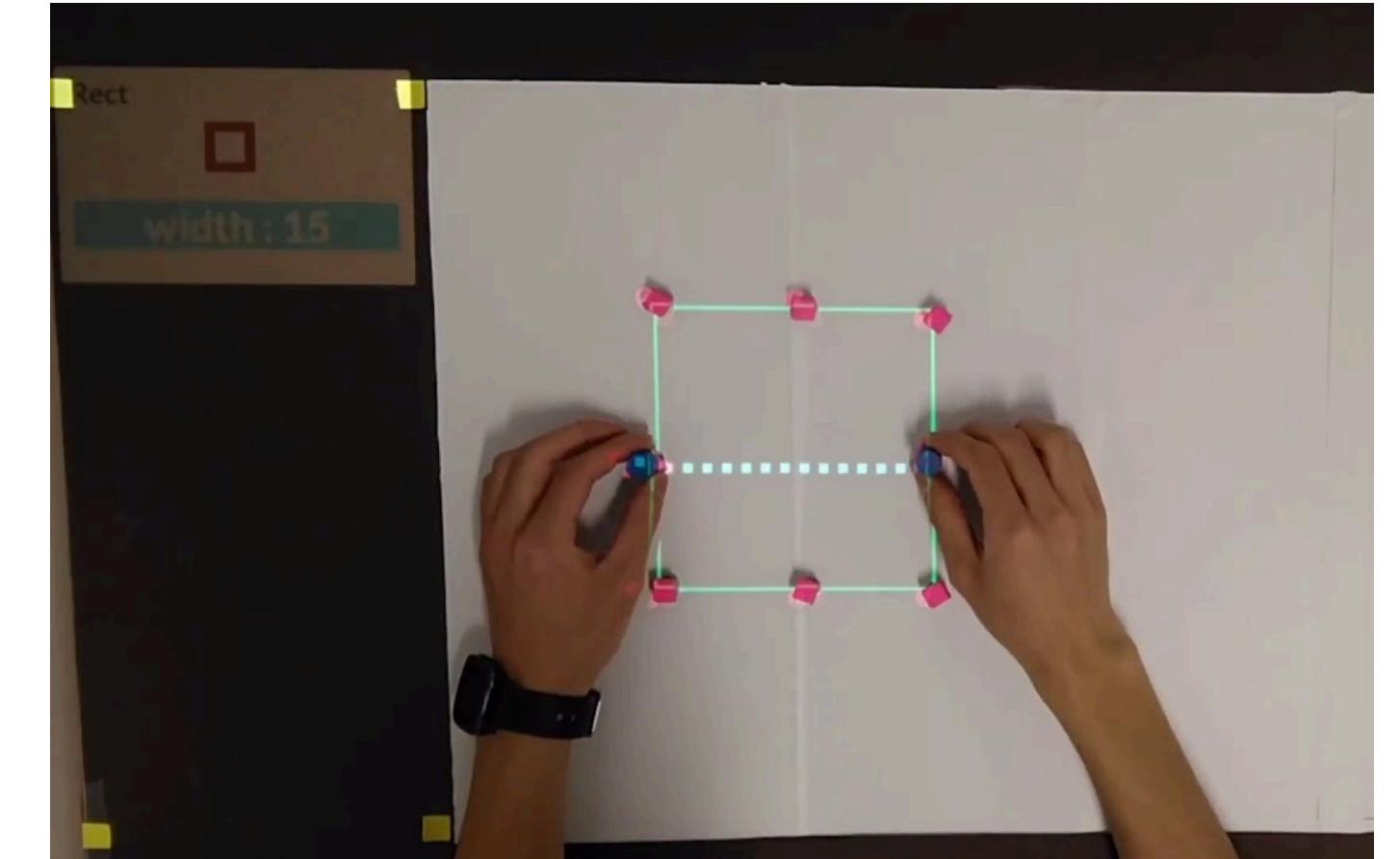
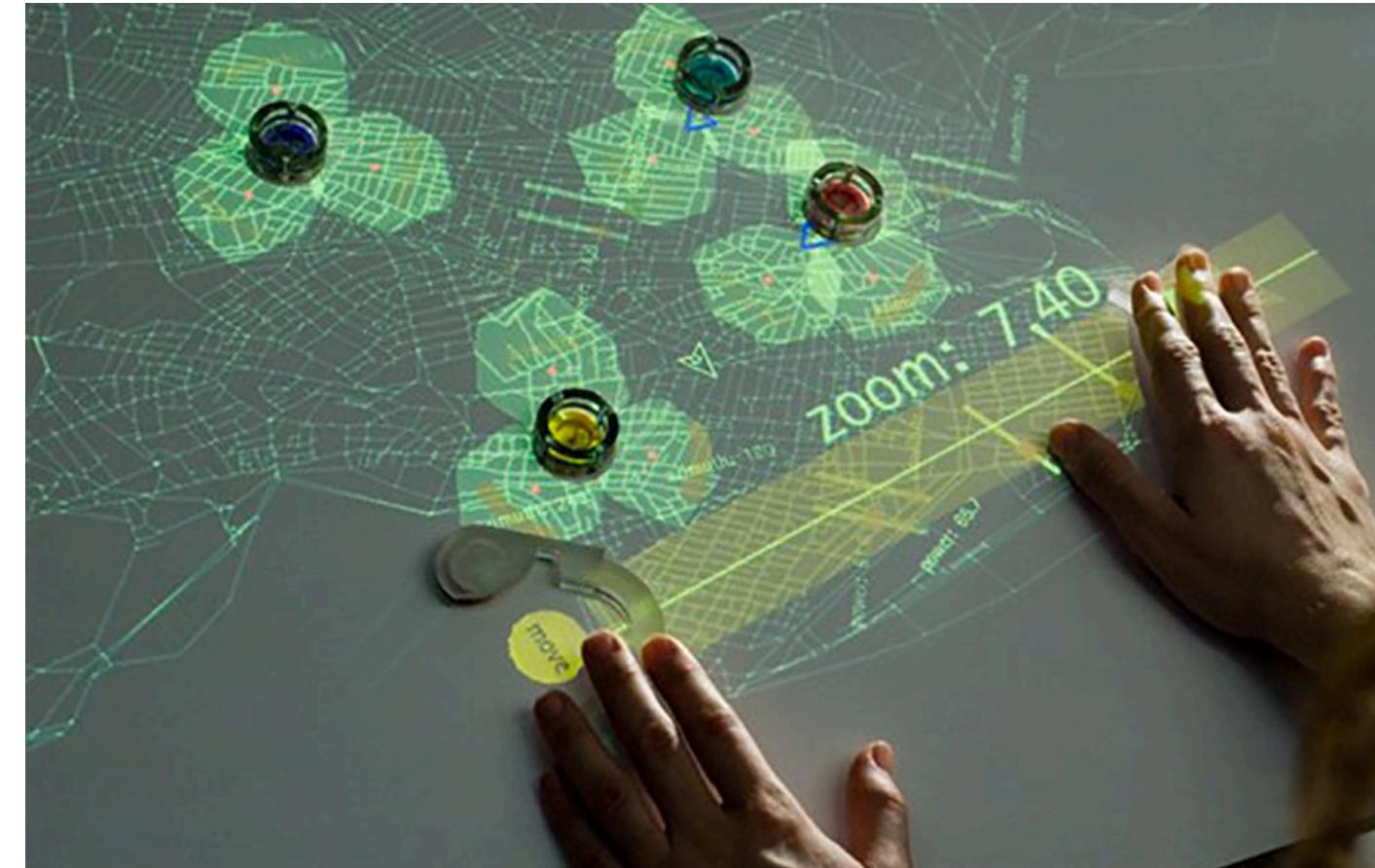
Swarm User Interfaces



Zoids

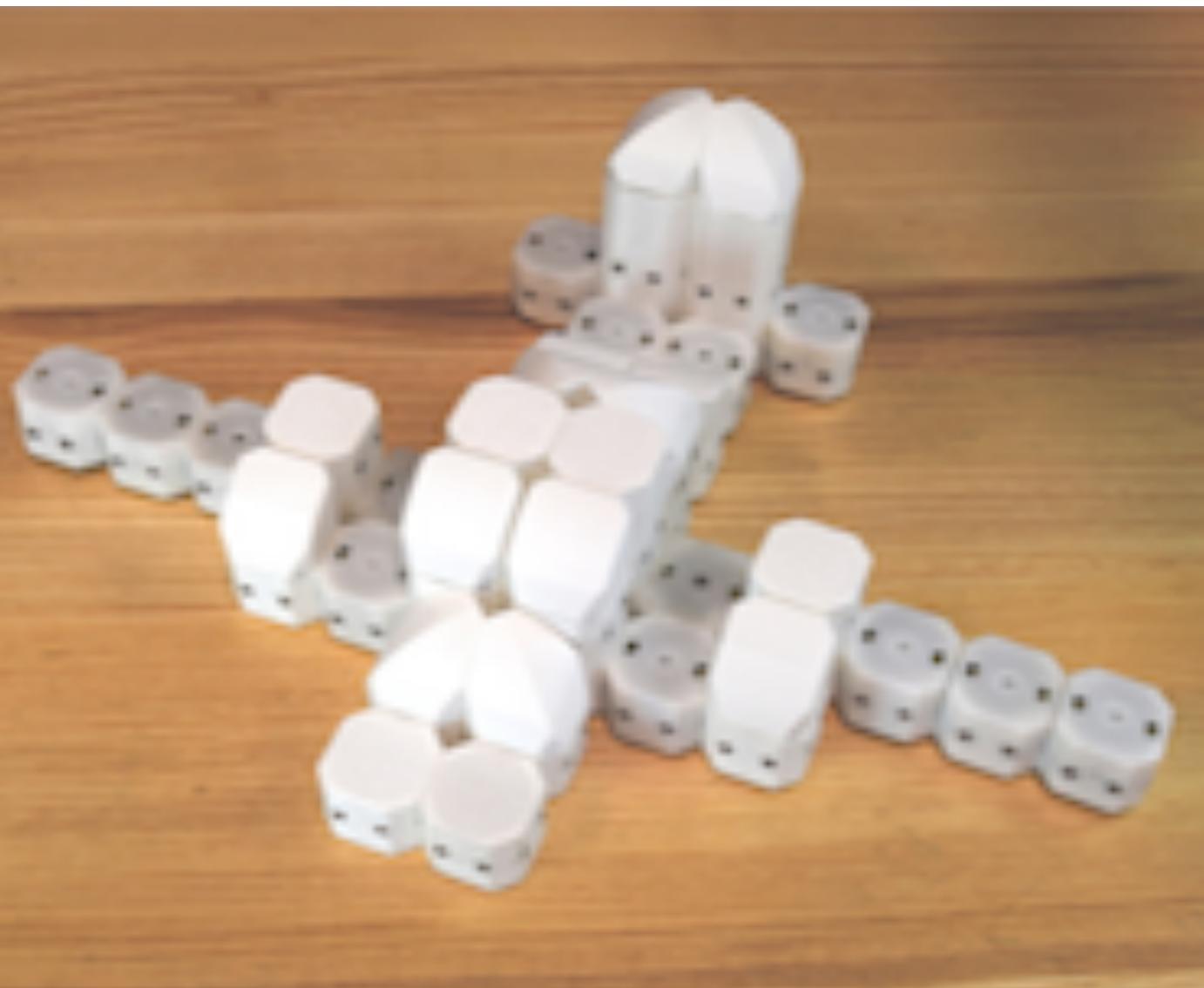


UbiSwarm



Beyond 2D Shape

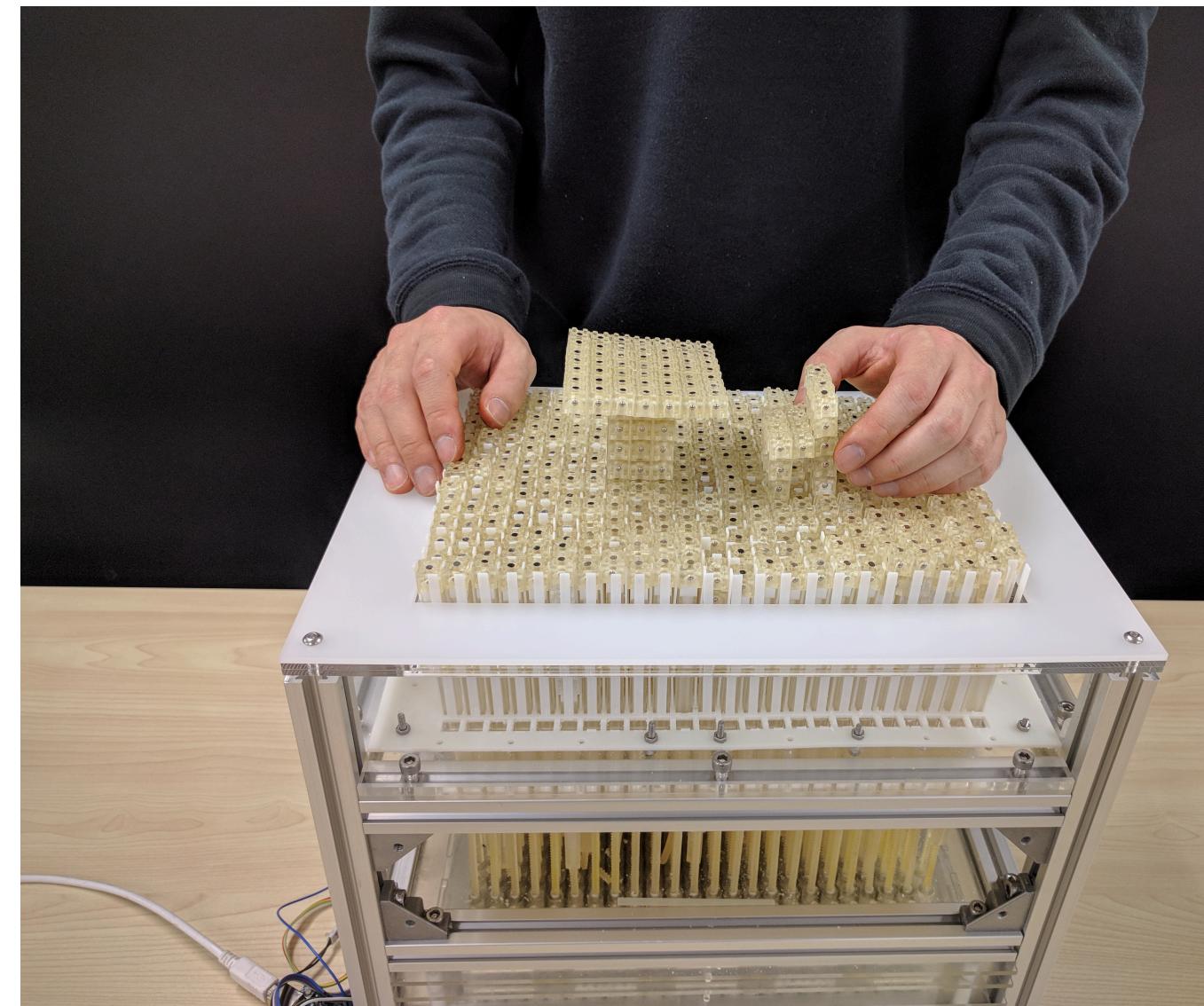
... but static



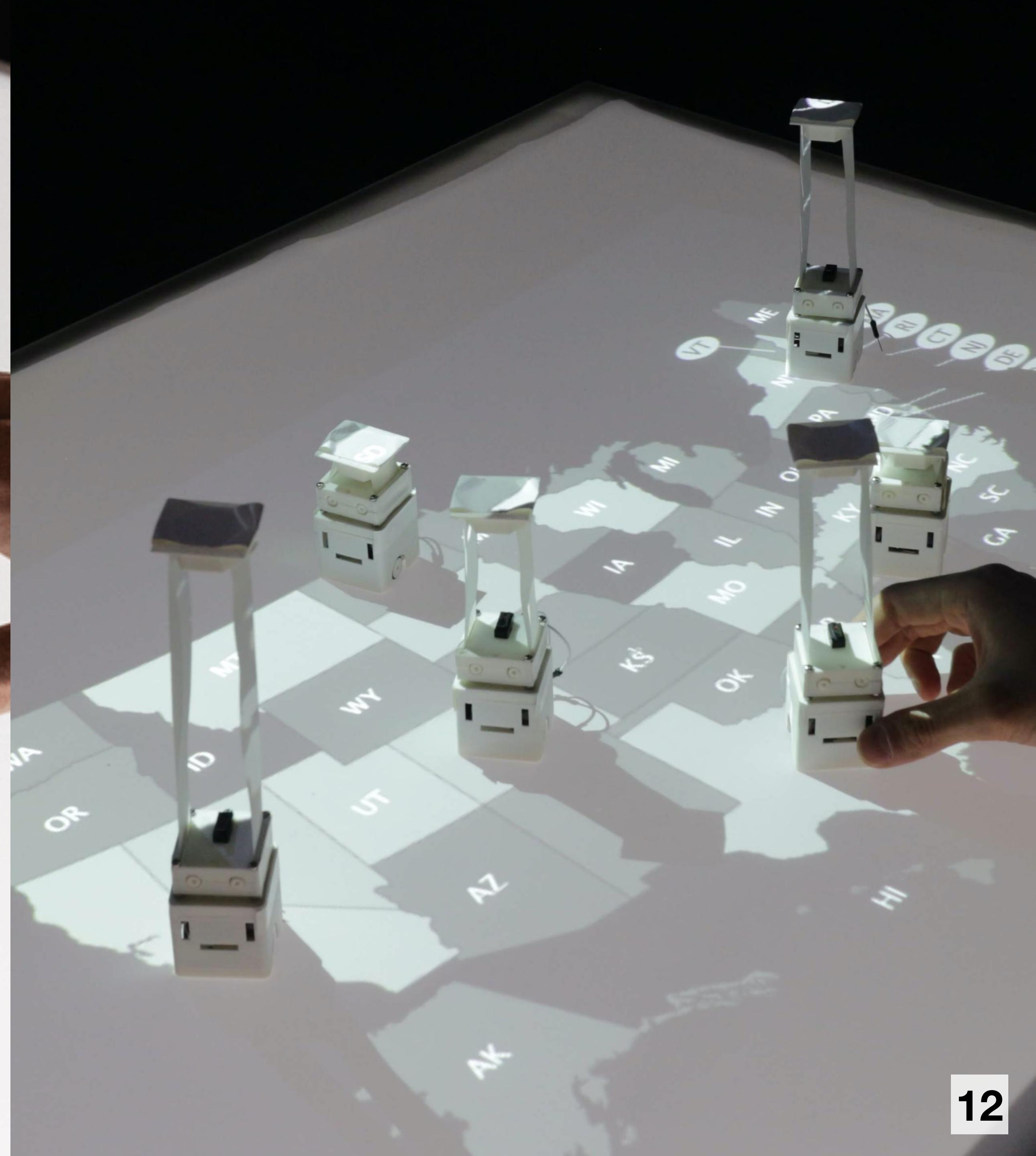
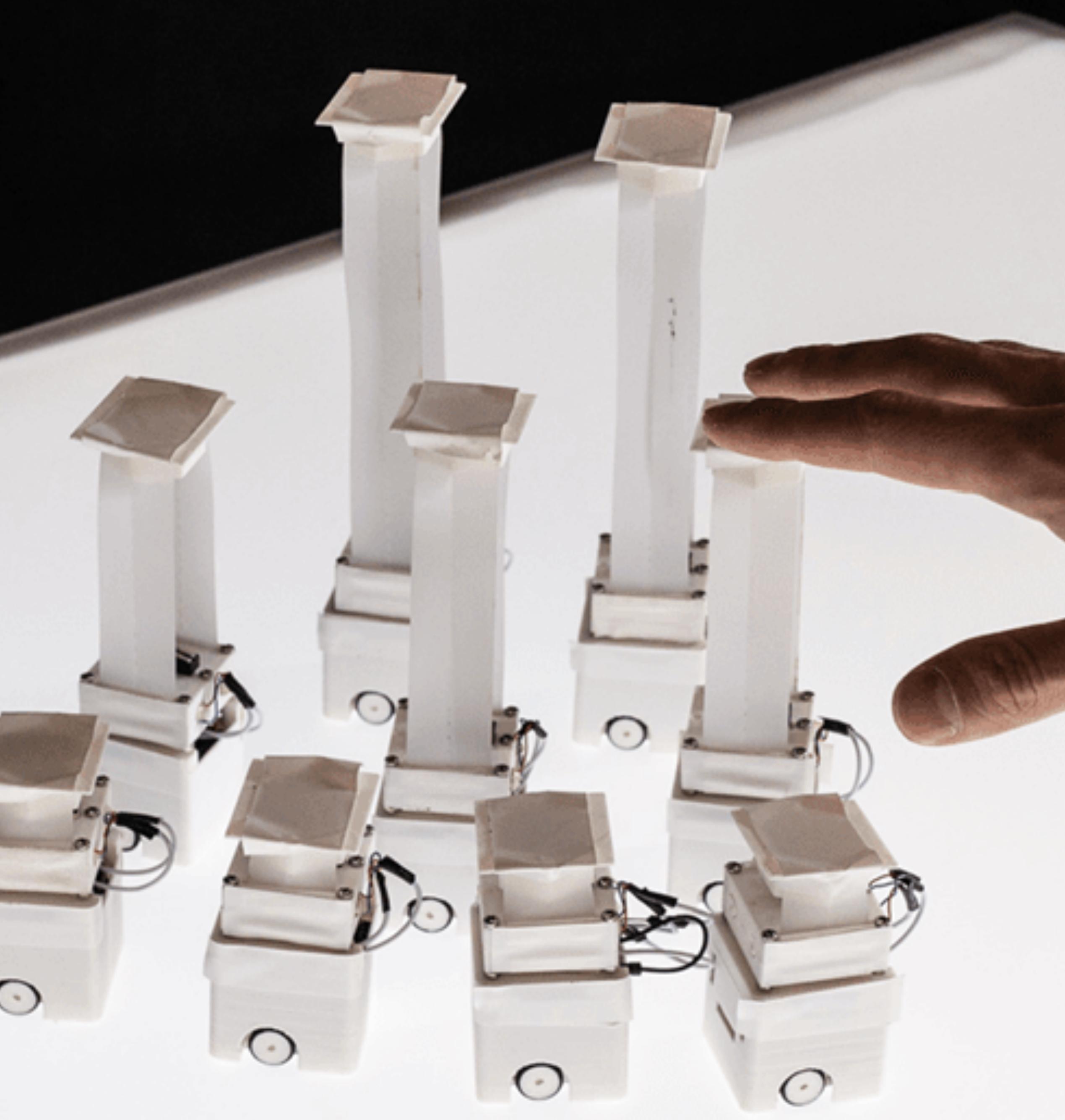
Robotic Assembly



Kinetic Blocks



Dynablock





Technical challenges

miniature size actuator
but large deformation capability

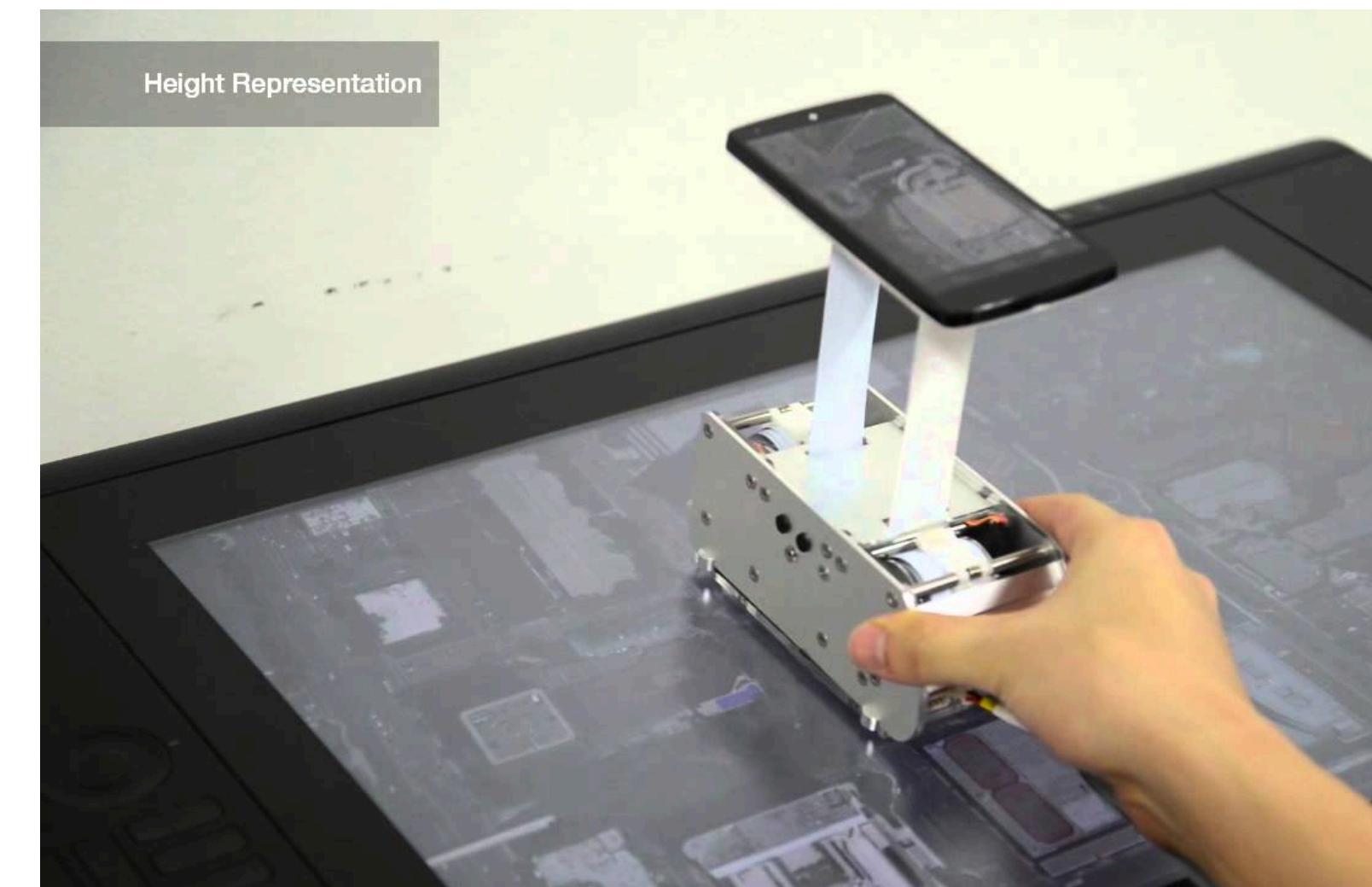
Highly extendable linear actuators



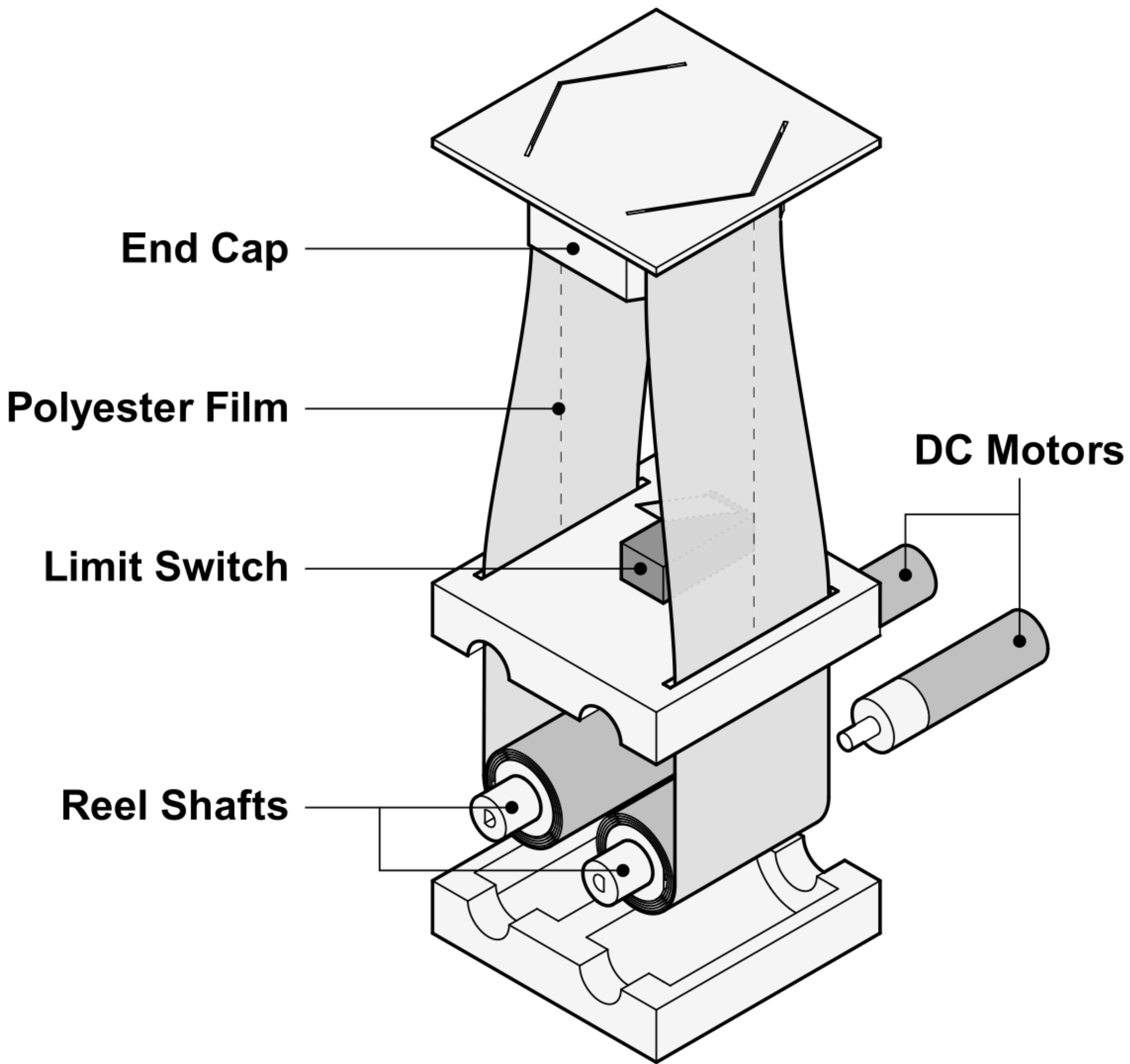
Pneumatic Reel Actuator



Morphys

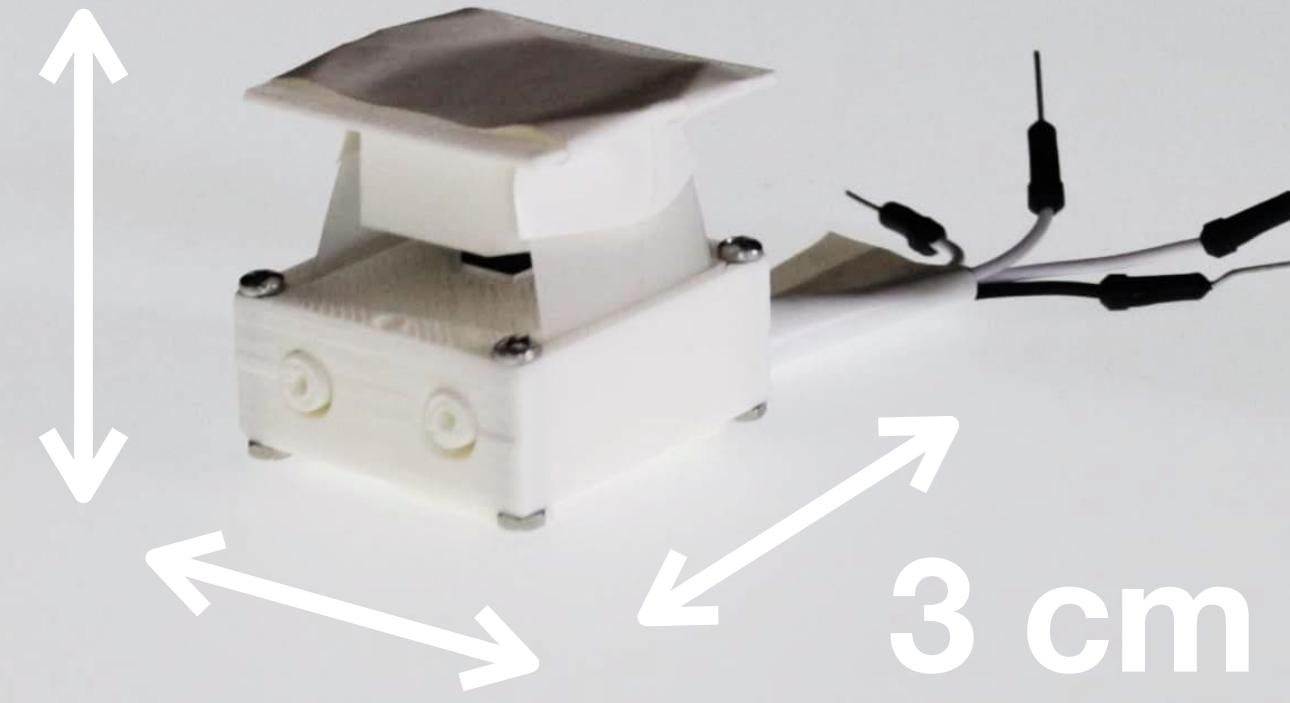


G-Raff

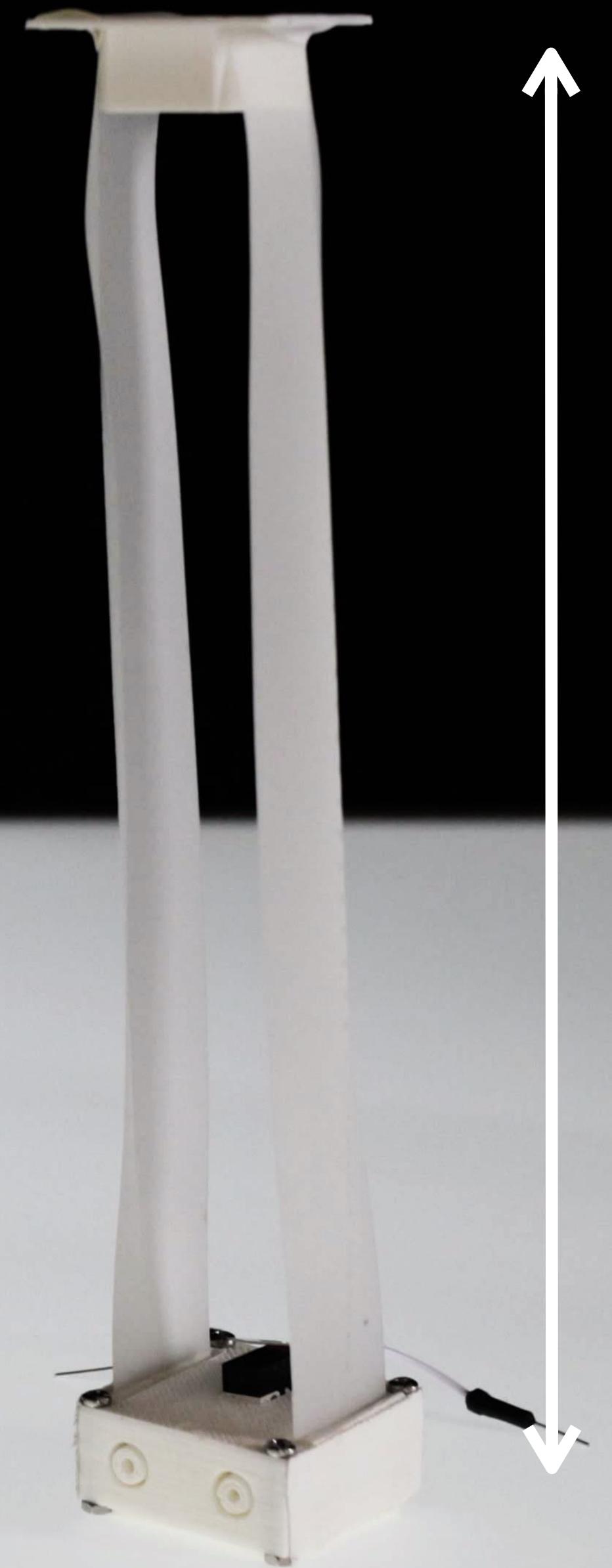


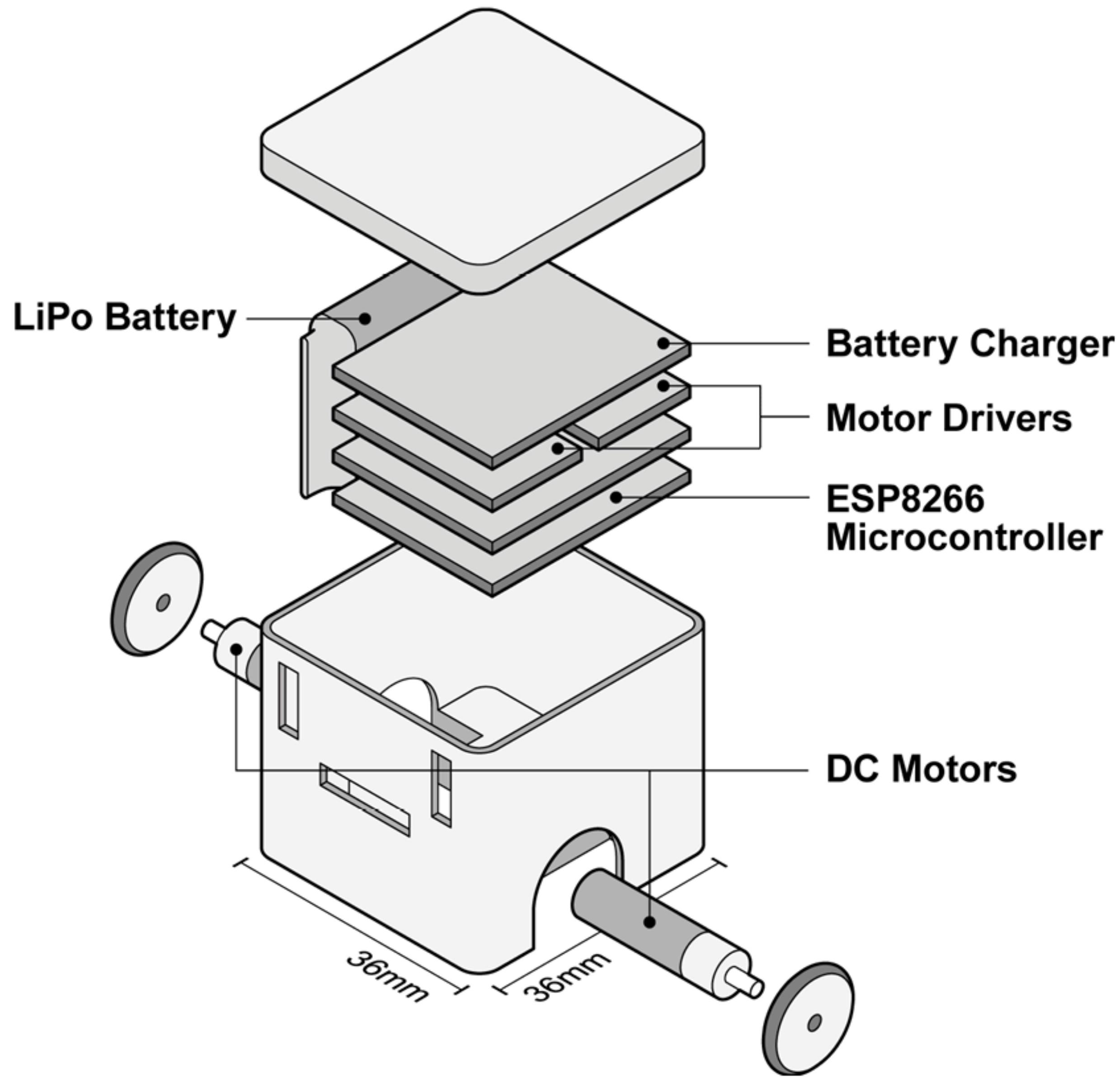


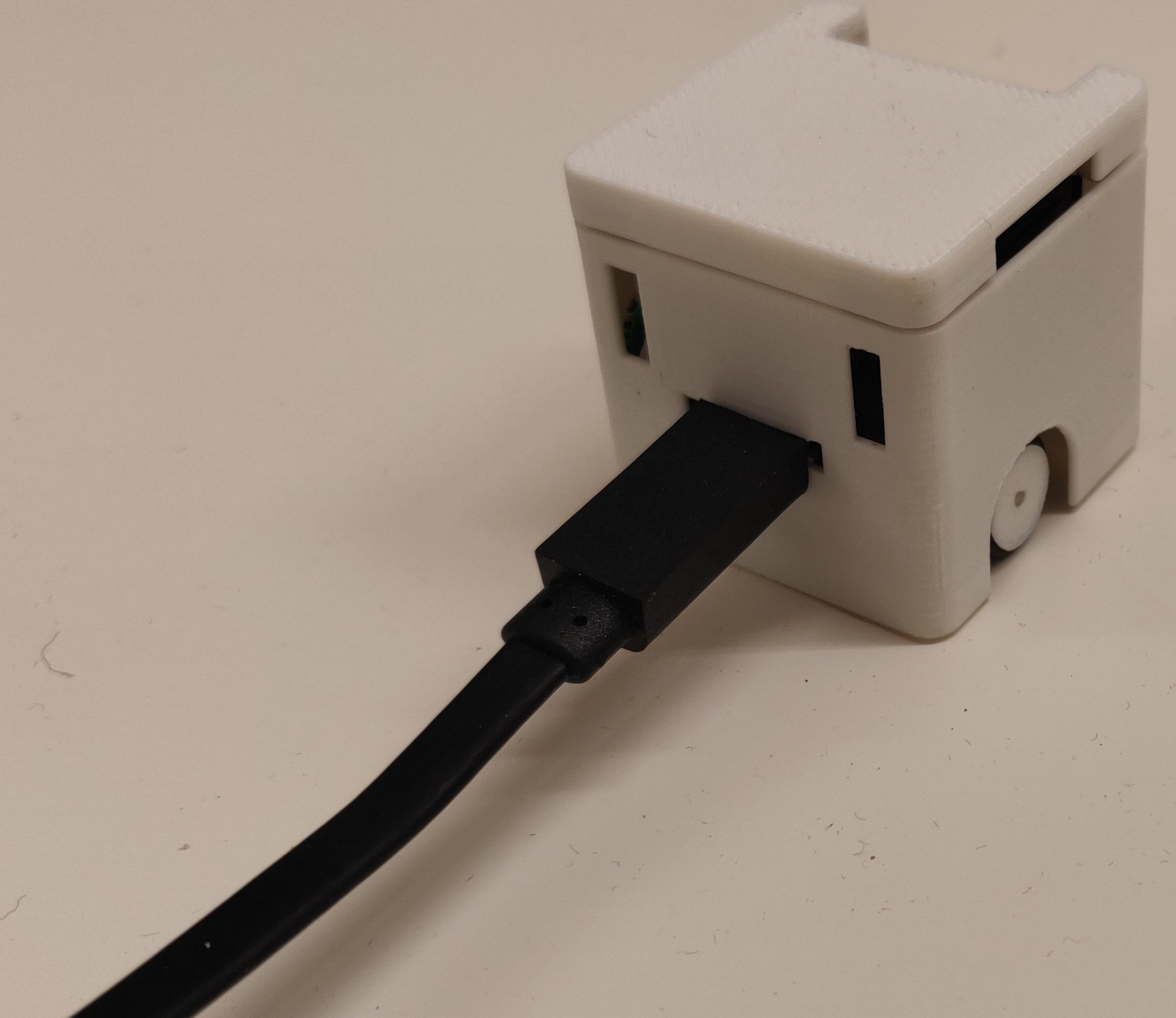
2 cm

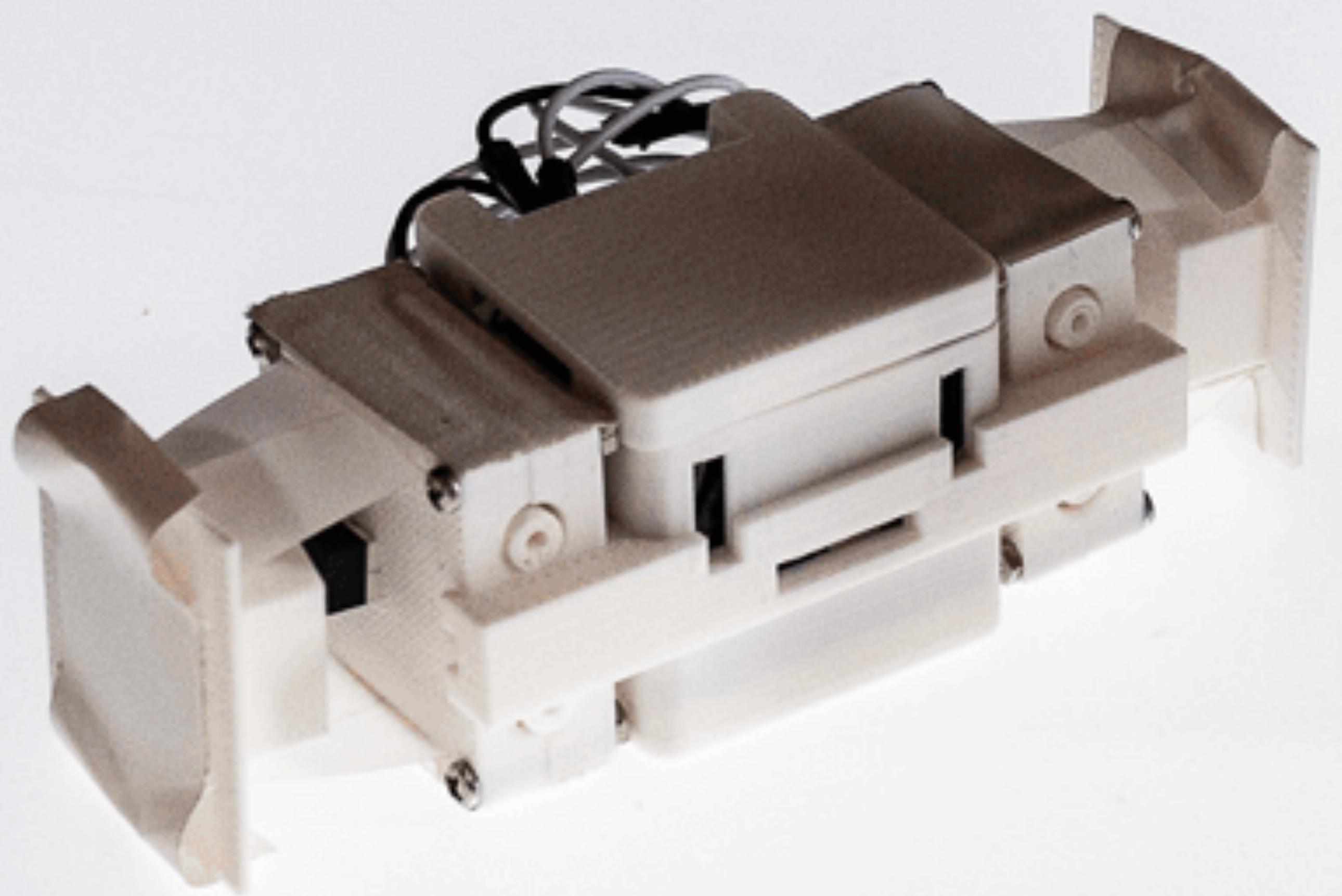


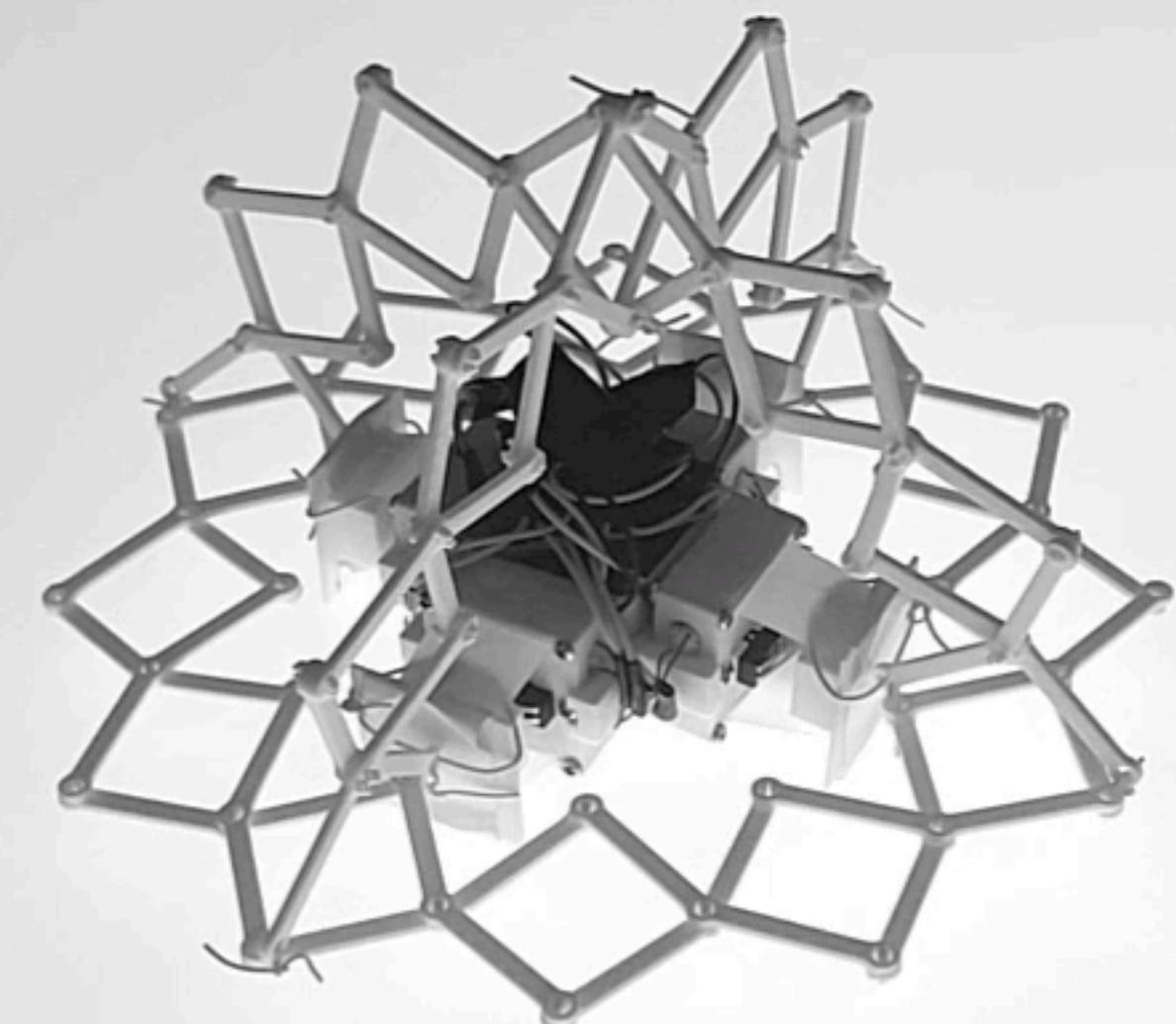
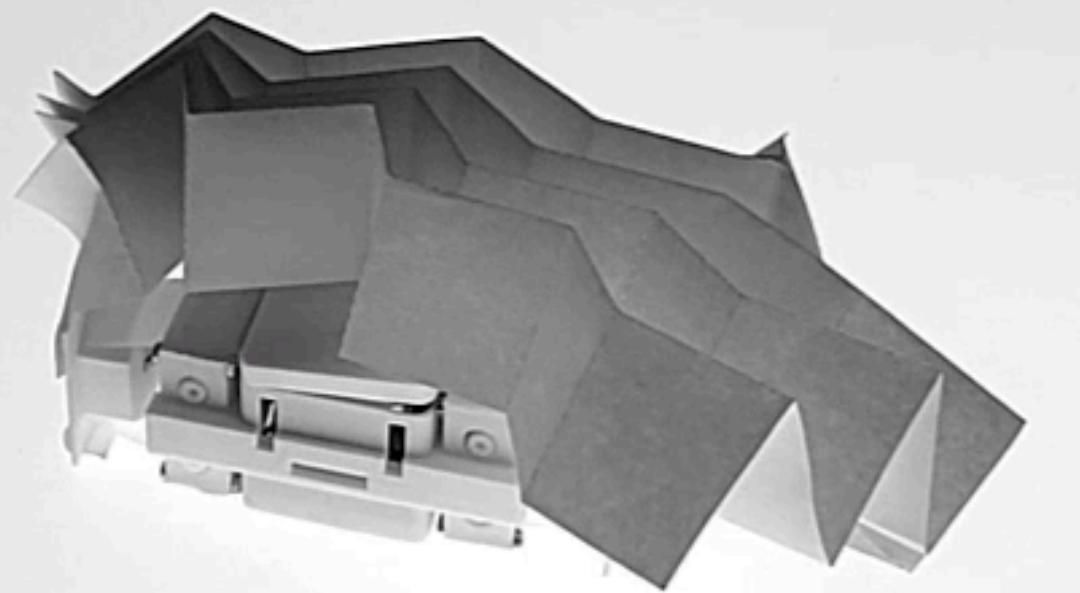
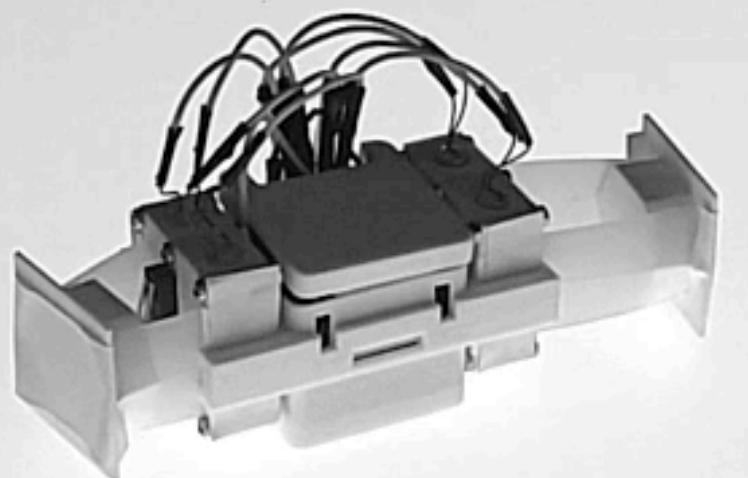
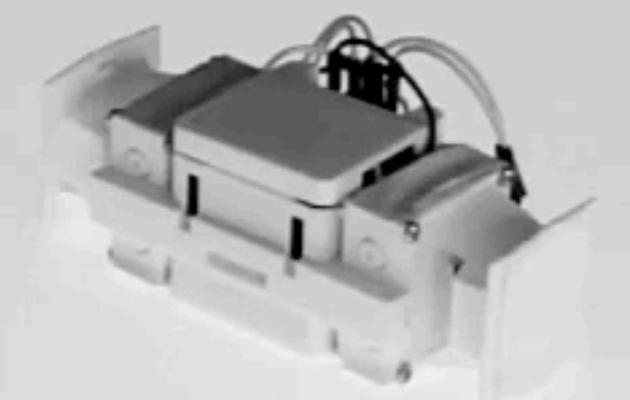
3 cm

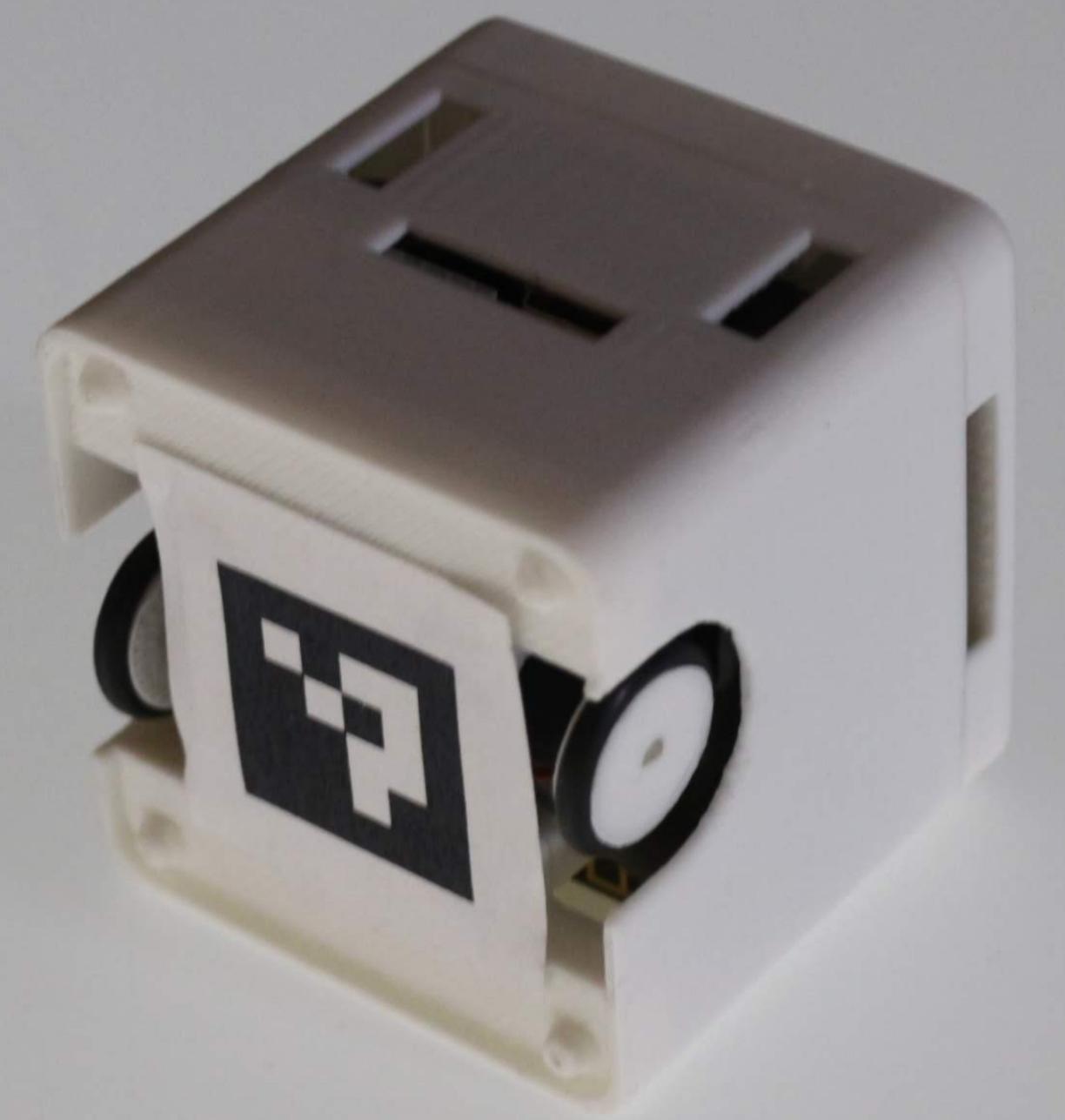


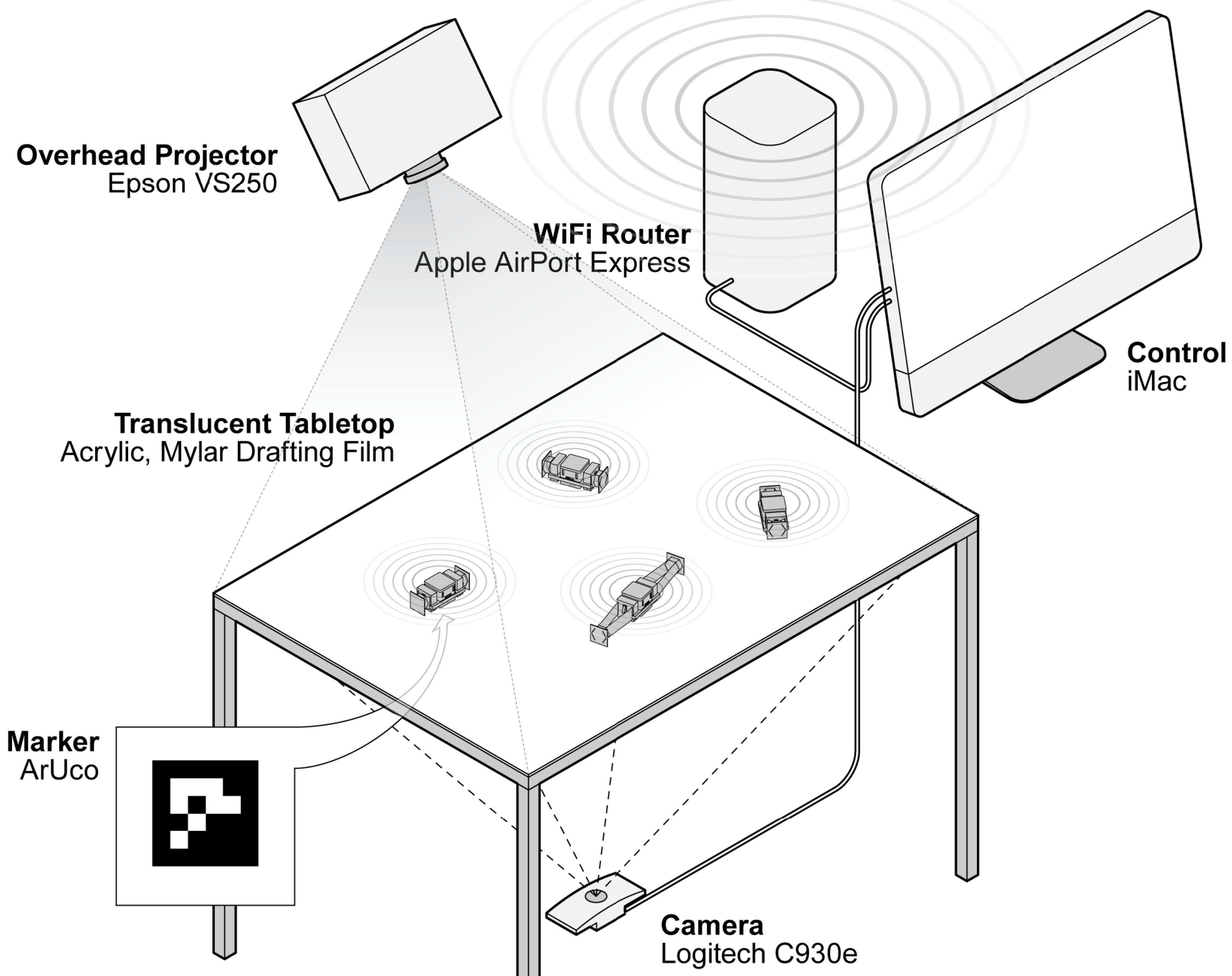




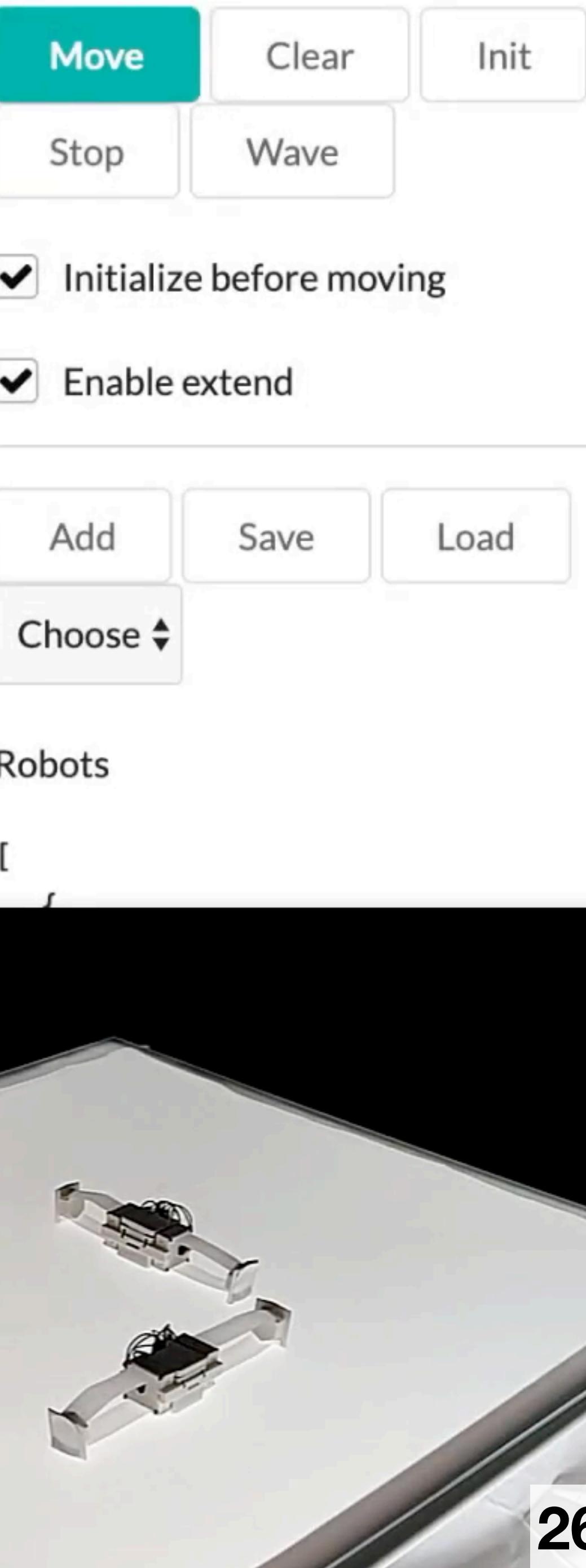
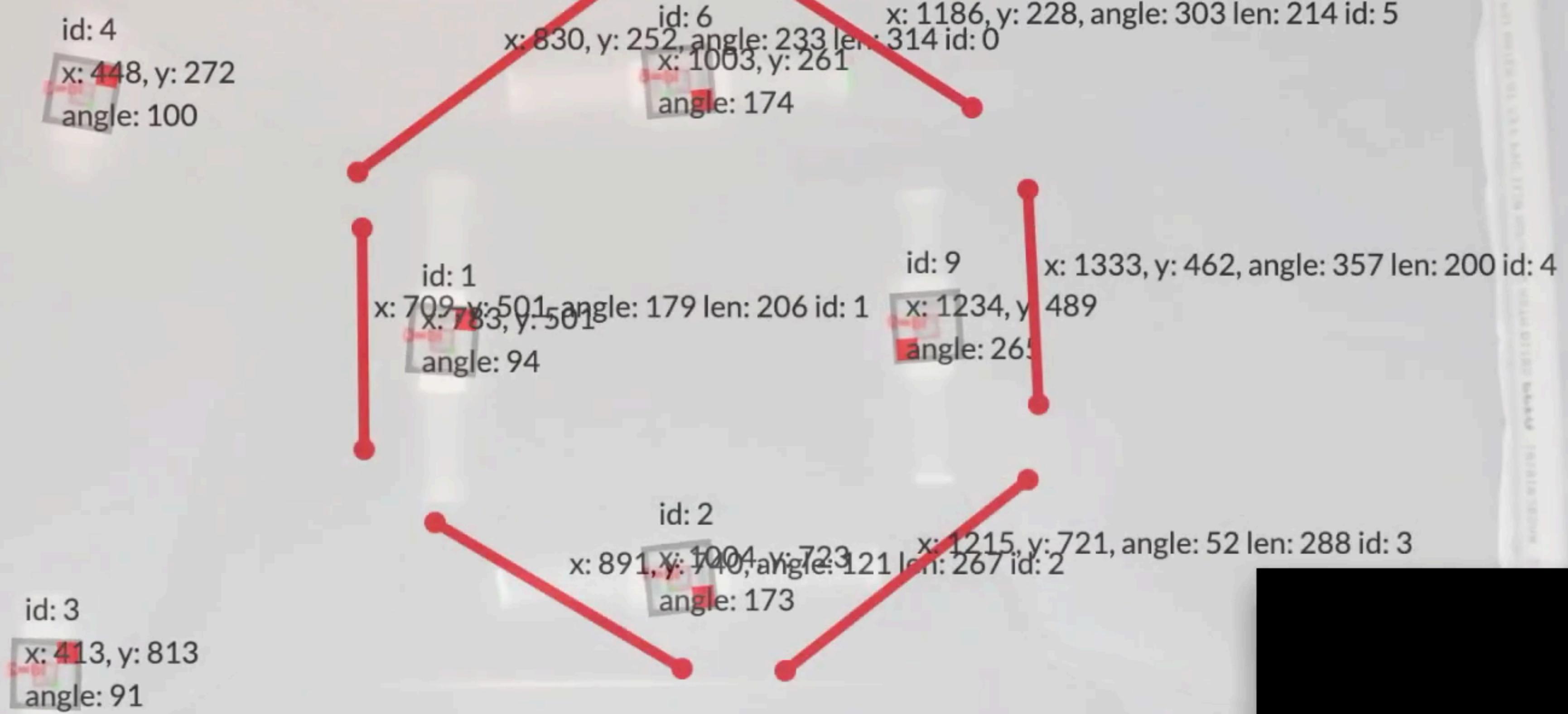


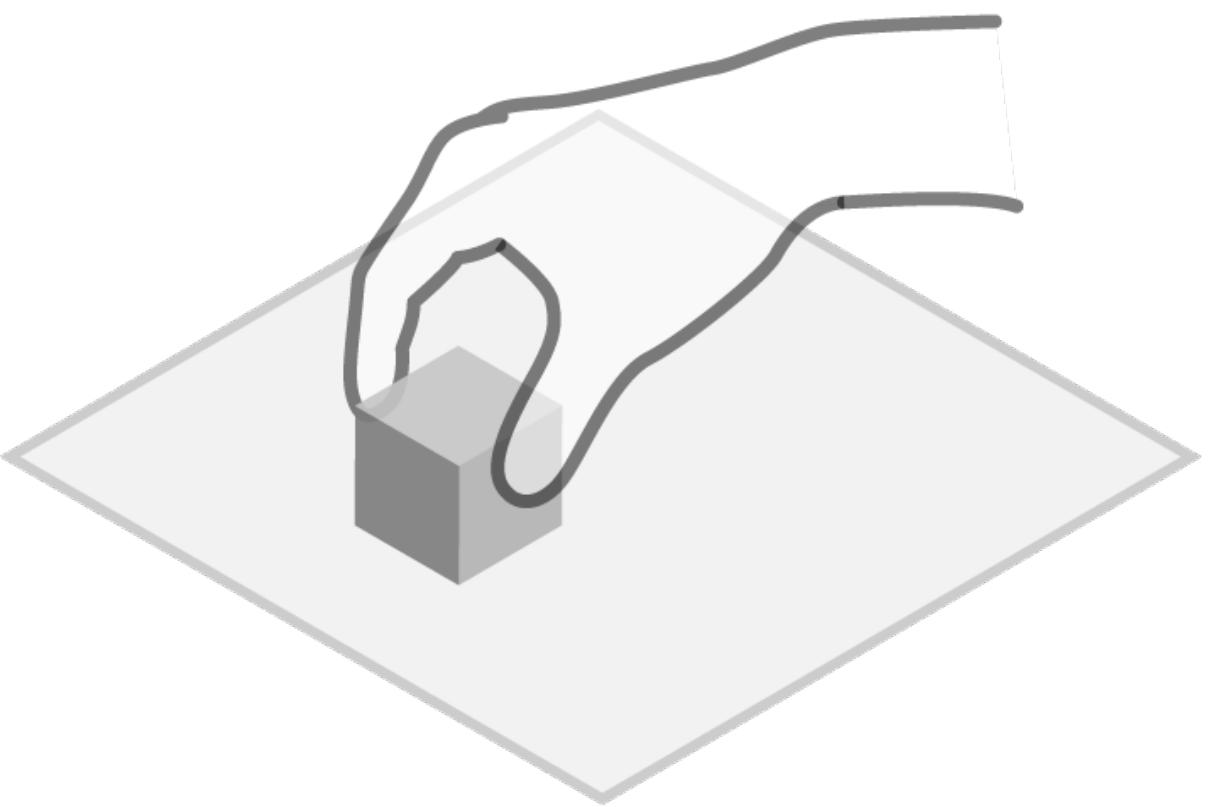




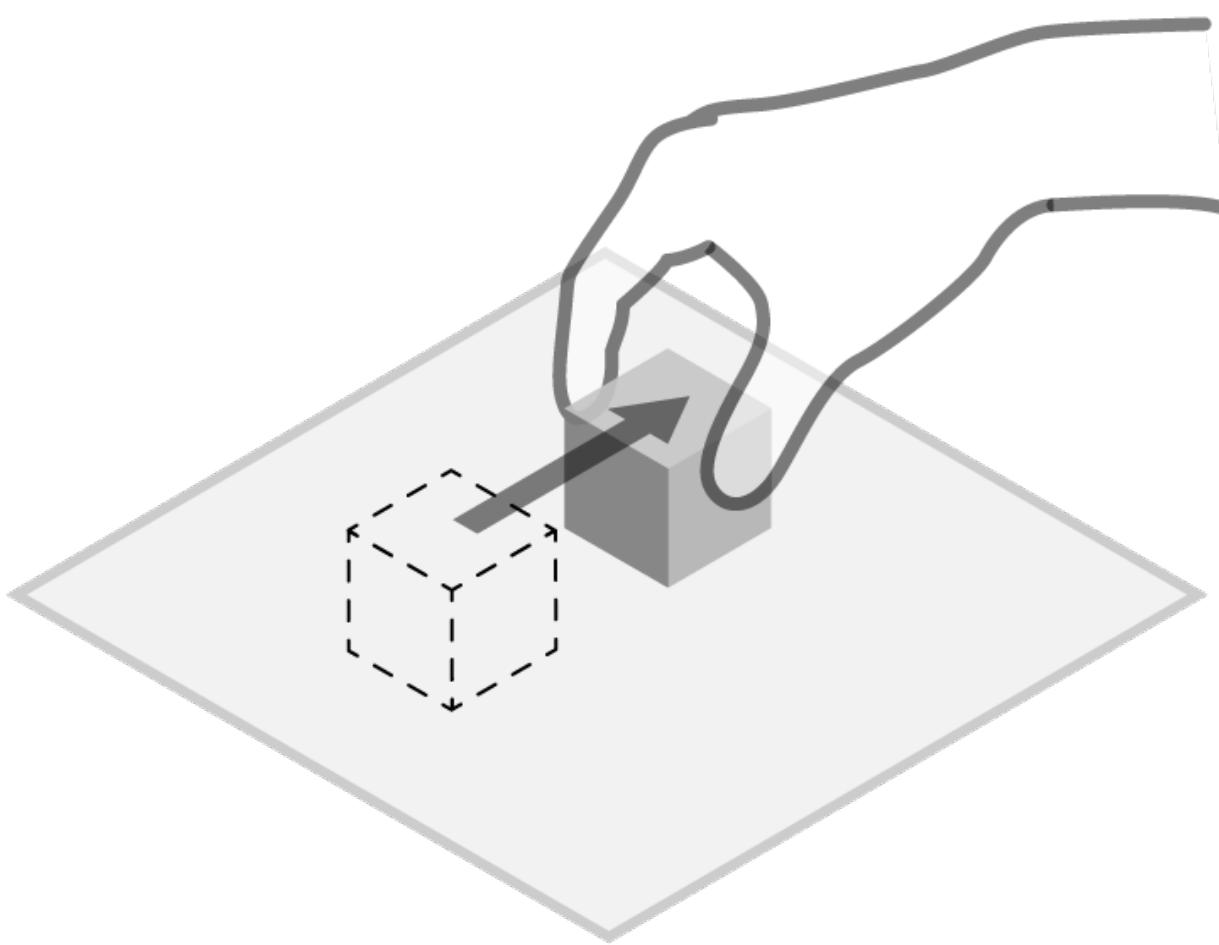


Tracking and GUI Controller

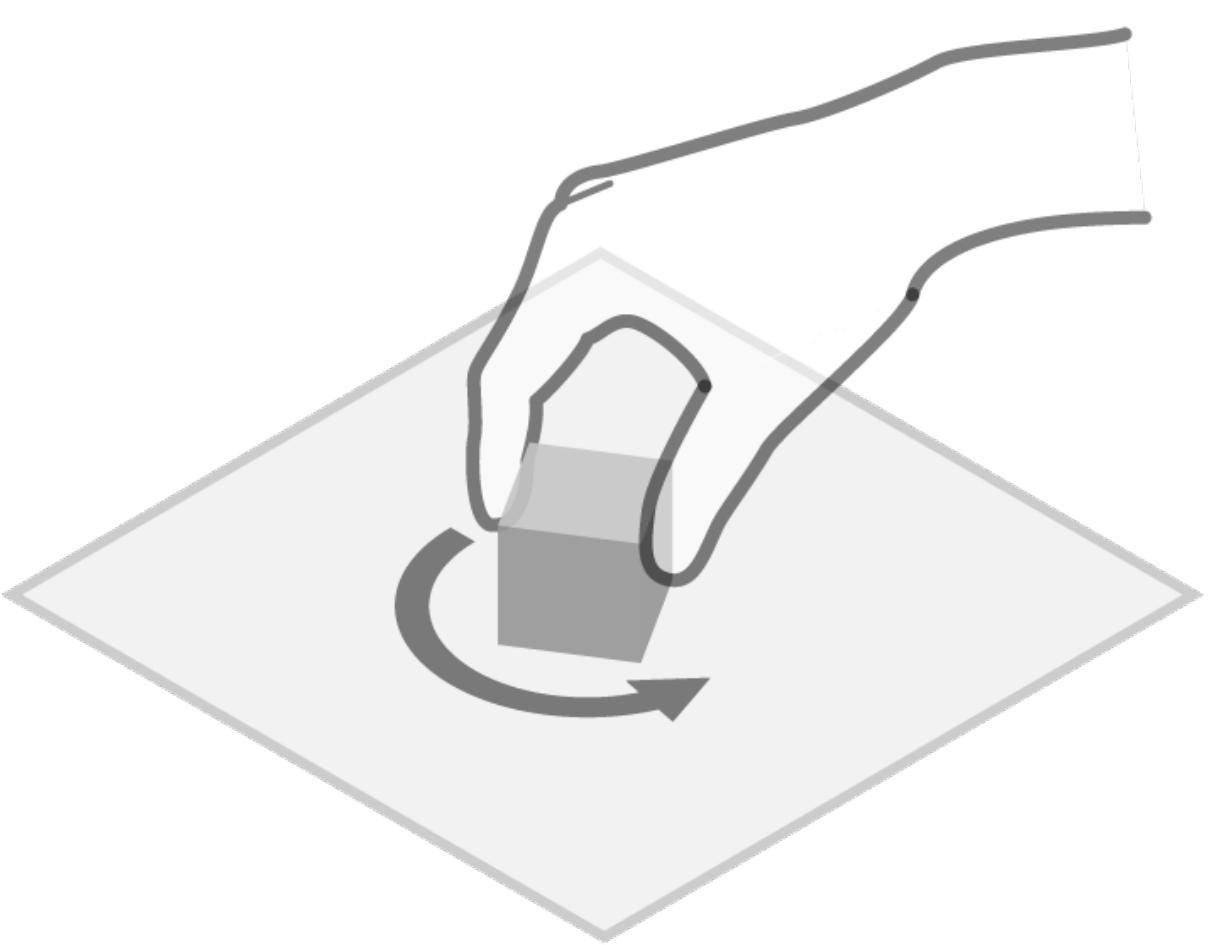




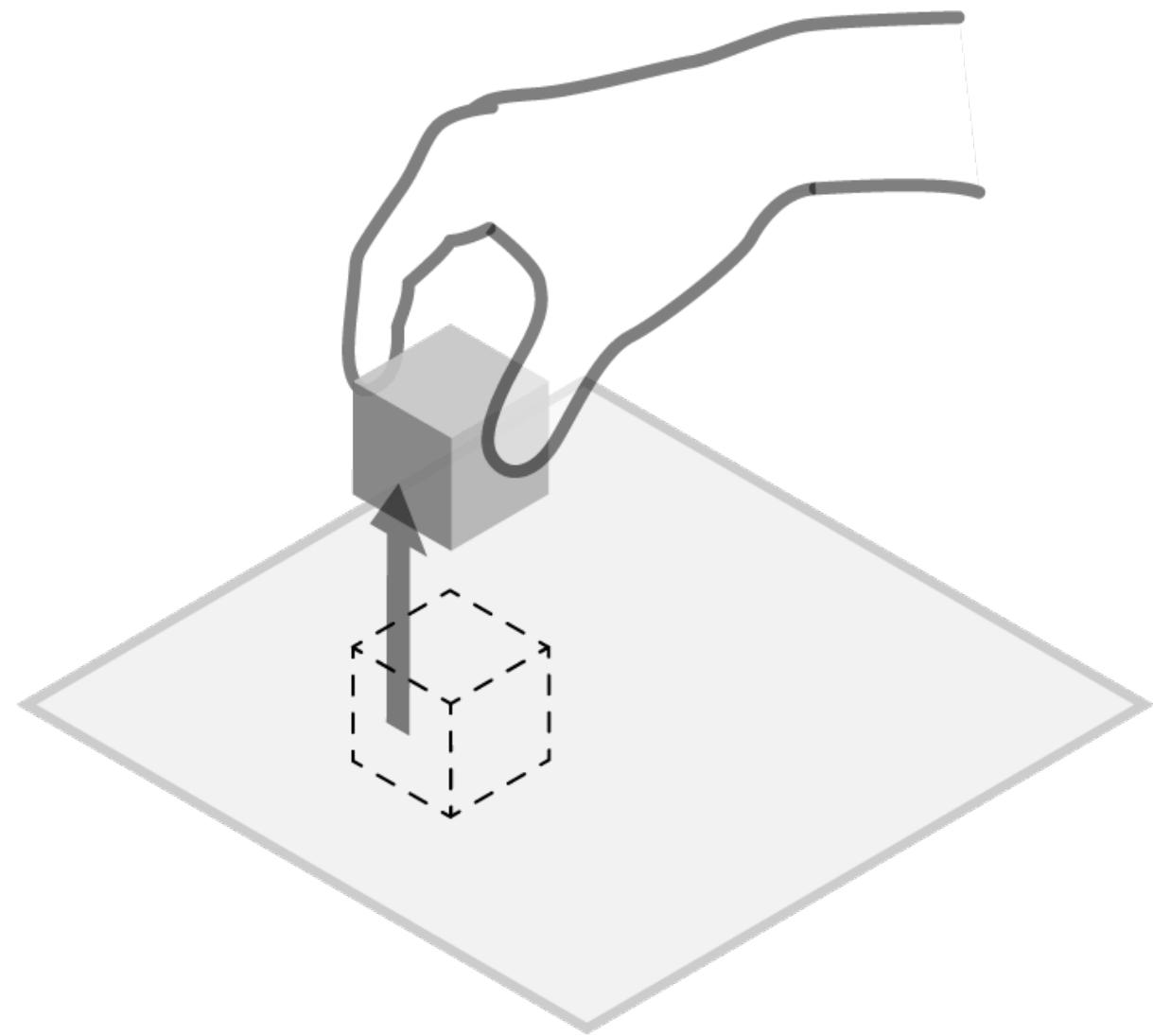
Locate



Move



Orient



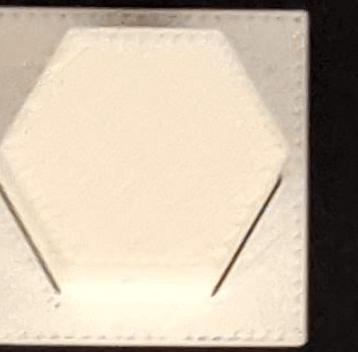
Pickup

Polyester Sheet

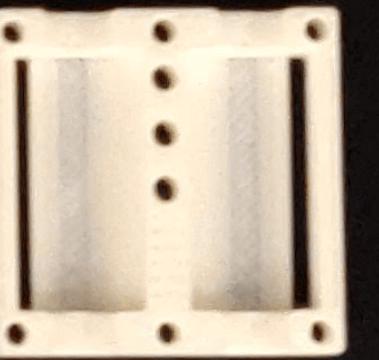
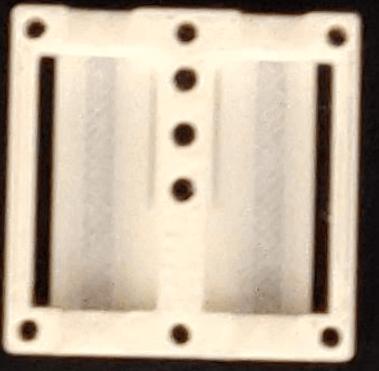


Reel Shafts

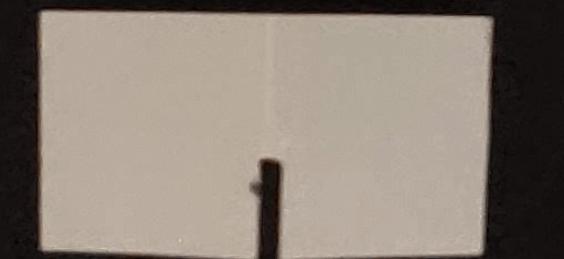
End Cap



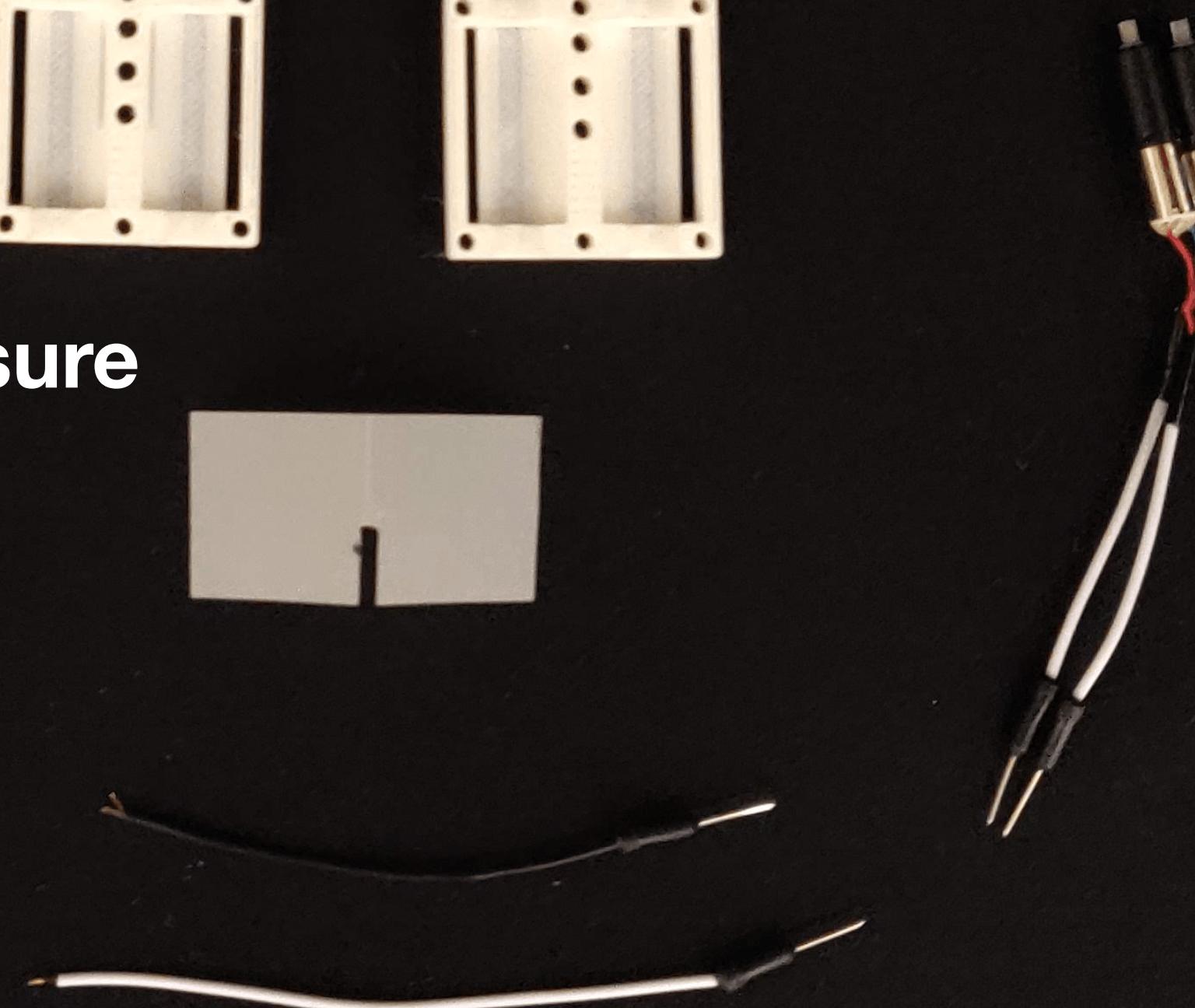
Enclosure

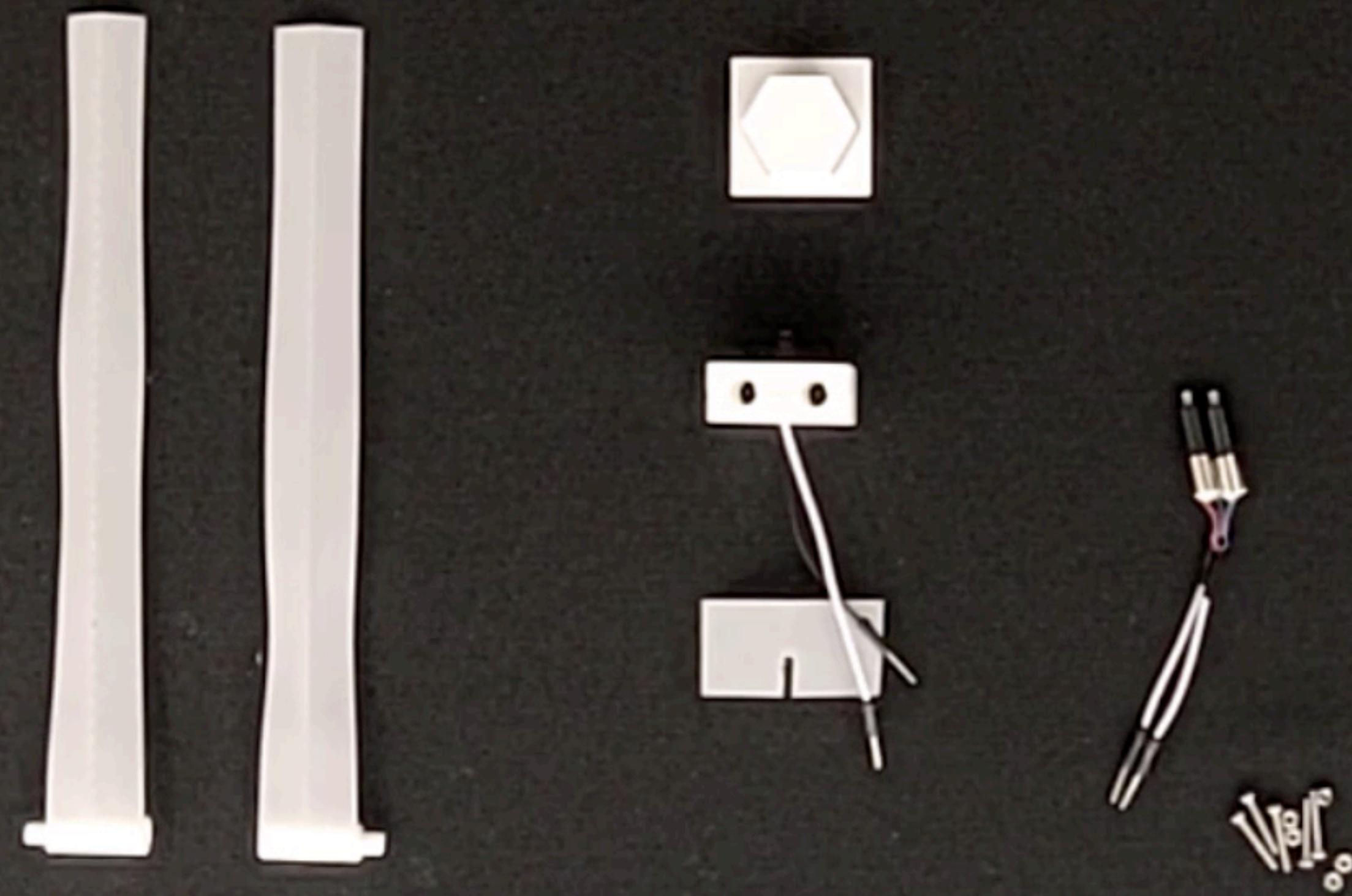


Limit Switch

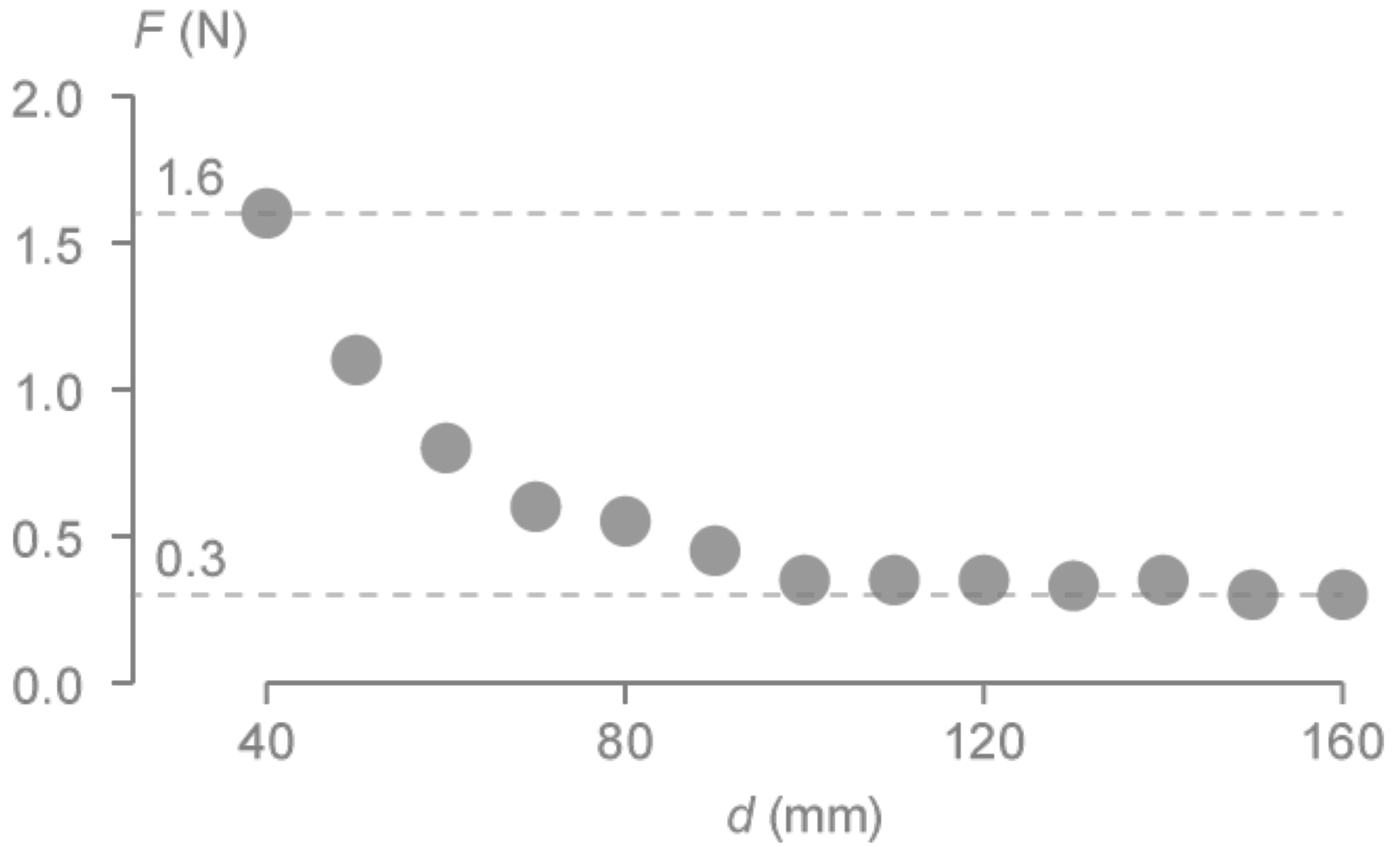
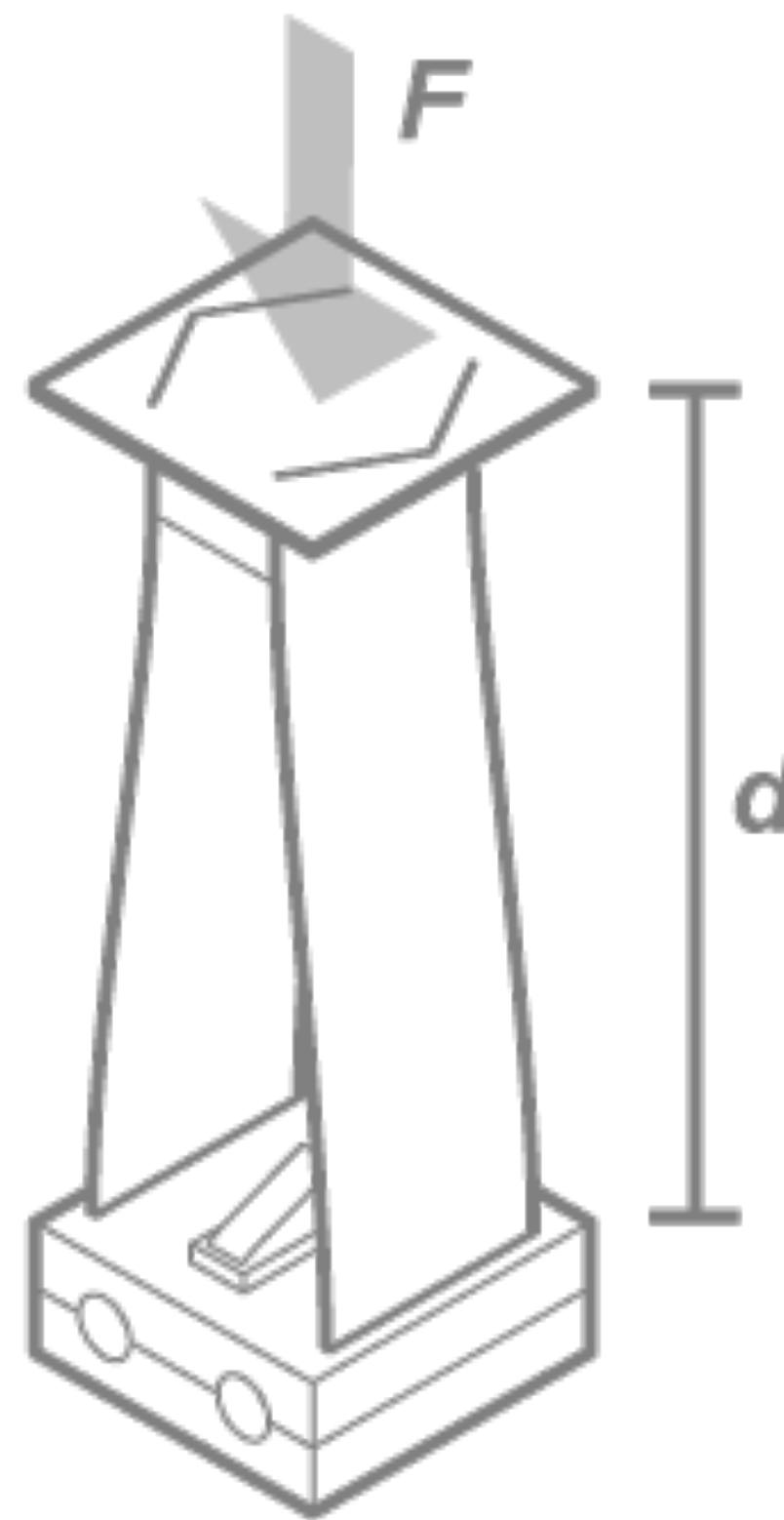


DC Motors



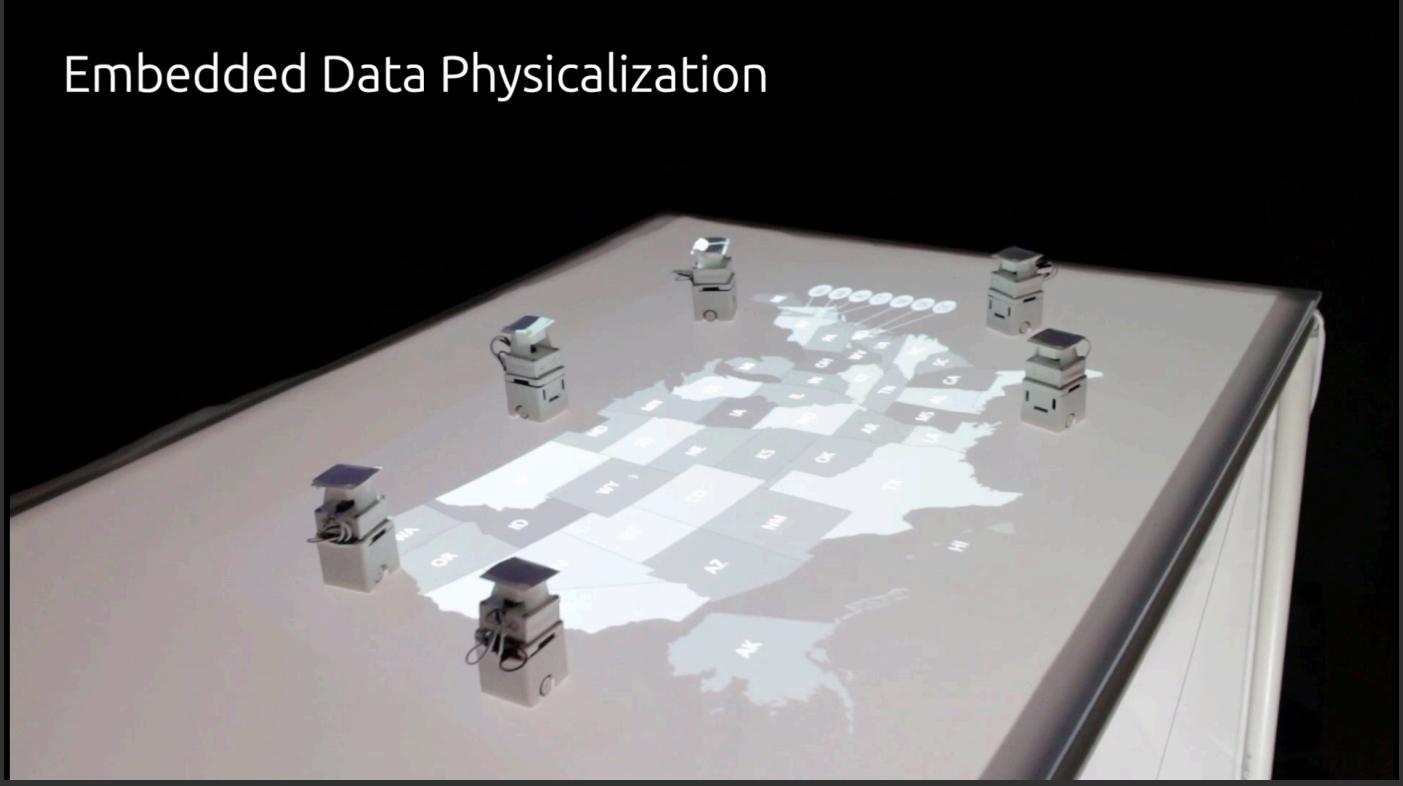




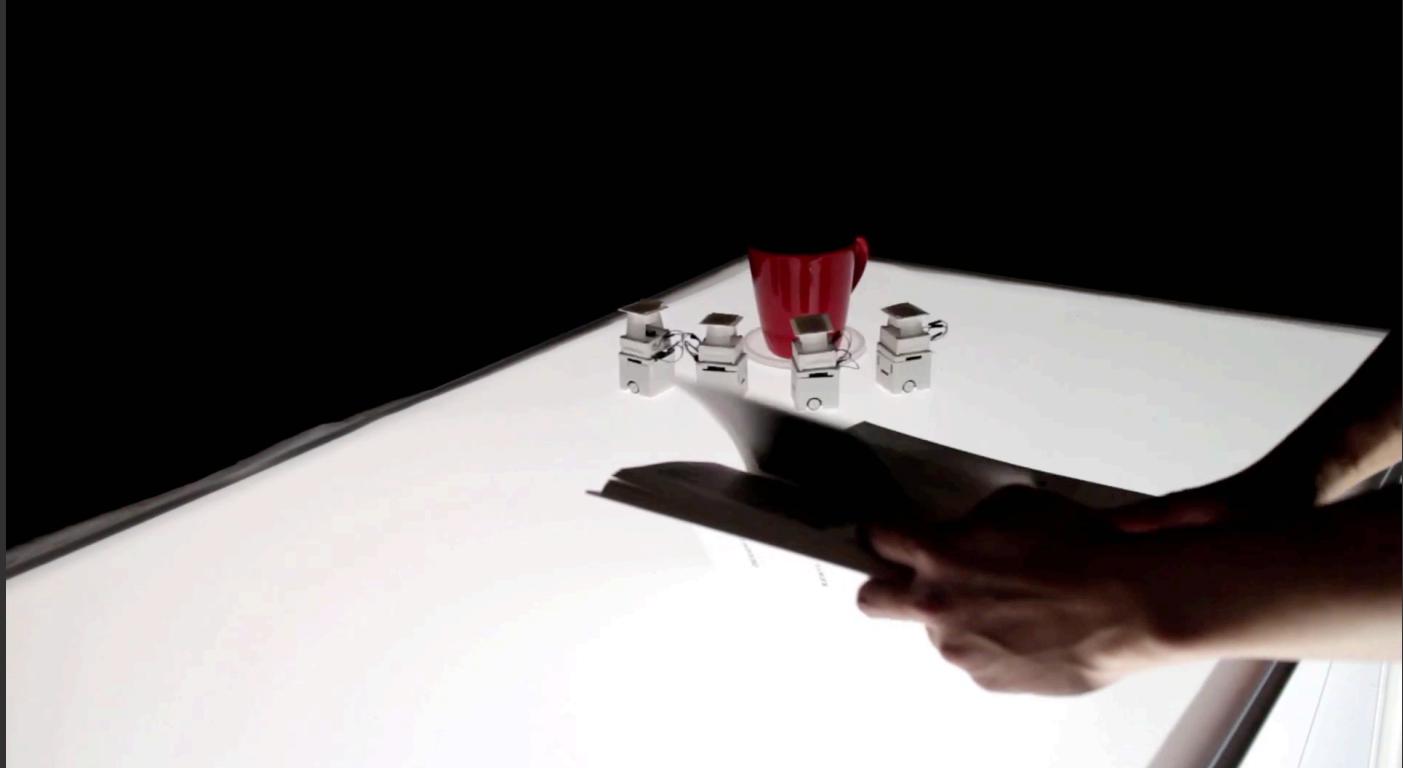
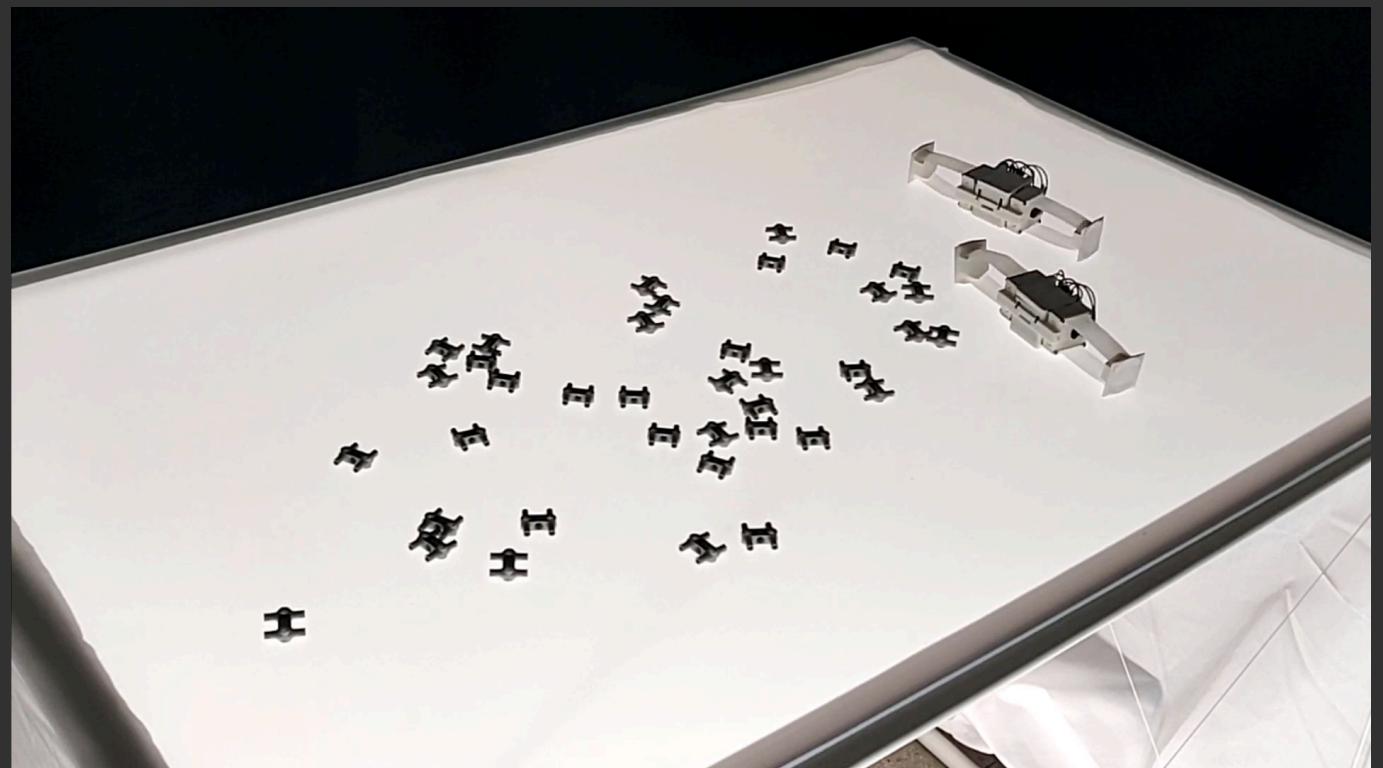


Applications

Tangible Media



Everyday Assistant

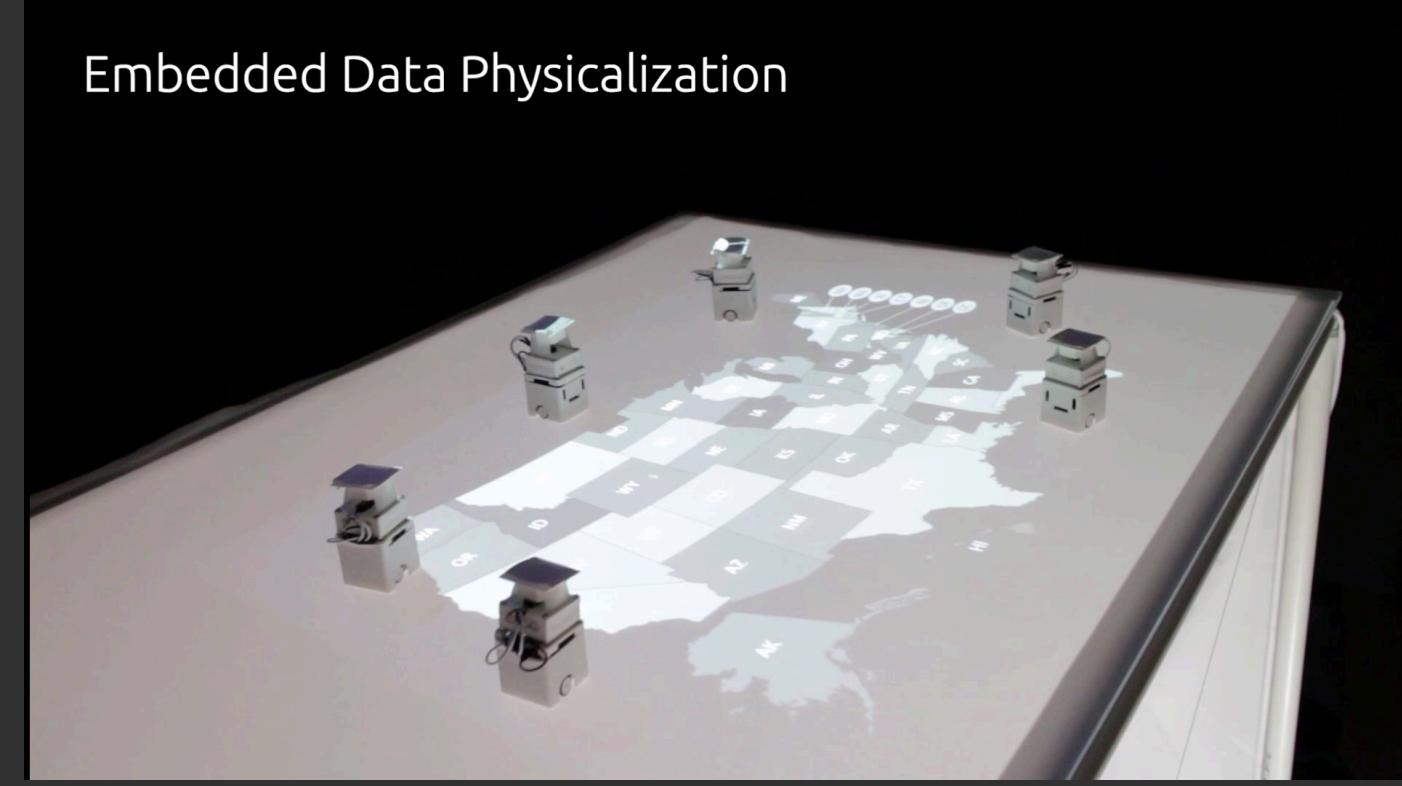
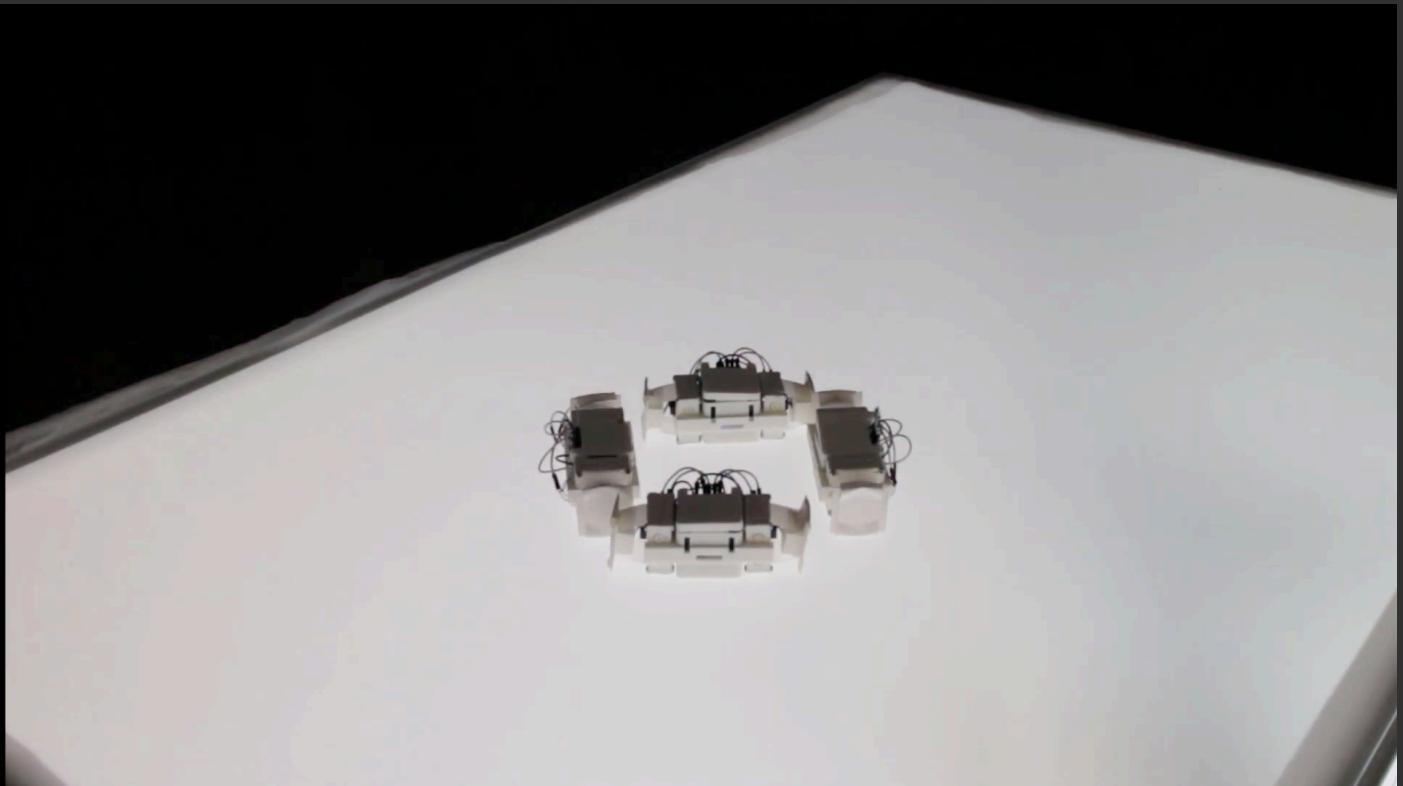


In-situ Physical Assistants

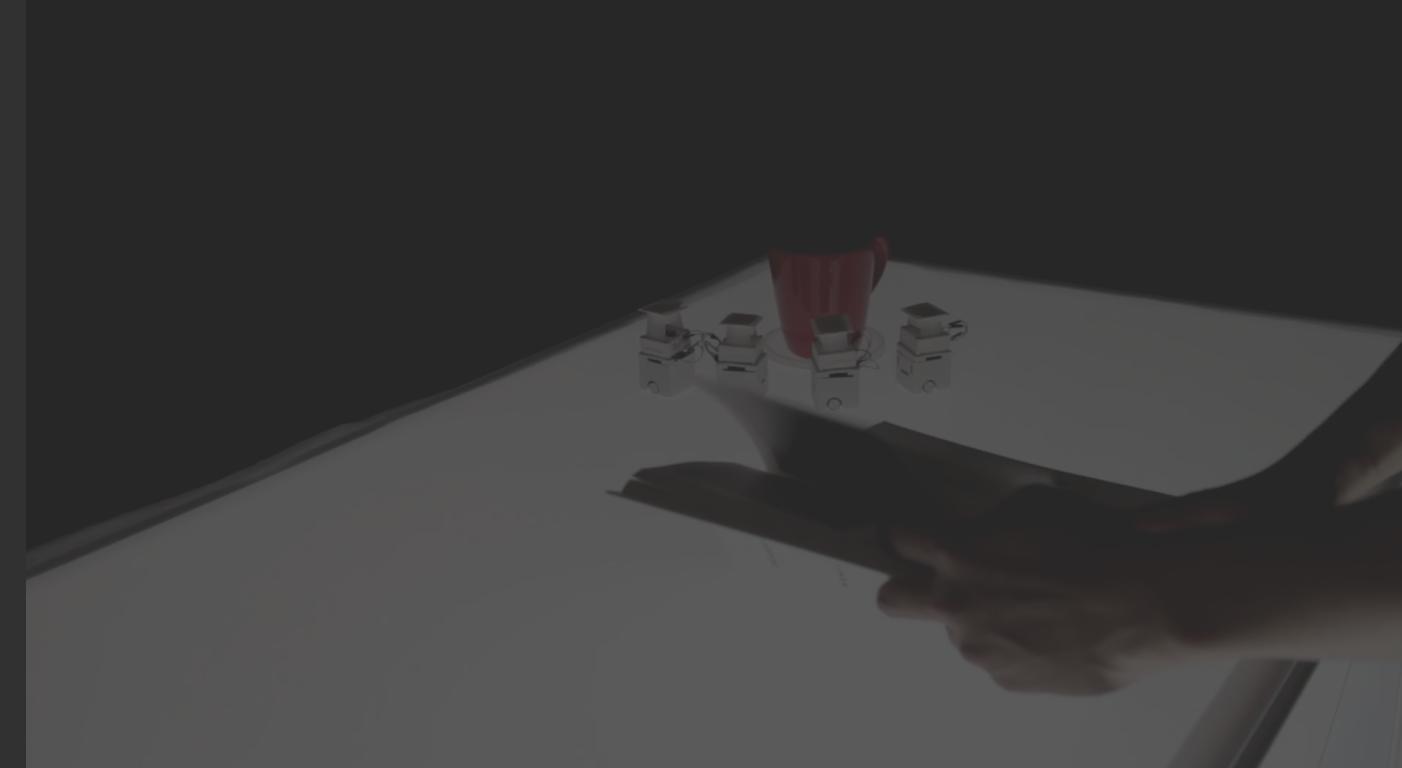
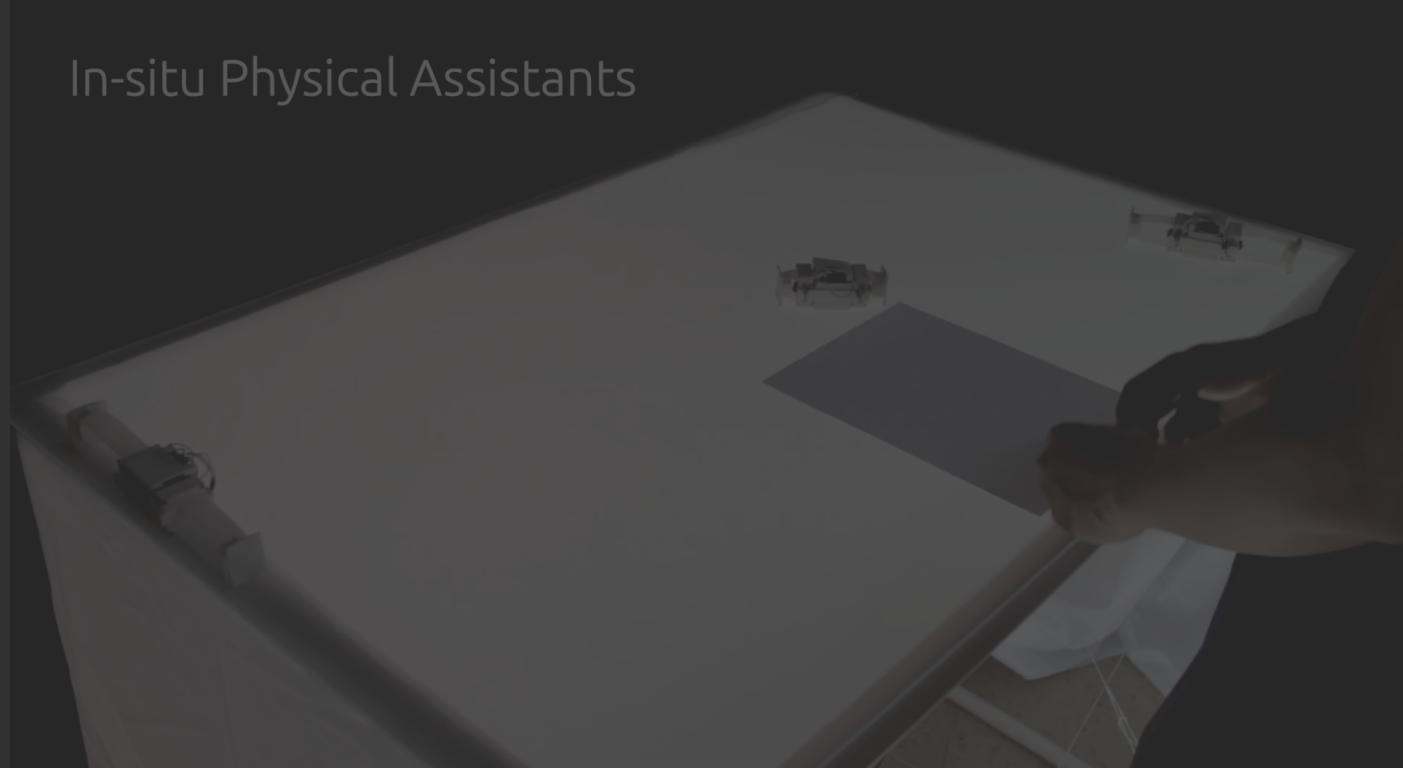


Embedded Data Physicalization

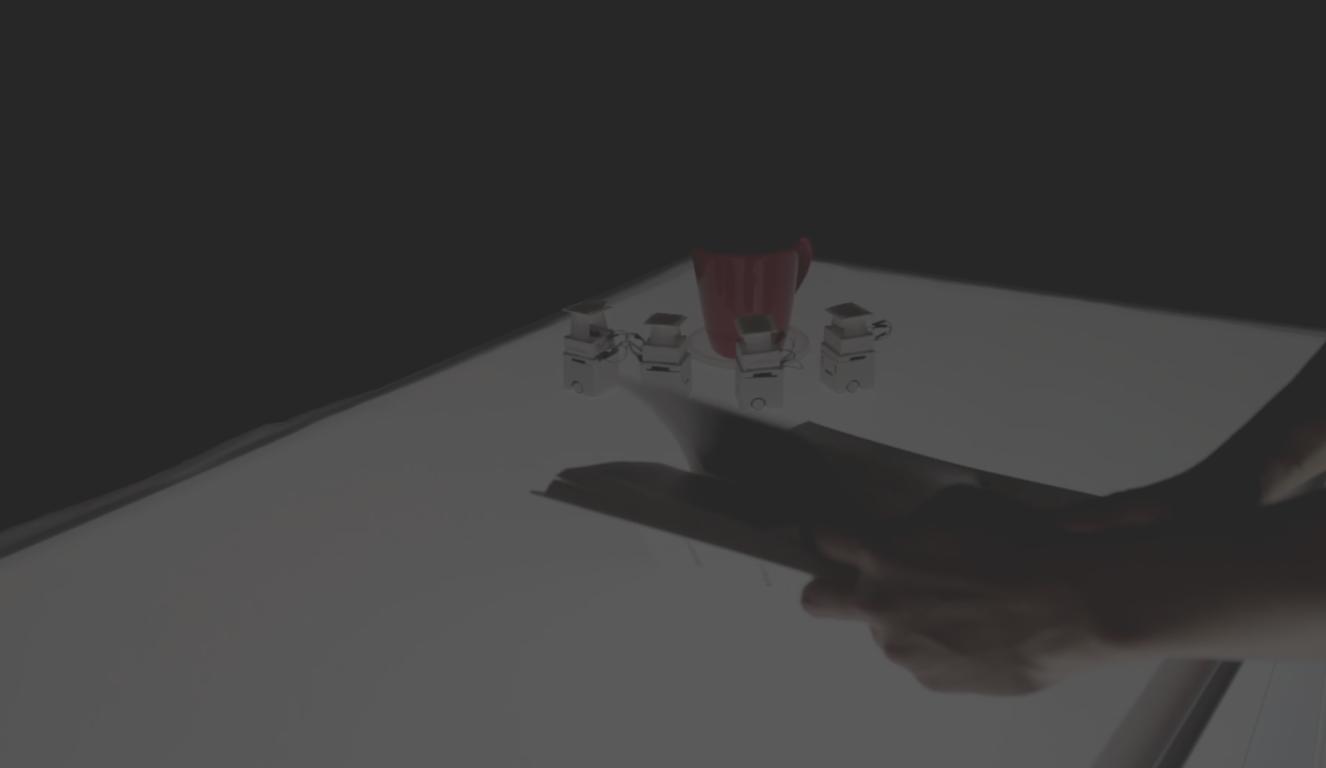
Tangible Media



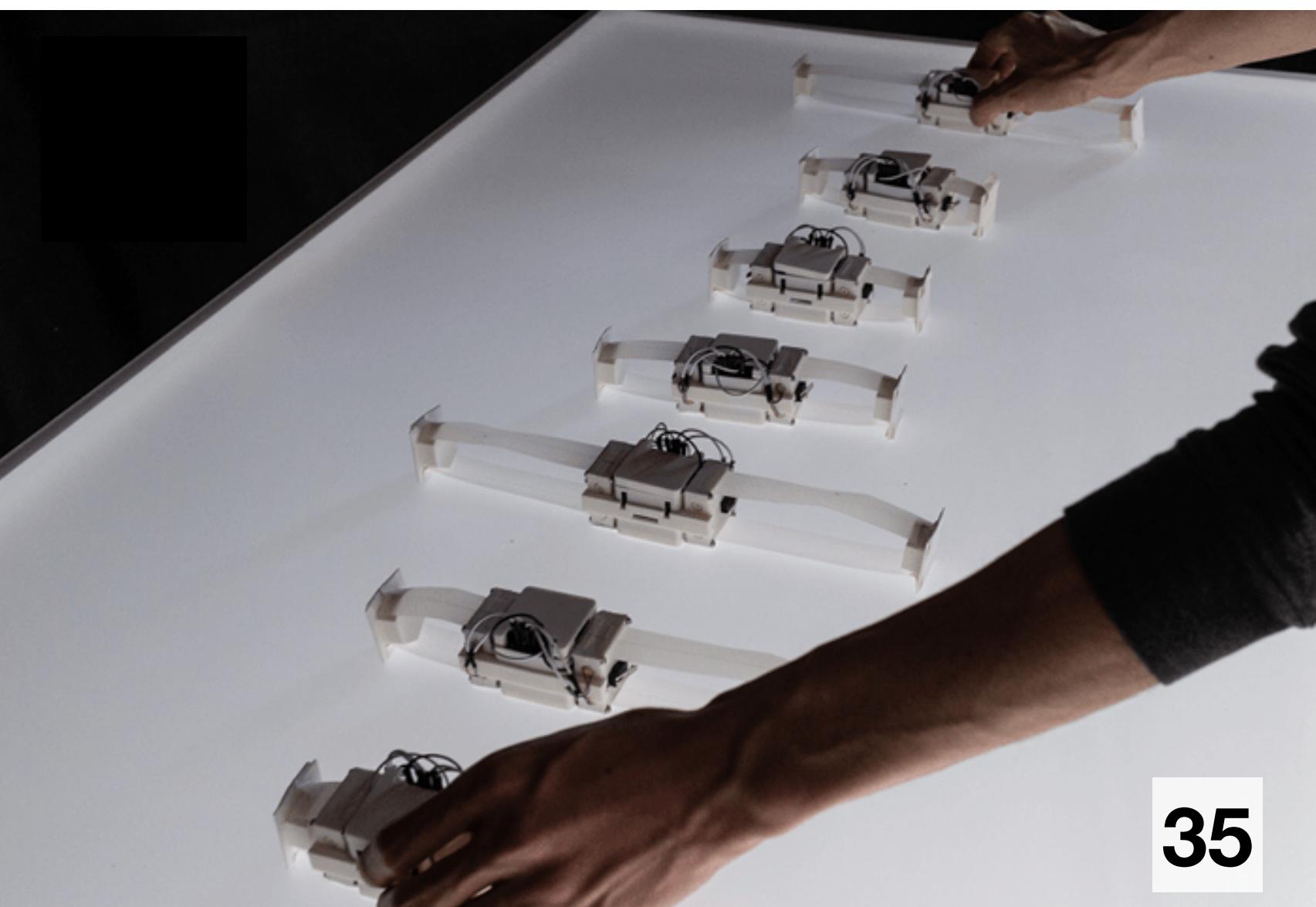
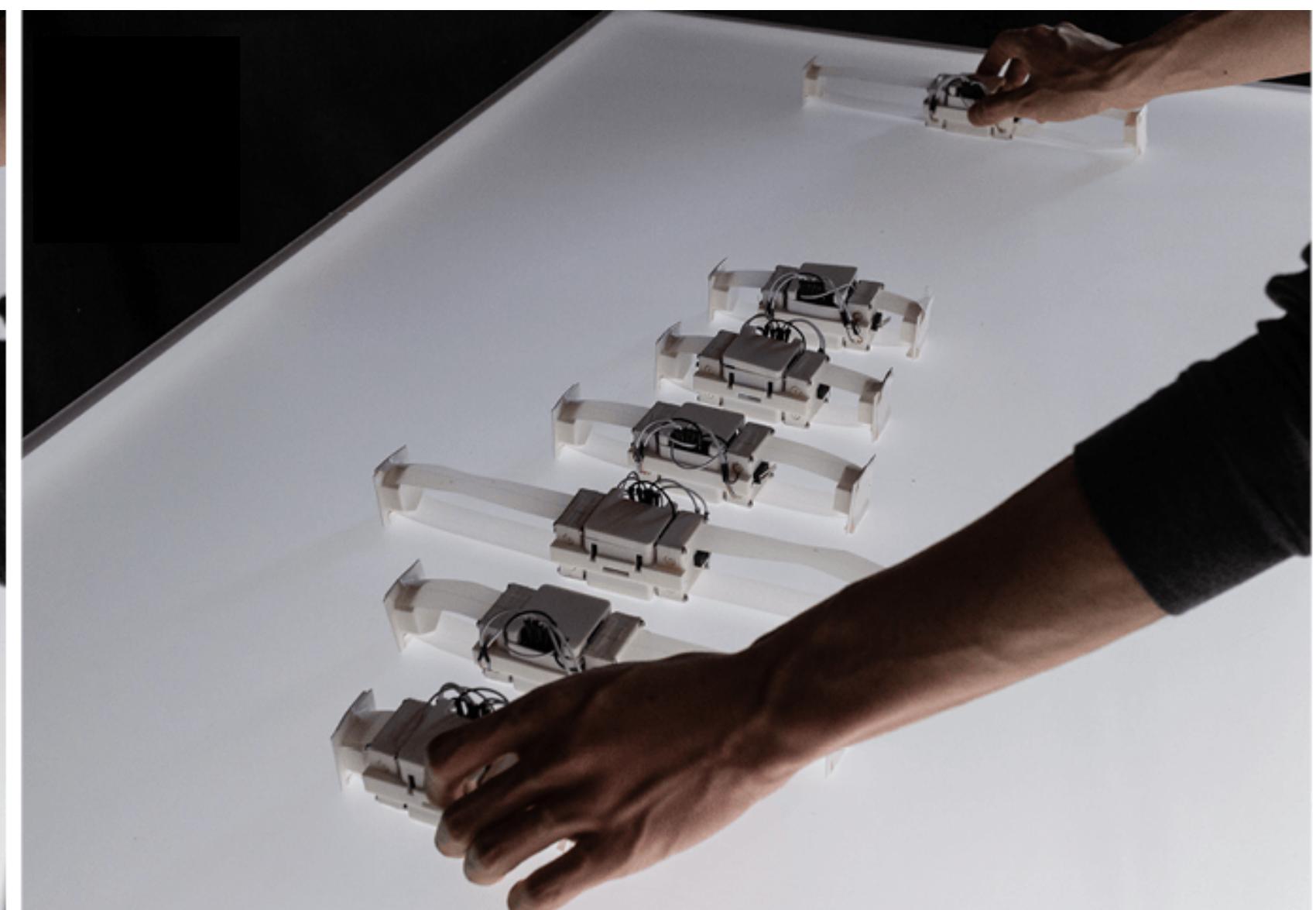
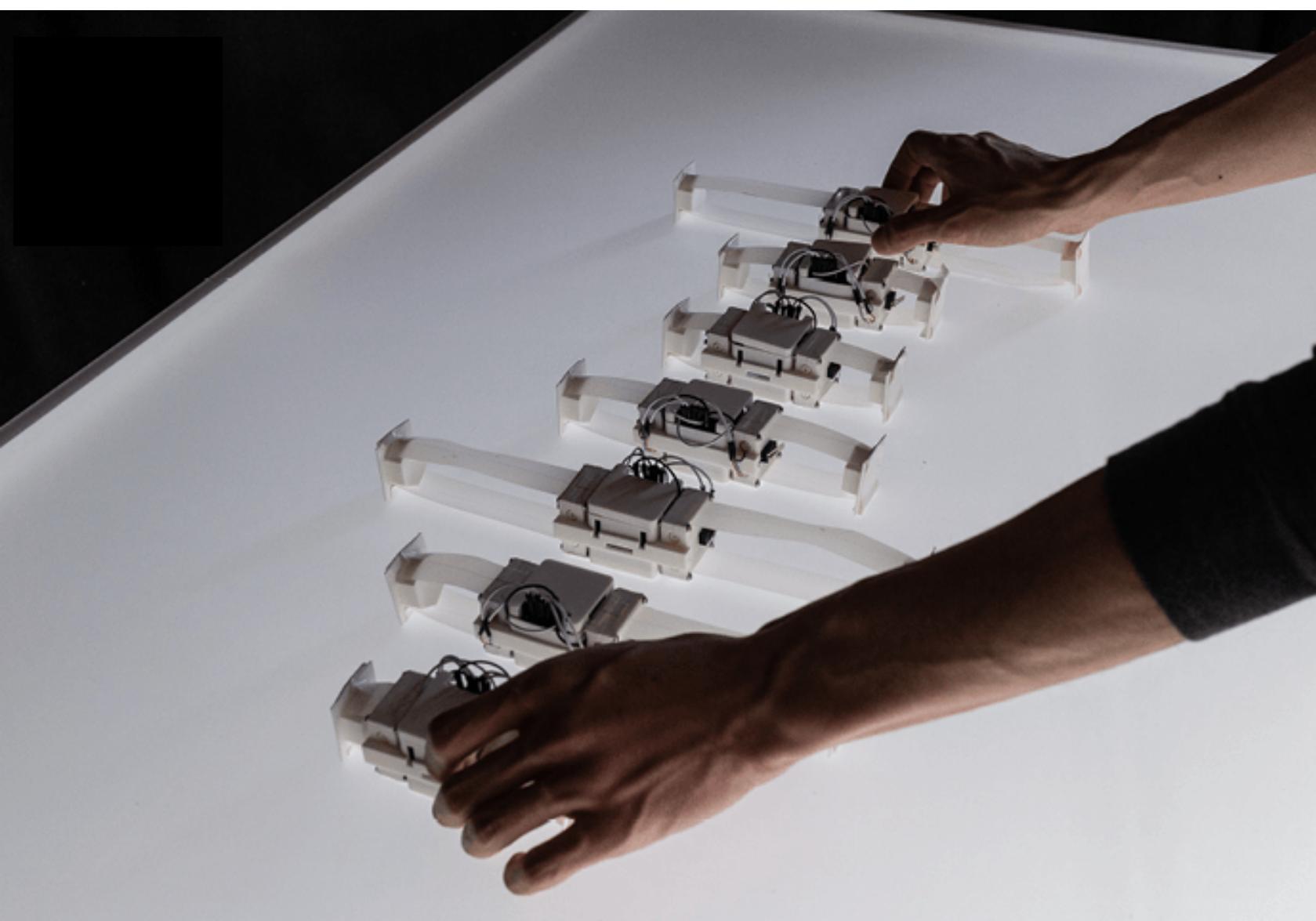
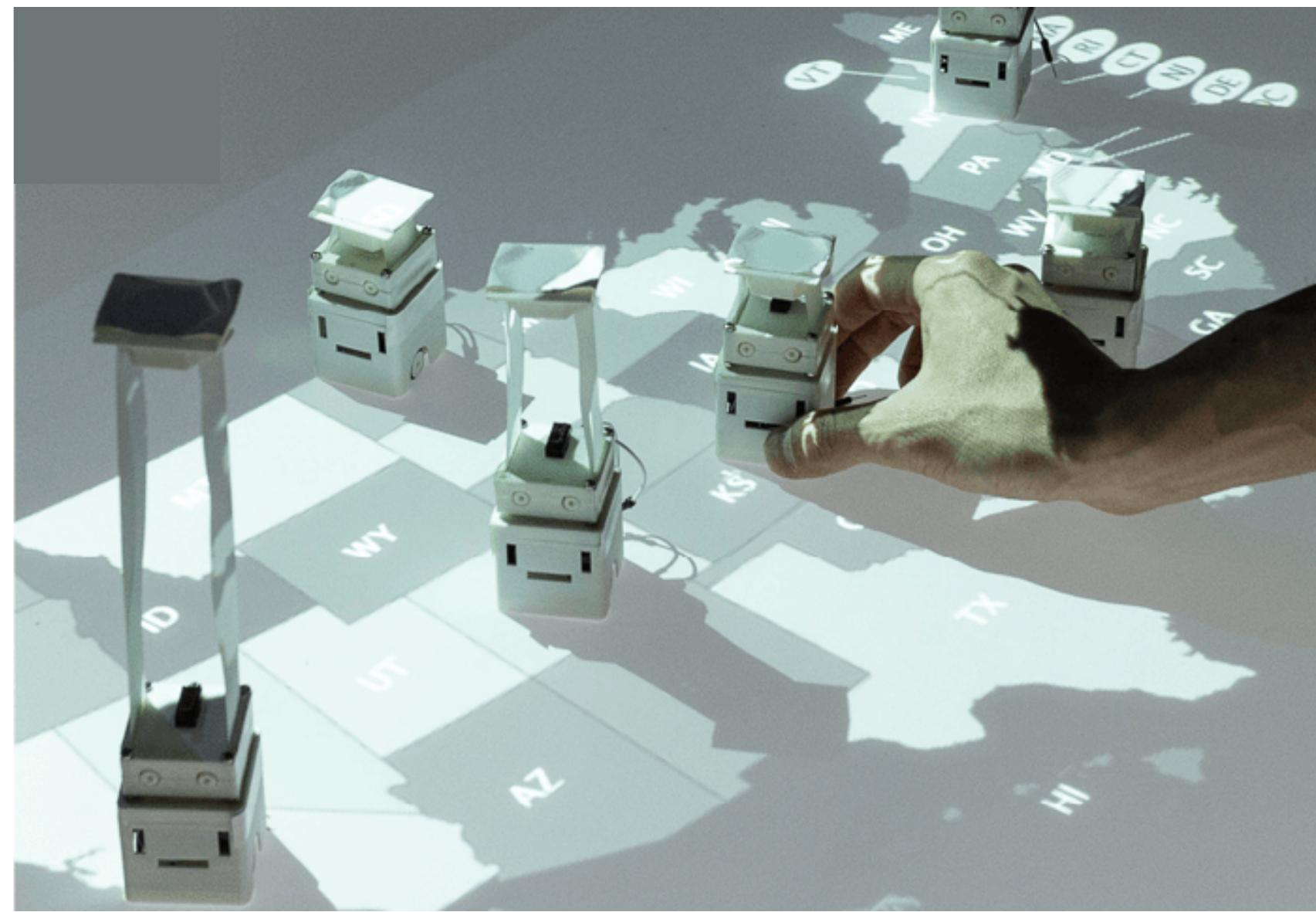
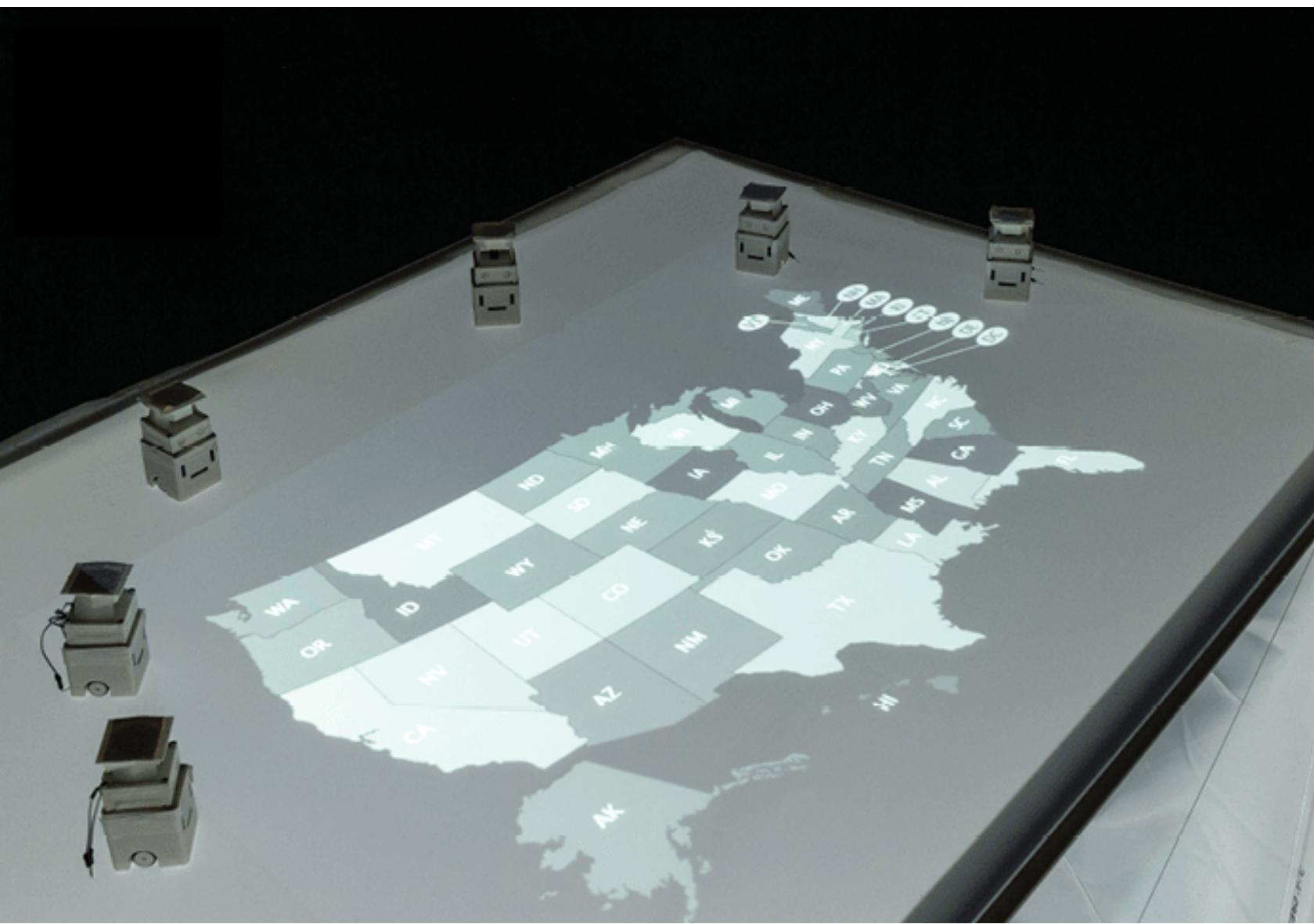
Everyday Assistant



In-situ Physical Assistants

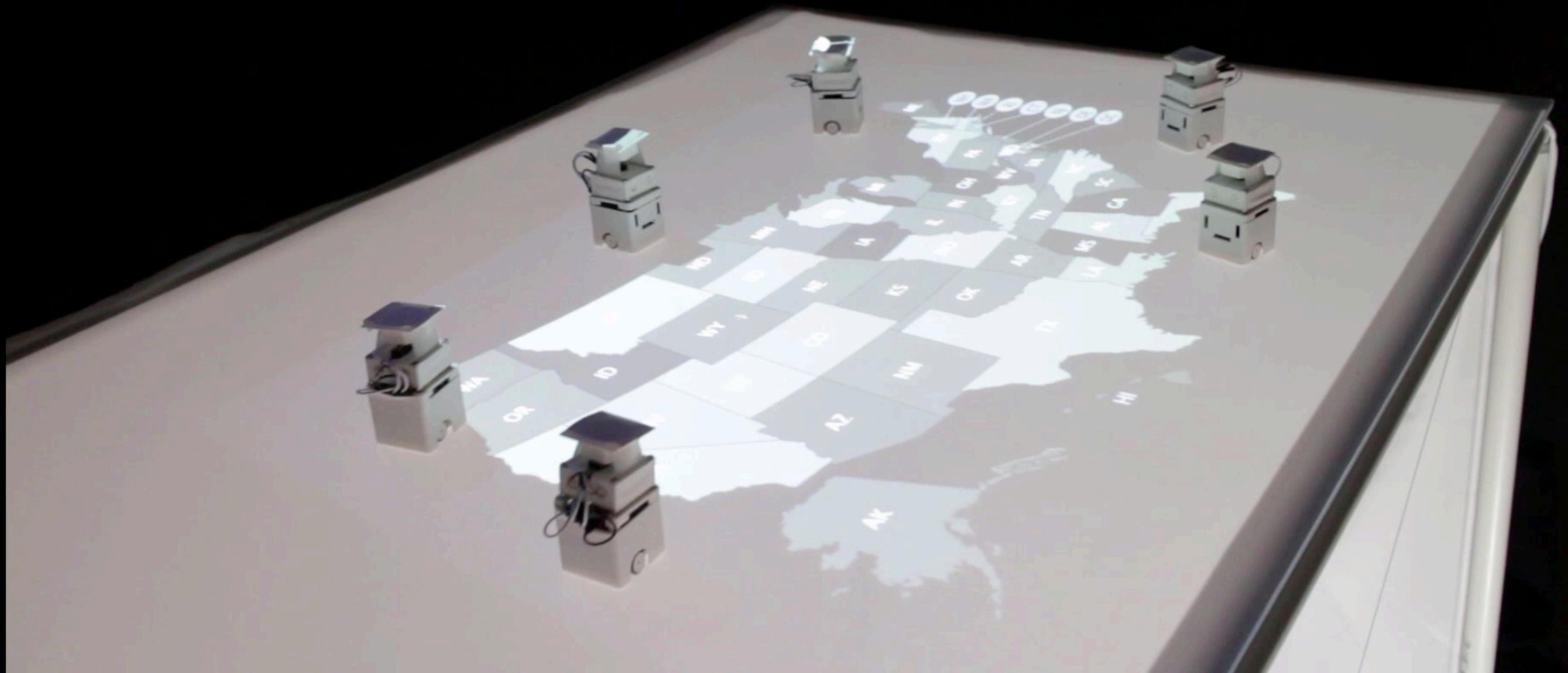


Dynamic Data Physicalization

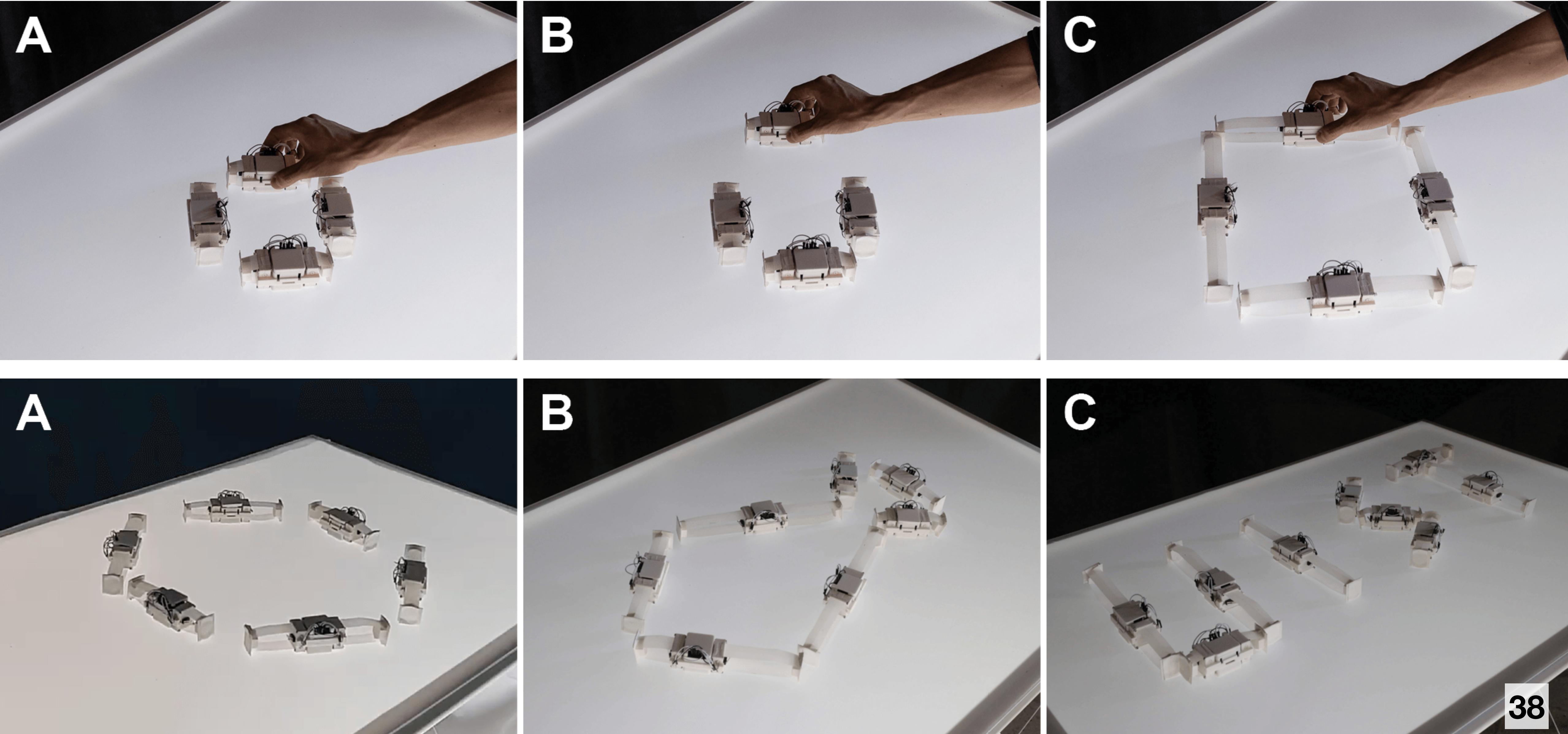




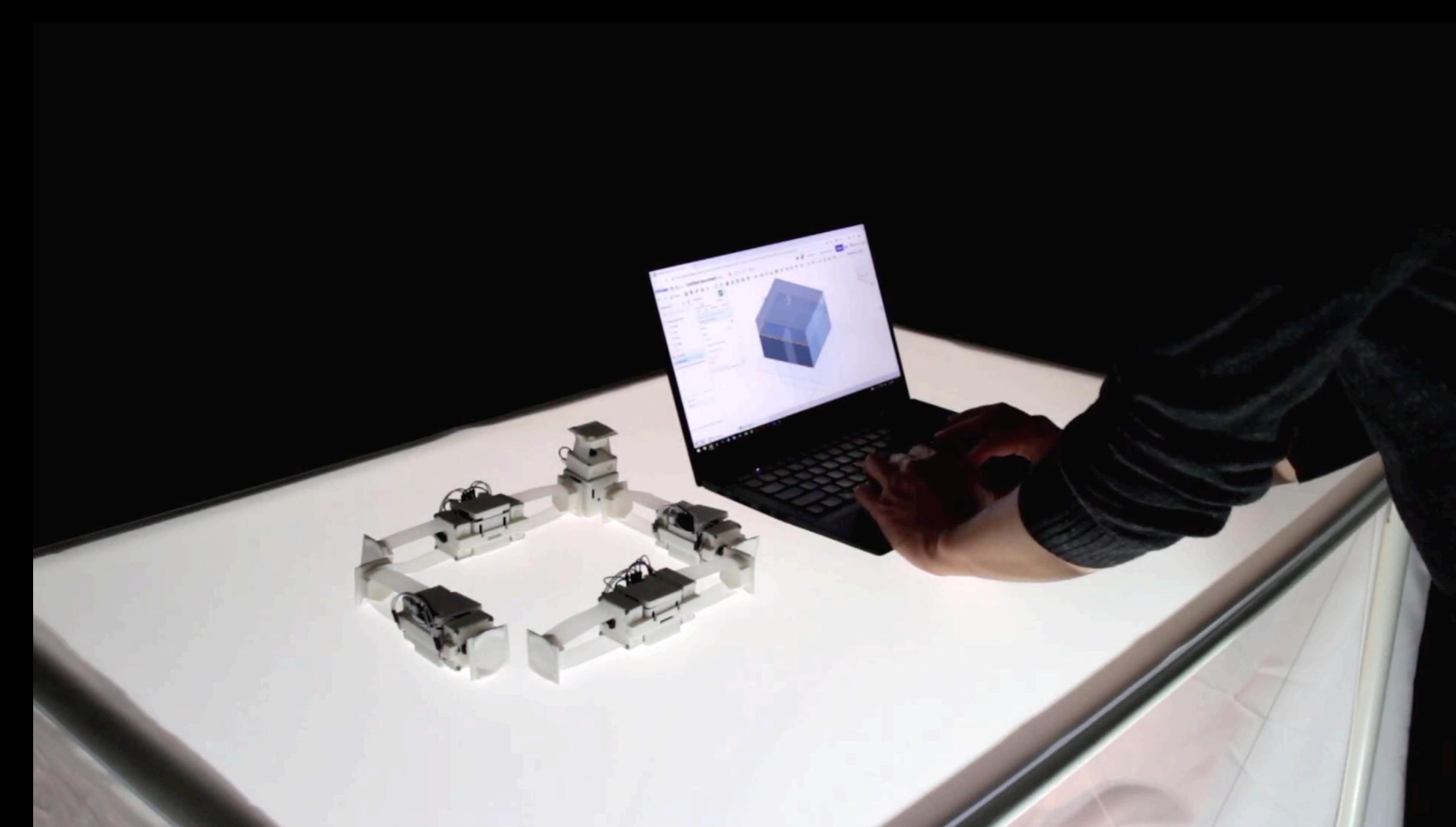
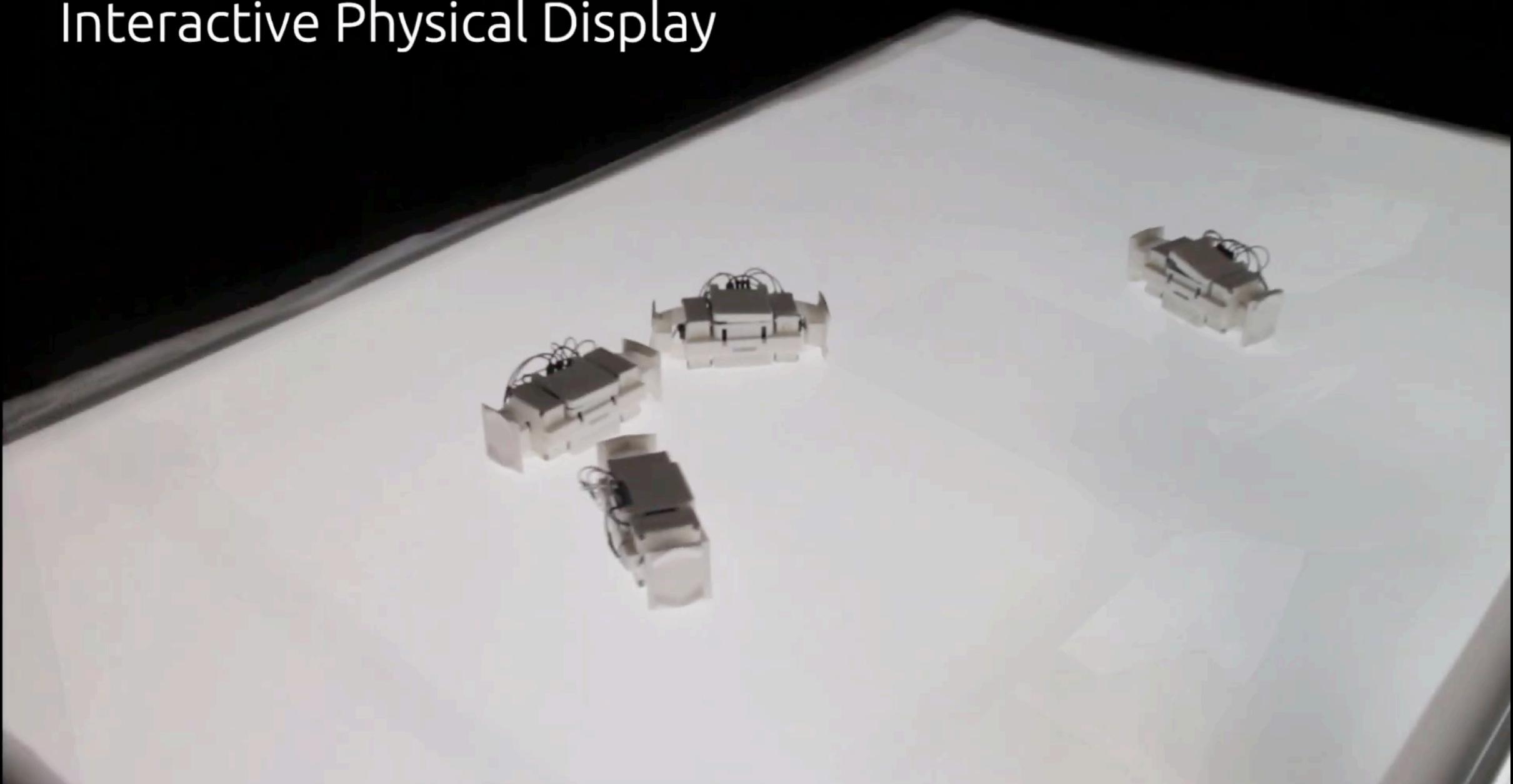
Embedded Data Physicalization



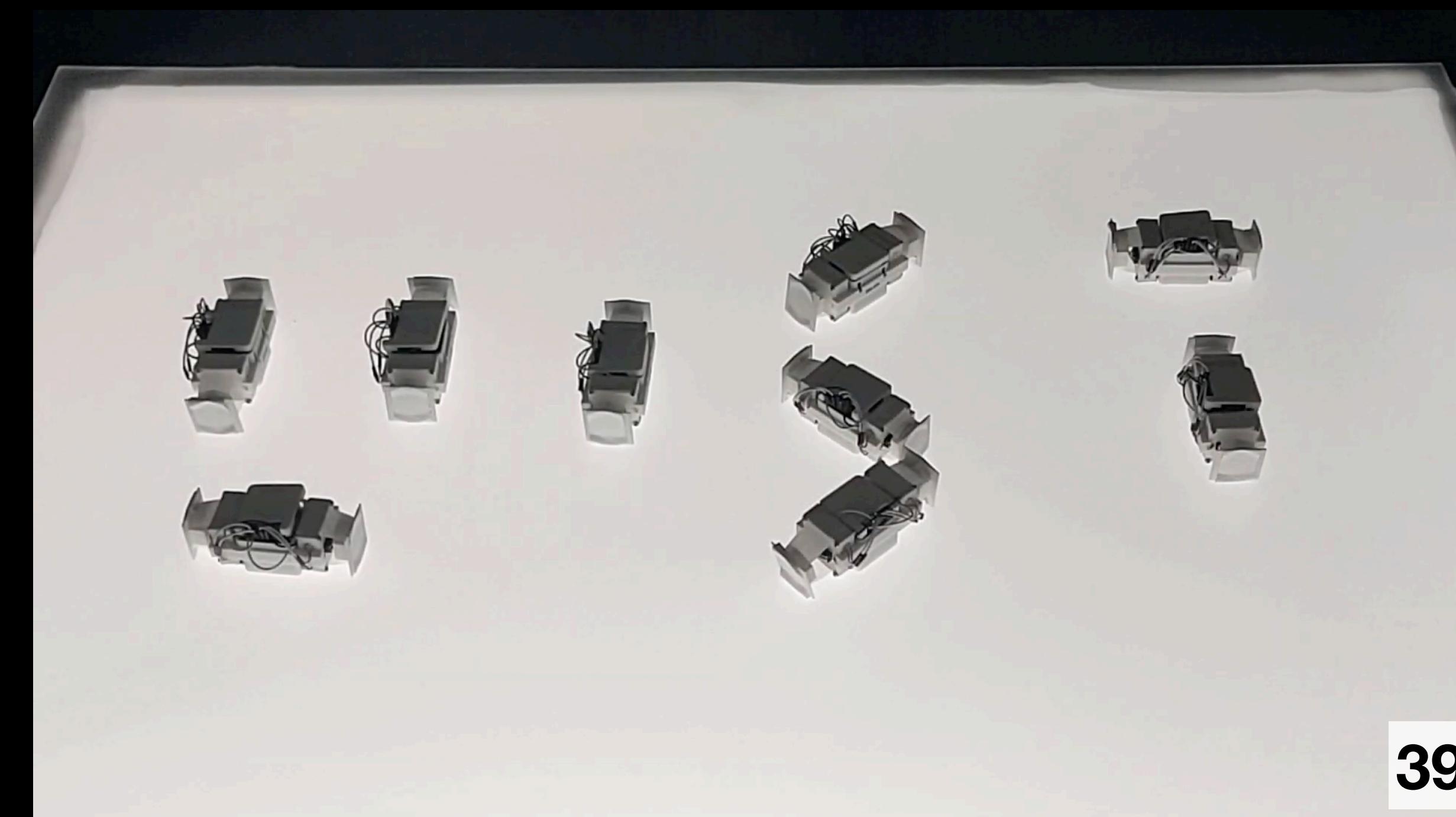
Interactive Information Display

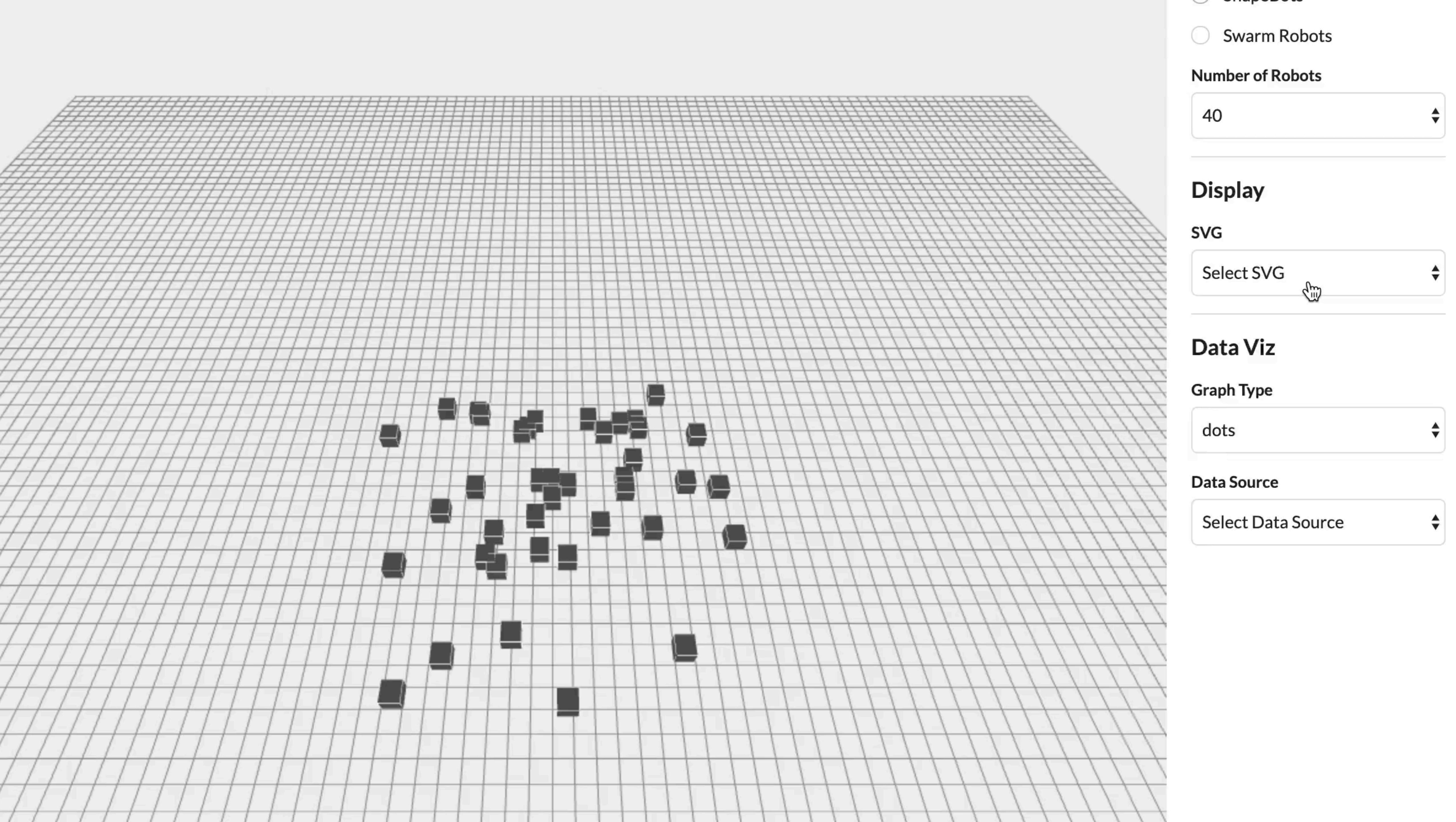


Interactive Physical Display



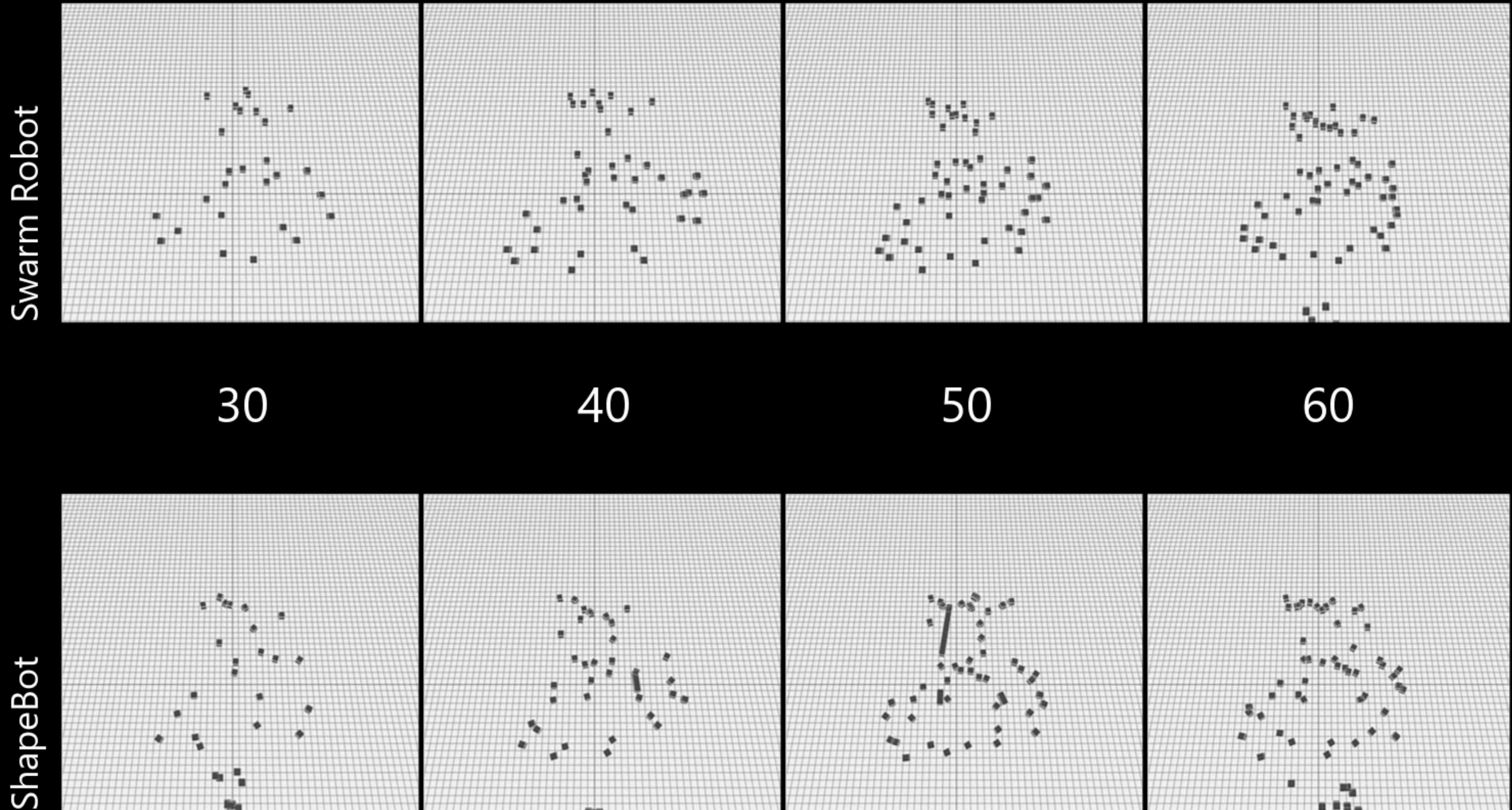
Dynamic Shape Construction



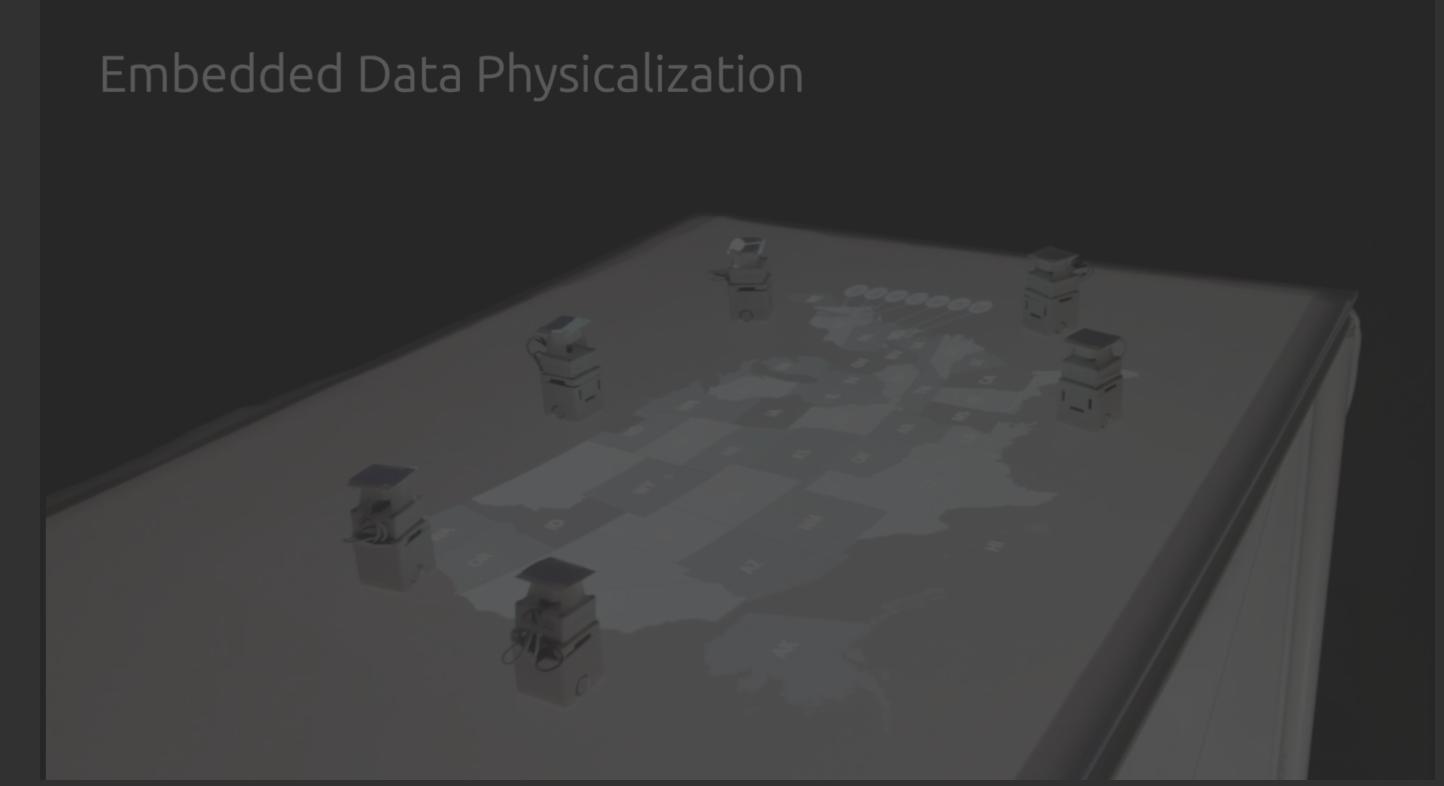




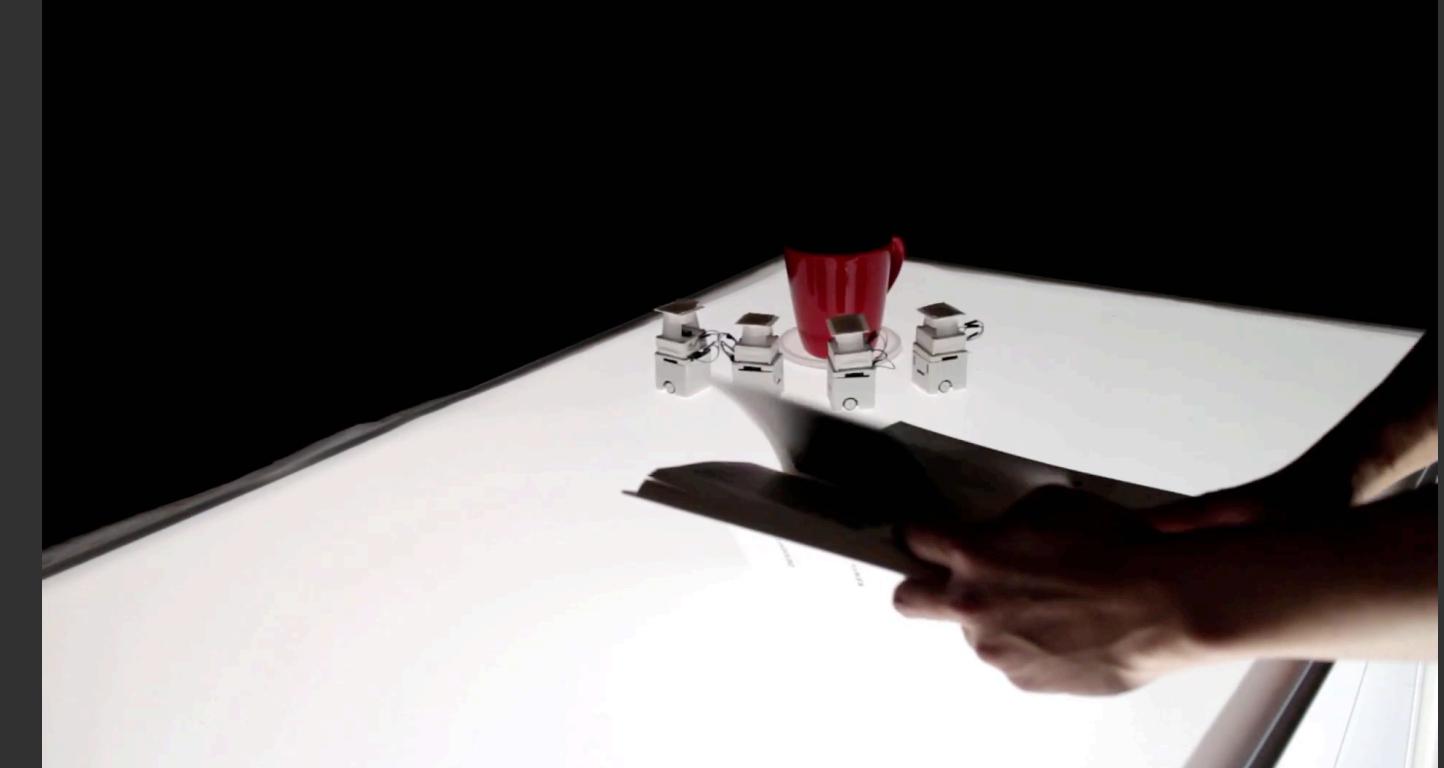
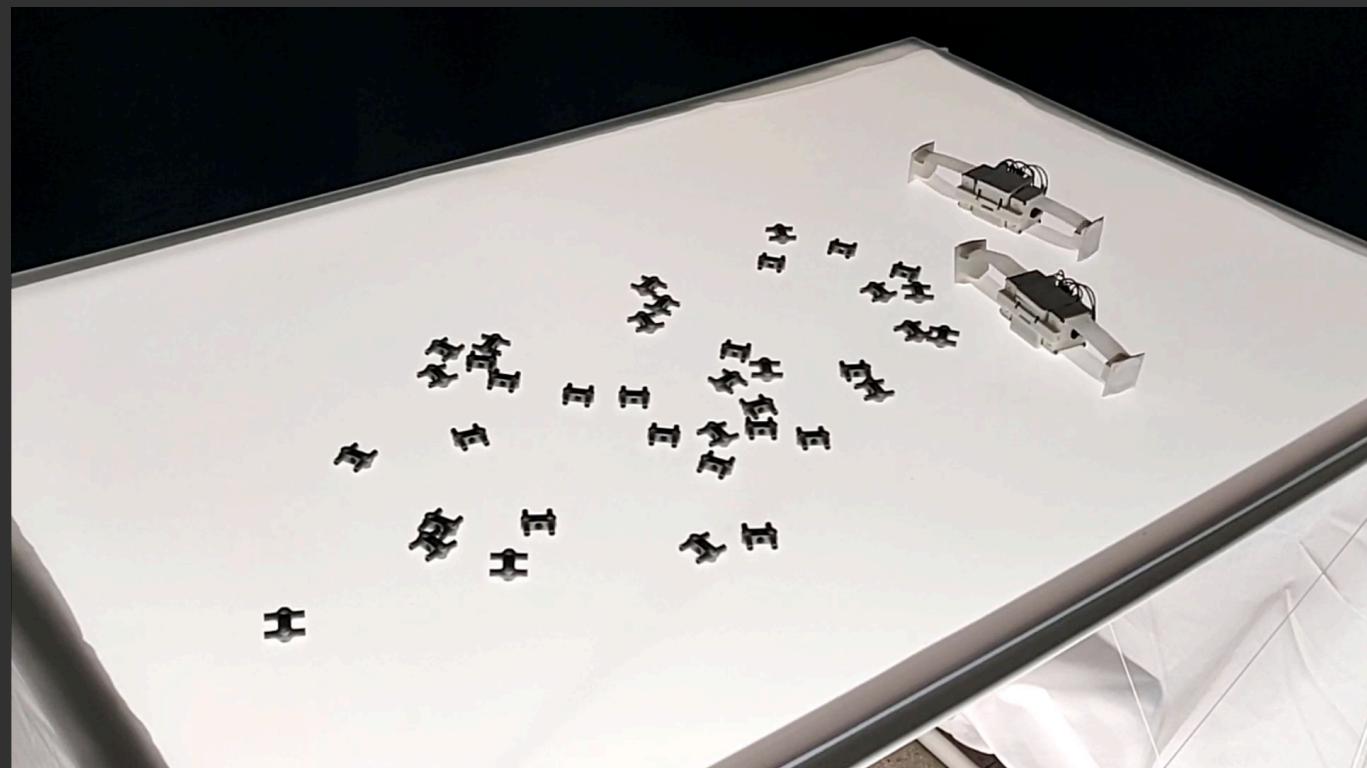
Input SVG



Tangible Media



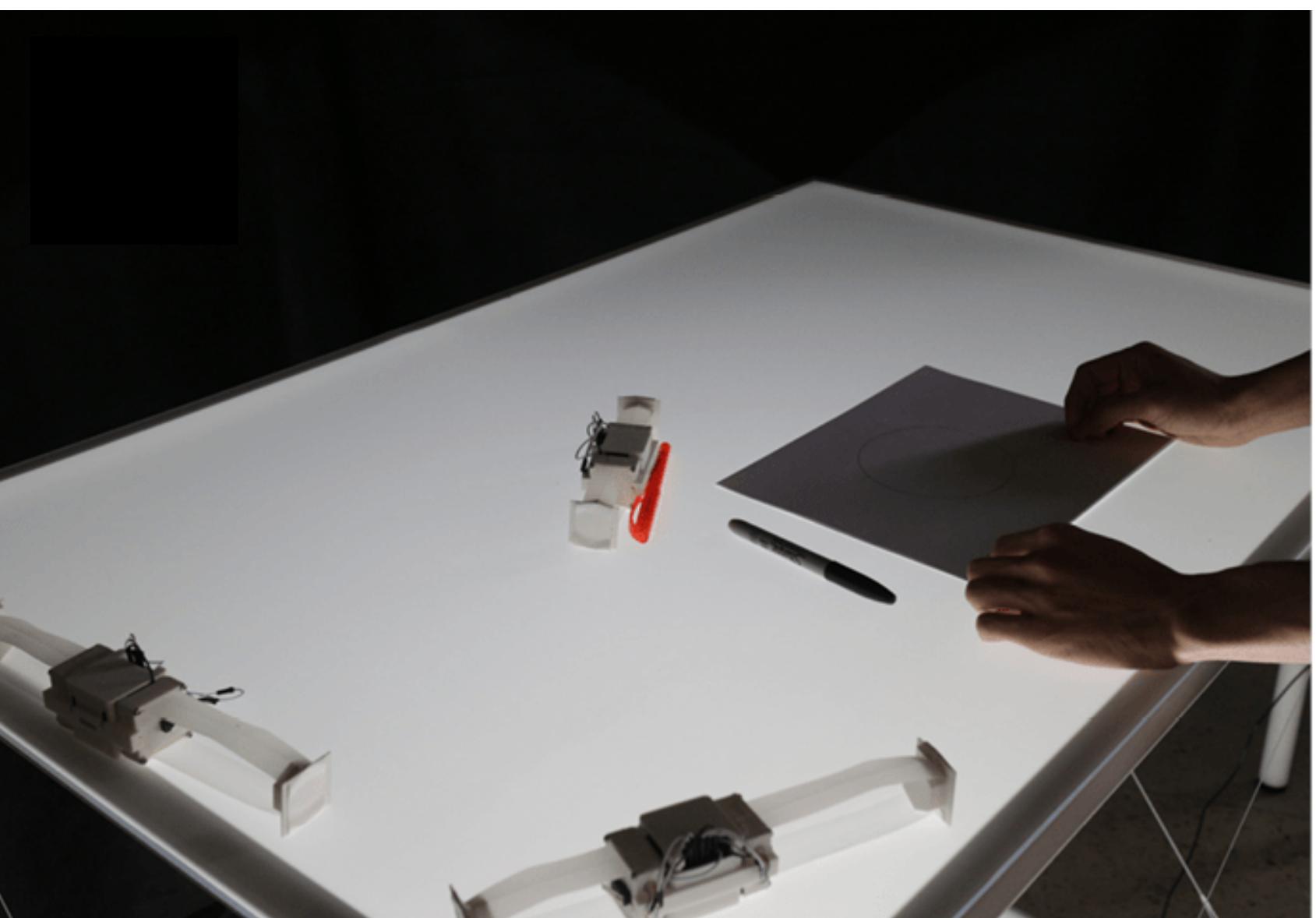
Everyday Assistant



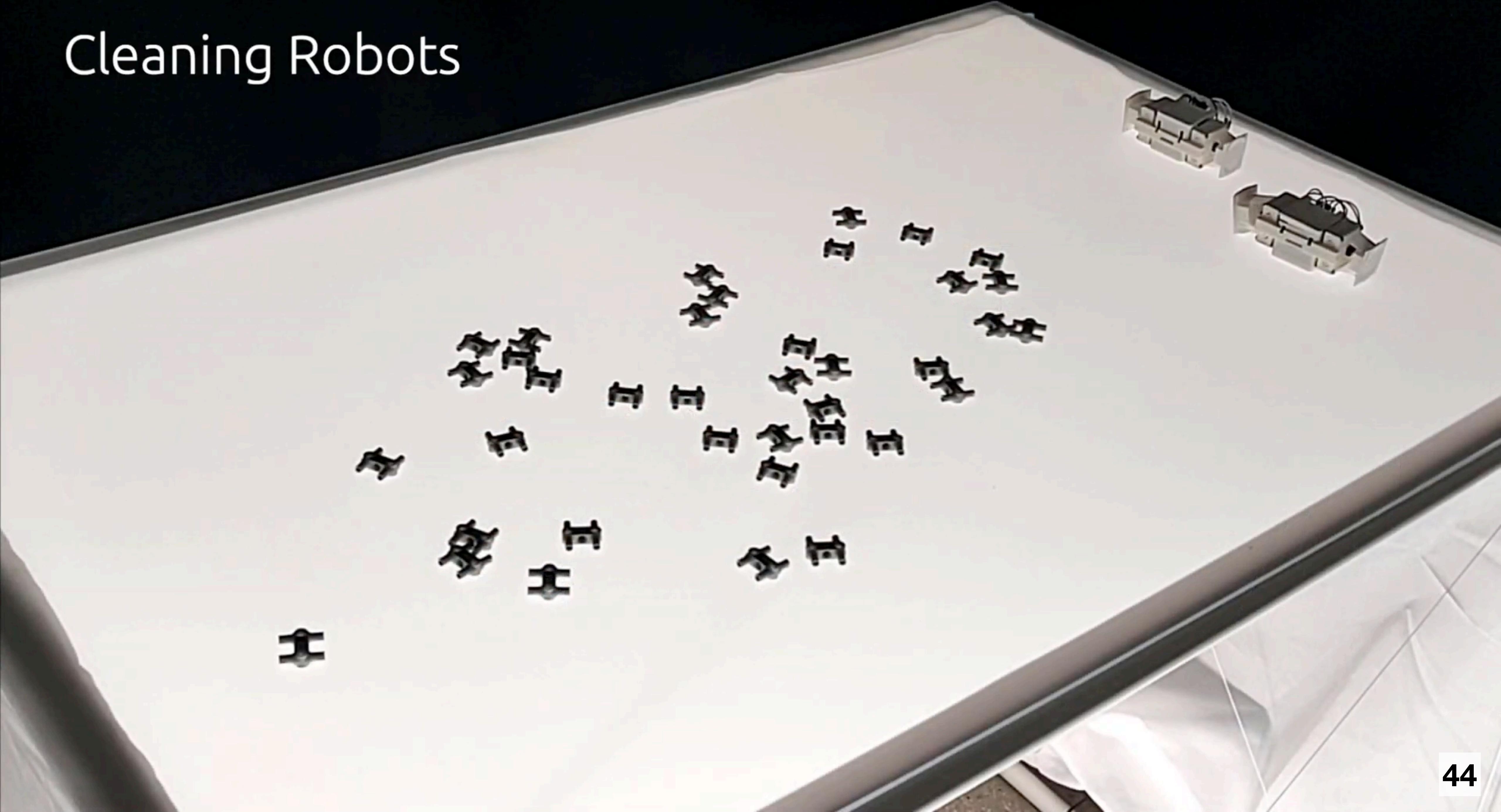
In-situ Physical Assistants

Embedded Data Physicalization

Everyday Assistant



Cleaning Robots

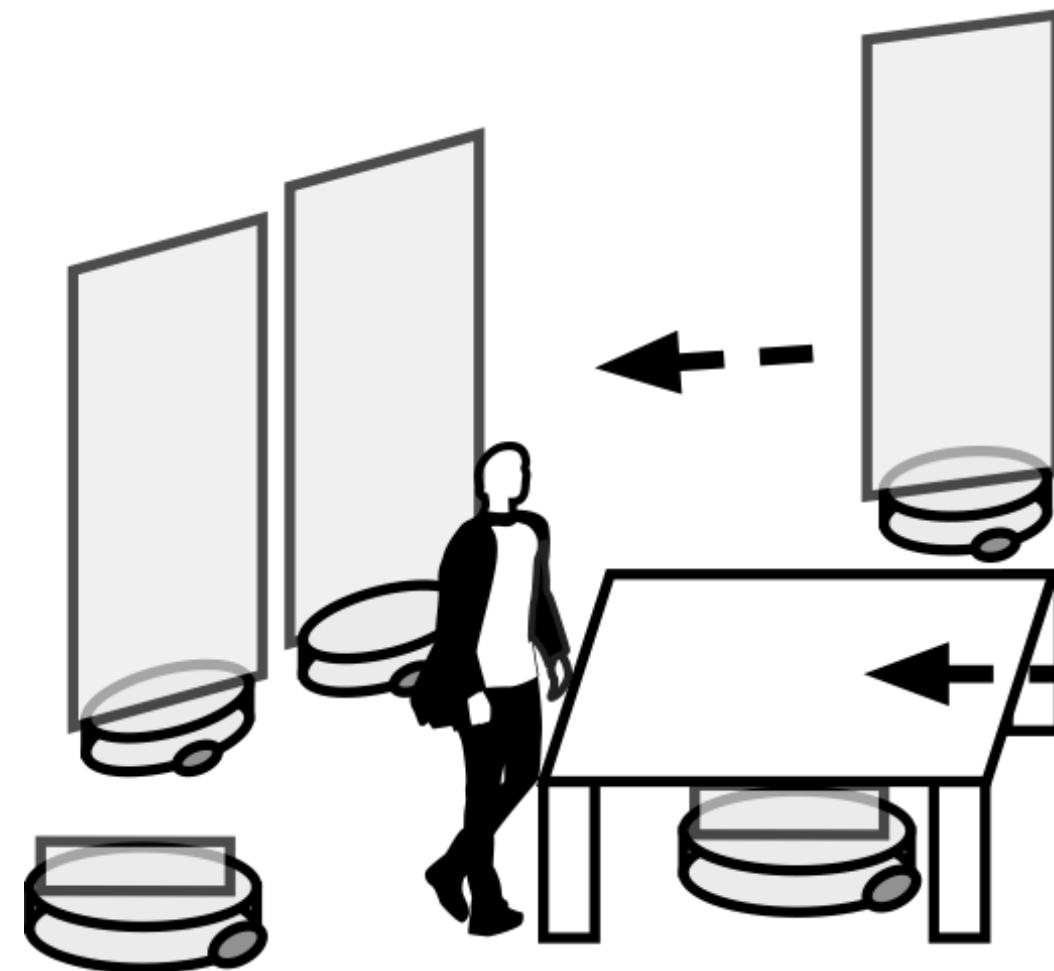




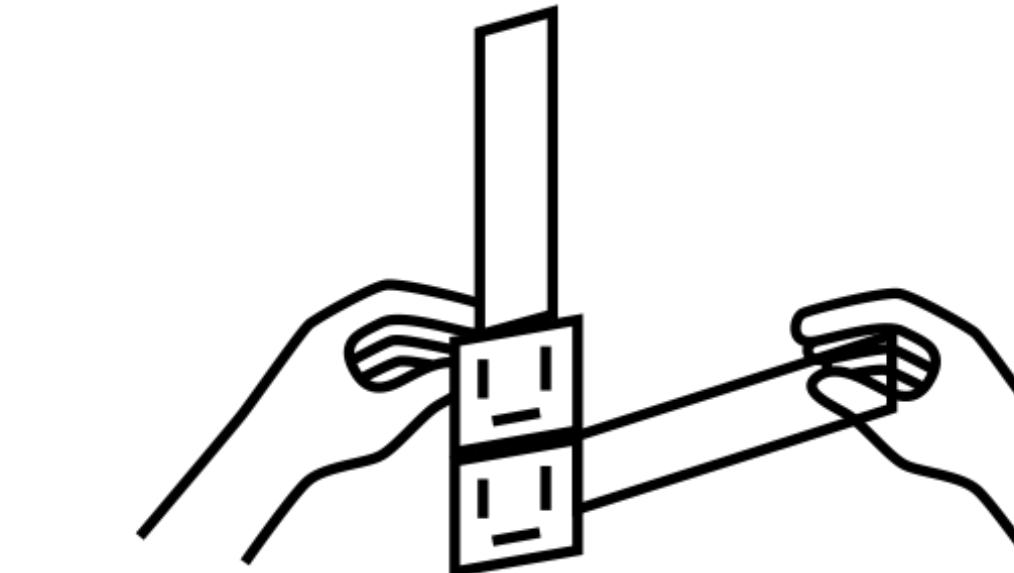
In-situ Physical Assistants



Design Space and Future Opportunities



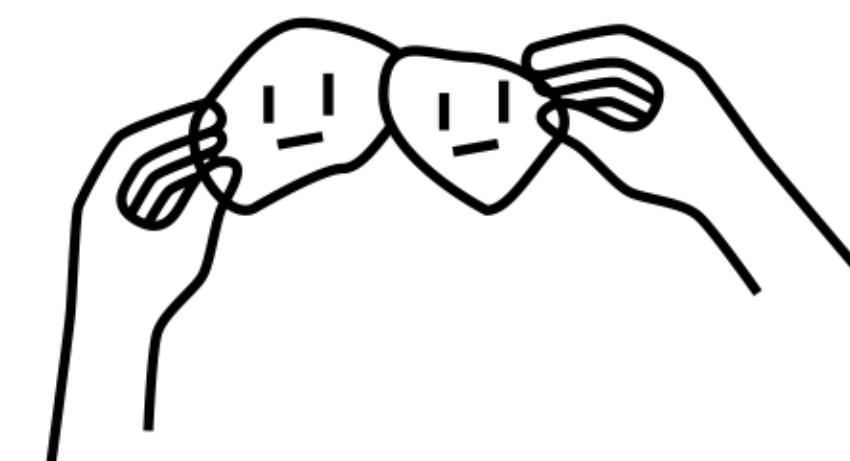
Size of Elements
e.g., Room-scale
robots



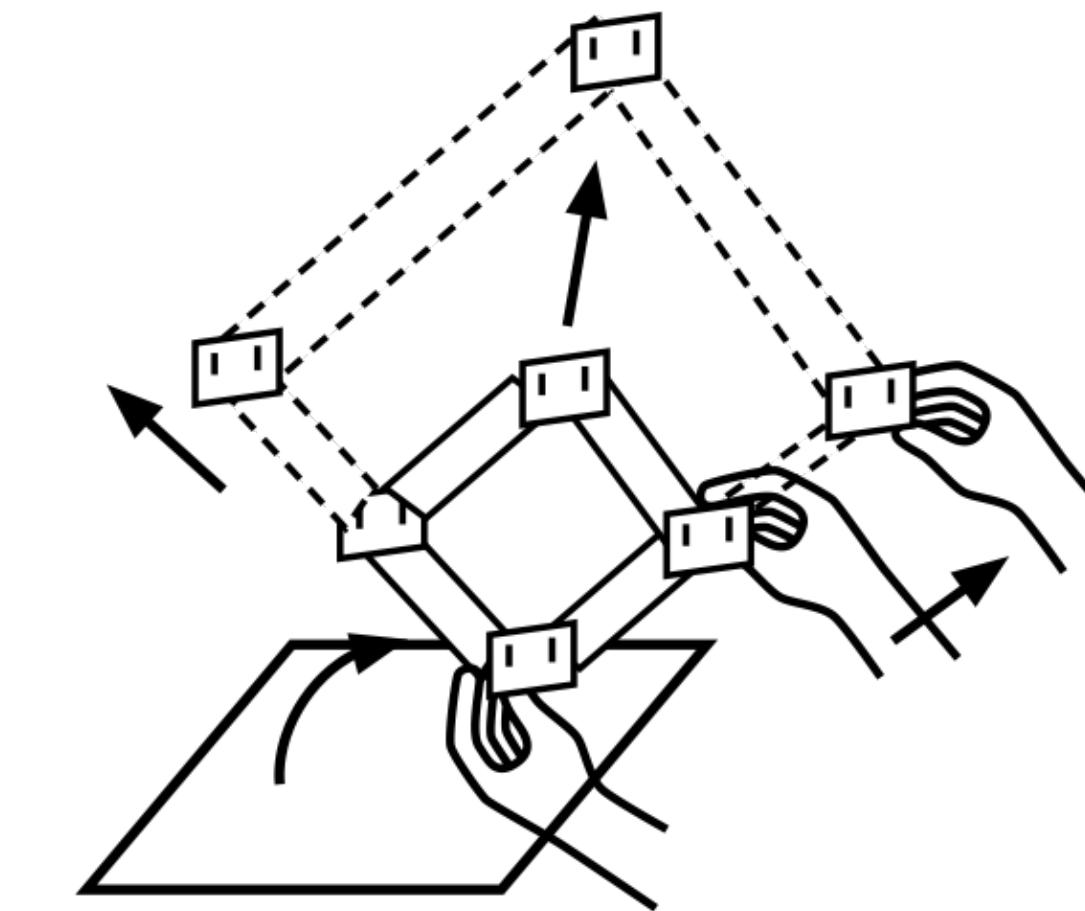
Input Capability
e.g., Deformation
and construction



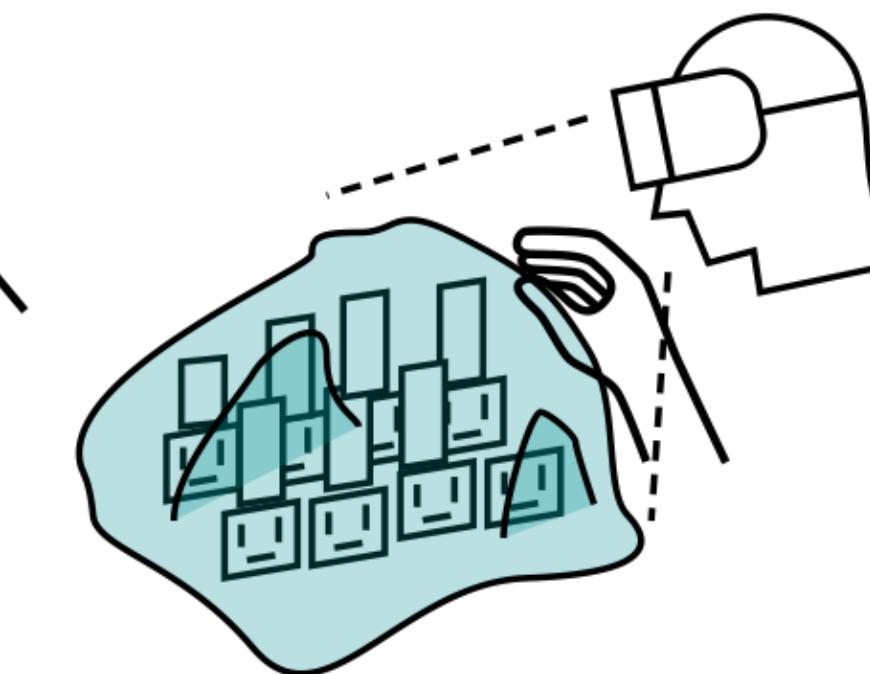
Locomotion Capability
e.g., Shape-changing
drones



Materiality
e.g., Shape-changing
swarm soft robots



Connectability
e.g., Connected for
graspable objects

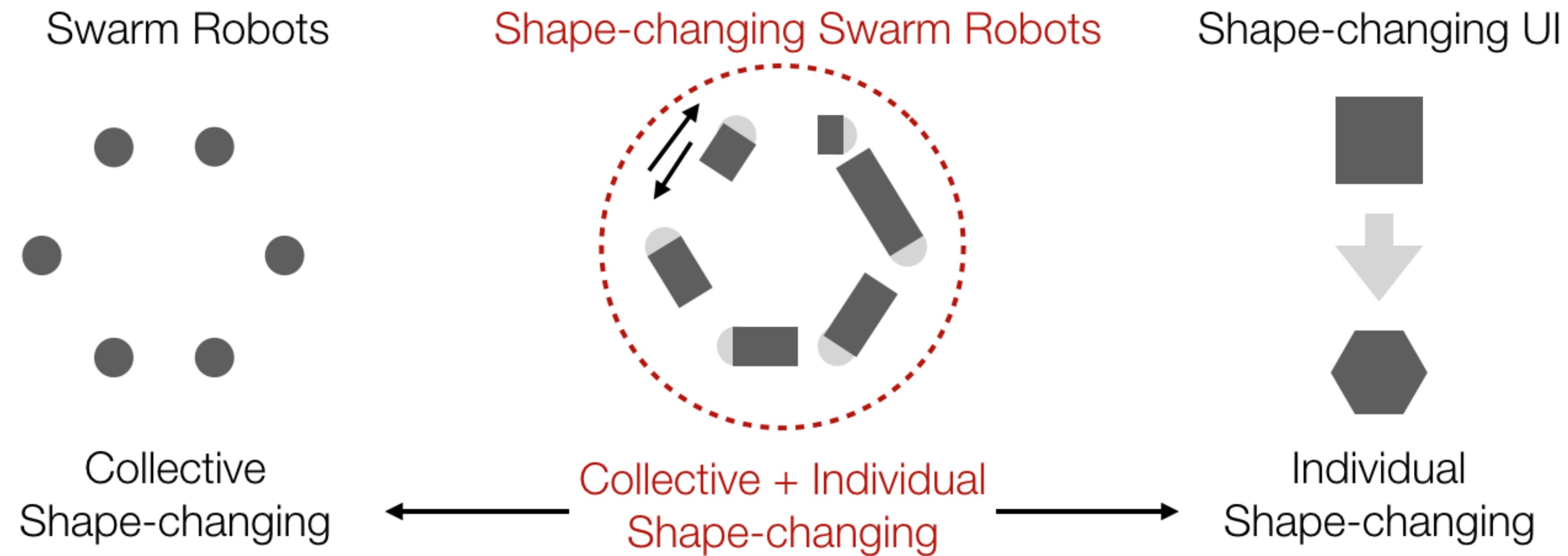


Representations
e.g., Haptic proxy for
AR

Conclusion

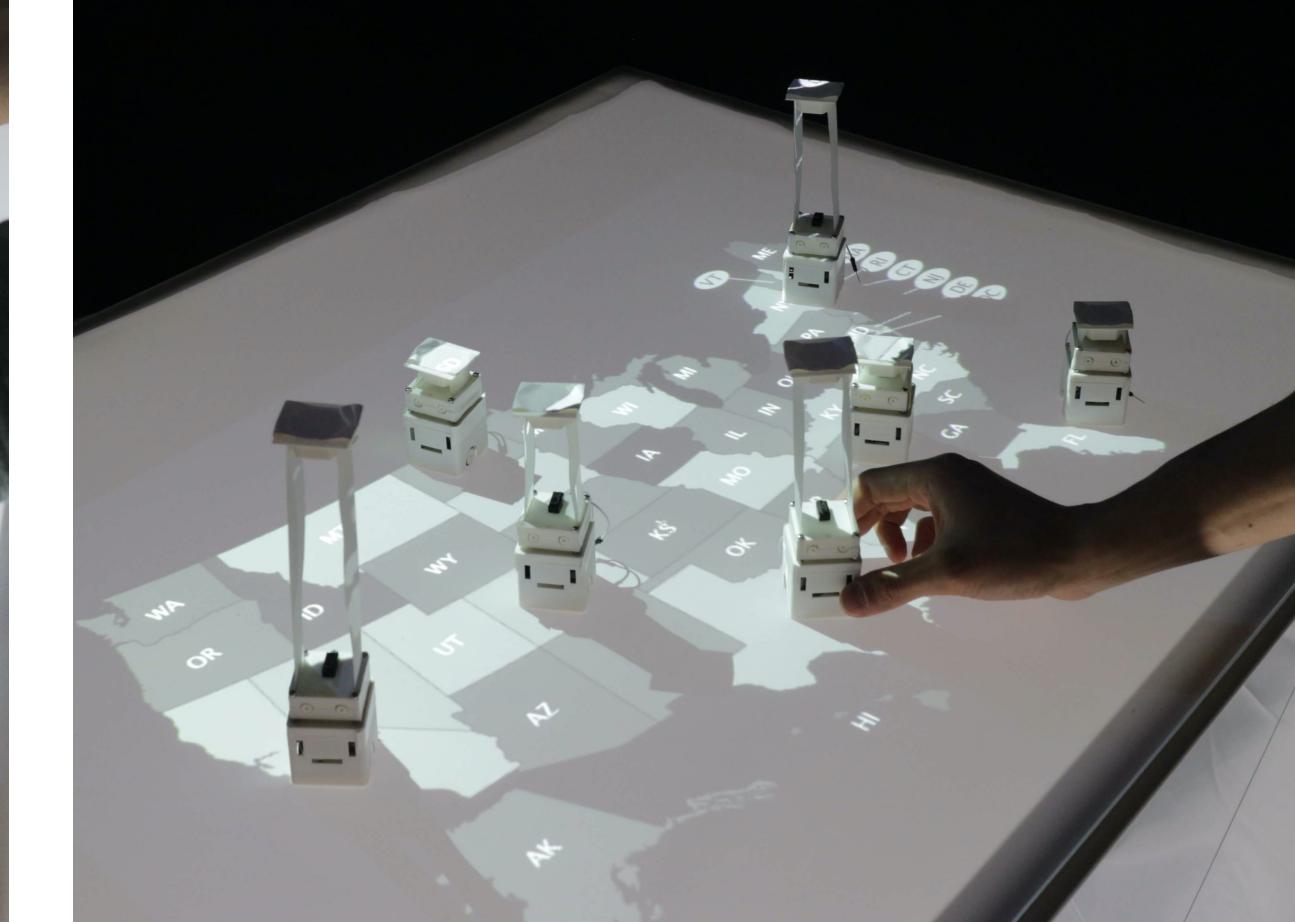
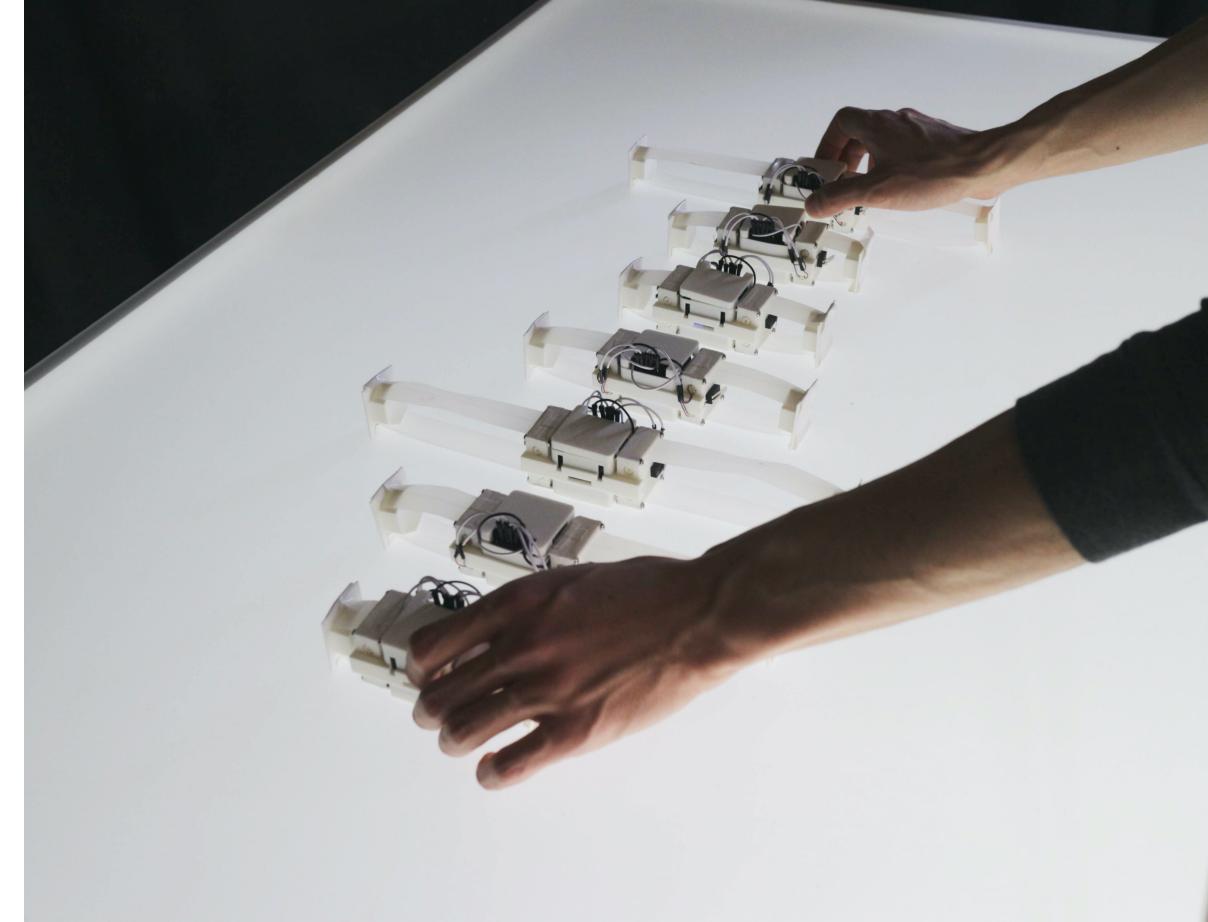
Contributions

1. Concept of shape-changing swarm robots



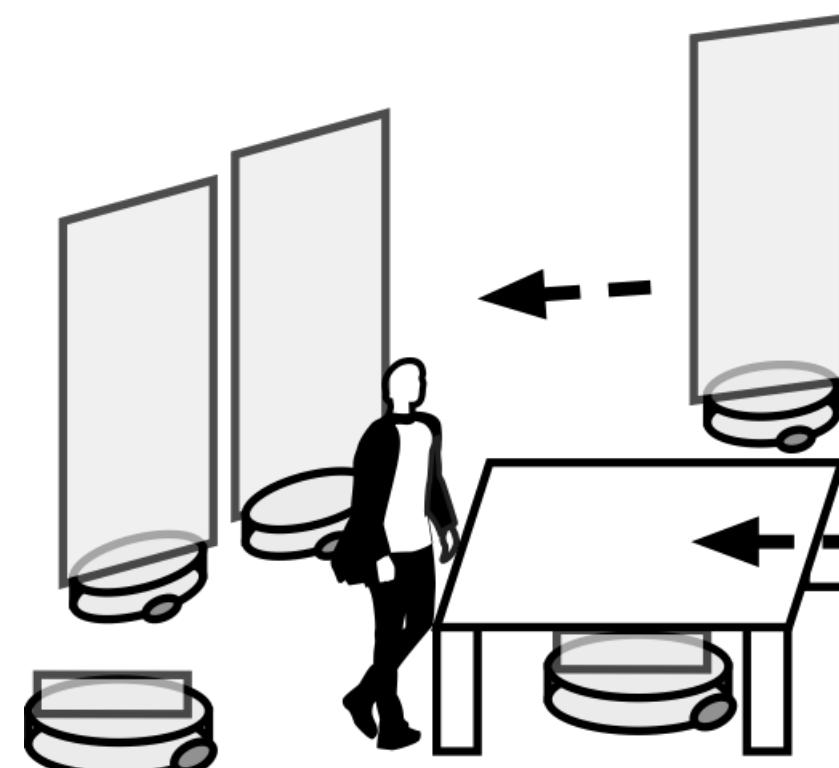
Contributions

2. ShapeBots design and applications

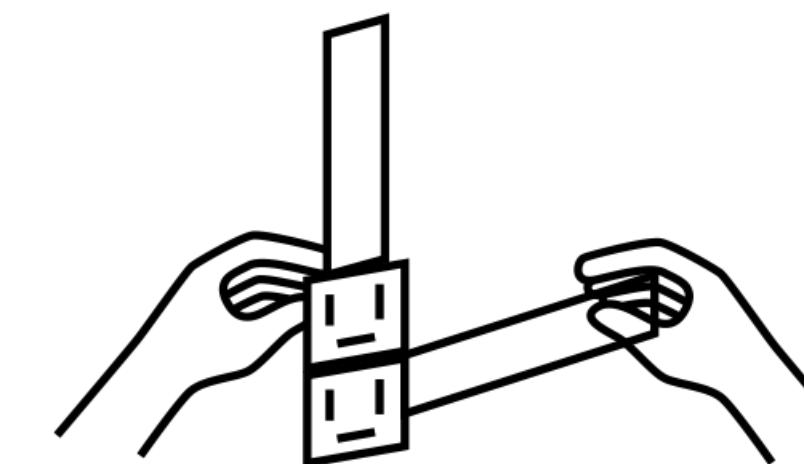


Contributions

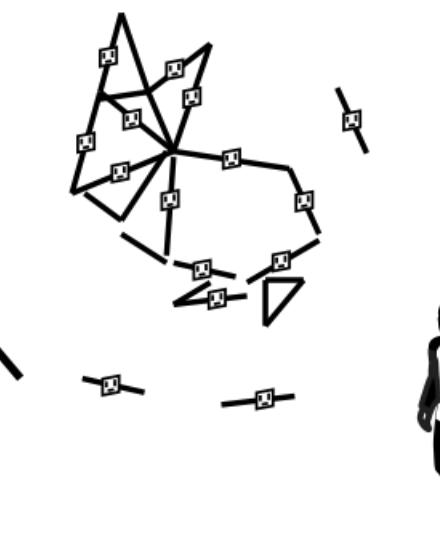
3. Design space exploration for future research opportunities



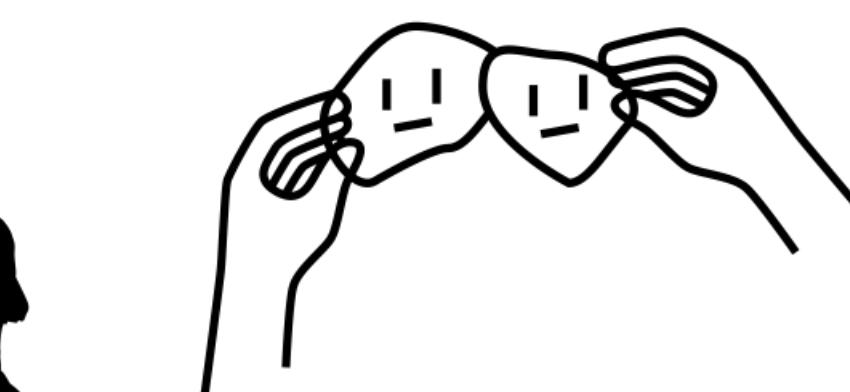
Size of Elements



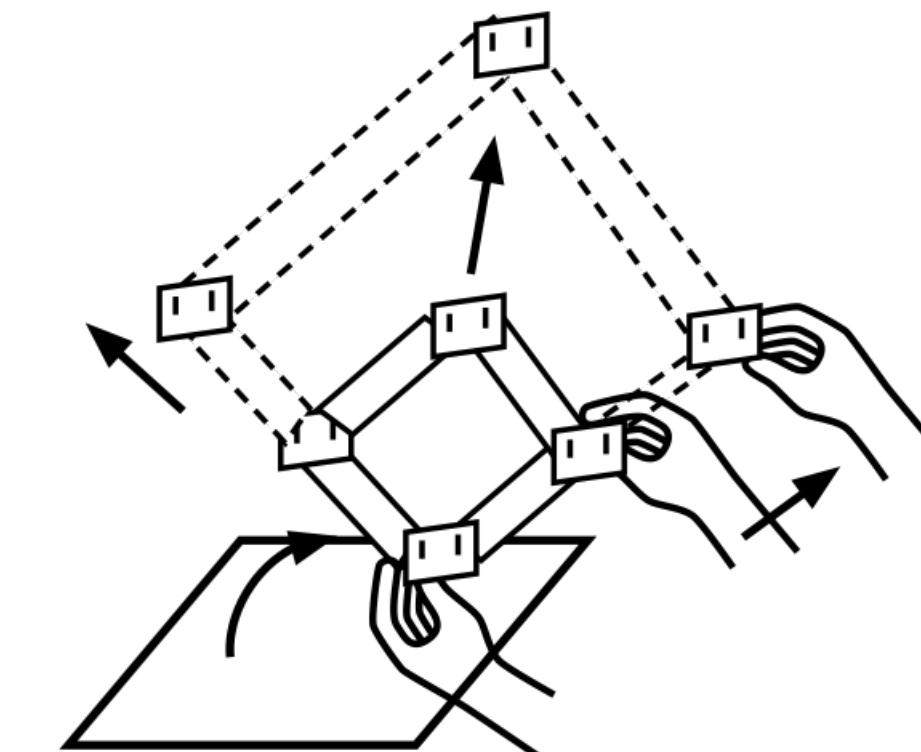
Input Capability



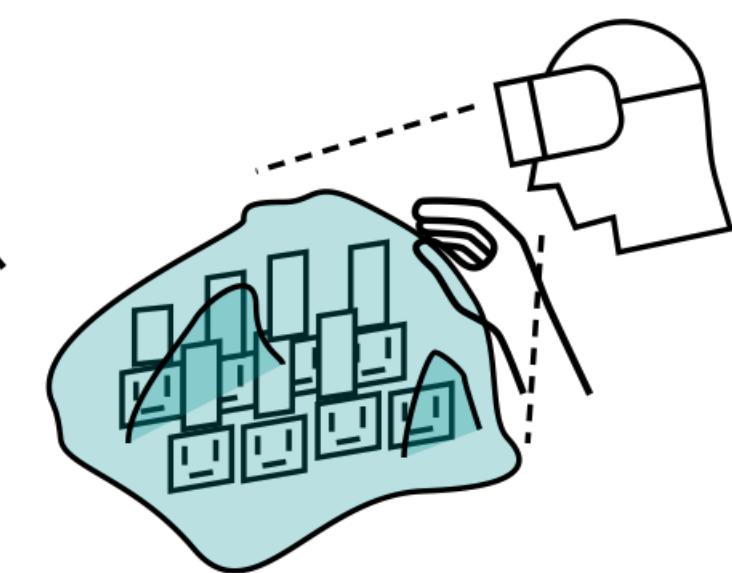
Locomotion Capability



Materiality



Connectability



Representations

ShapeBots

Shape-changing Swarm Robots

Ryo Suzuki

Clement Zheng

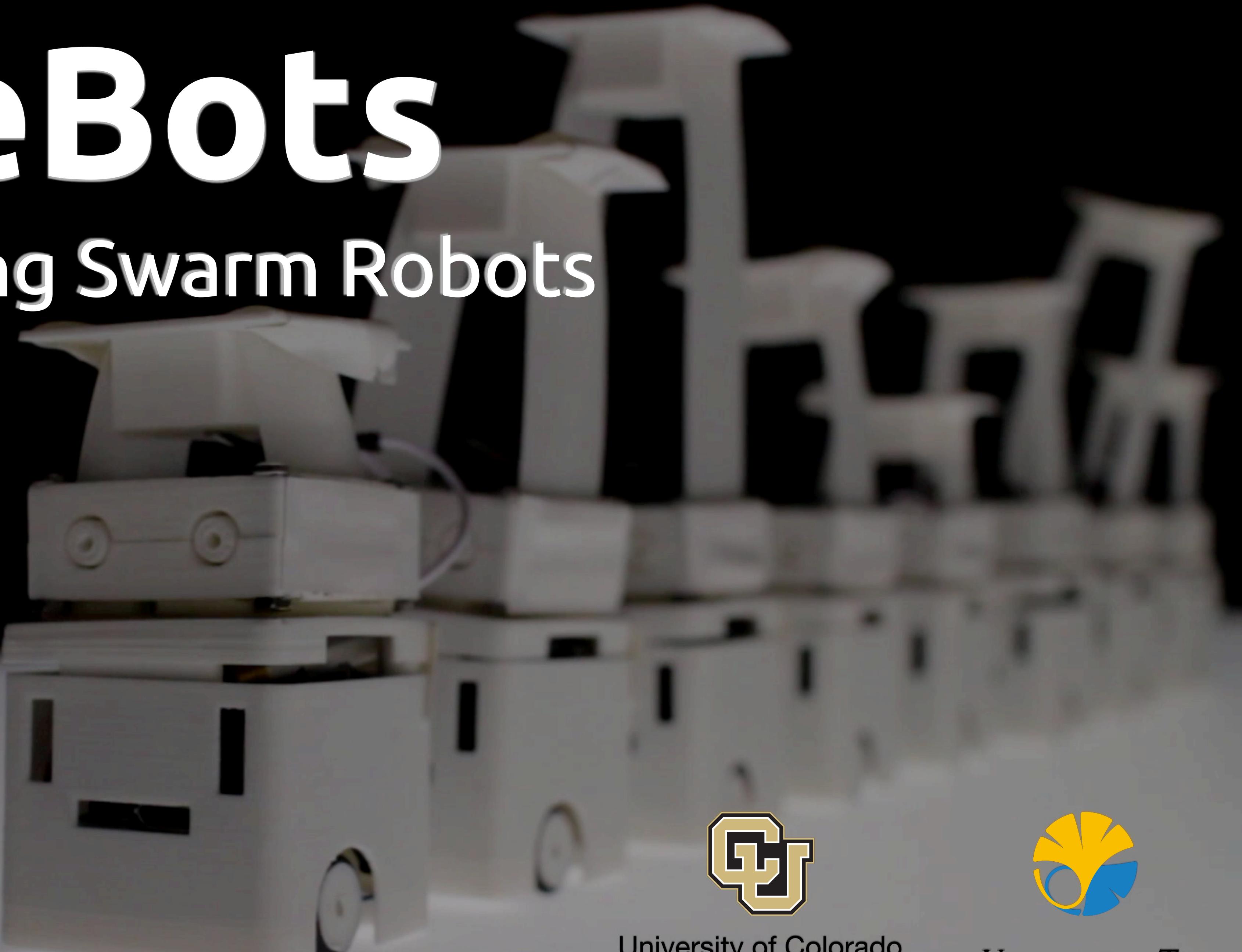
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