

ShapeBots

Shape-changing Swarm Robots

Ryo Suzuki

Clement Zheng

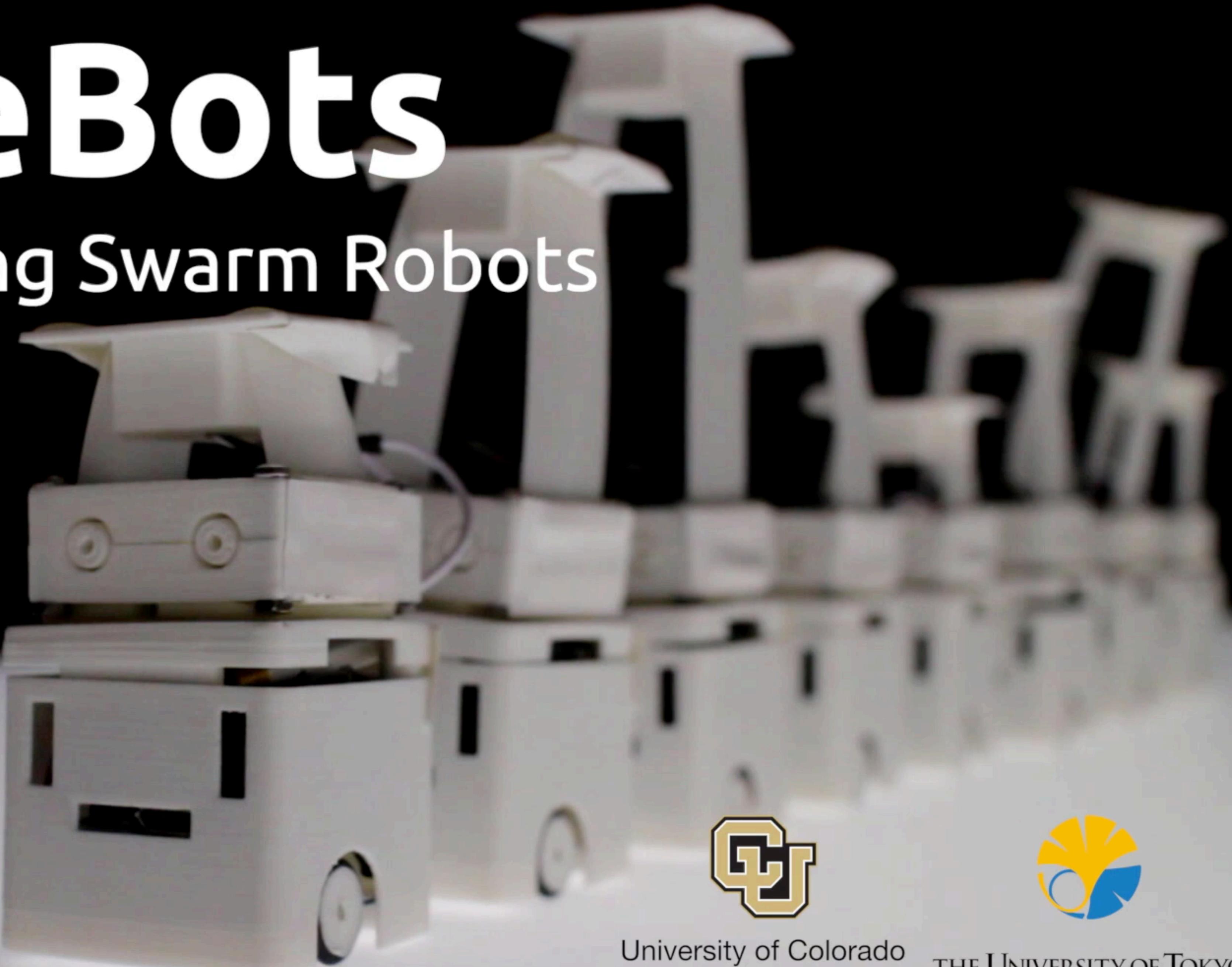
Yasuaki Kakehi

Tom Yeh

Ellen Yi-Luen Do

Mark Gross

Daniel Leithinger

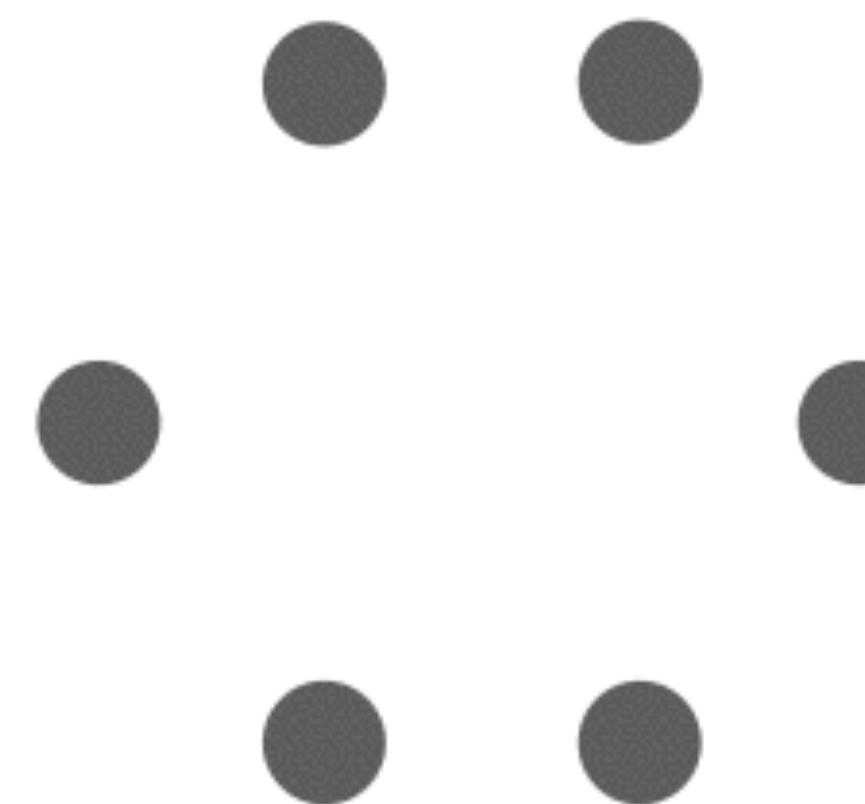


University of Colorado
Boulder



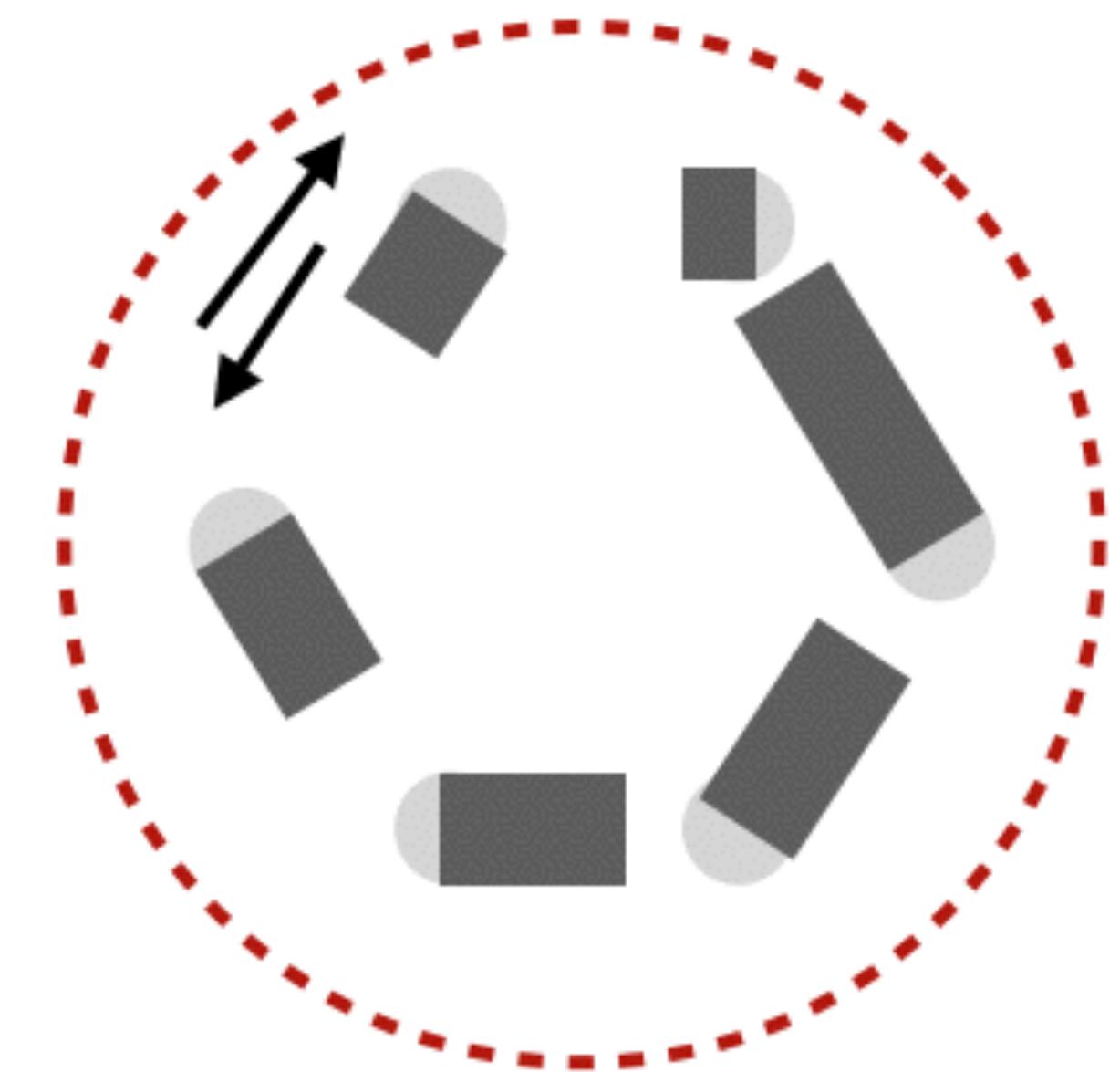
THE UNIVERSITY OF TOKYO

Swarm Robots



Collective
Shape-changing

Shape-changing Swarm Robots



Collective + Individual
Shape-changing

Shape-changing UI

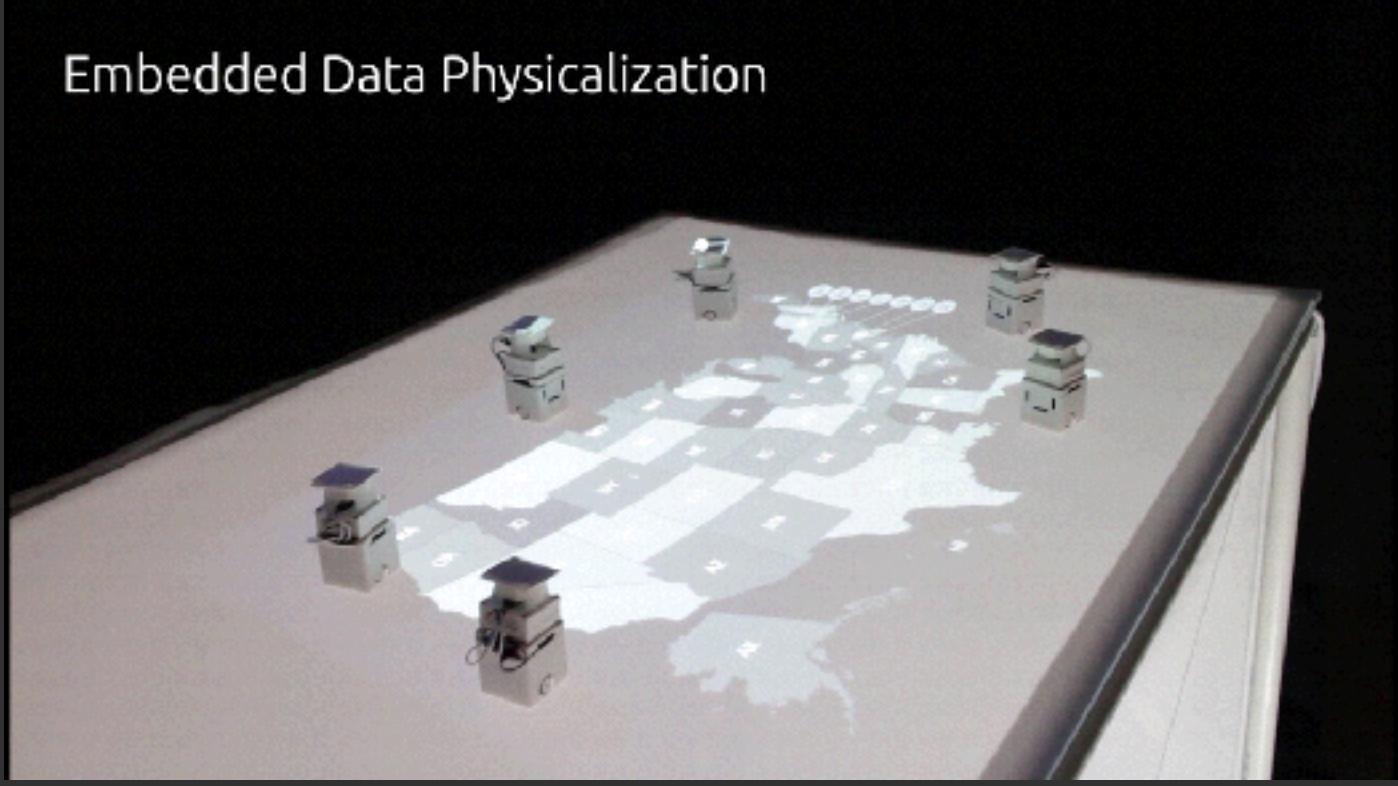
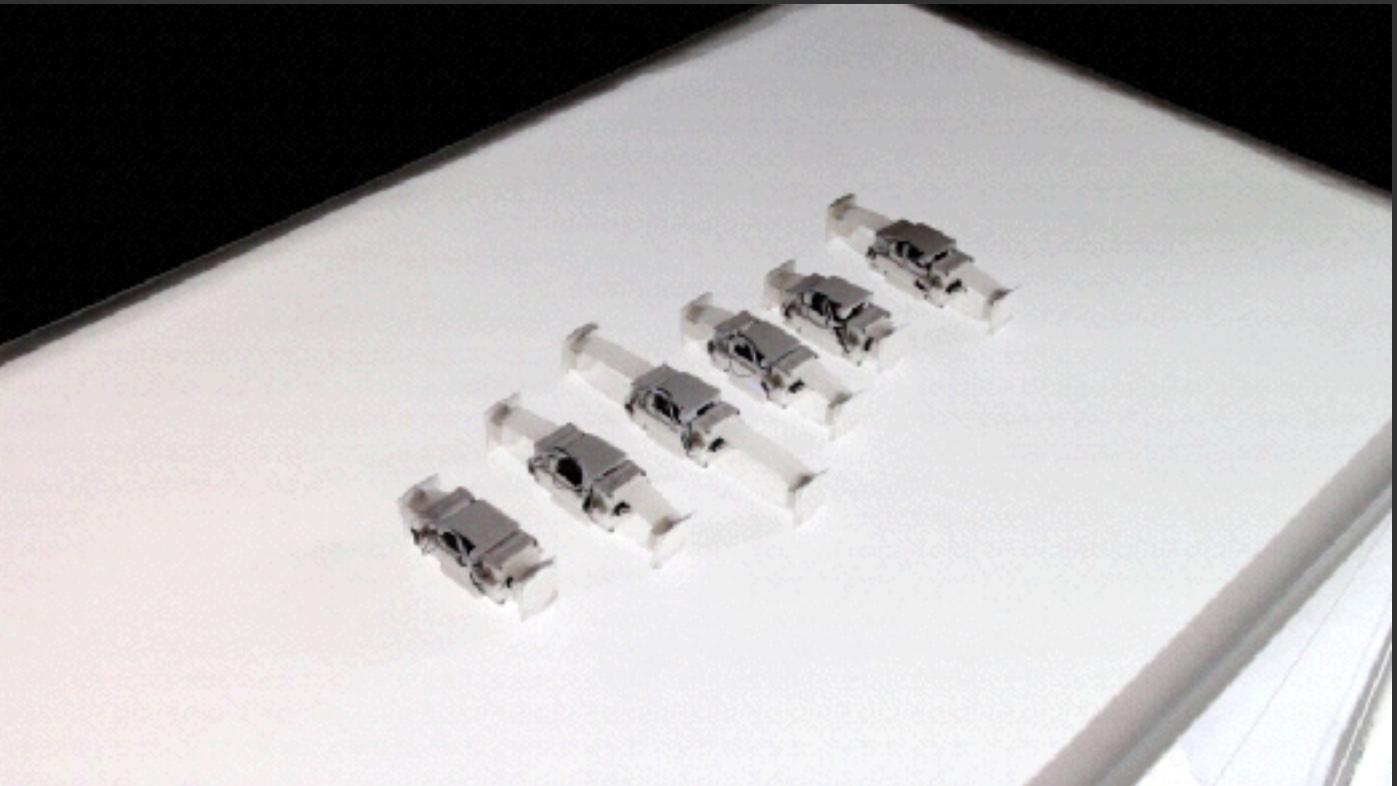
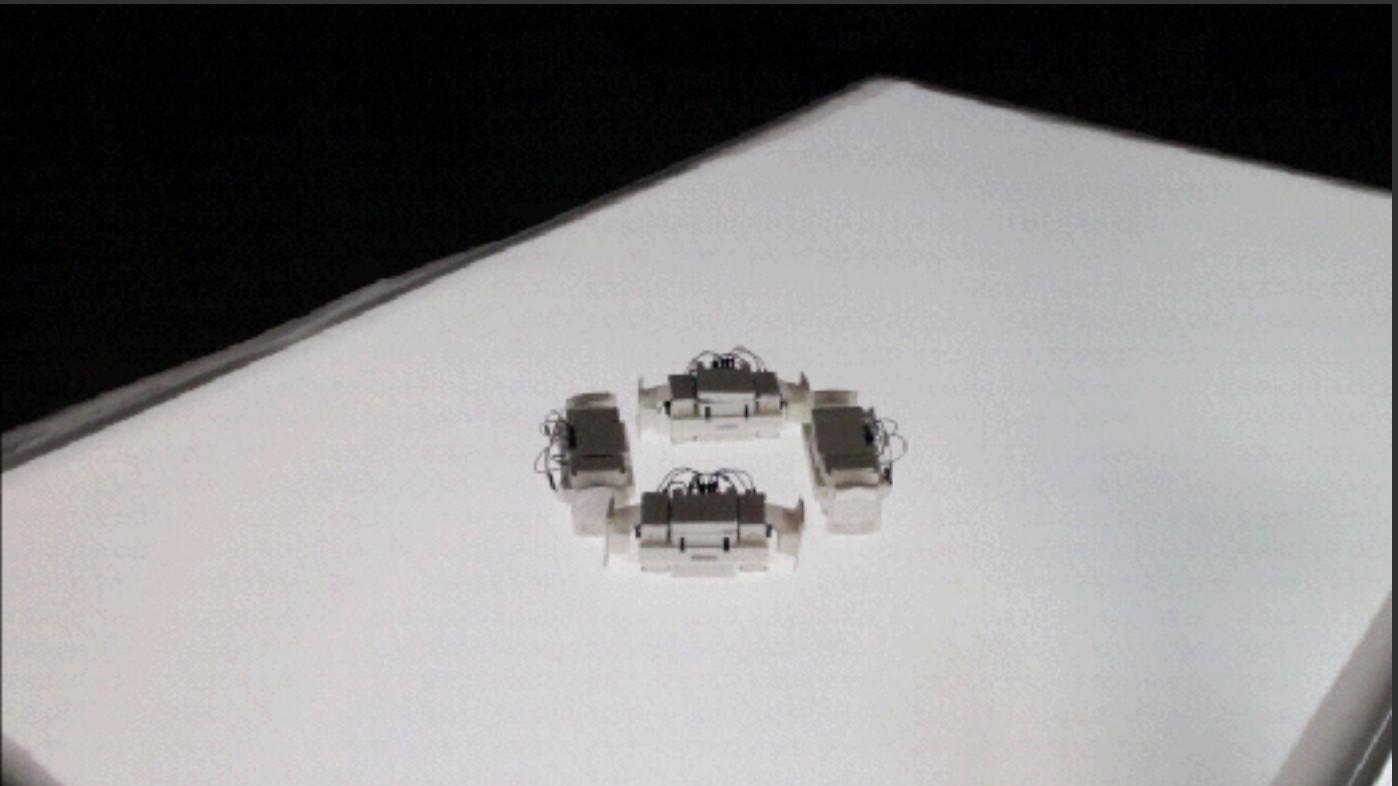


Individual
Shape-changing

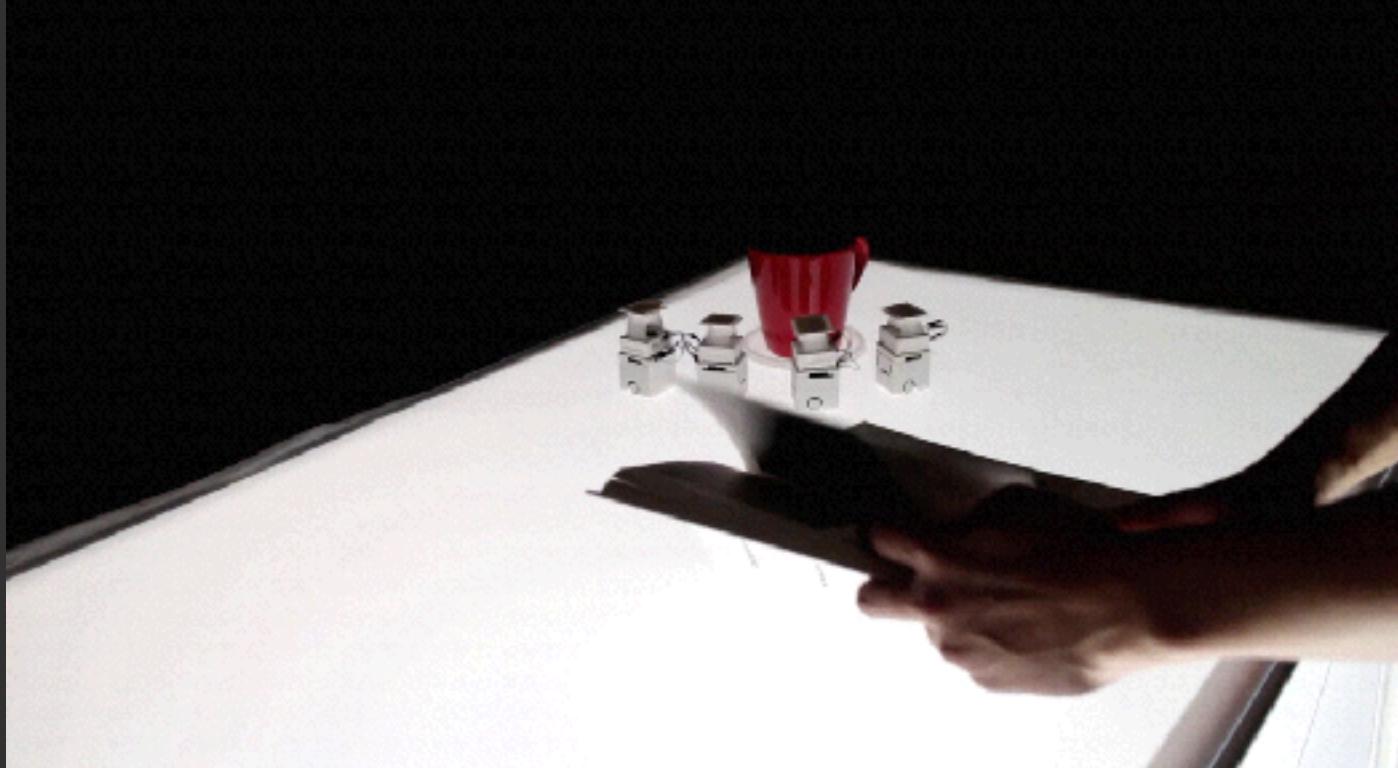
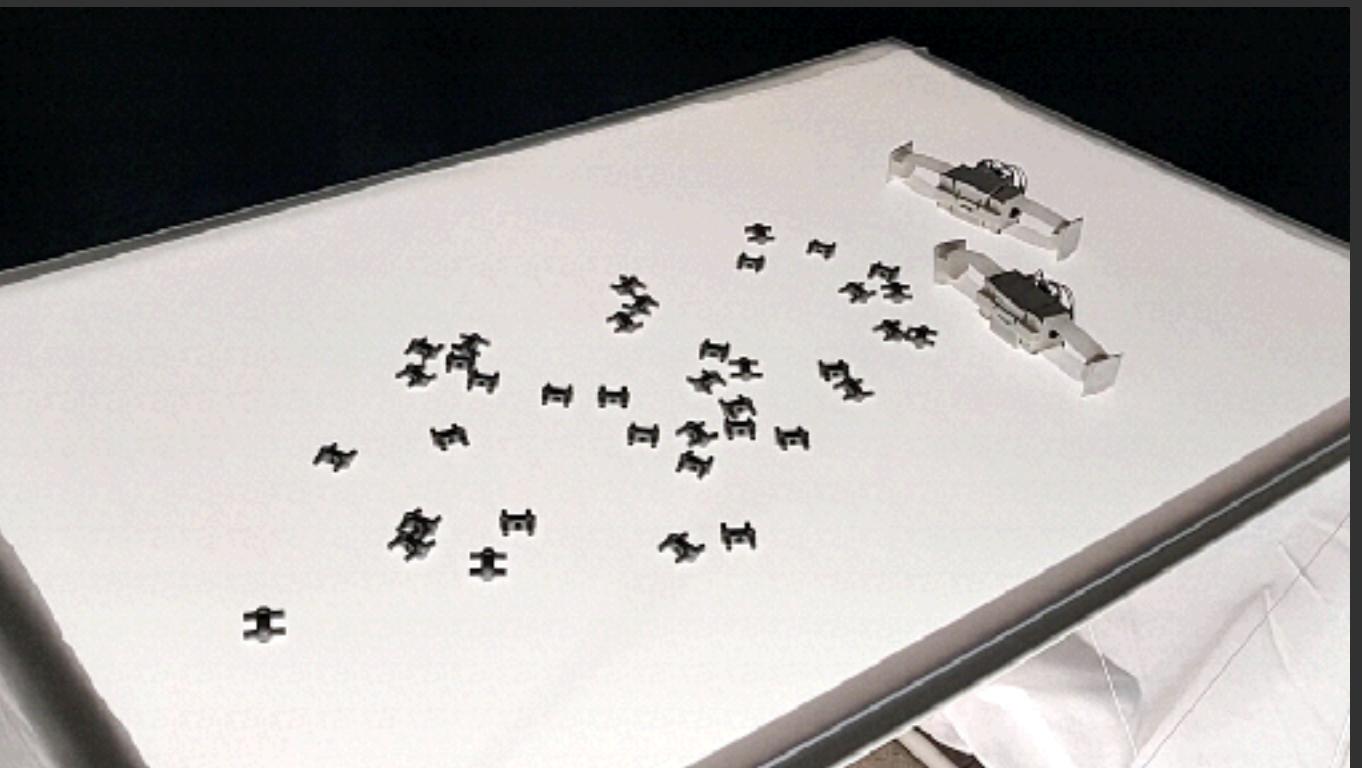
Shape-changing Swarm Robots

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

Tangible Media



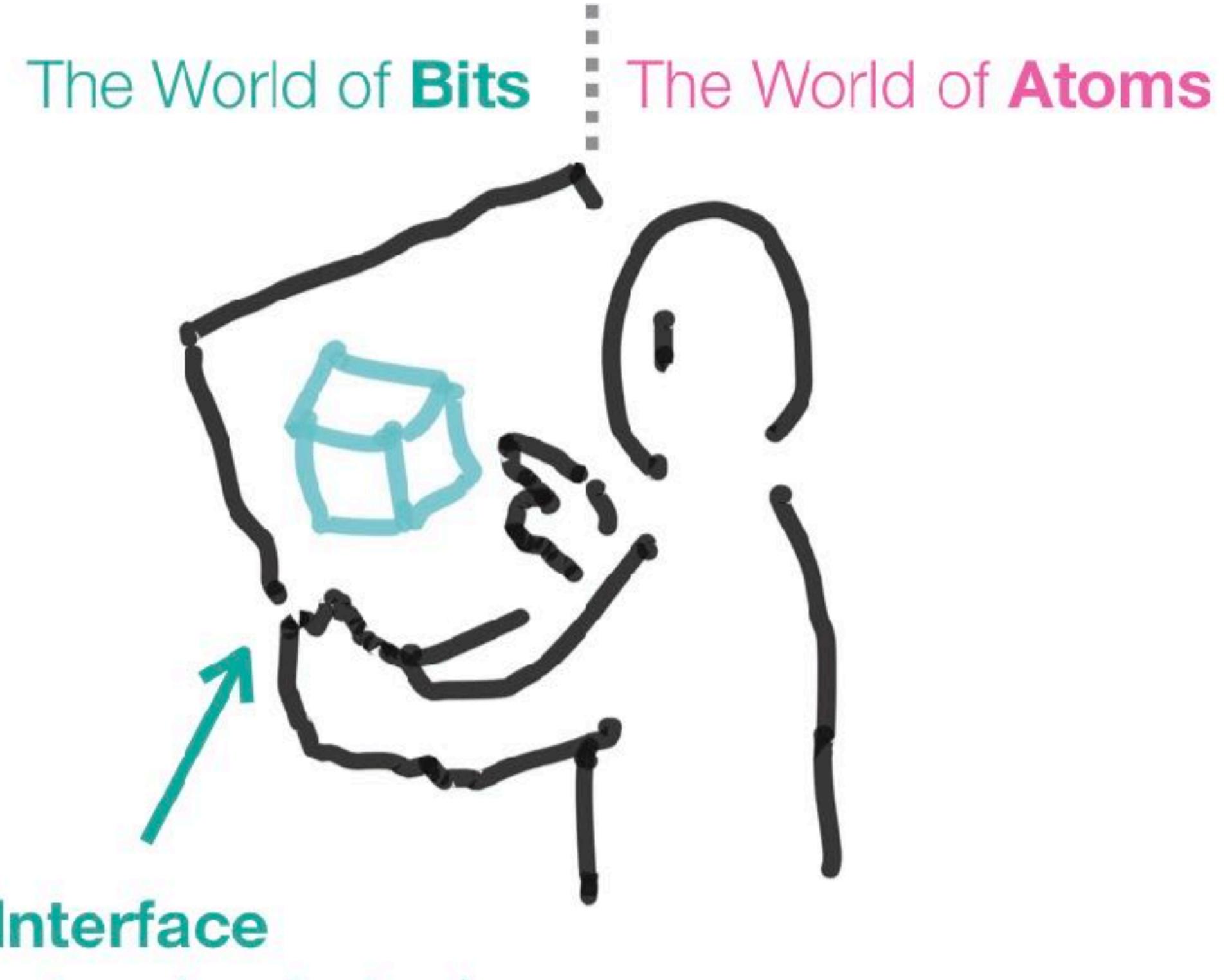
Everyday Assistant



Embedded Data Physicalization

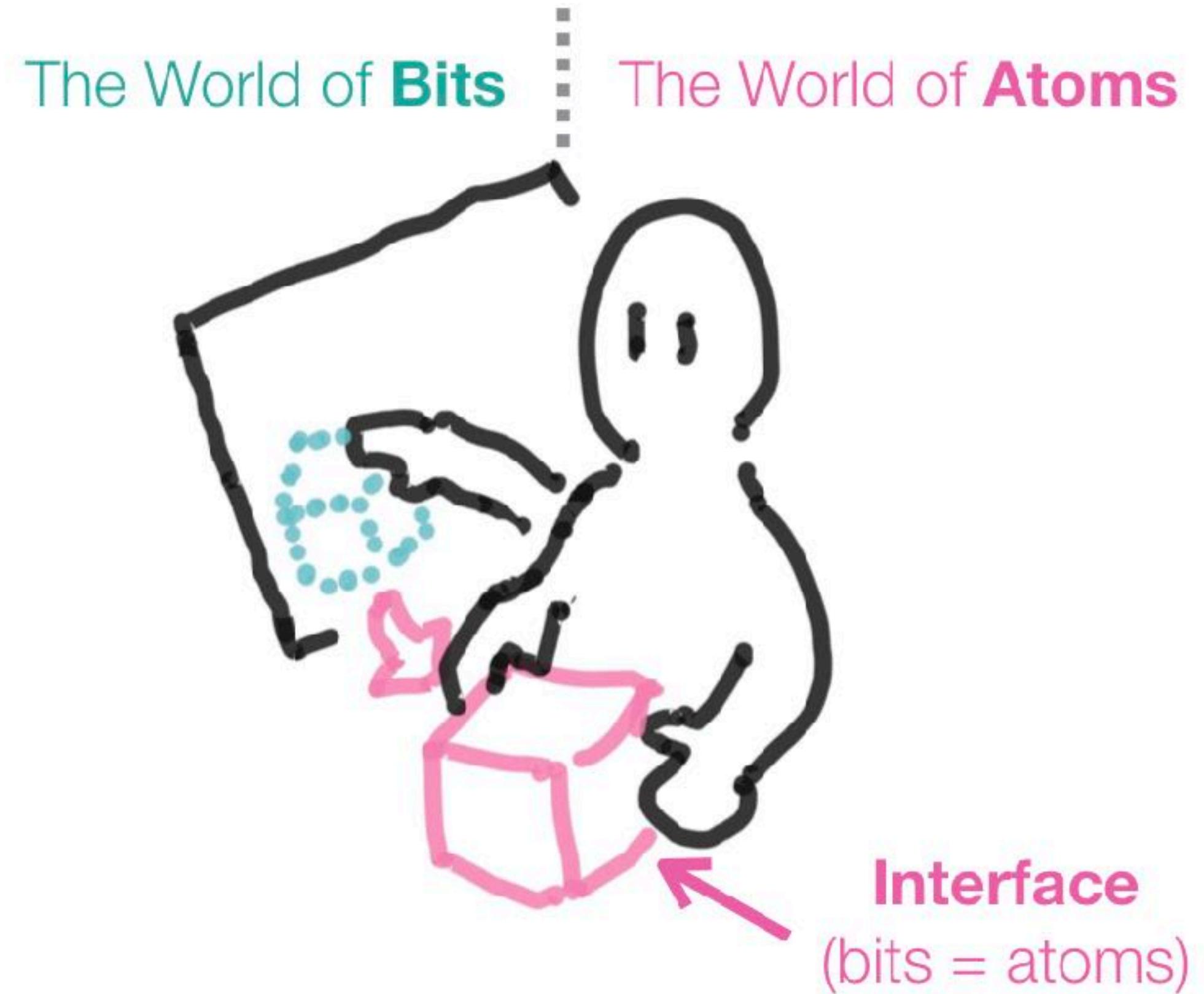
In-situ Physical Assistants

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

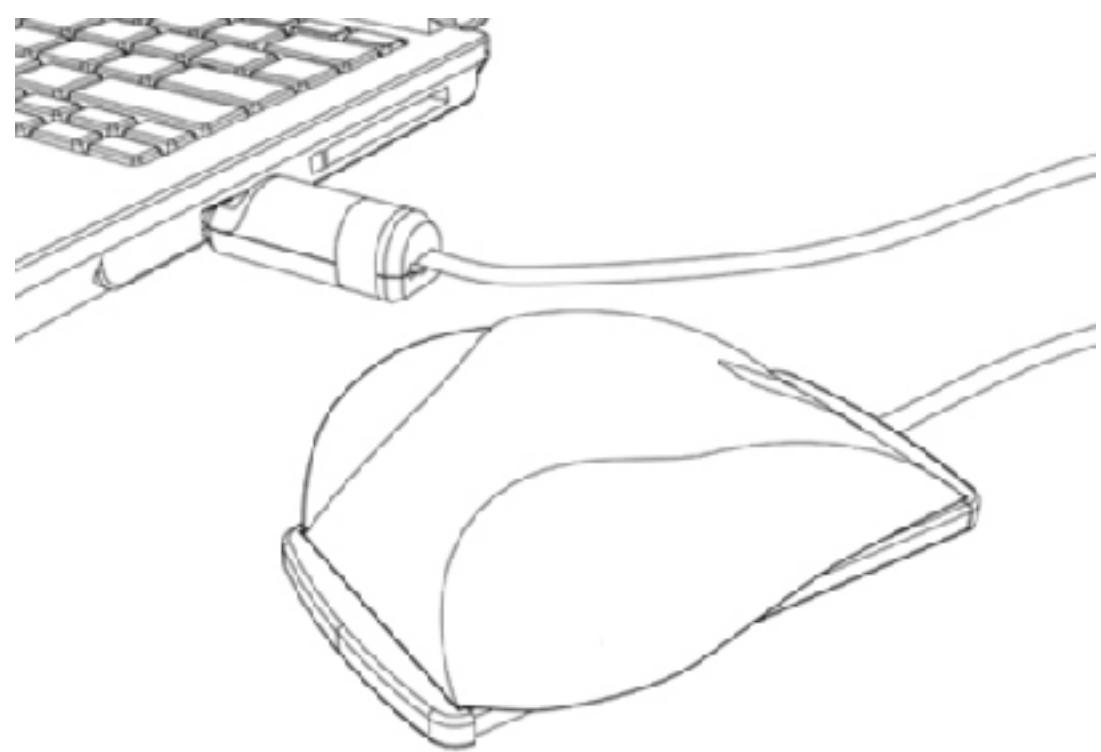
Shape-changing Interfaces

dynamic physical objects to fully represent the fluidity of digital information

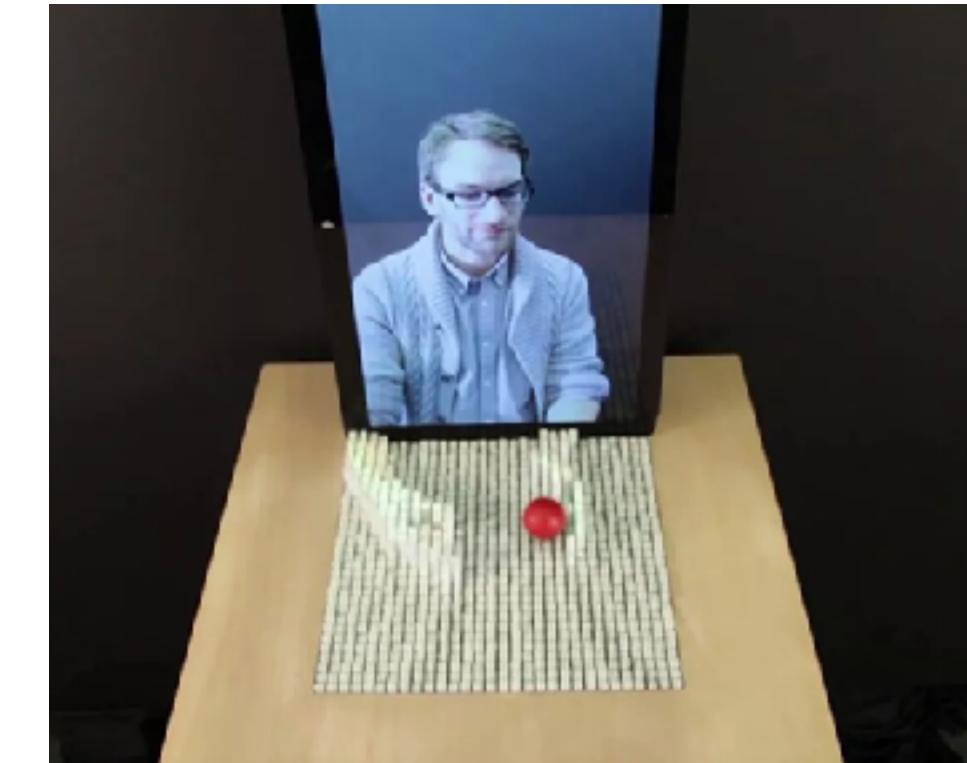
Shape-changing Interfaces



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]

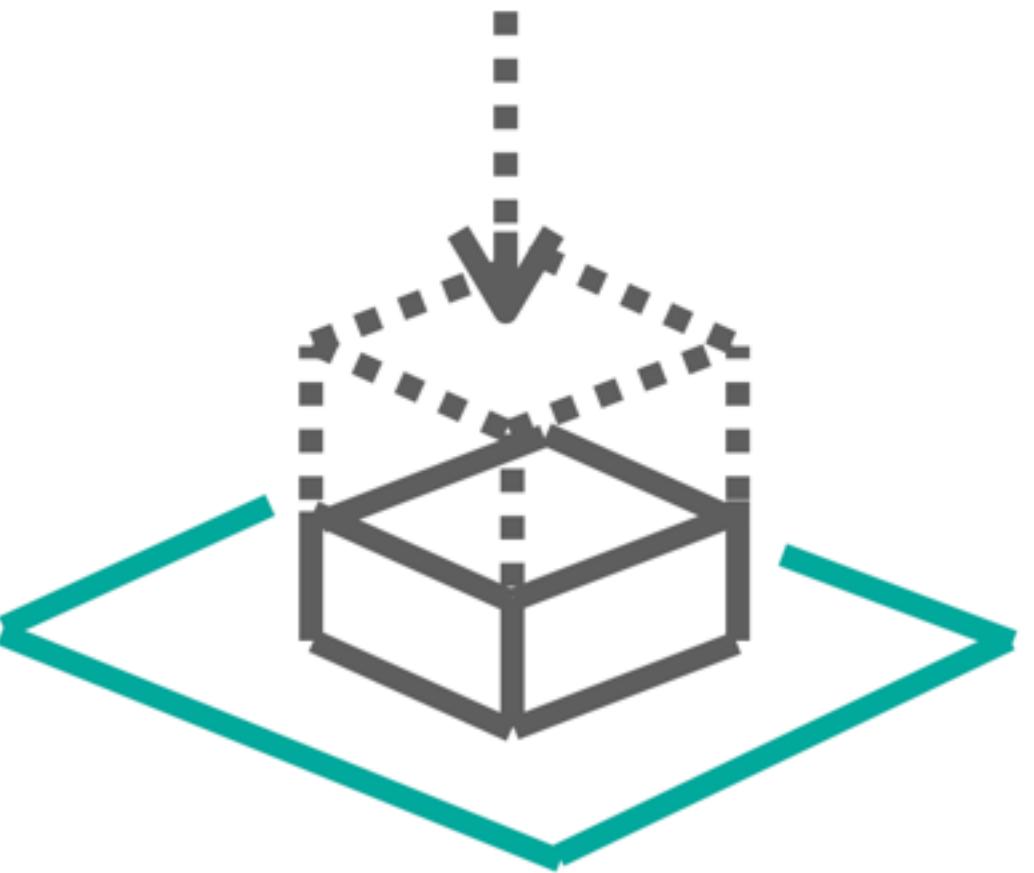


HypoSurface [Goulthorpe '01]

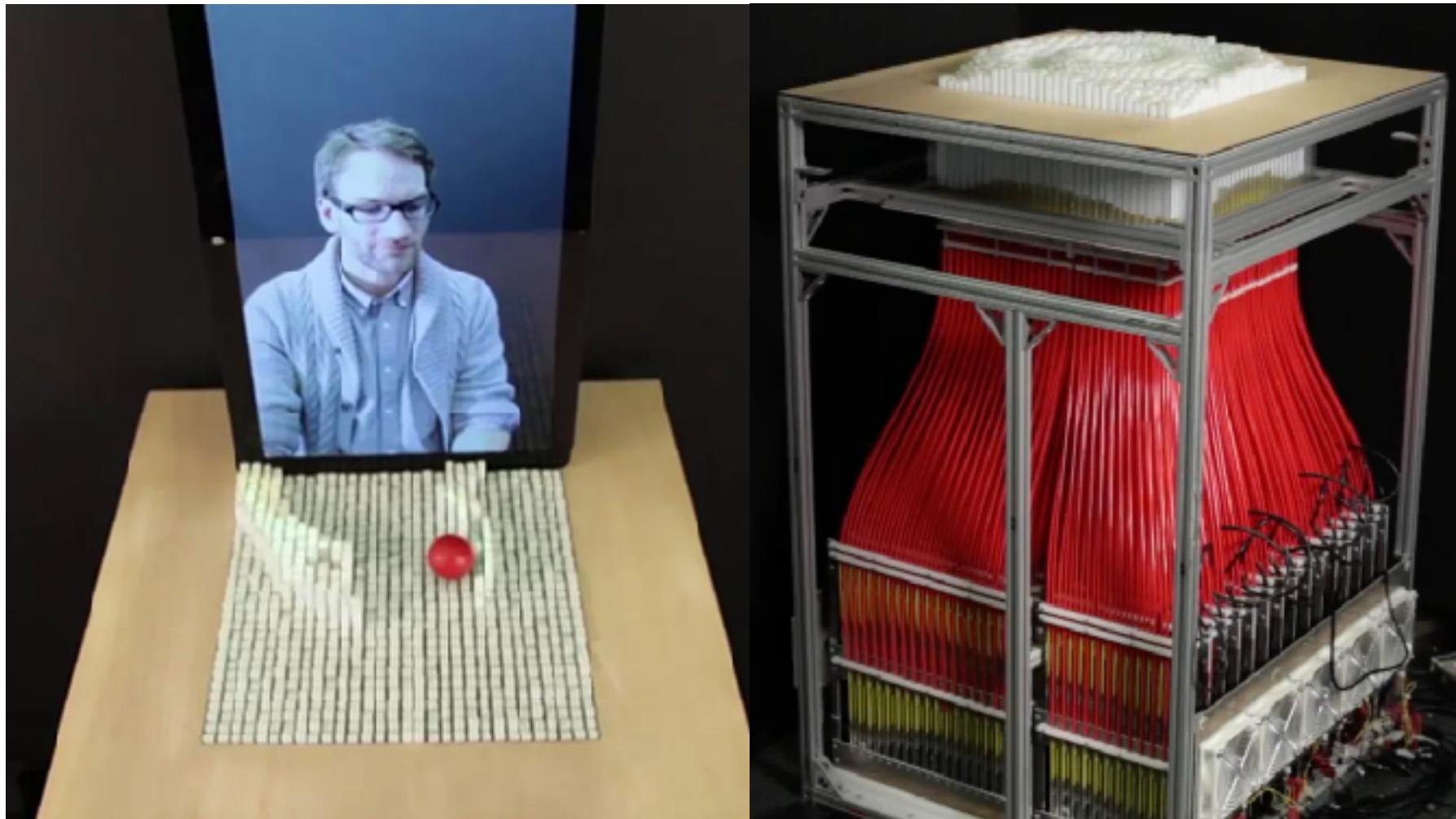
single-purpose



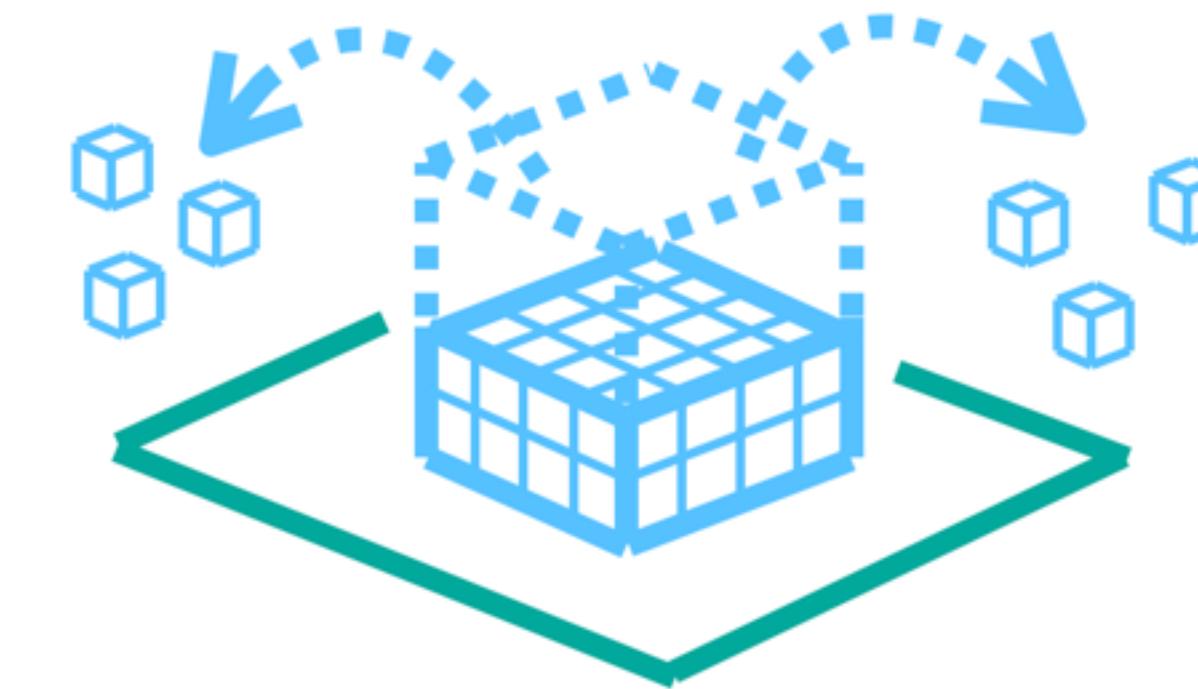
general-purpose



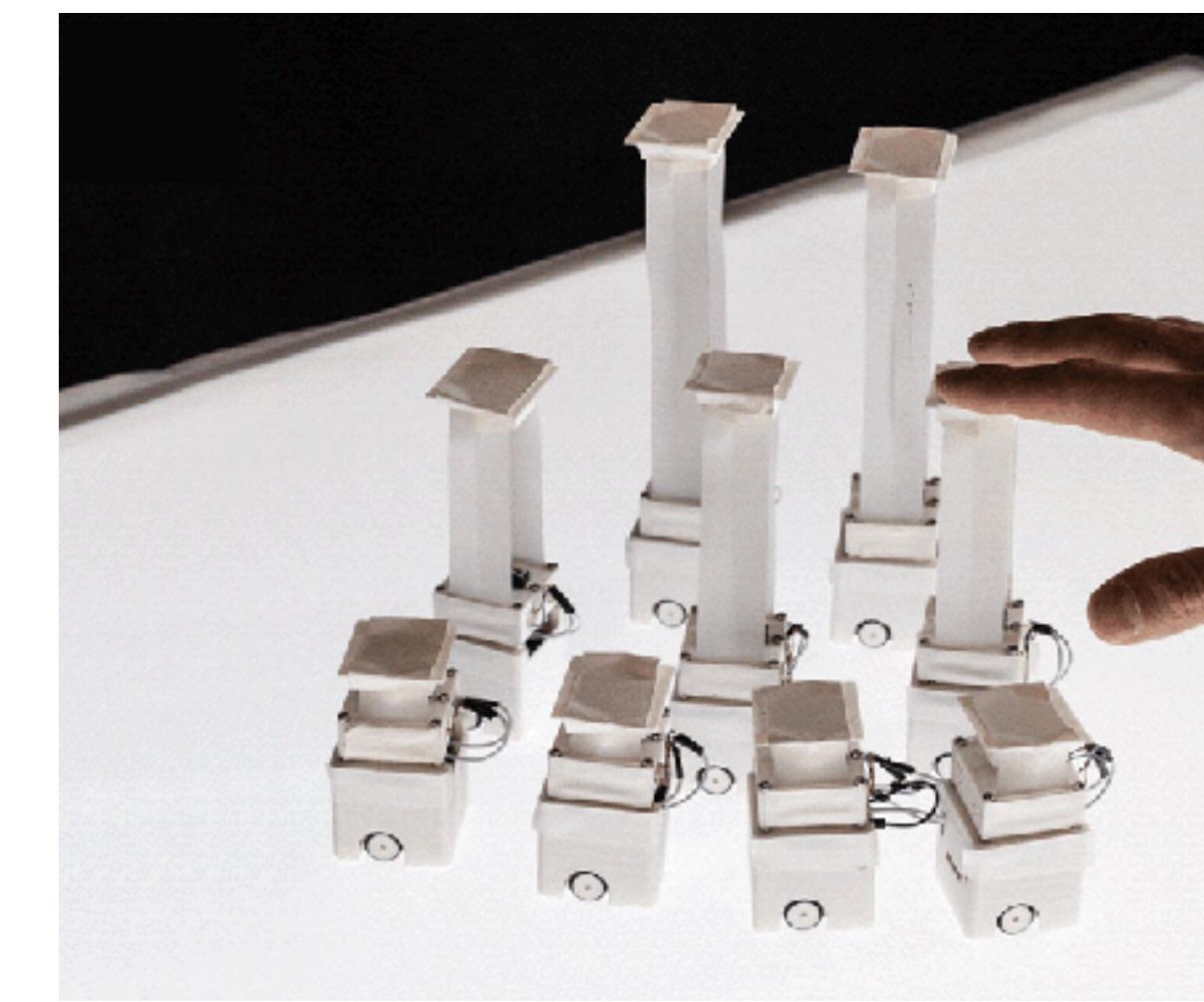
Monolithic



large, heavy, complex



Discrete and Distributed

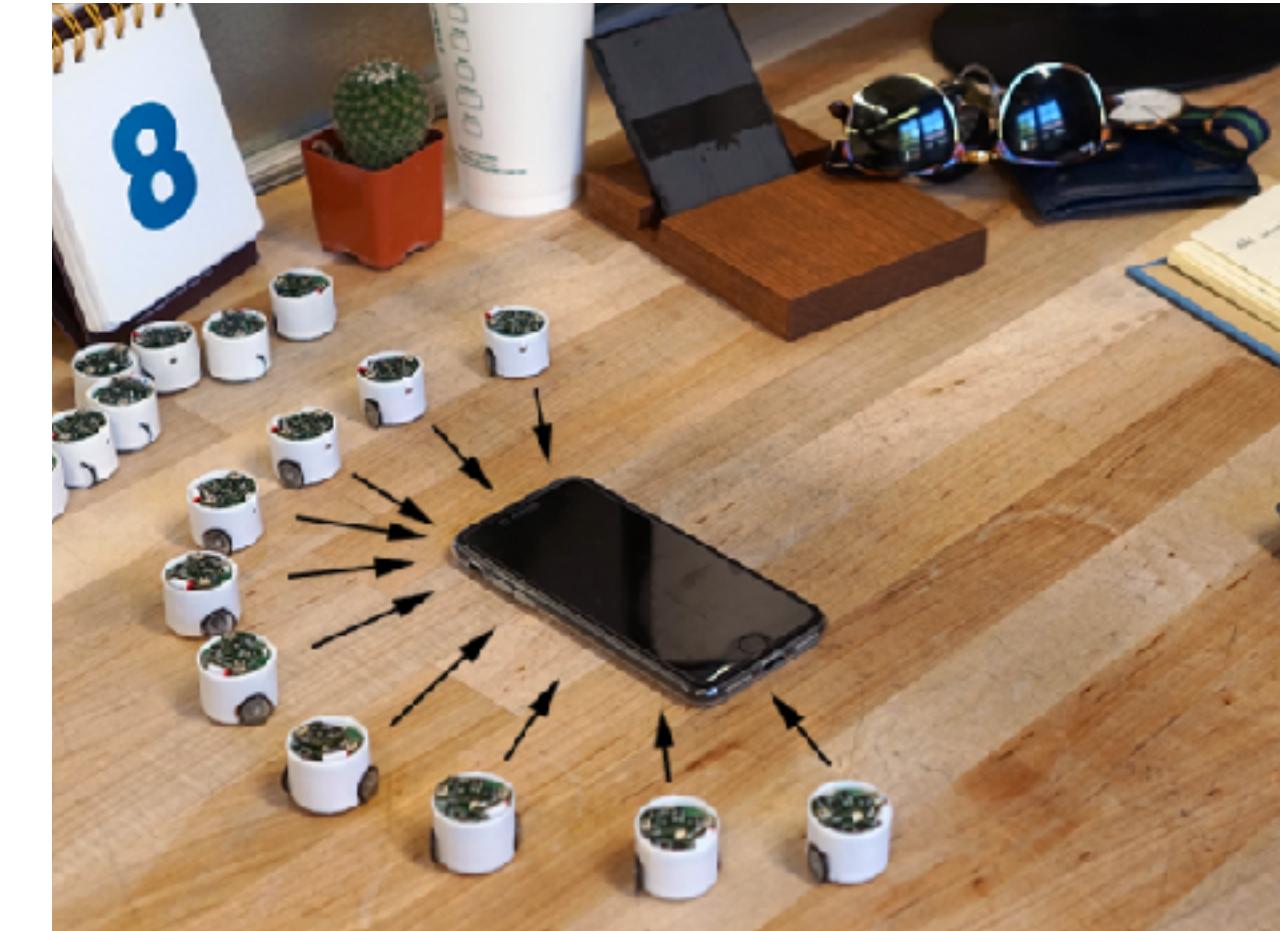


modular, scalable, deployable

Swarm User Interfaces



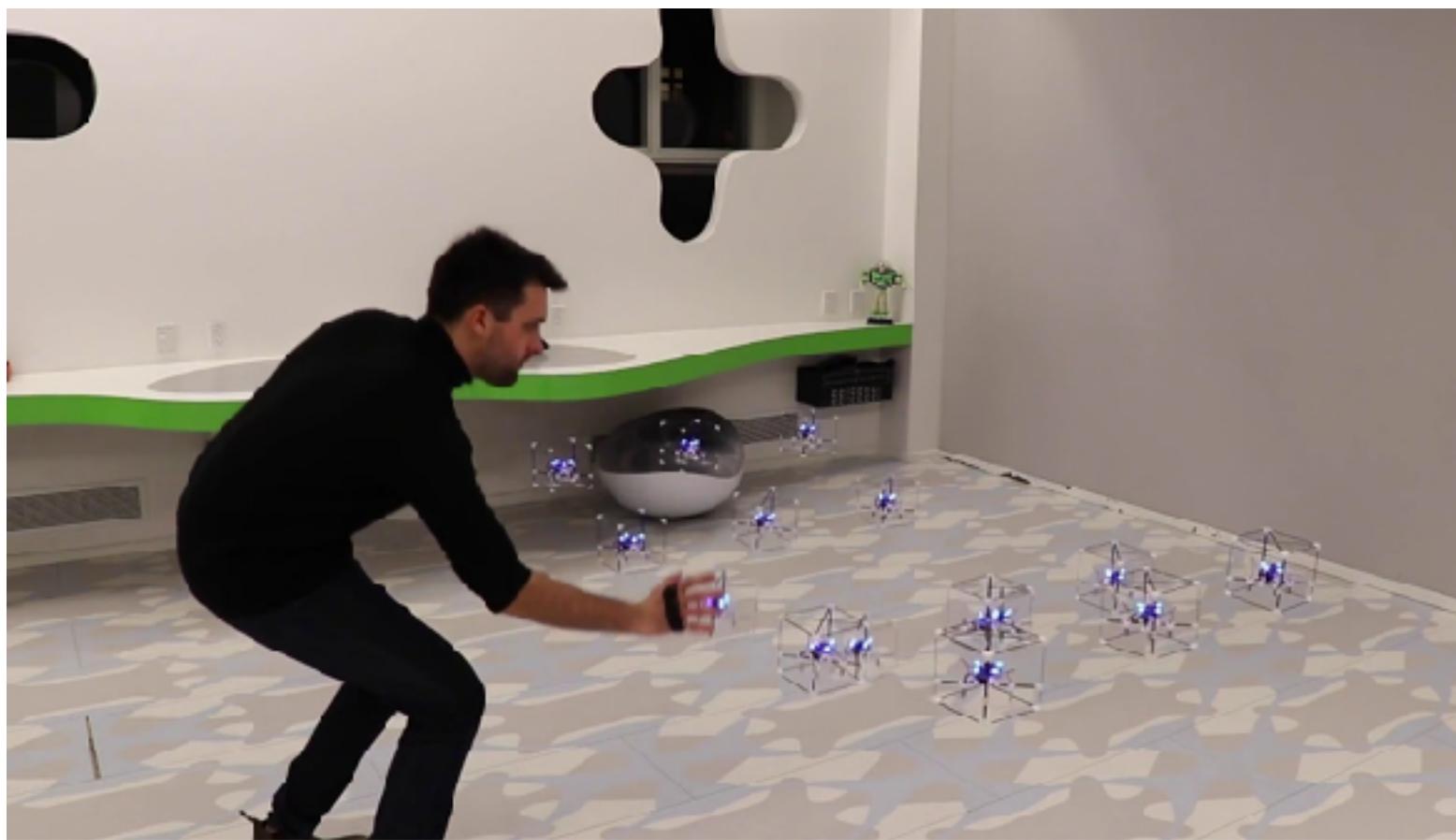
Zoids



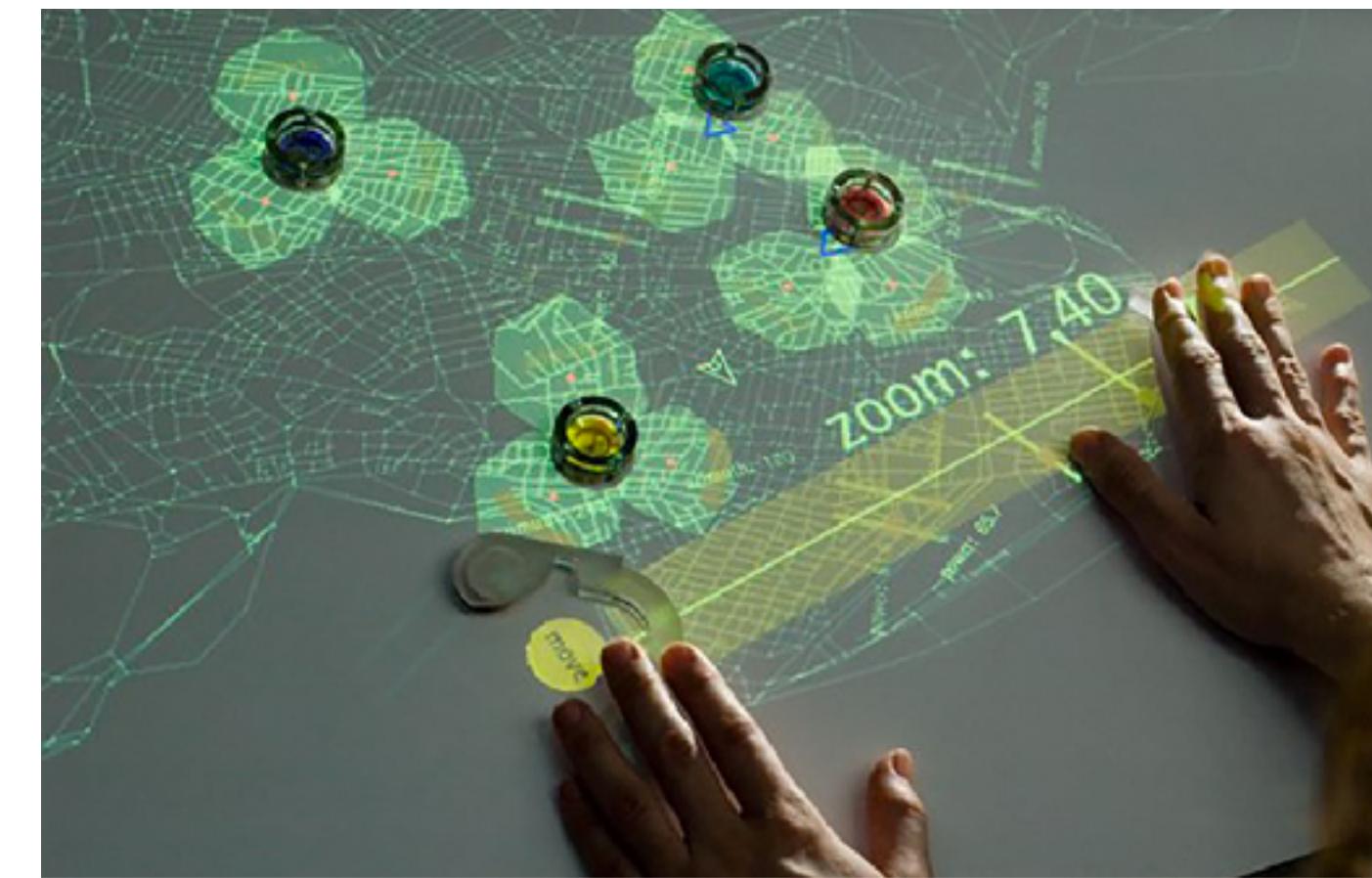
UbiSwarm



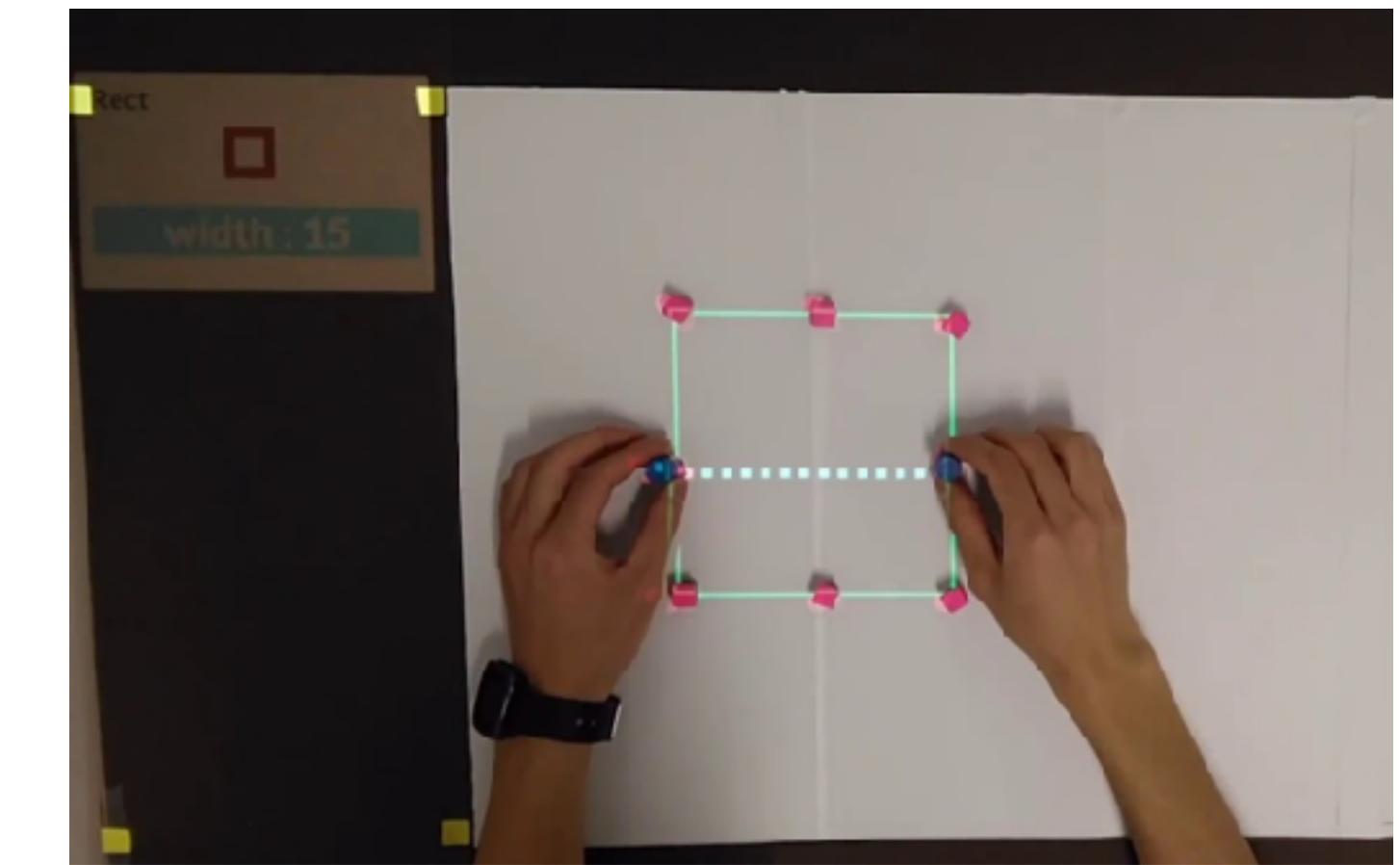
Rovables



GridDrones



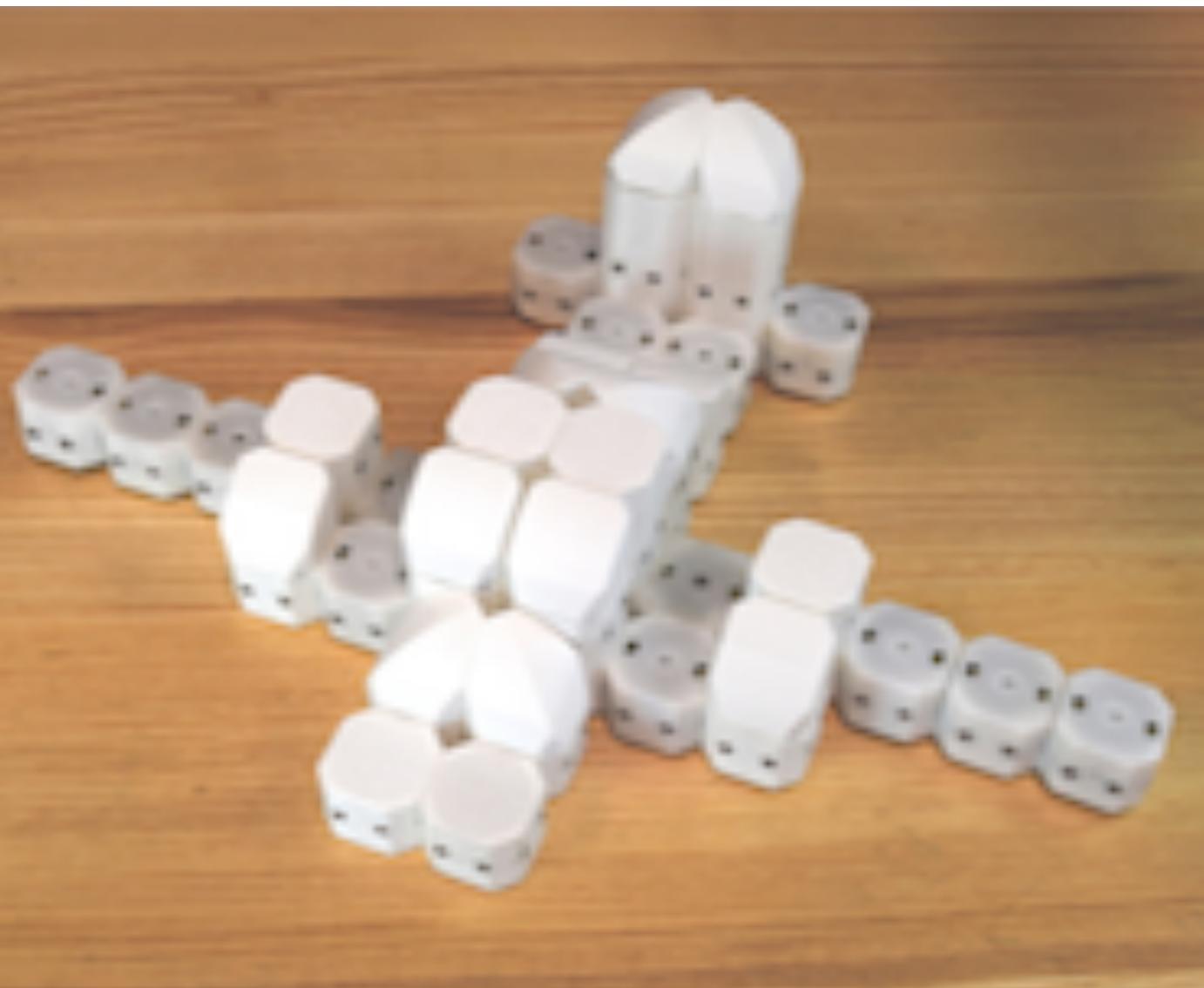
PICO



Reactile

Beyond 2D Shape

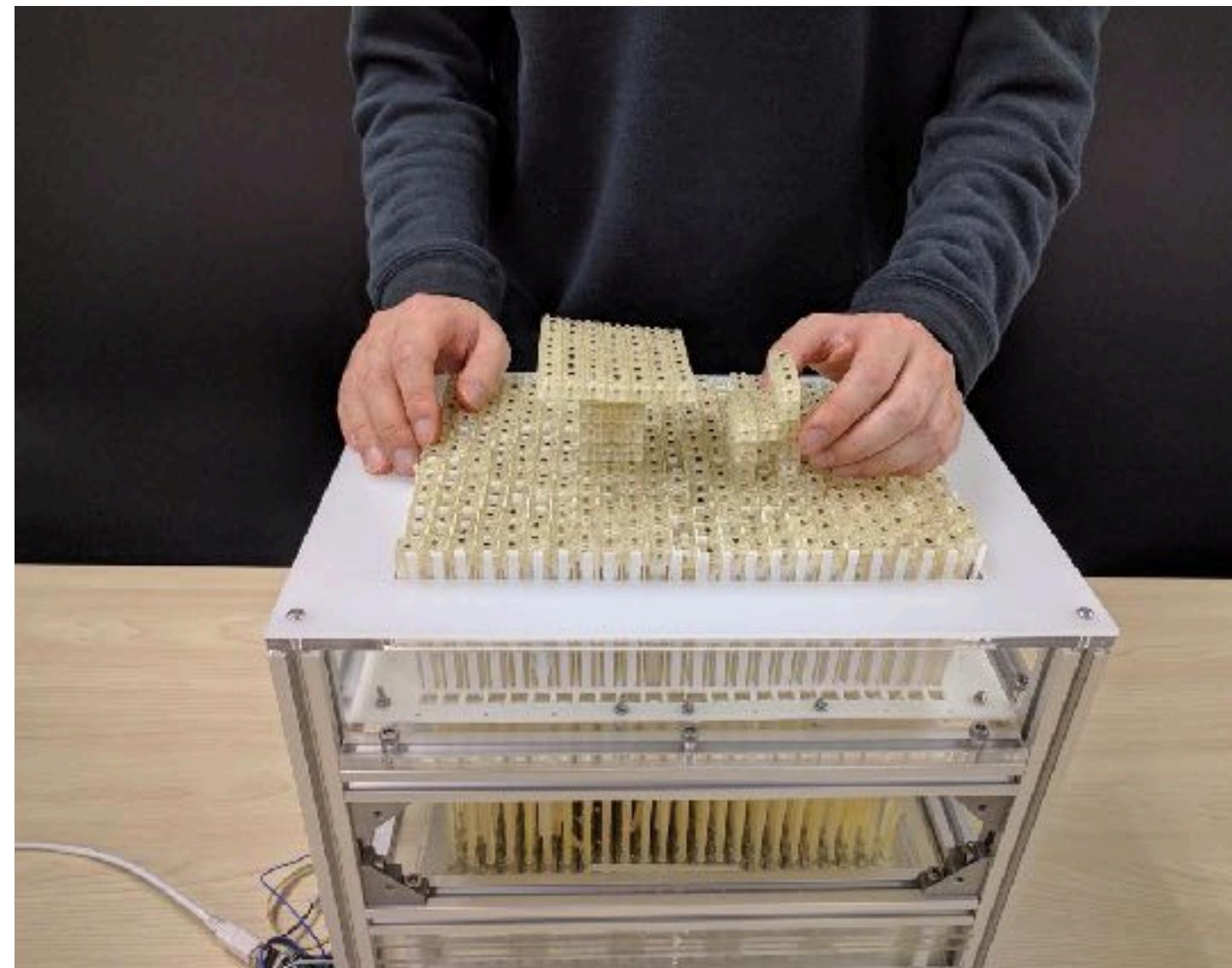
... but static



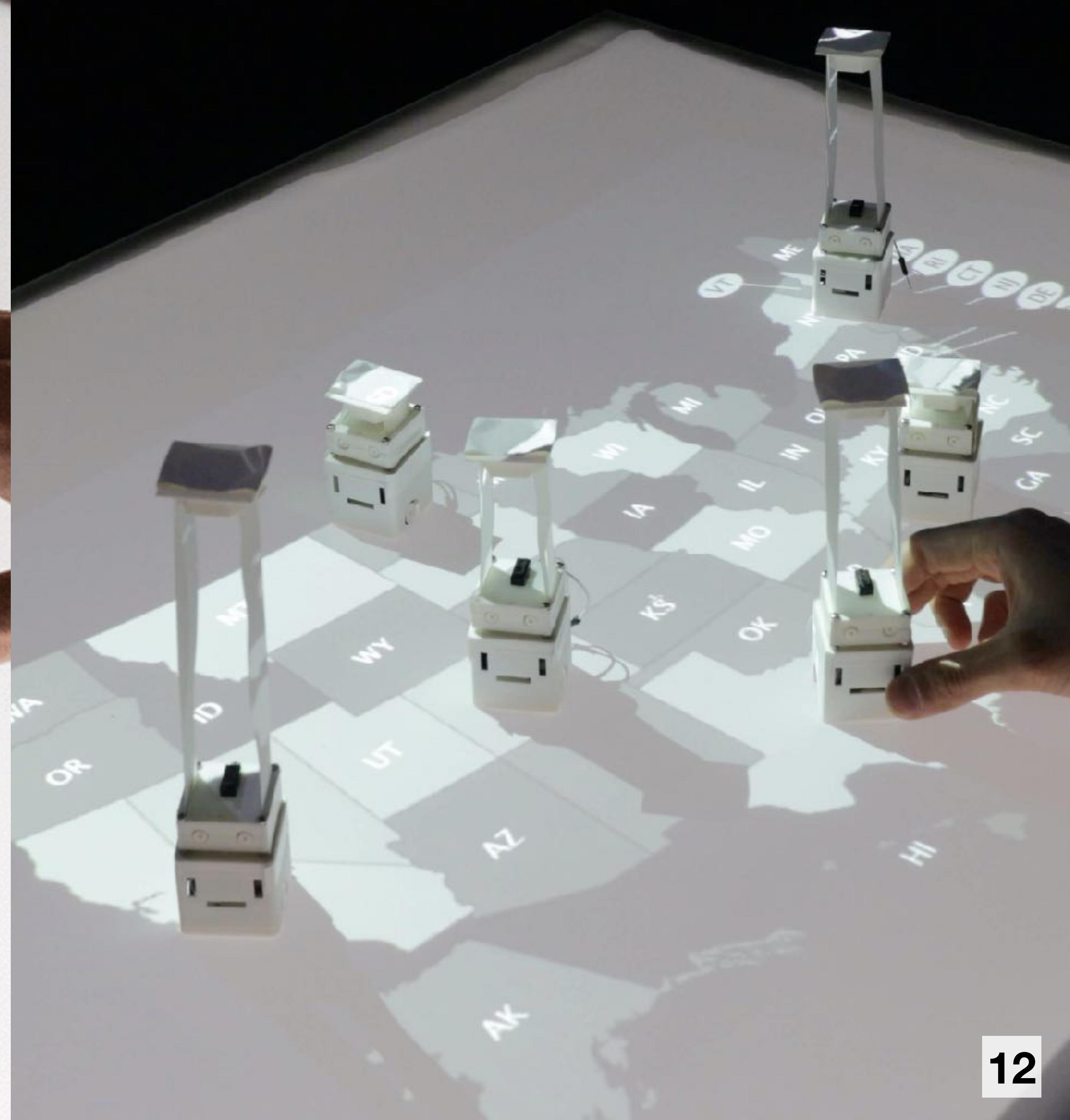
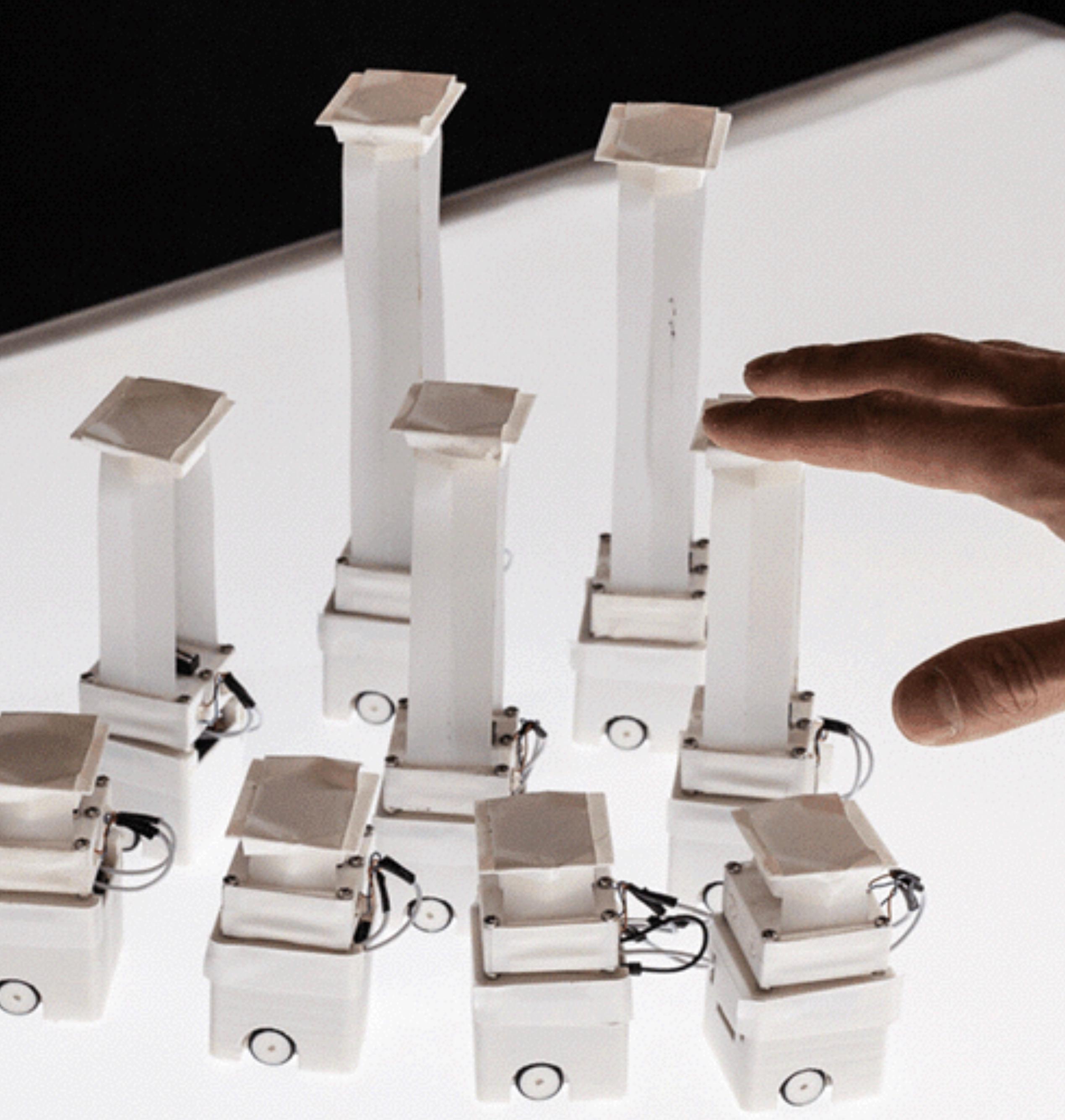
Robotic Assembly



Kinetic Blocks



Dynablock





Technical challenges

miniature size actuator
but large deformation capability

Highly extendable linear actuators



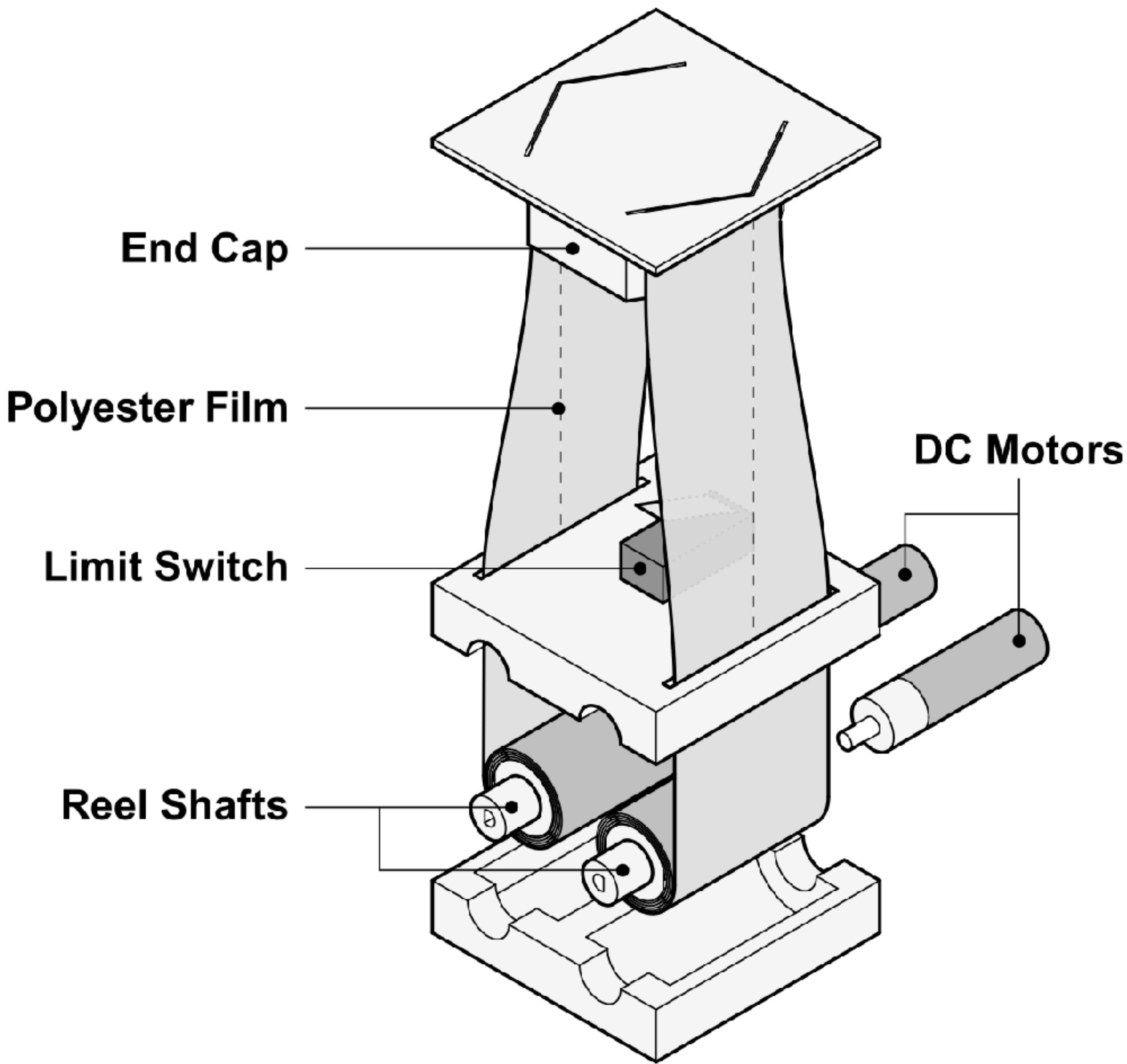
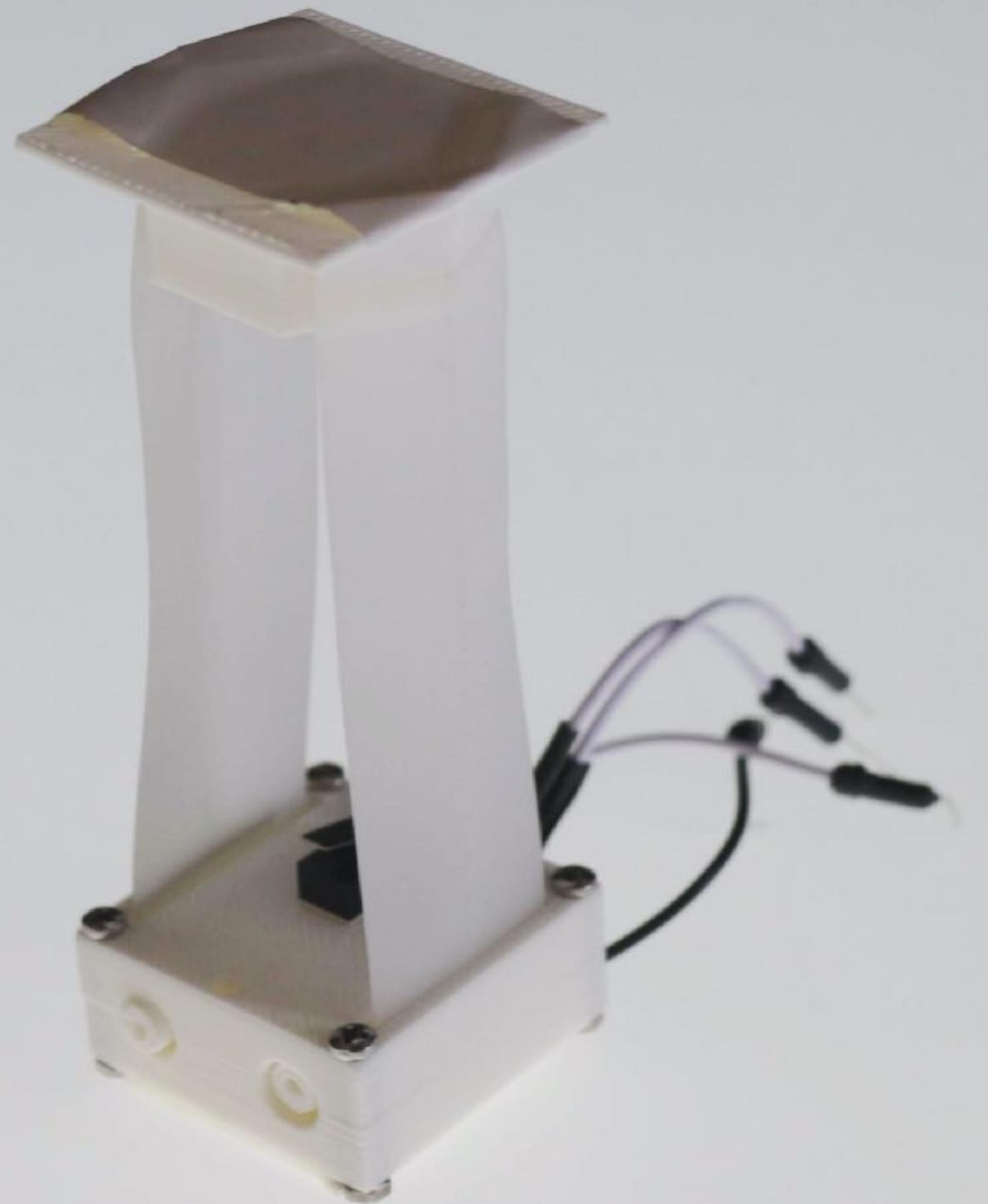
Pneumatic Reel Actuator

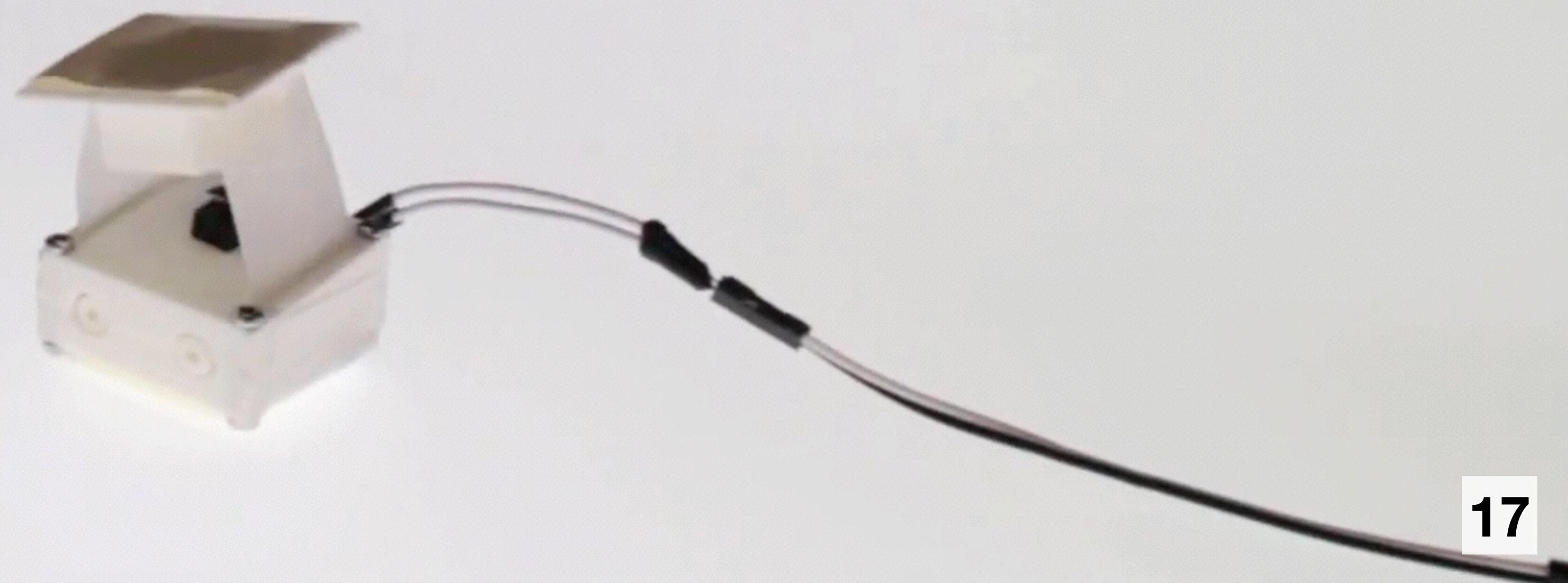


Morphys

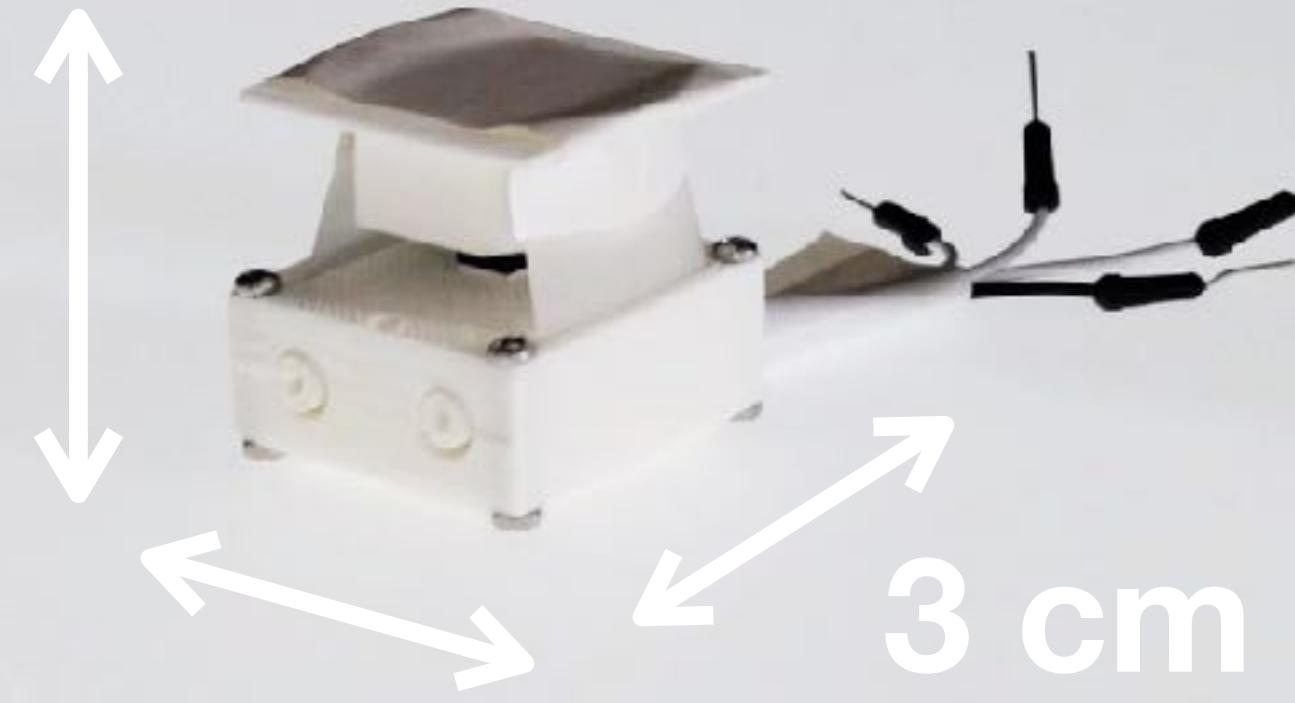


G-Raff

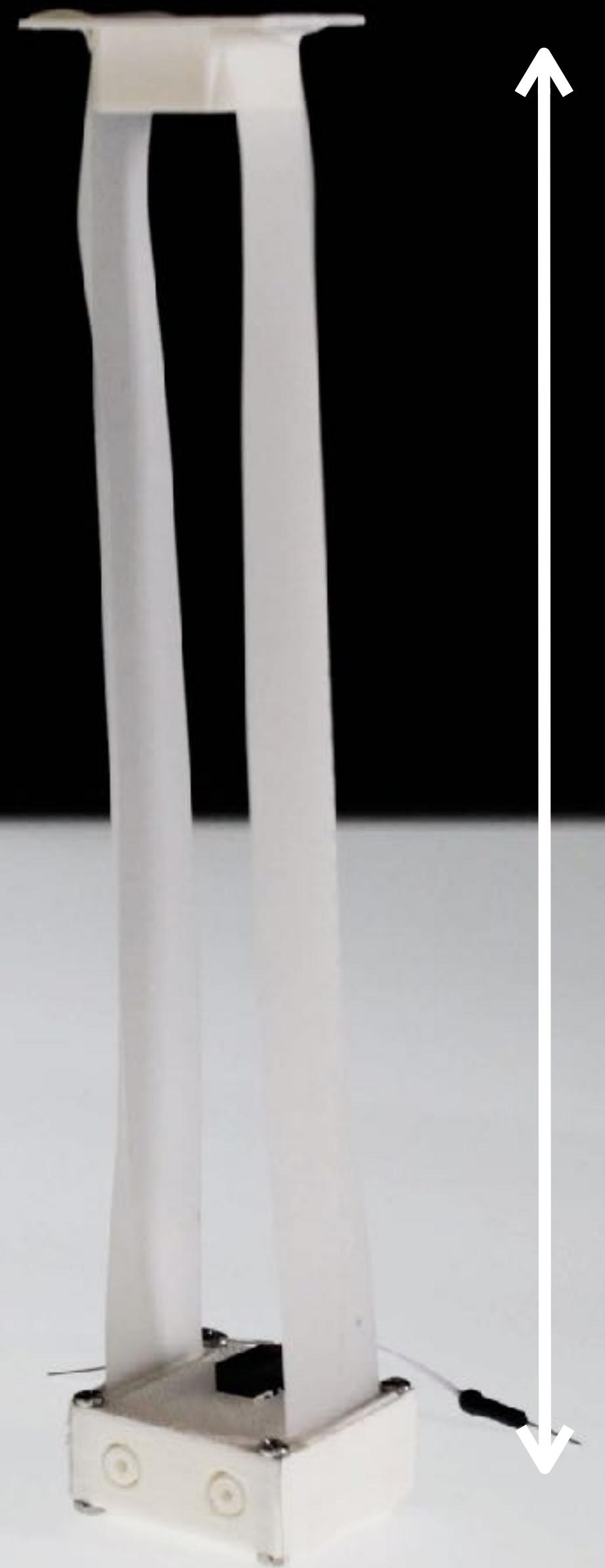


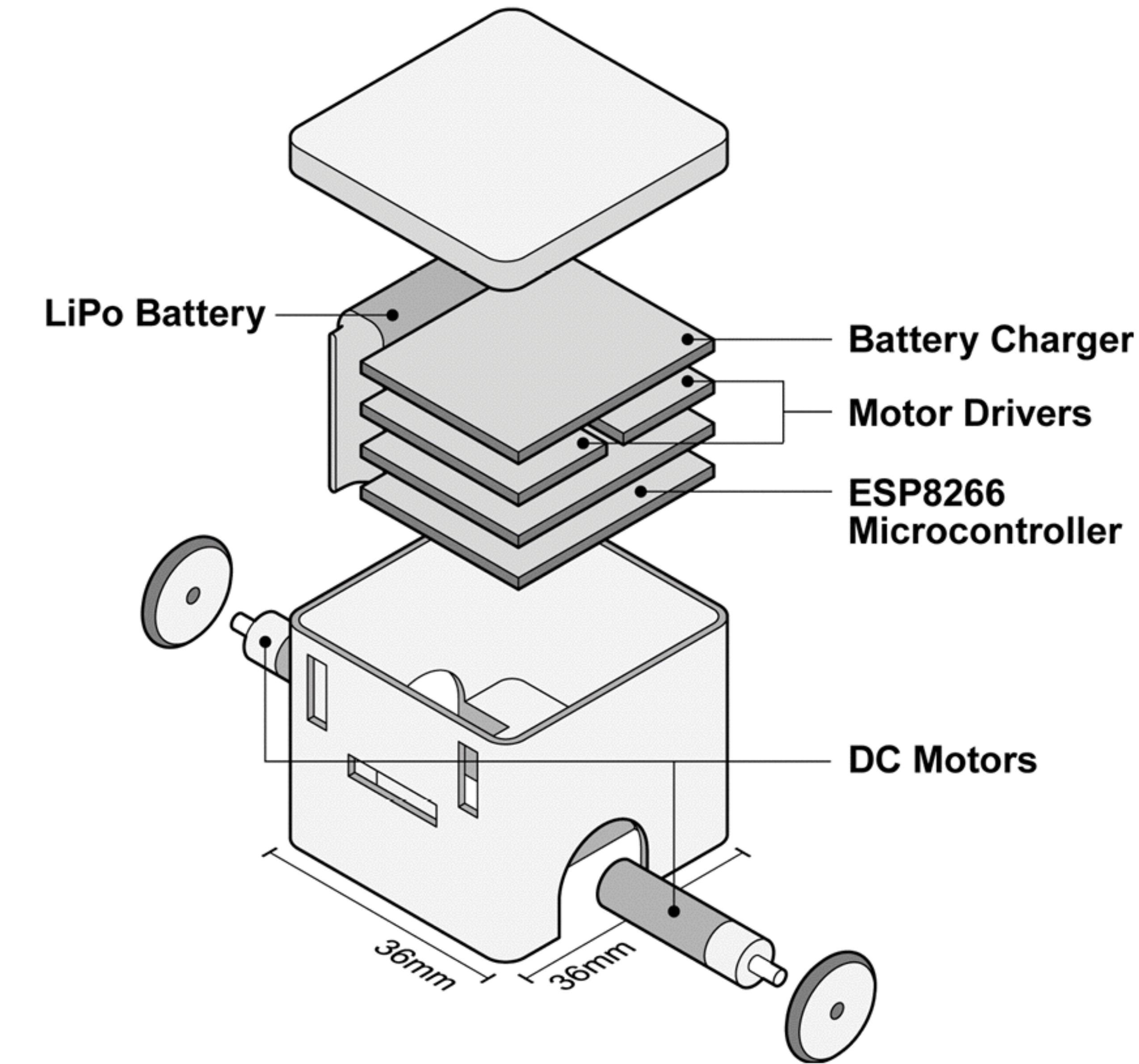


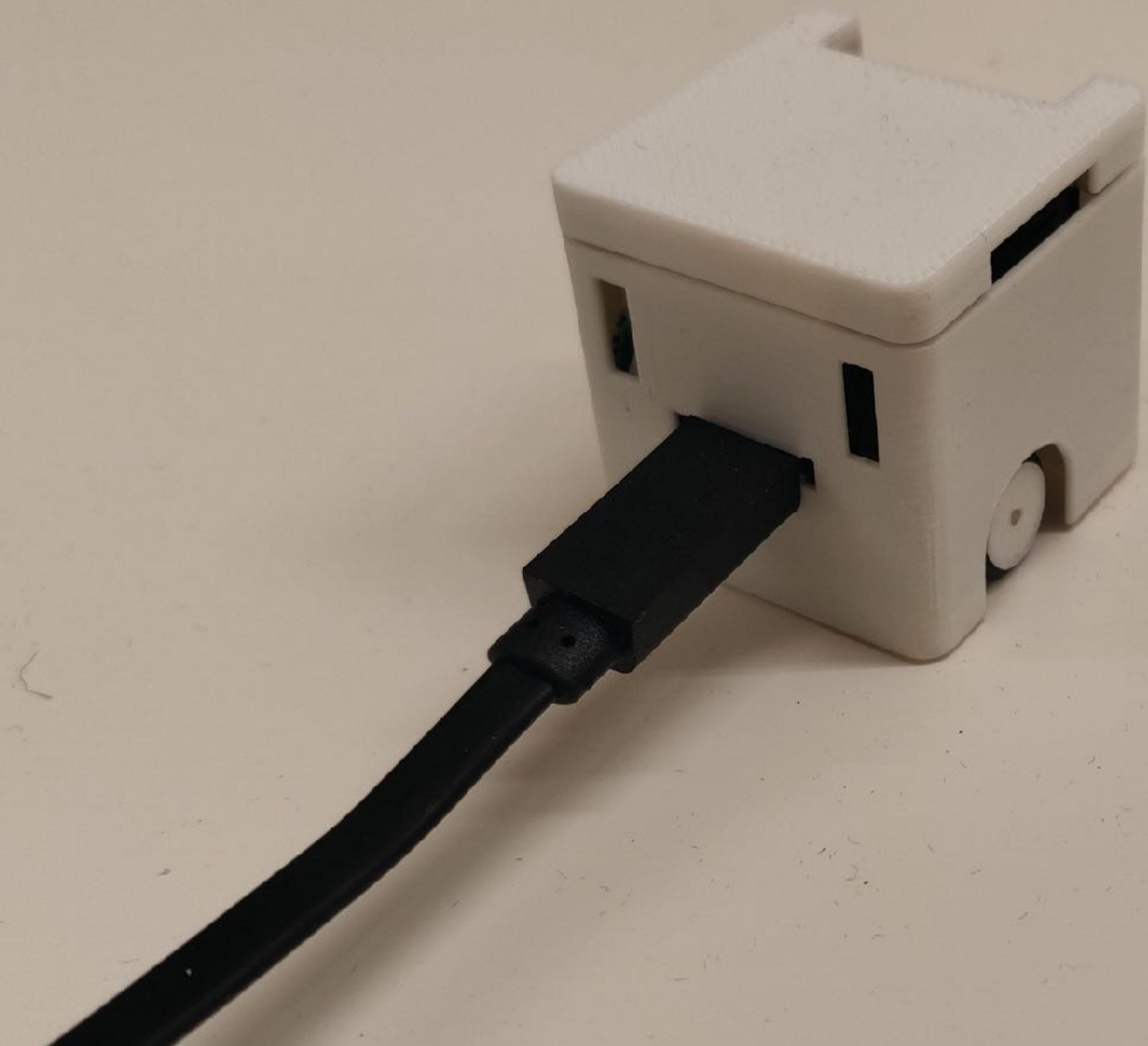
2 cm

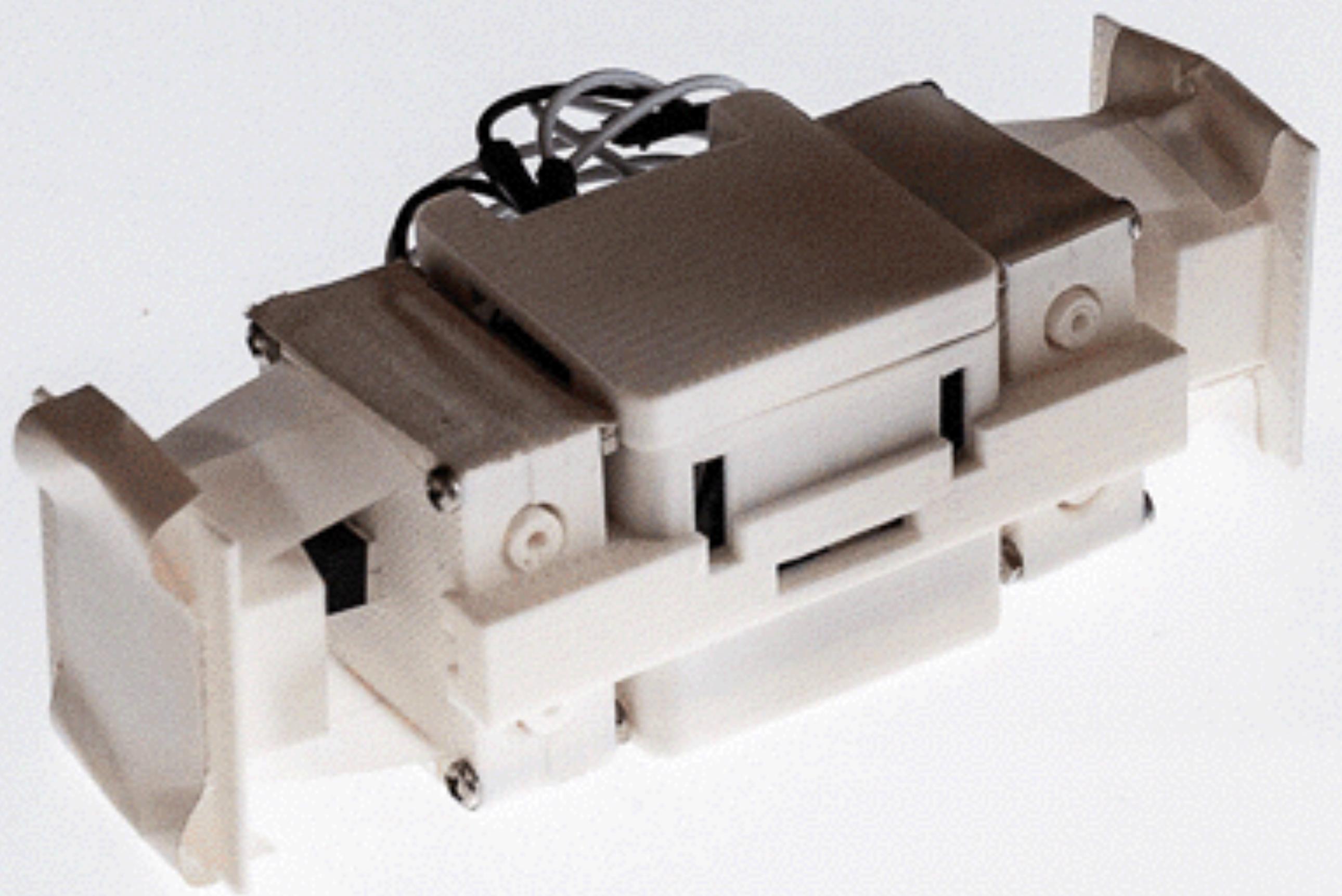


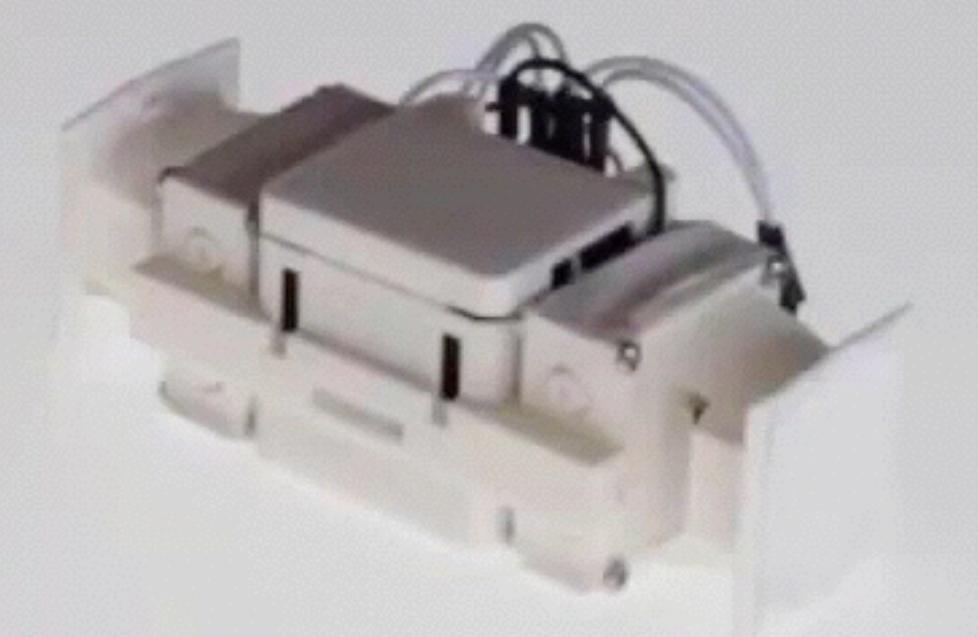
3 cm

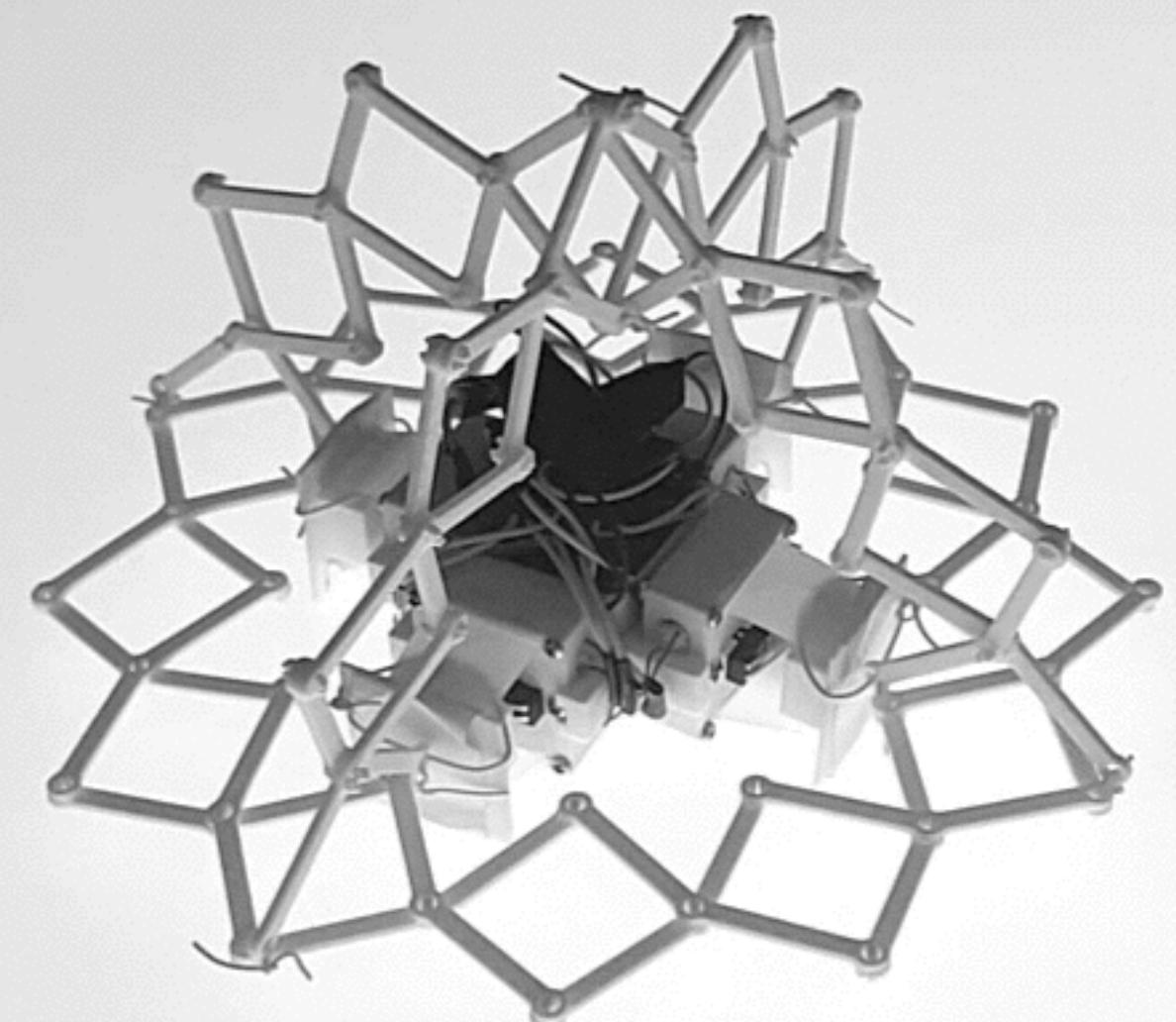
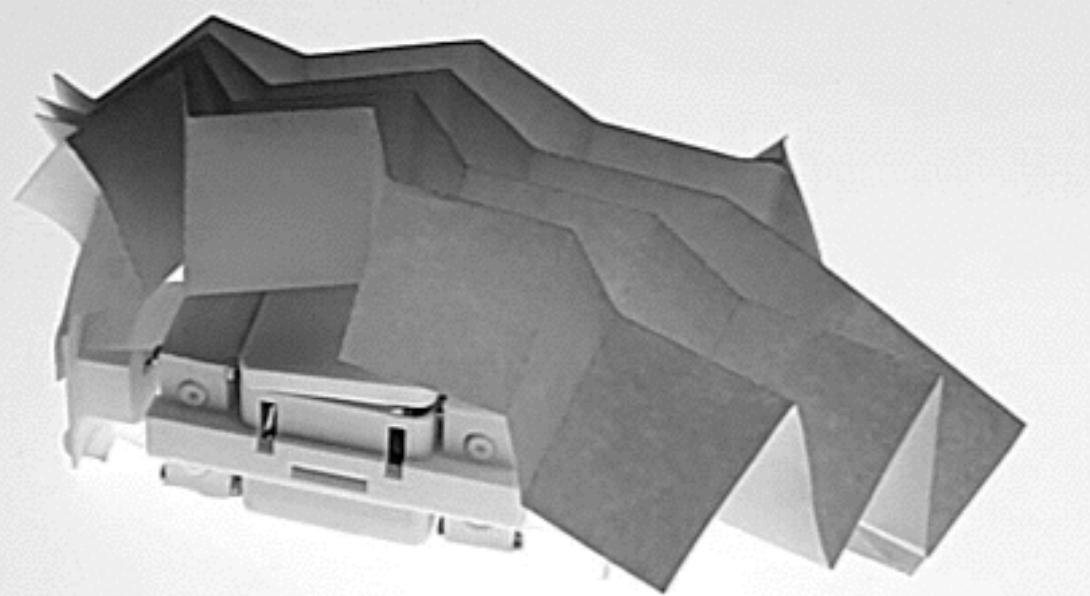
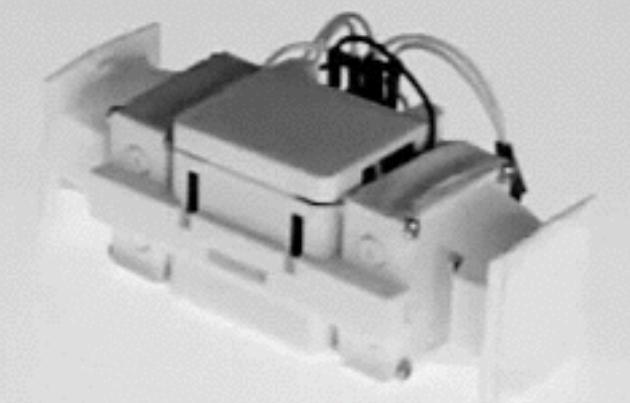
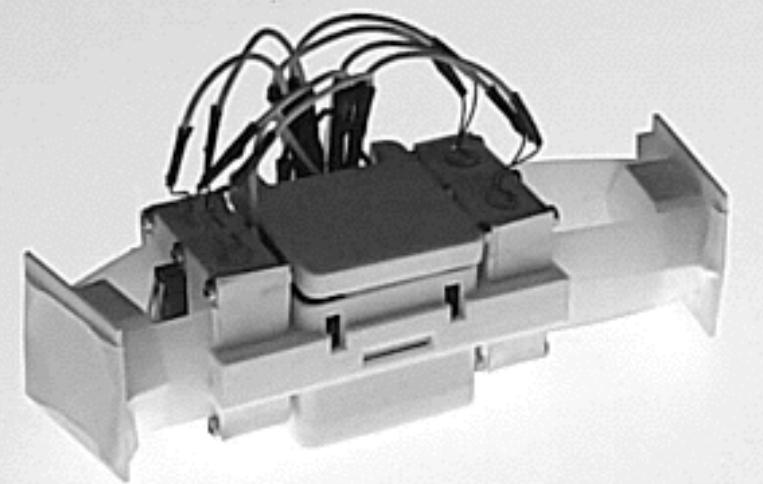




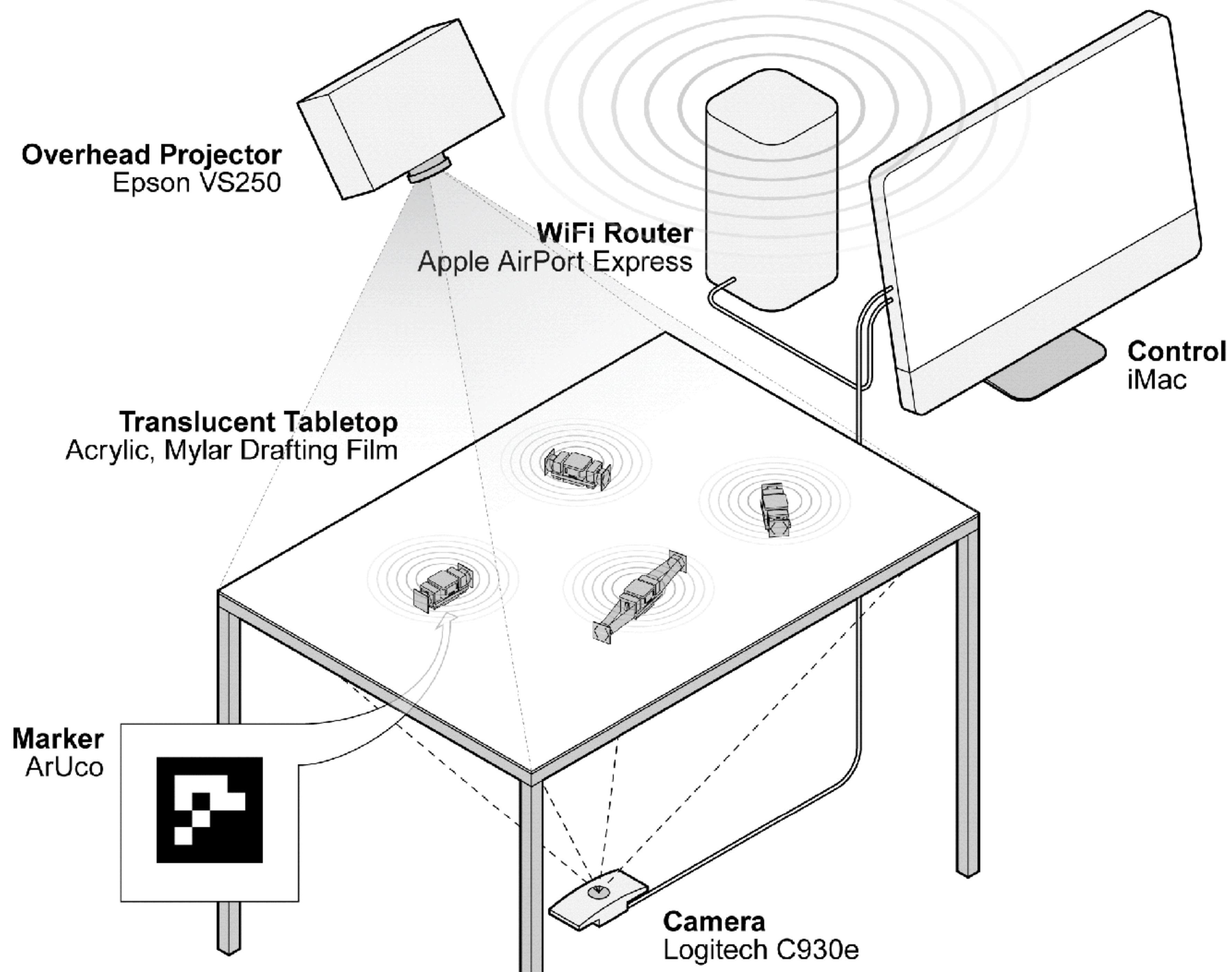




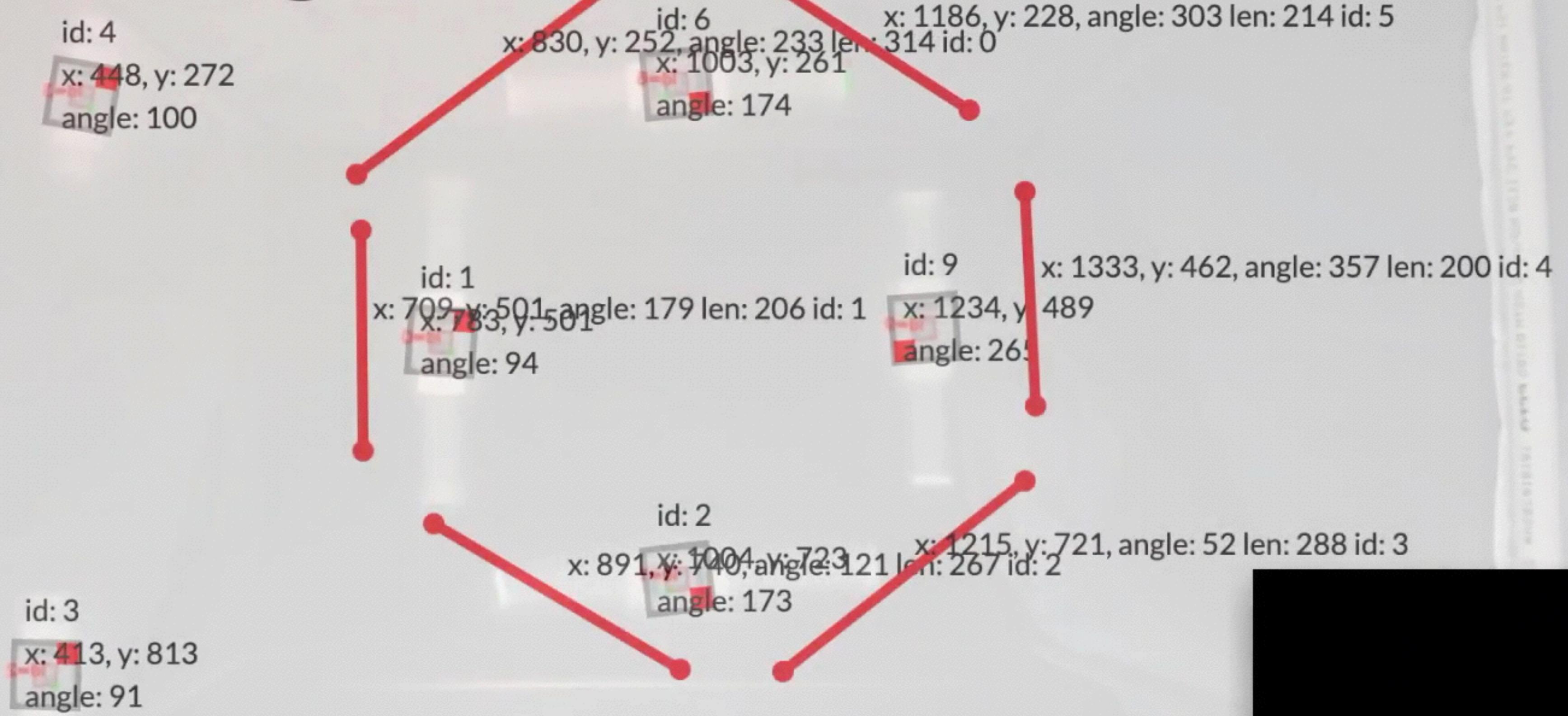








Tracking and GUI Controller



Move	Clear	Init
Stop	Wave	

Initialize before moving

Enable extend

Add

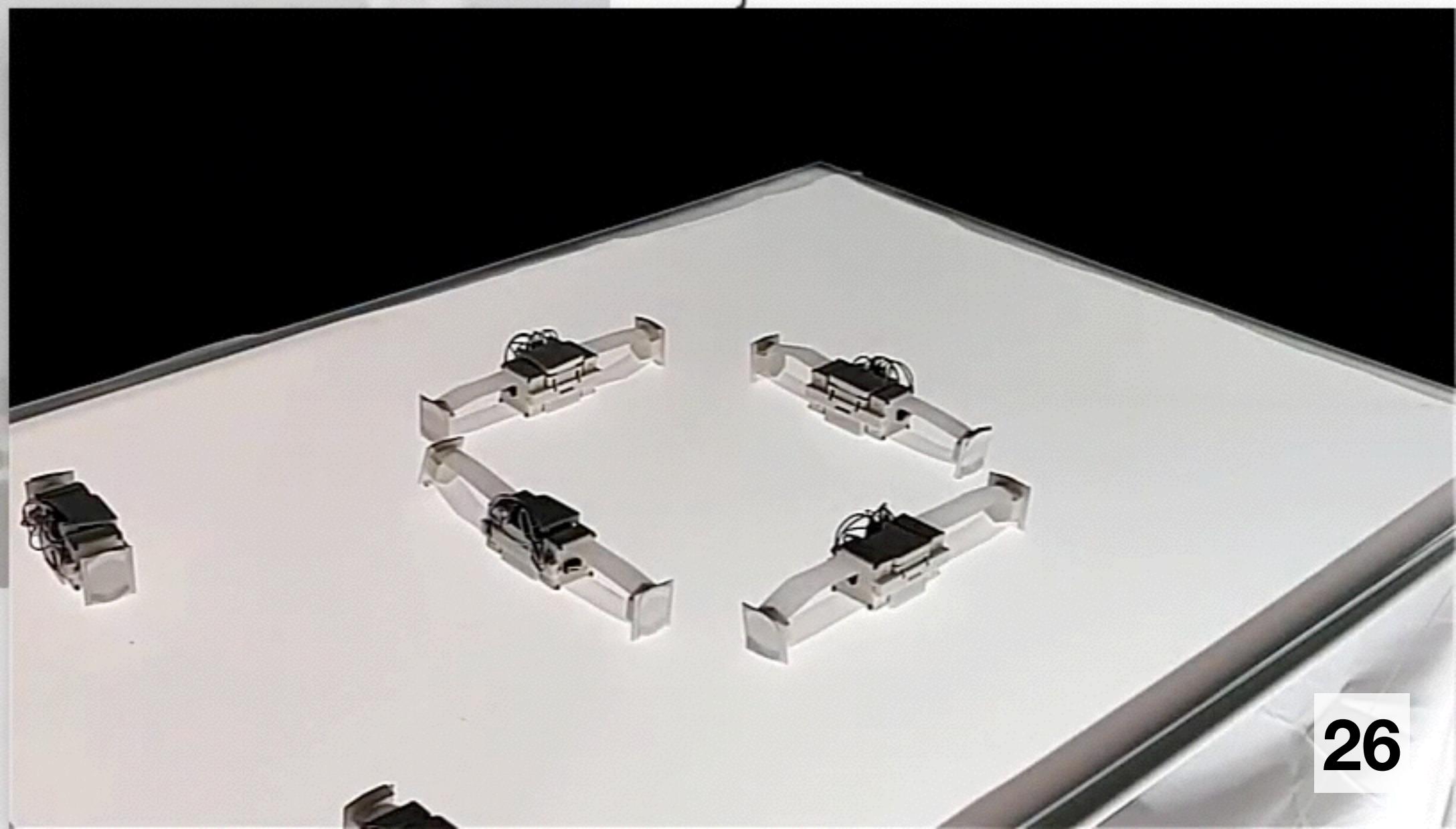
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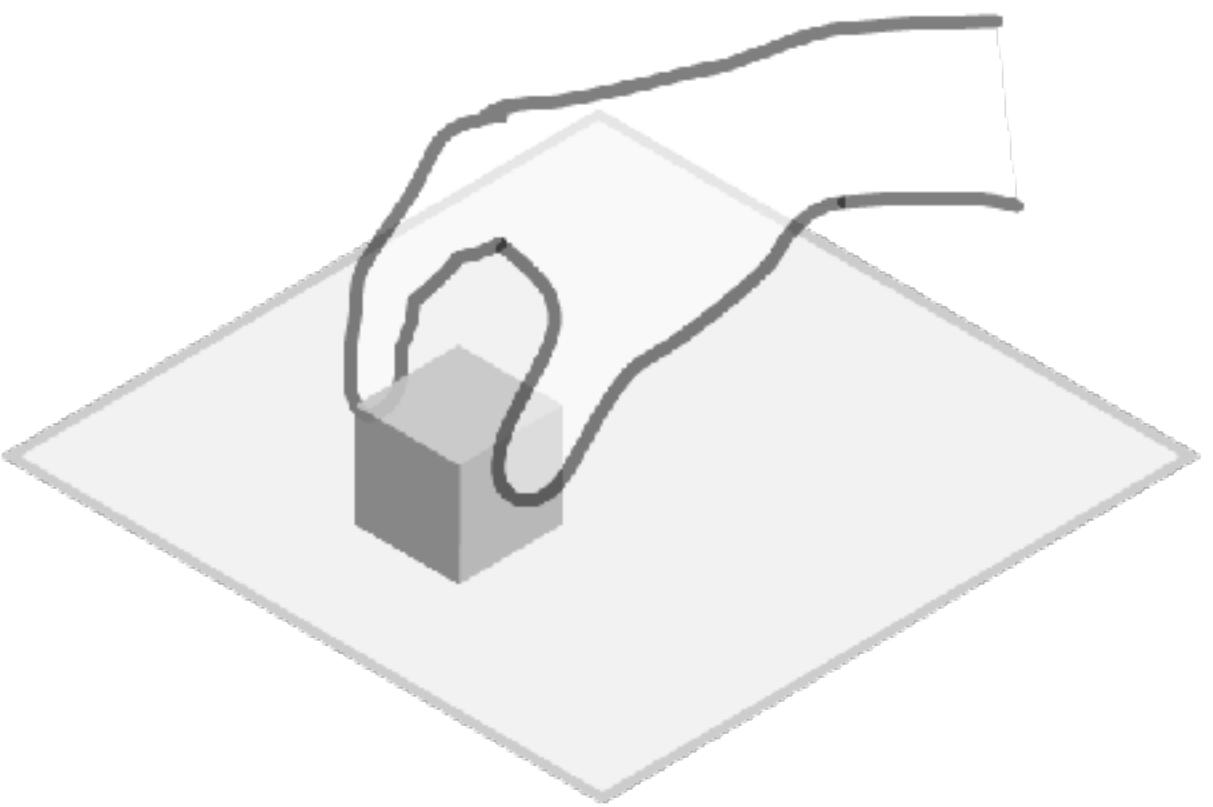
Load

Choose ▾

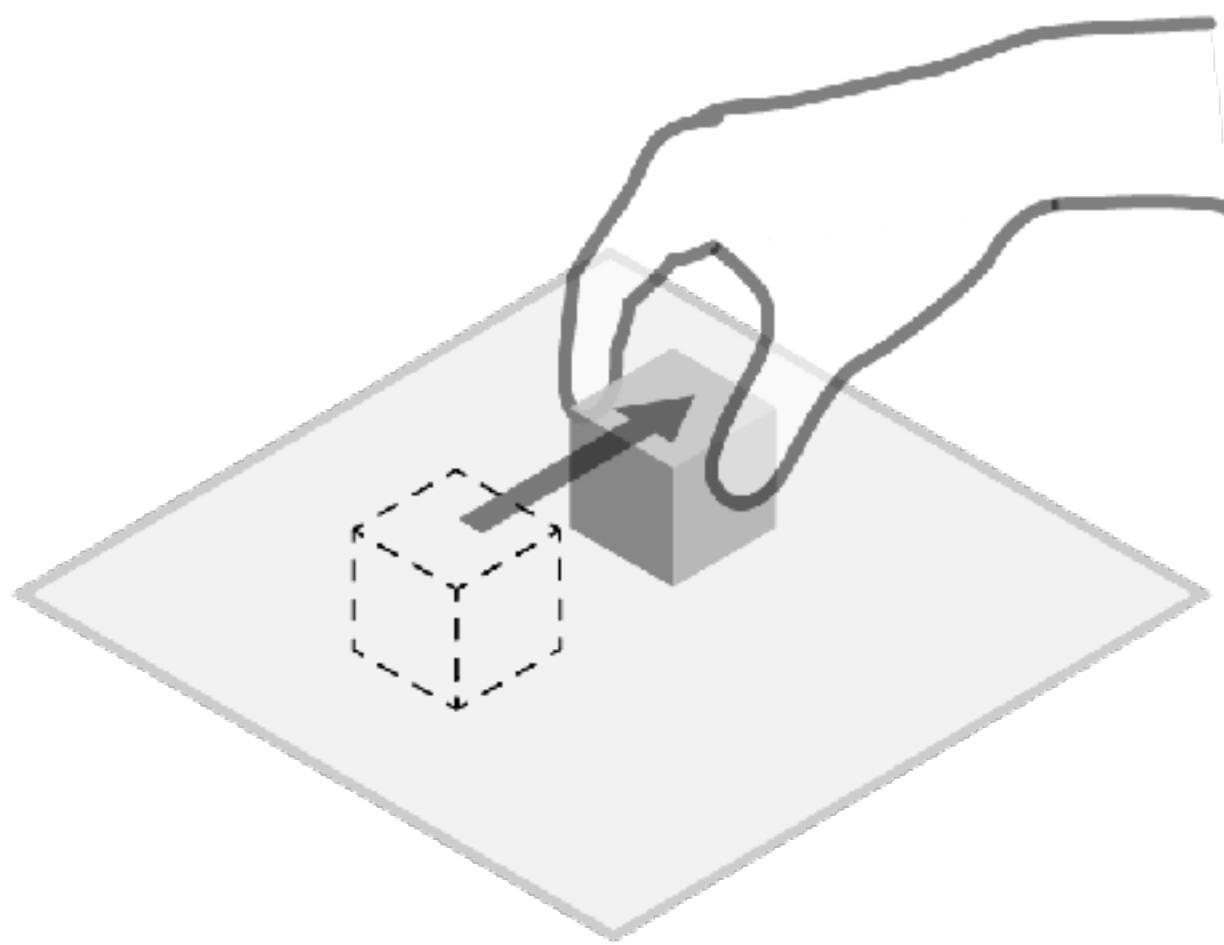
Robots

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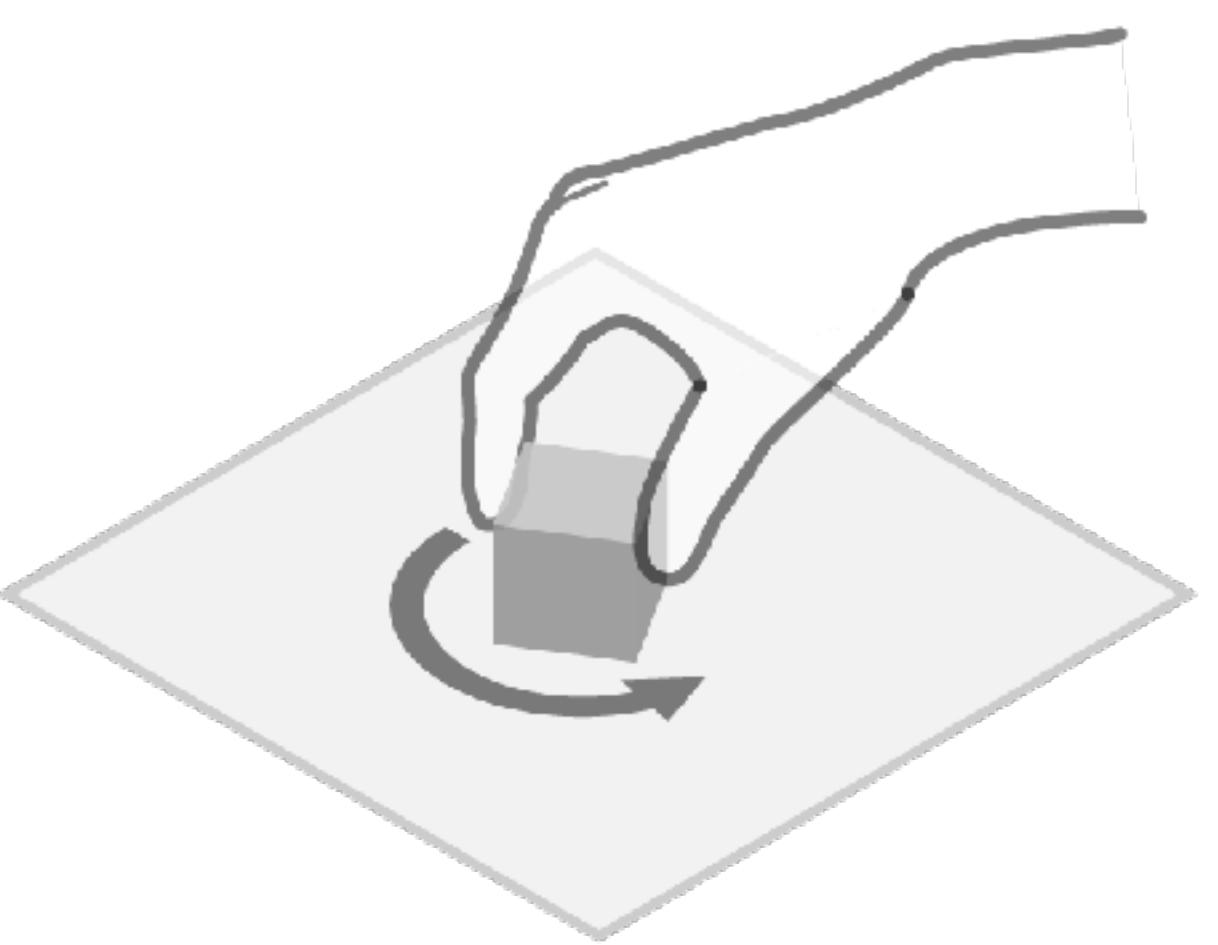




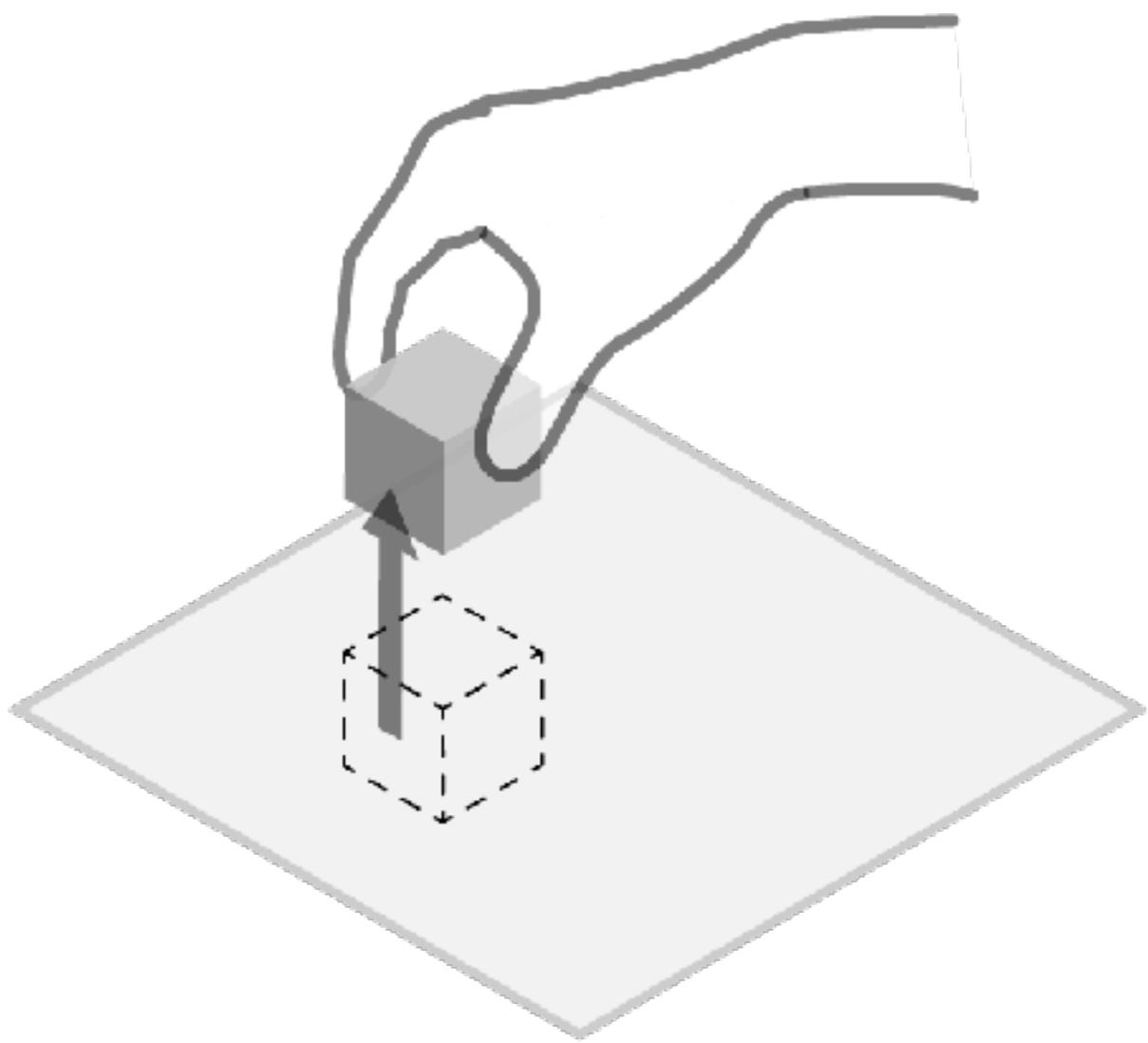
Locate



Move

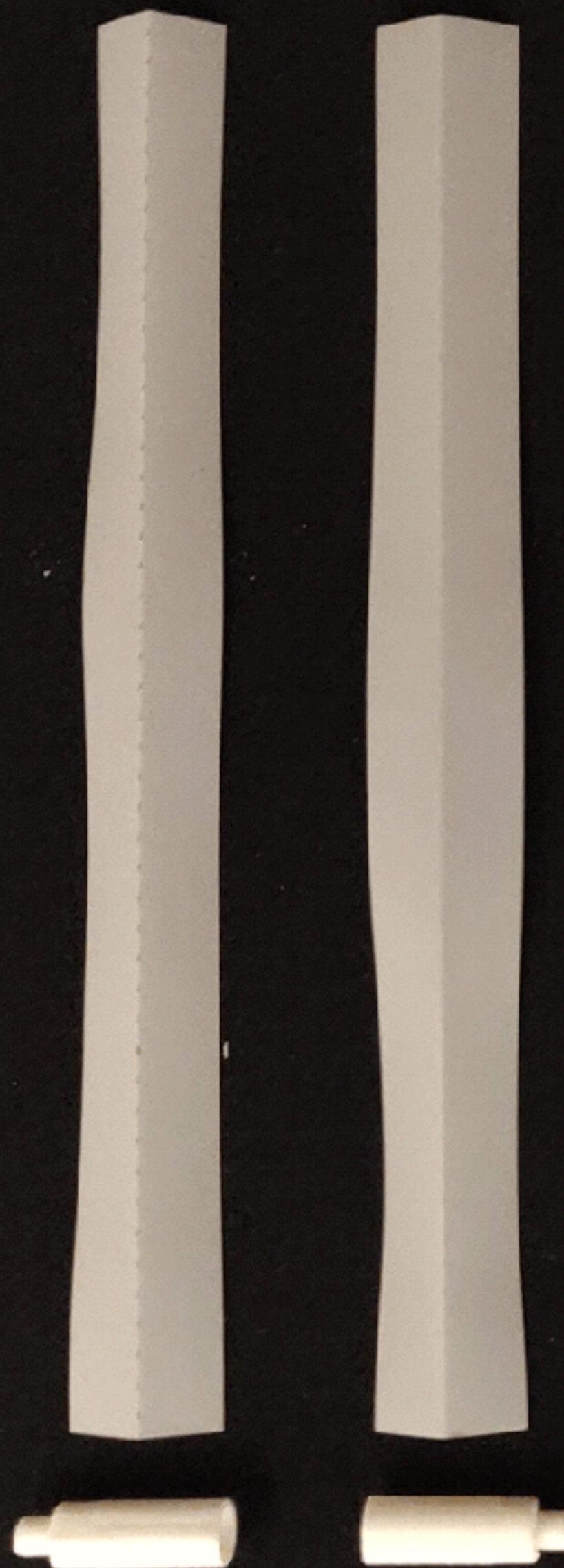


Orient



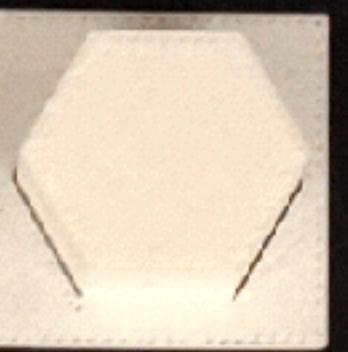
Pickup

Polyester Sheet

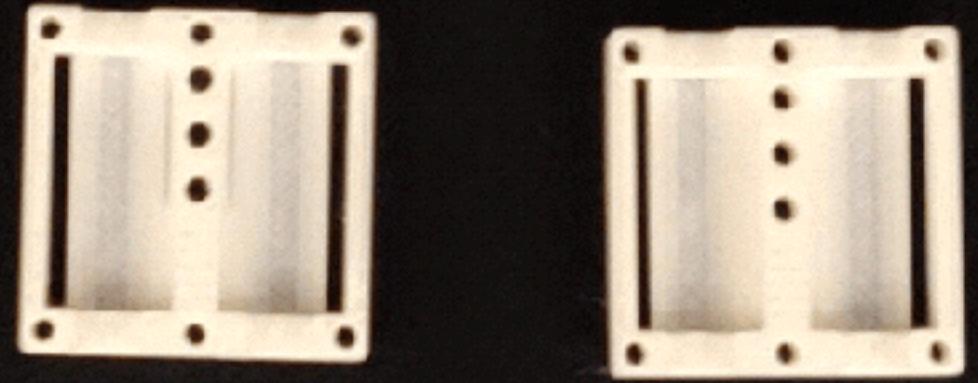


Reel Shafts

End Cap



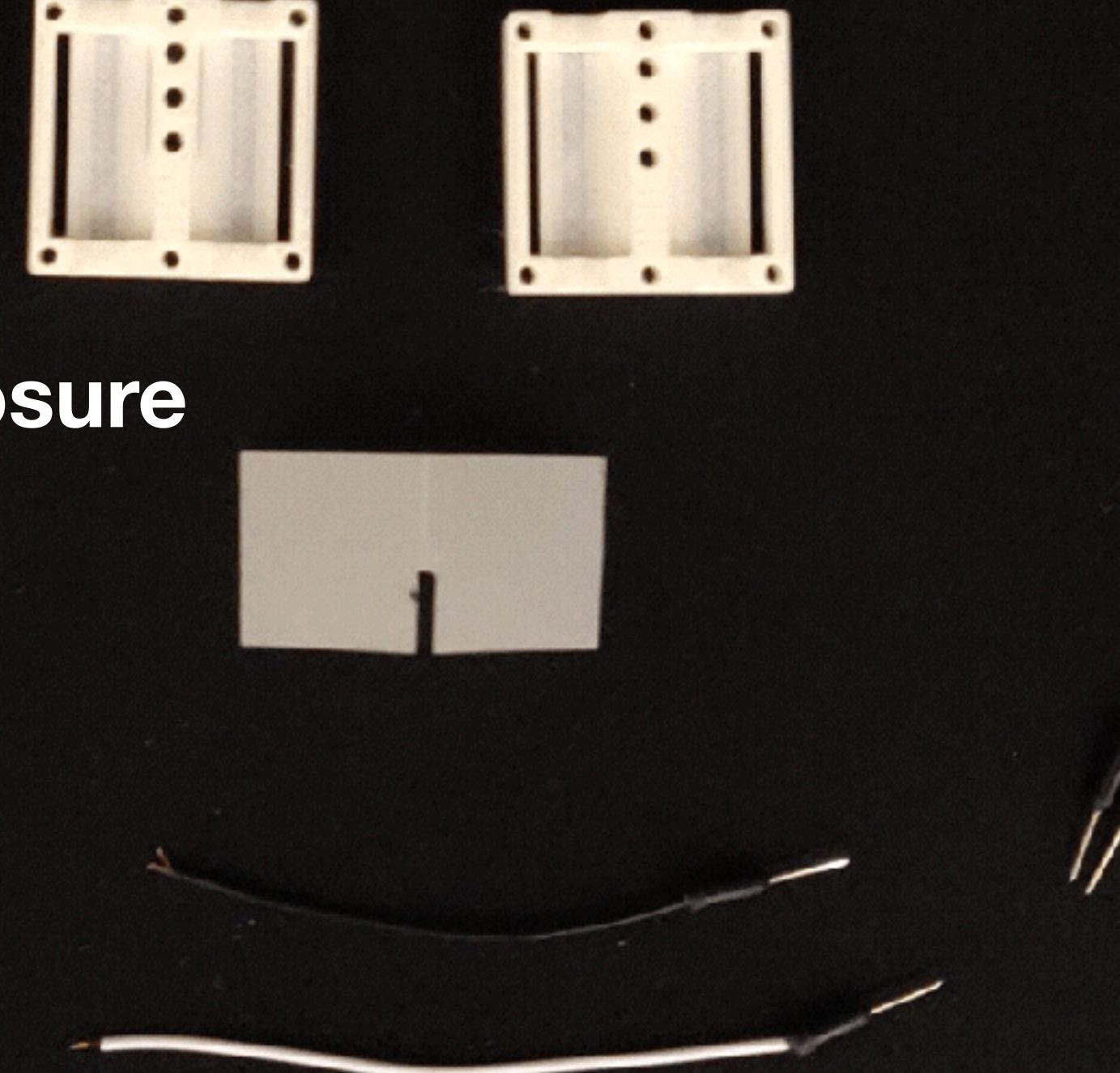
Enclosure

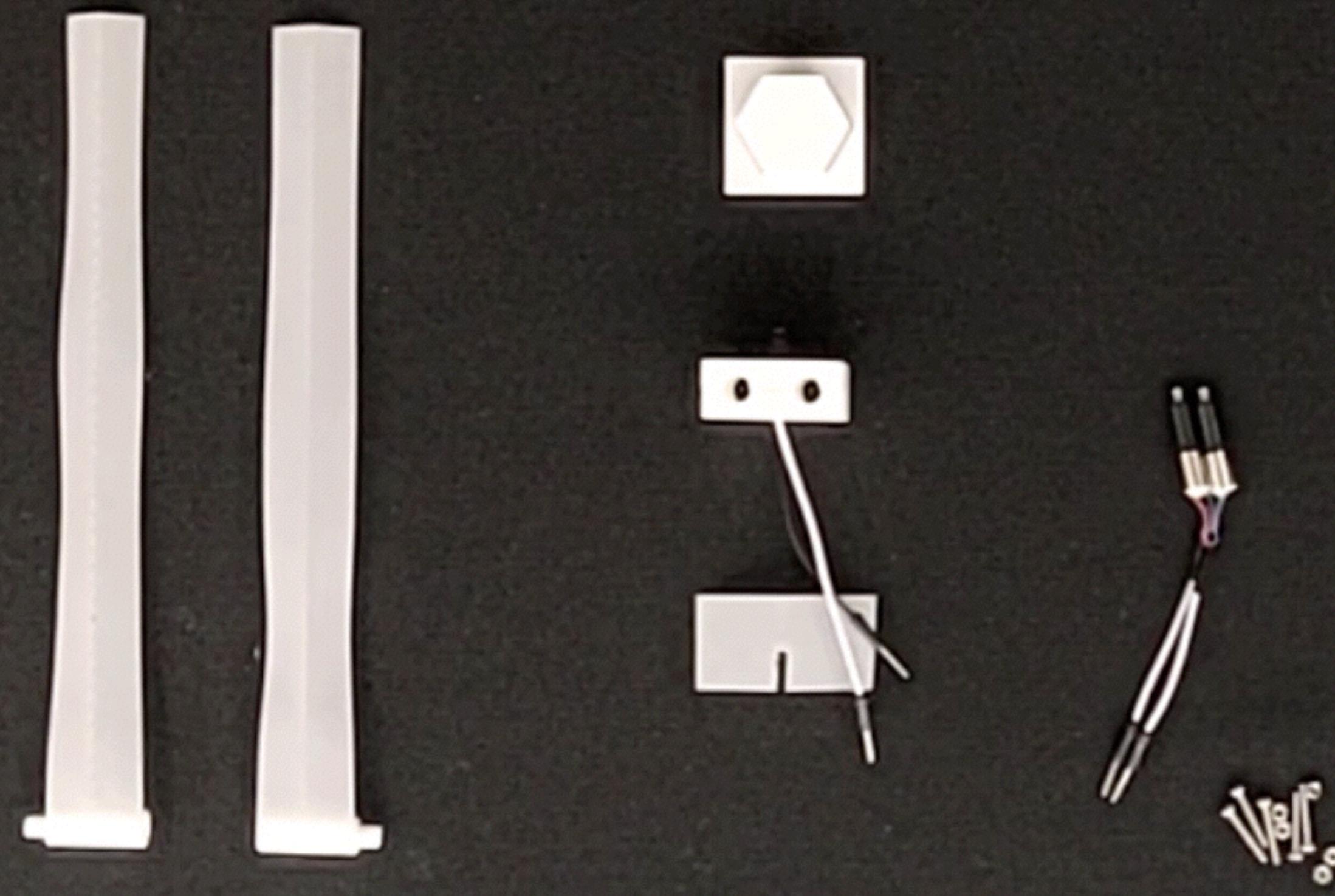


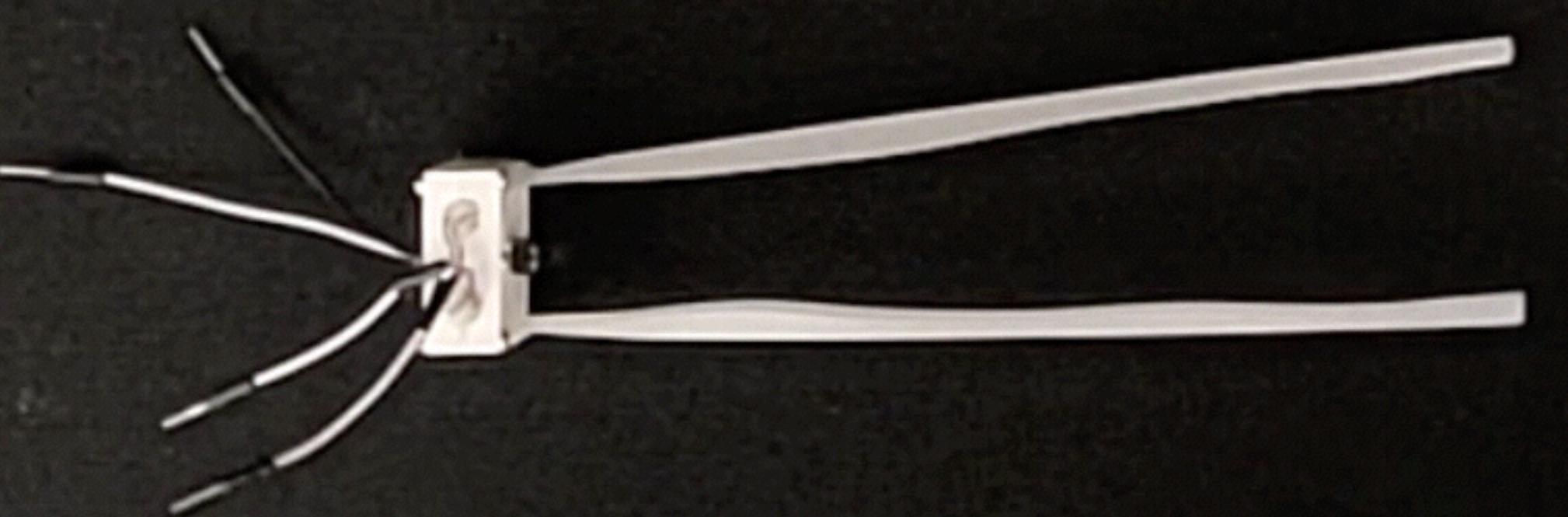
Limit Switch

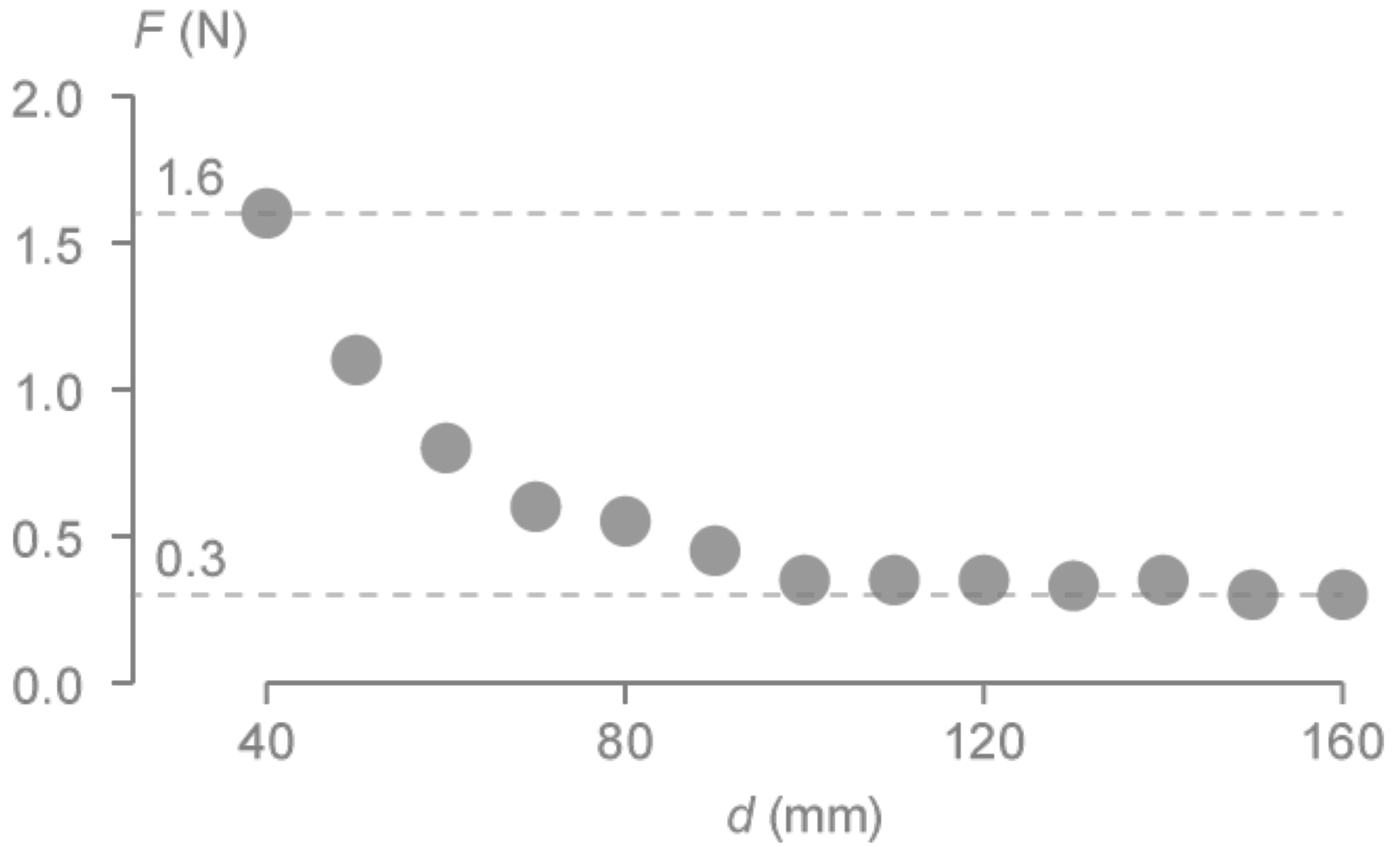
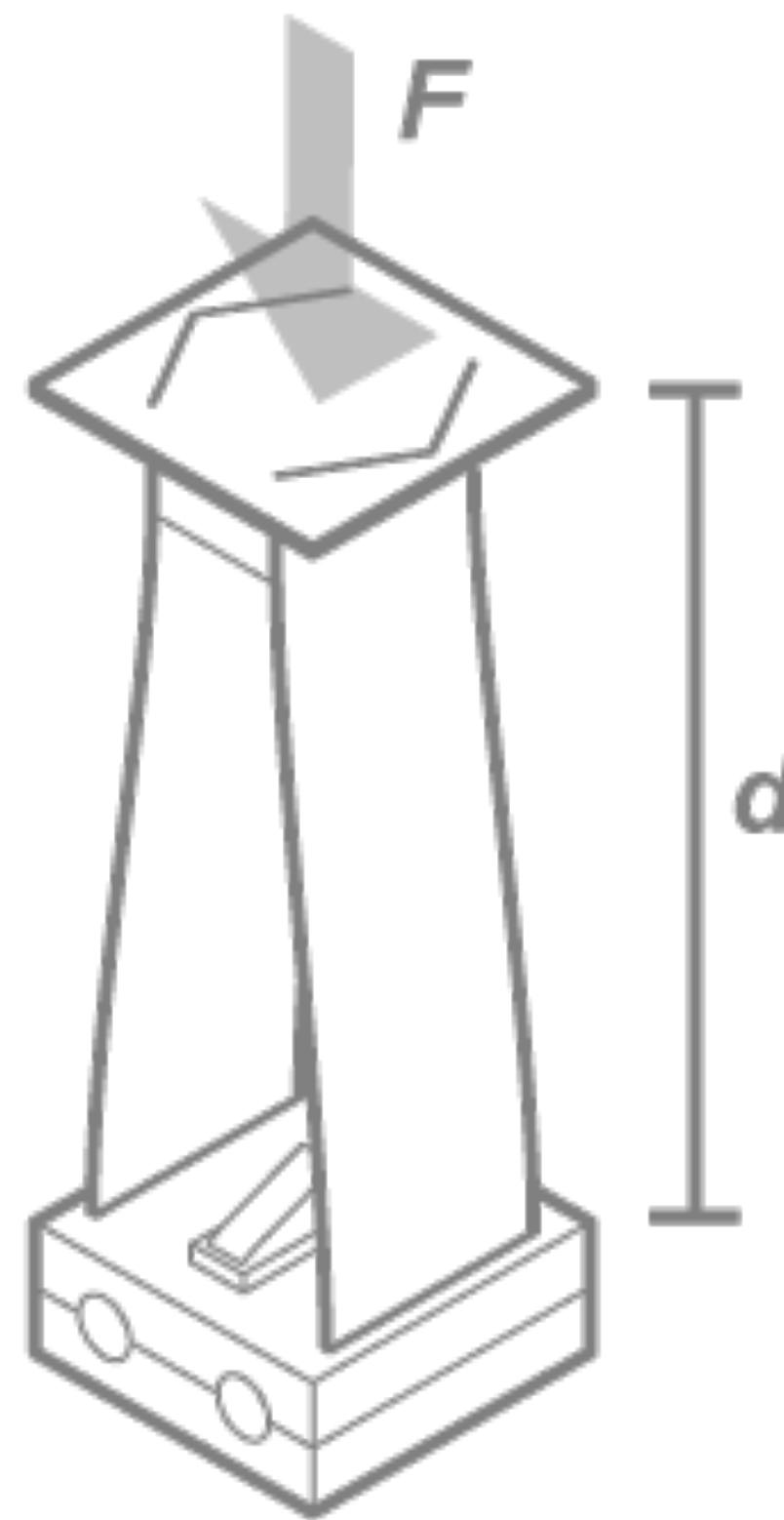


DC Motors



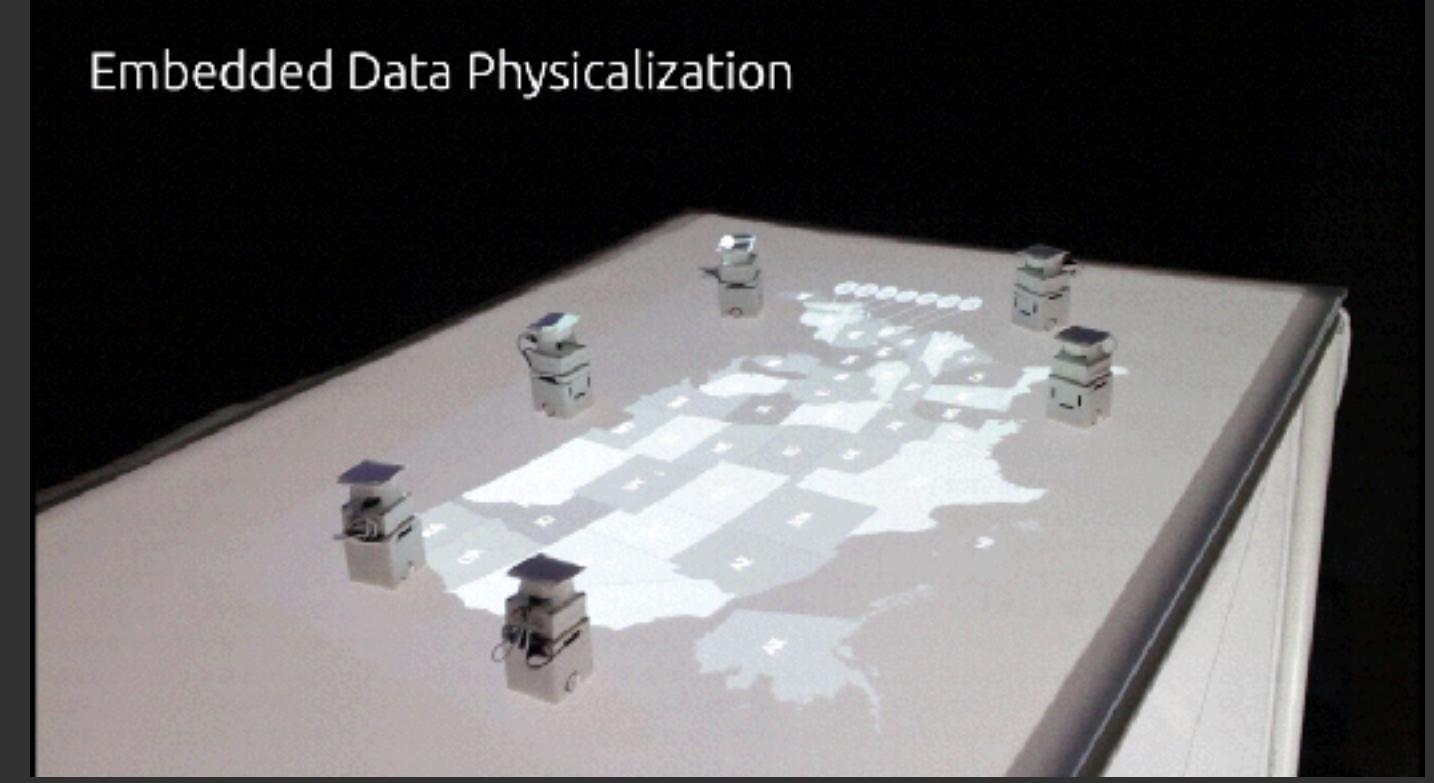
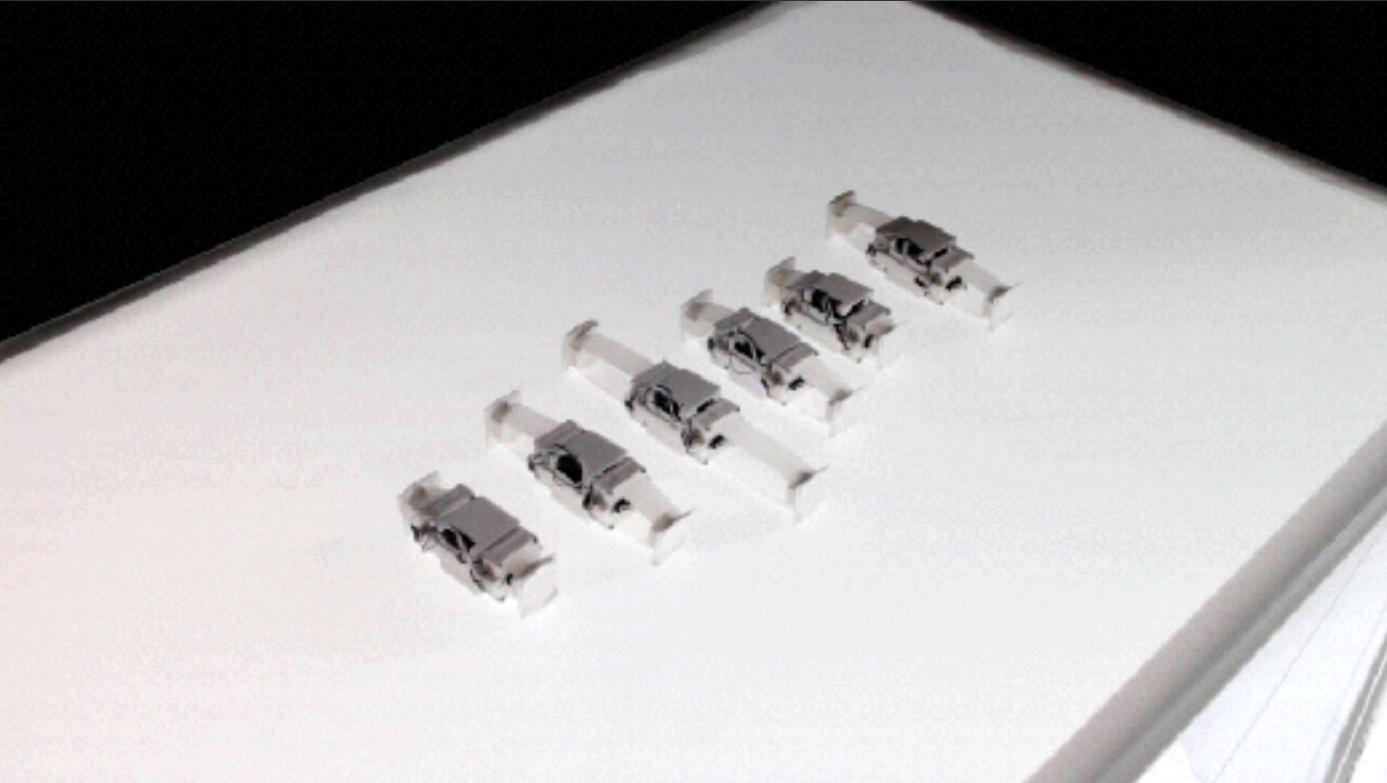
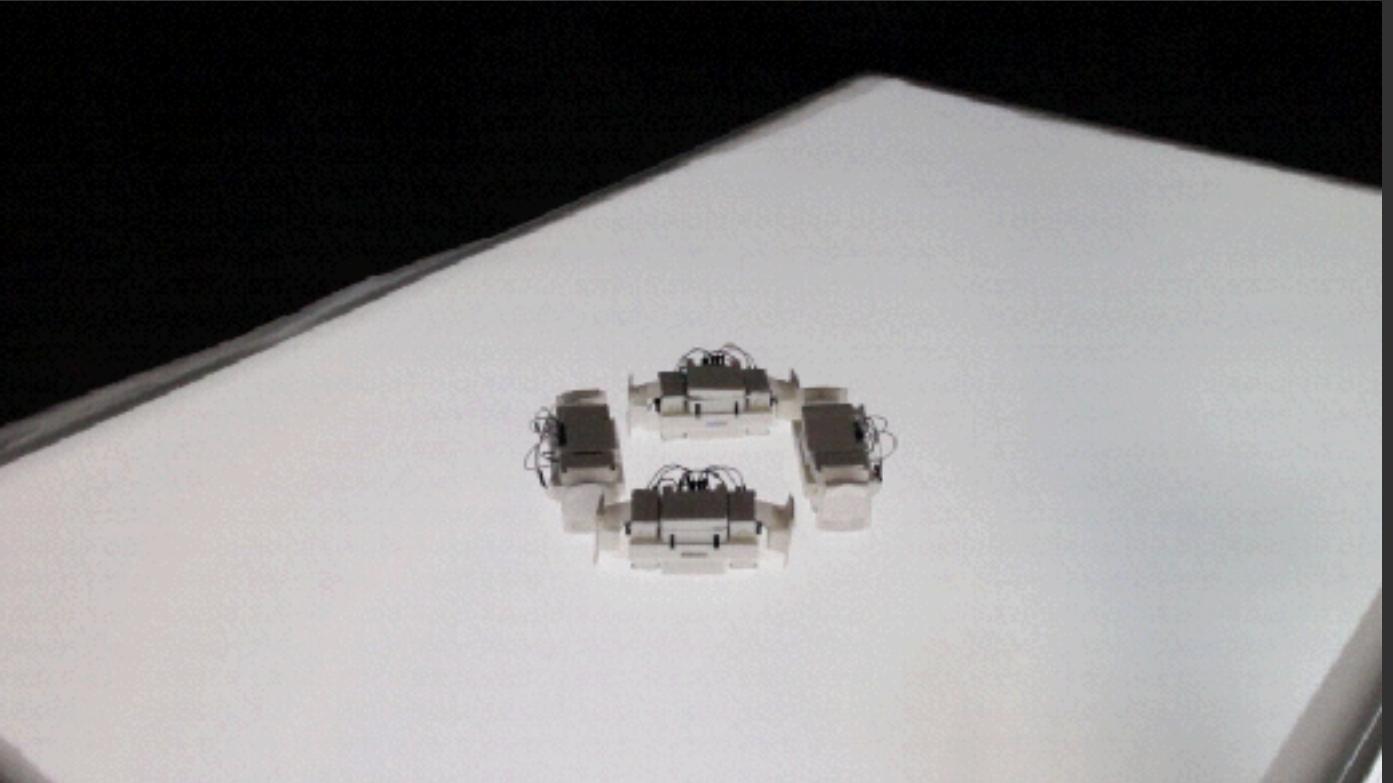




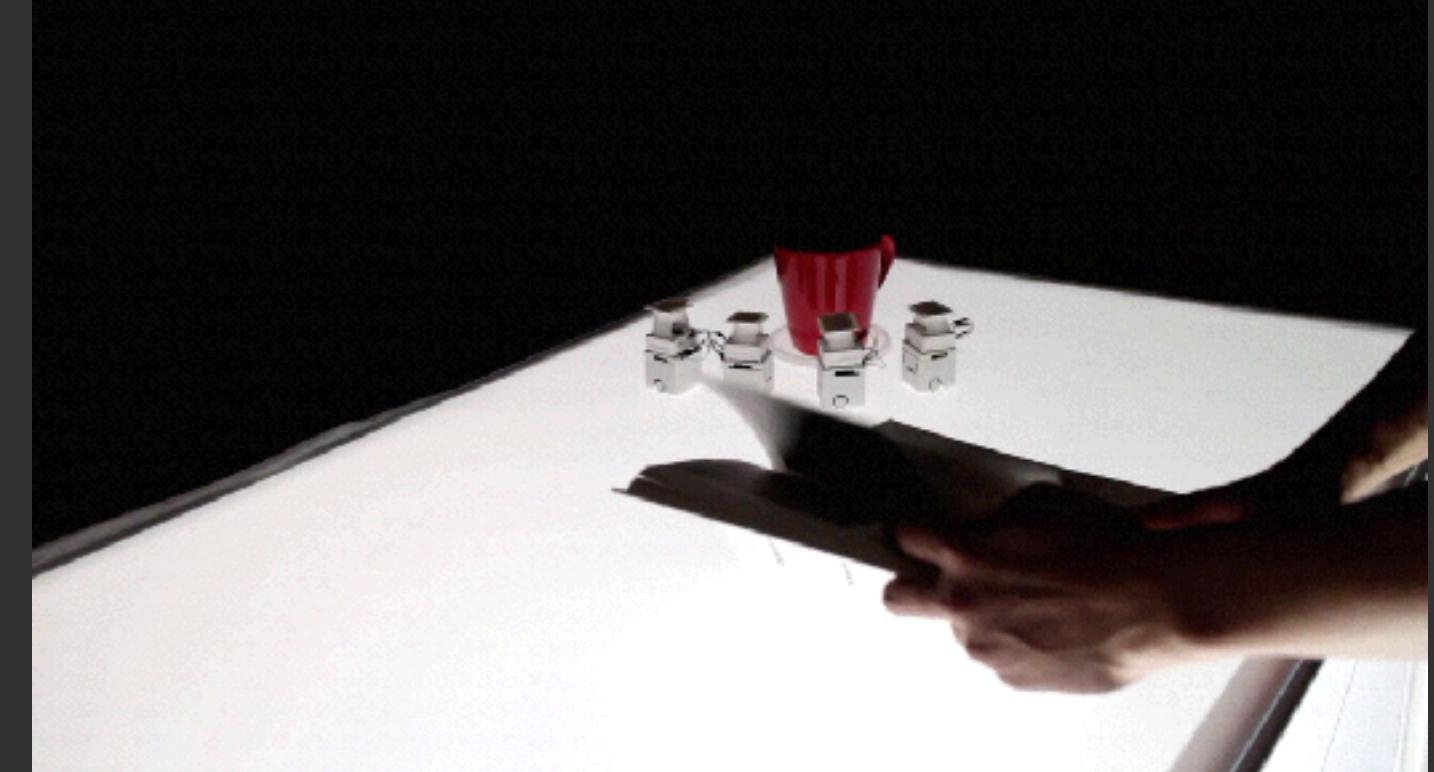
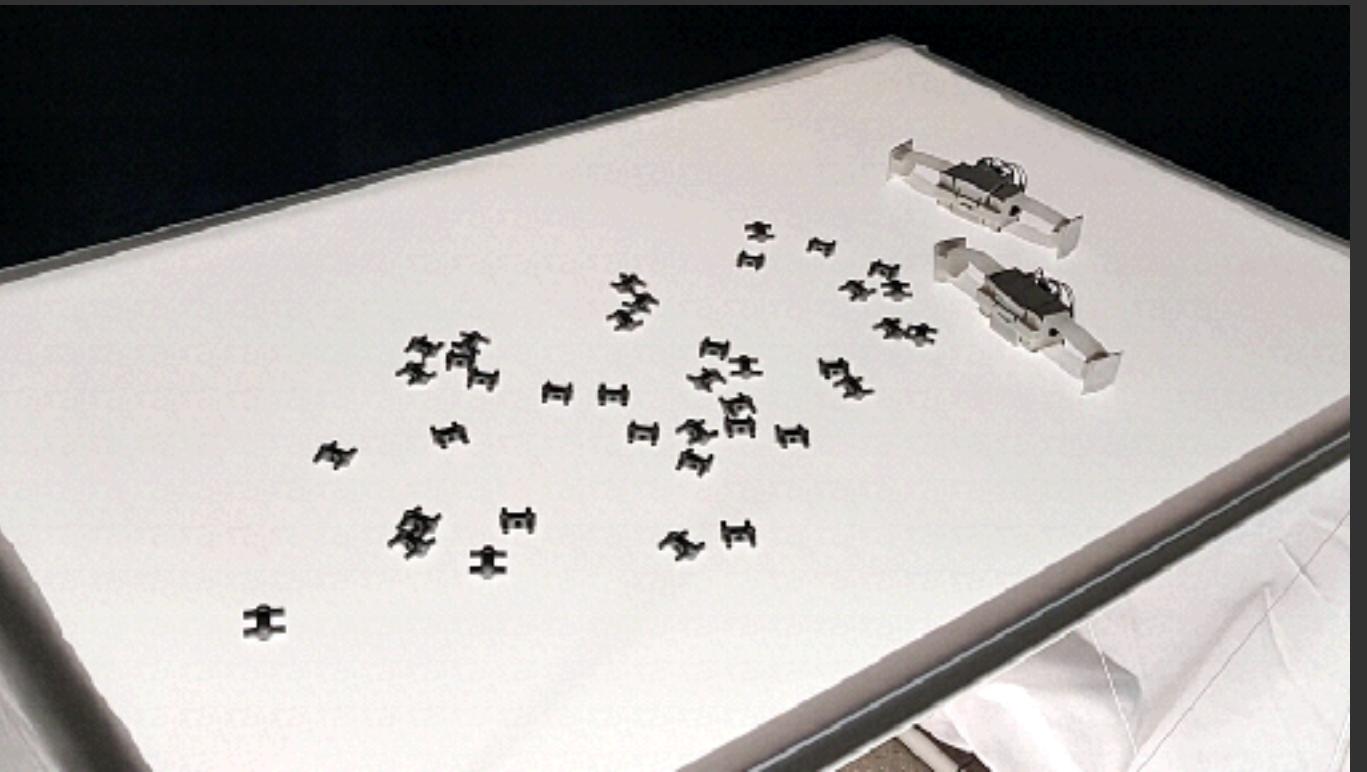


Applications

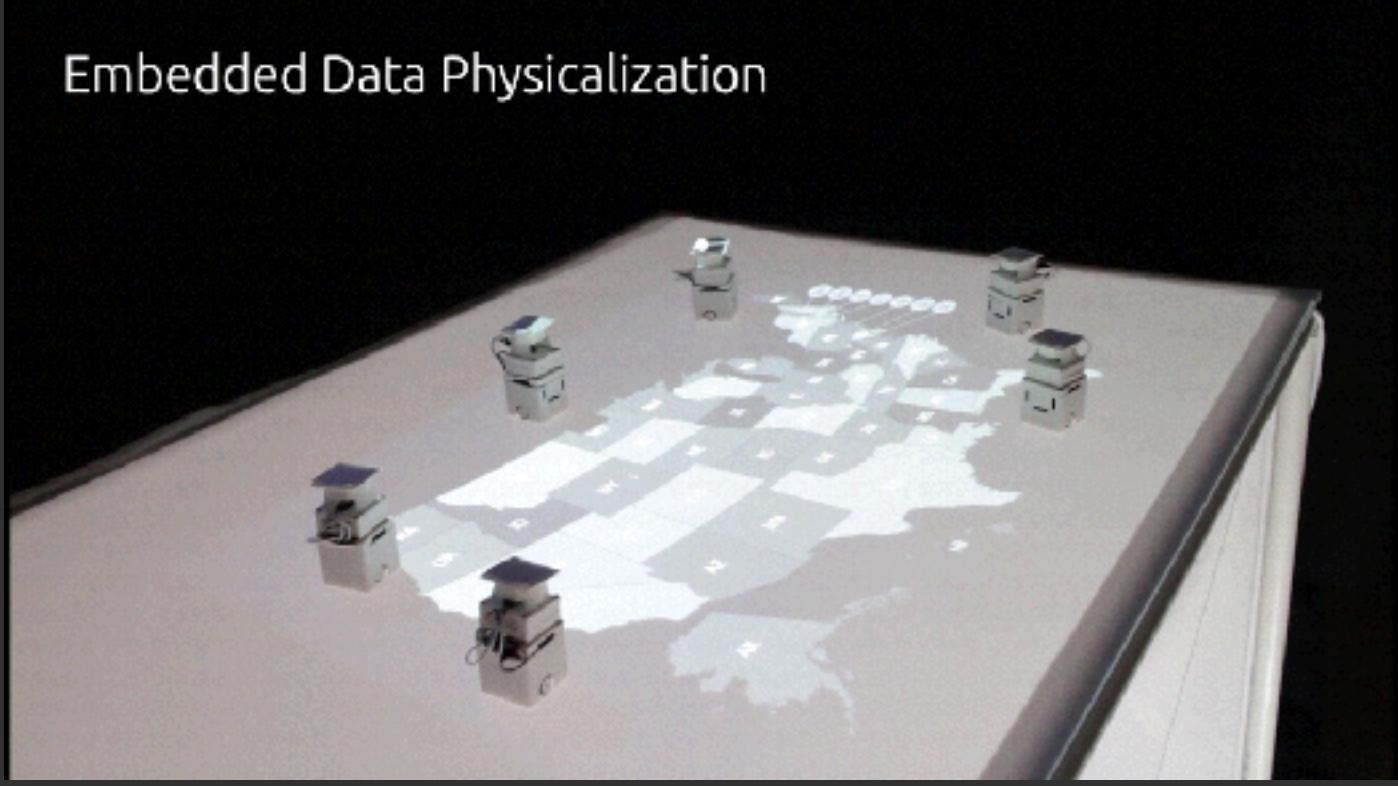
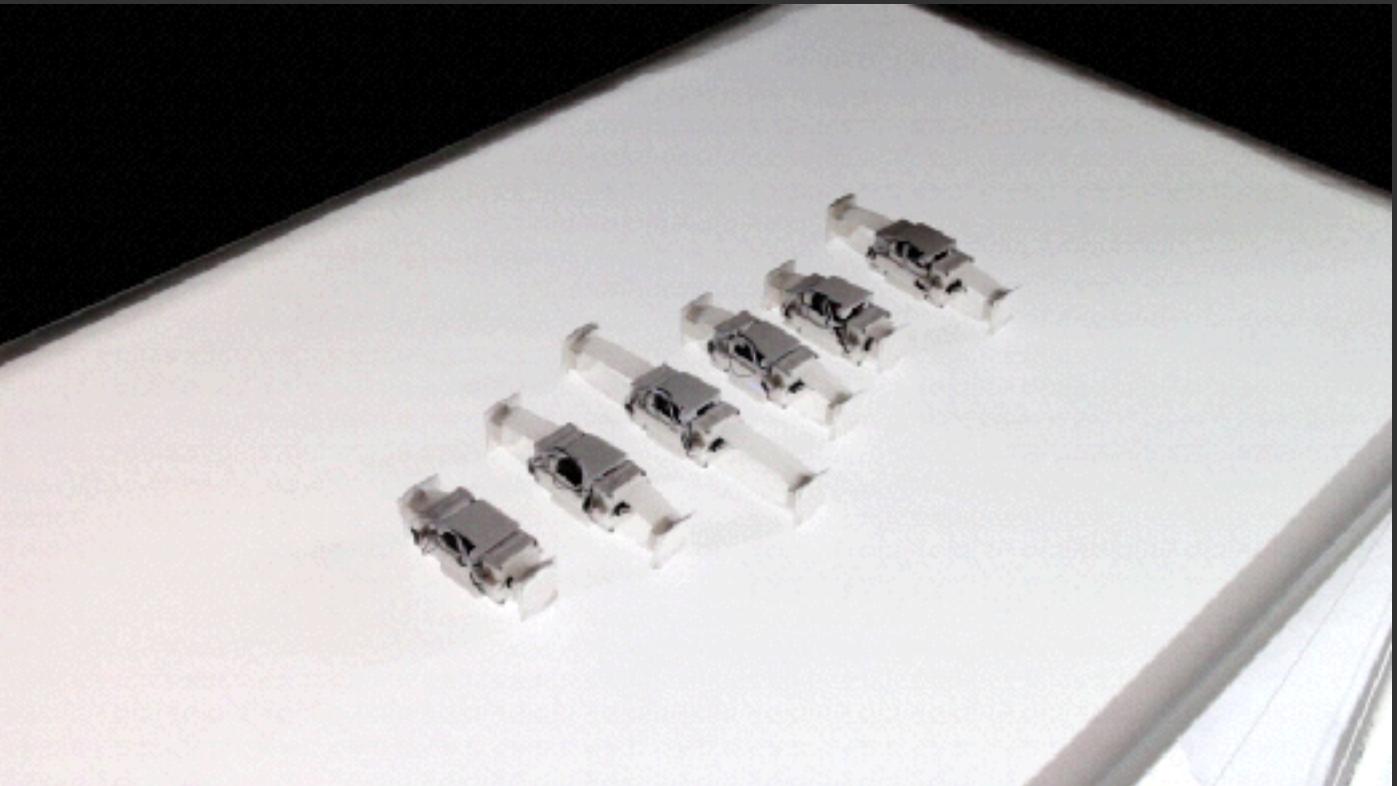
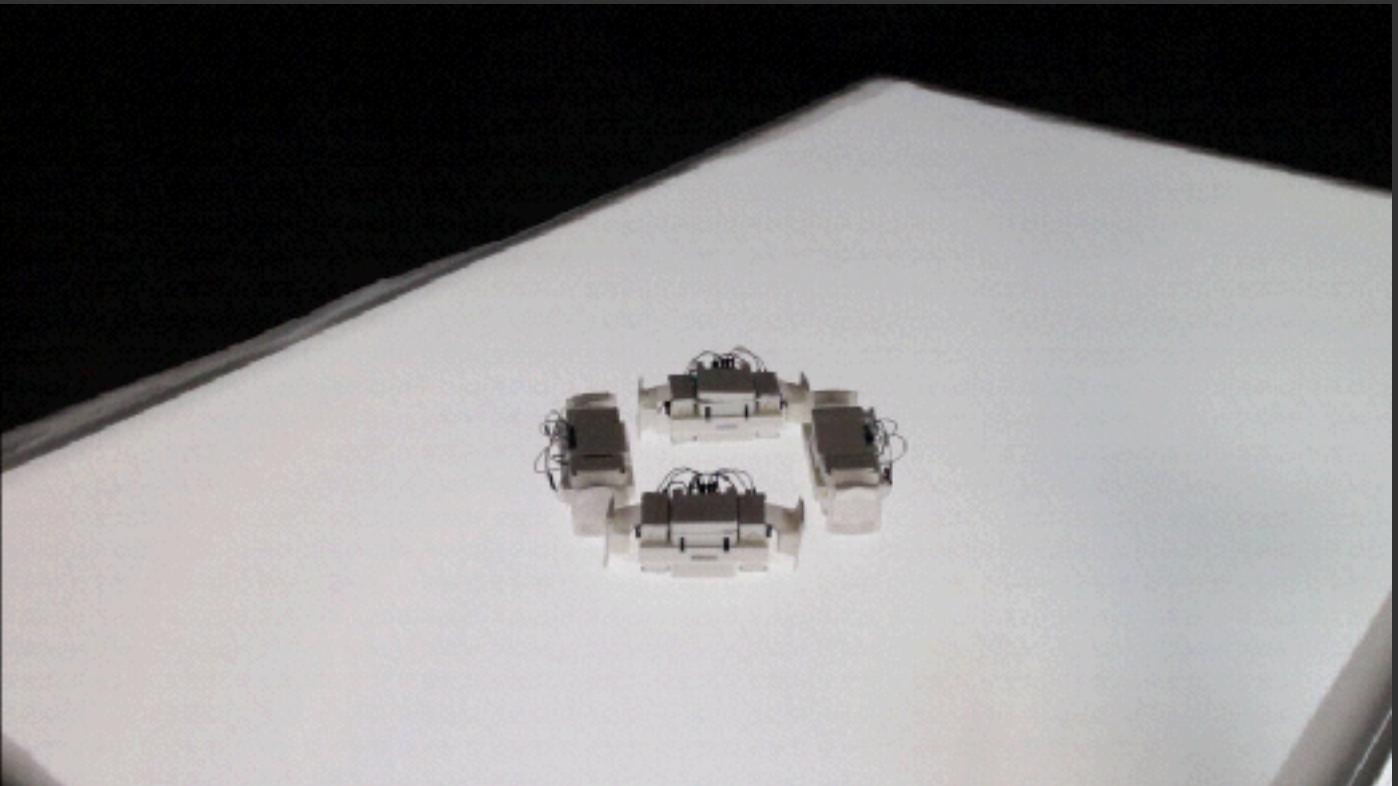
Tangible Media



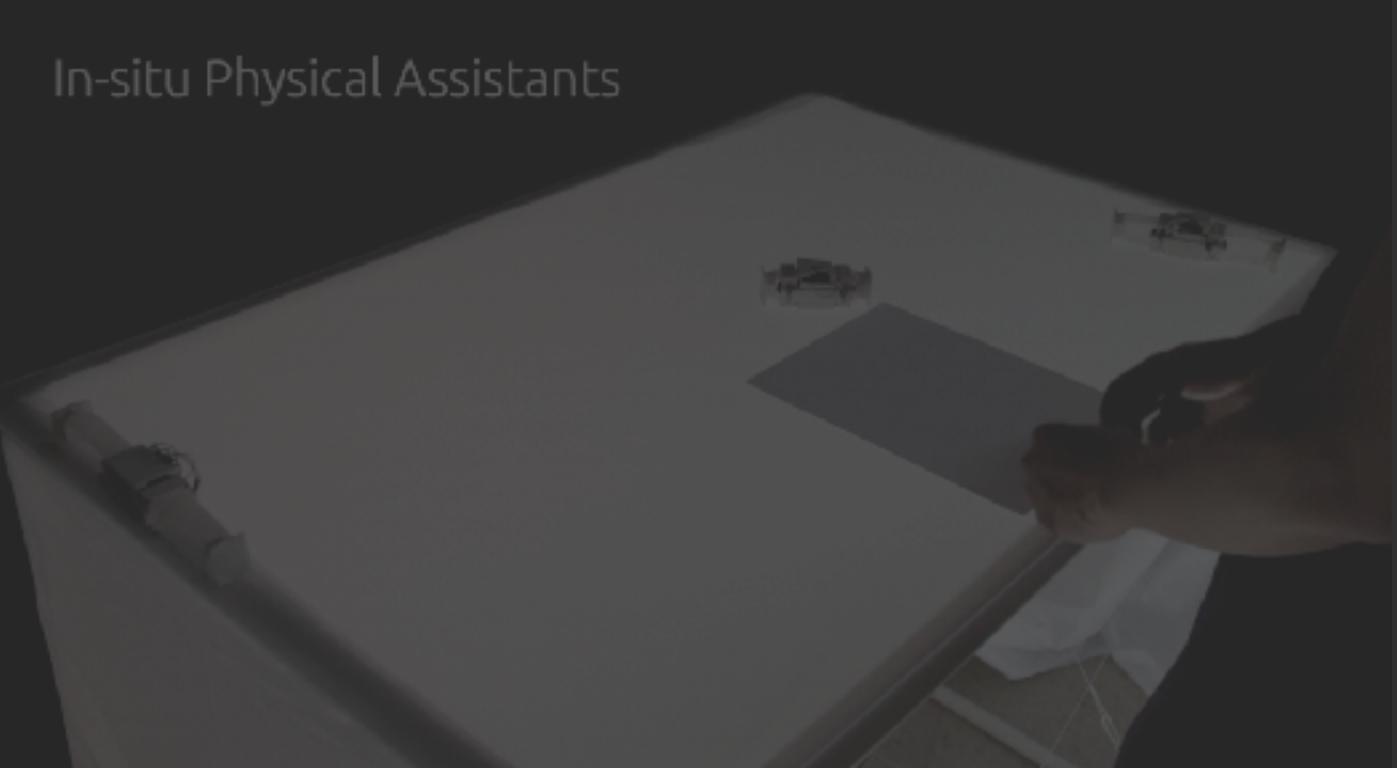
Everyday Assistant



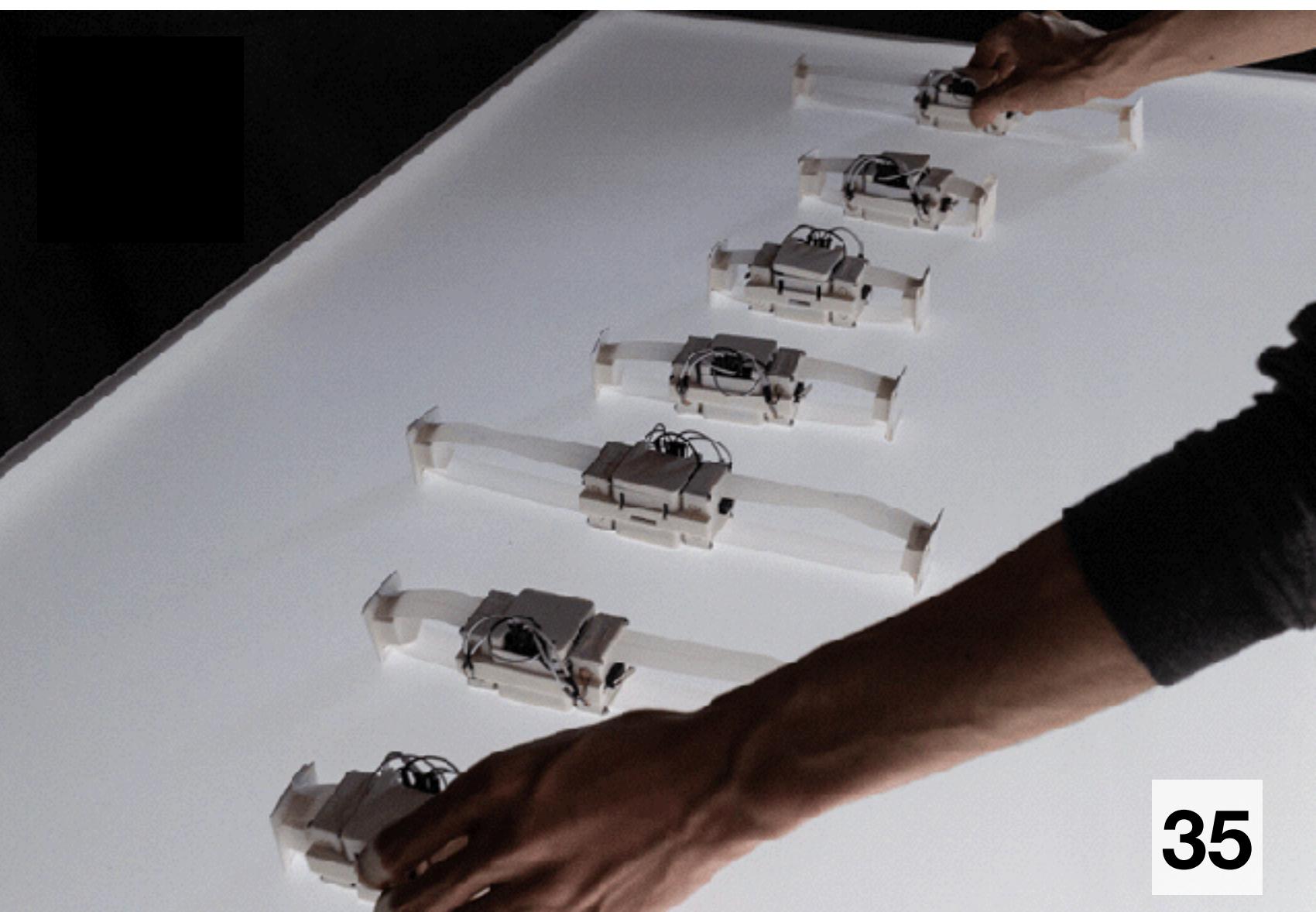
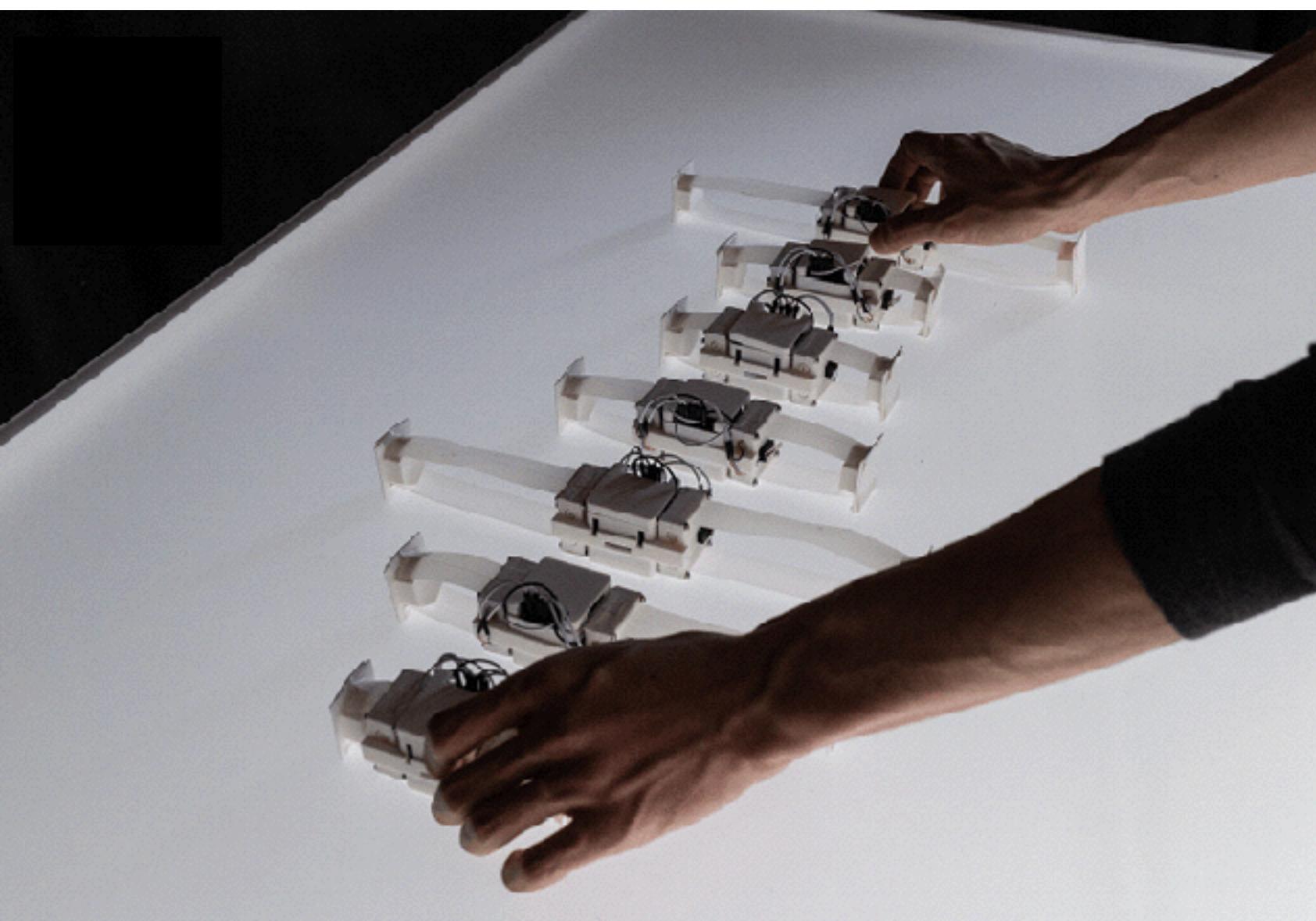
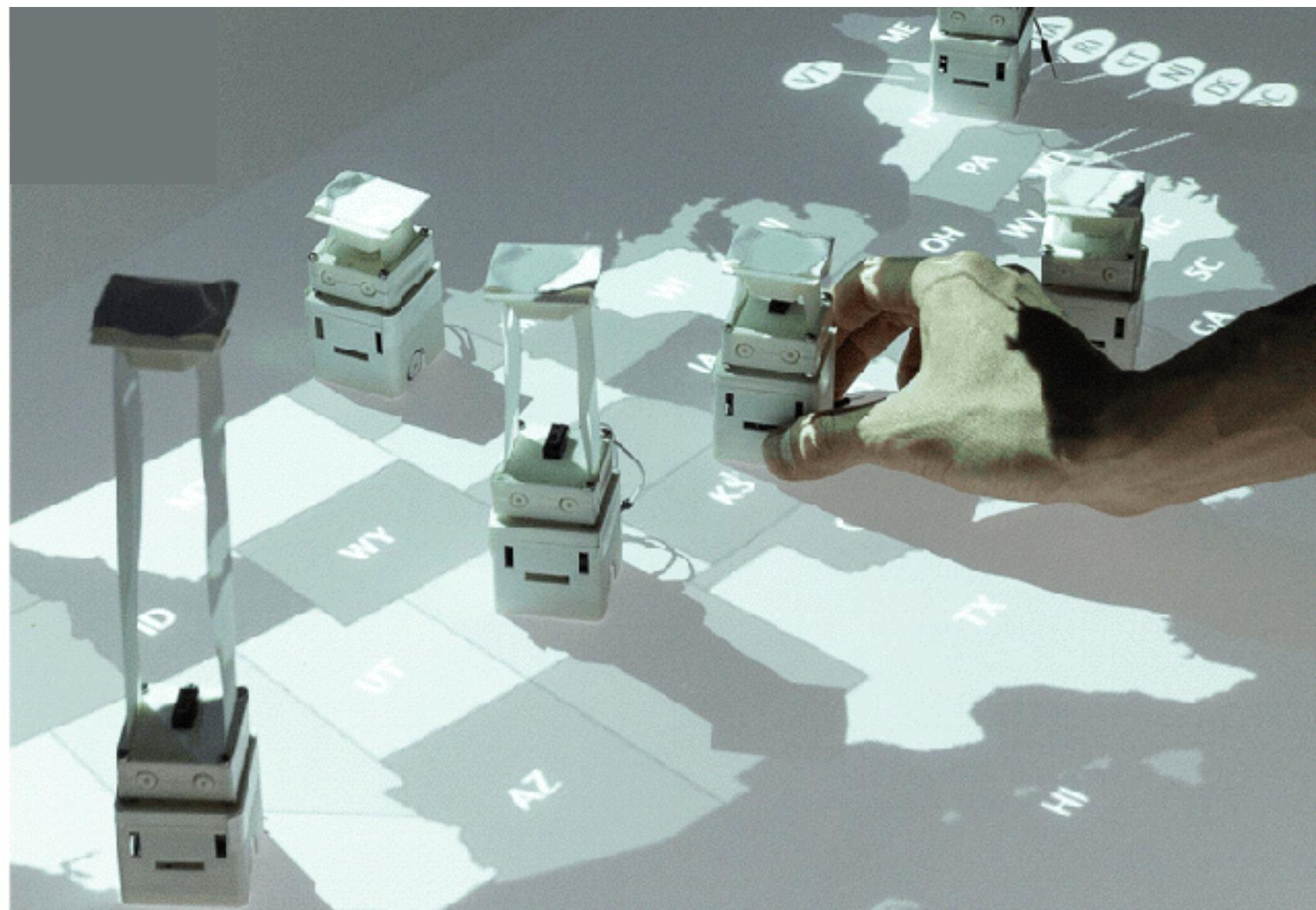
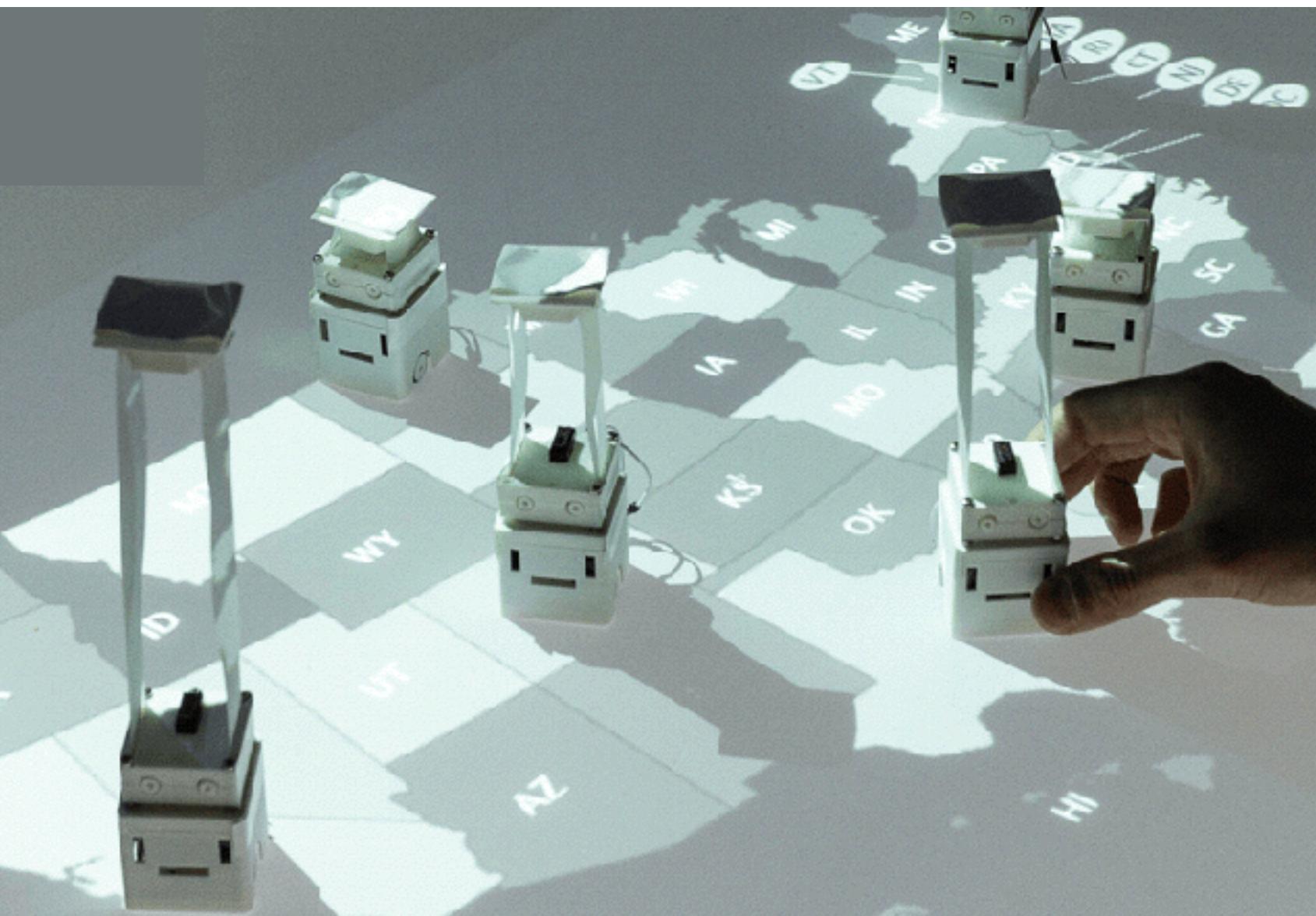
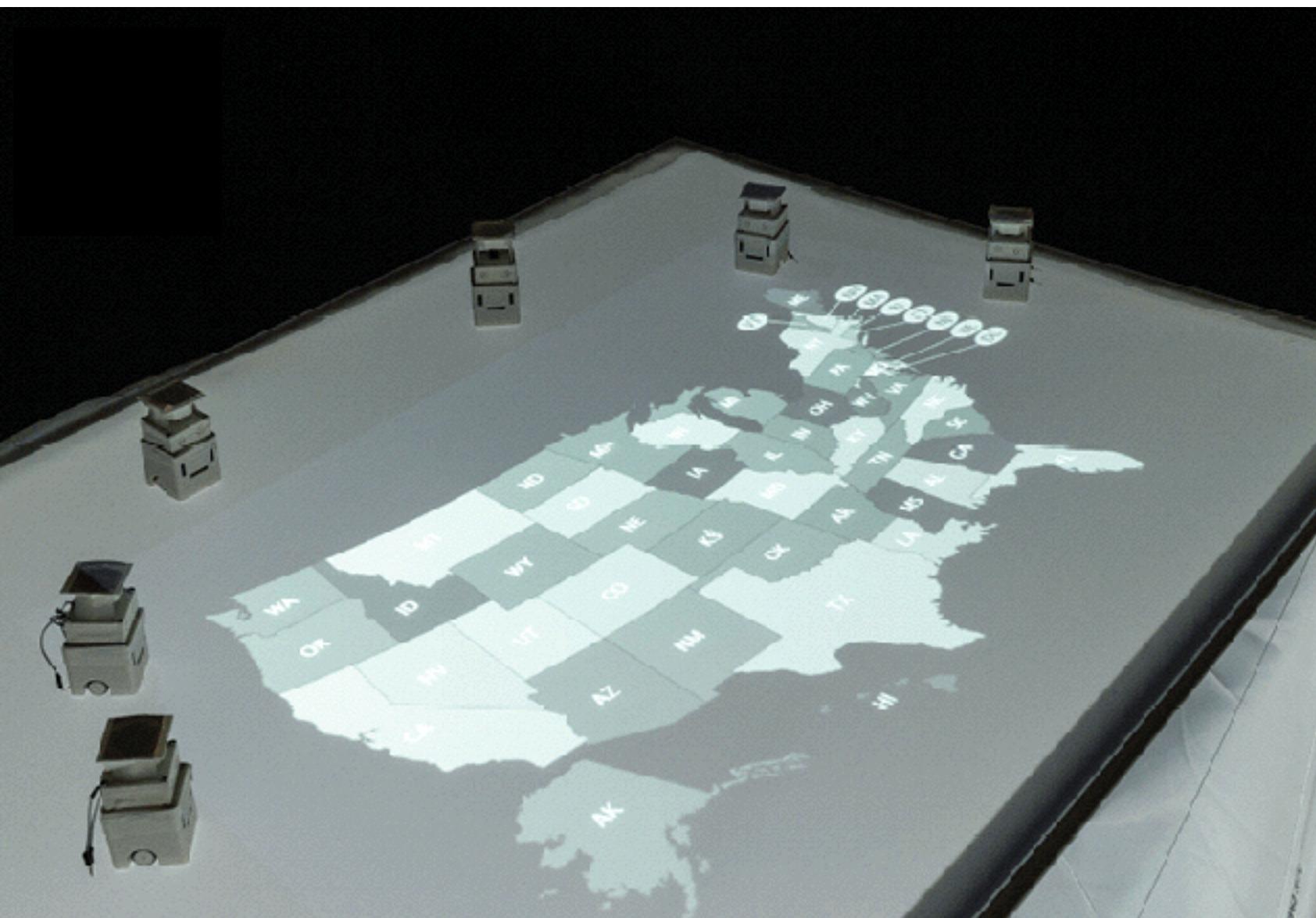
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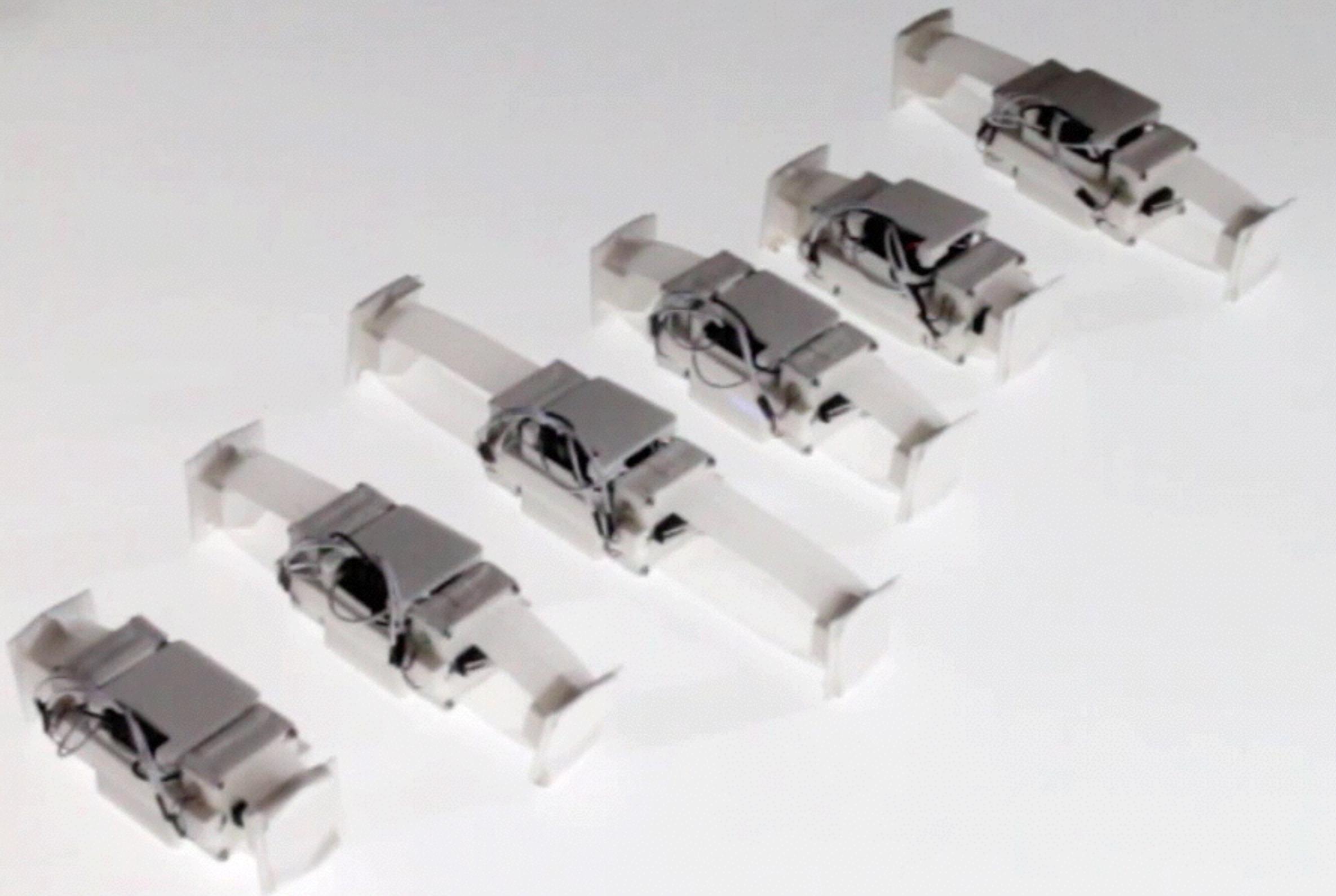


Everyday Assistant

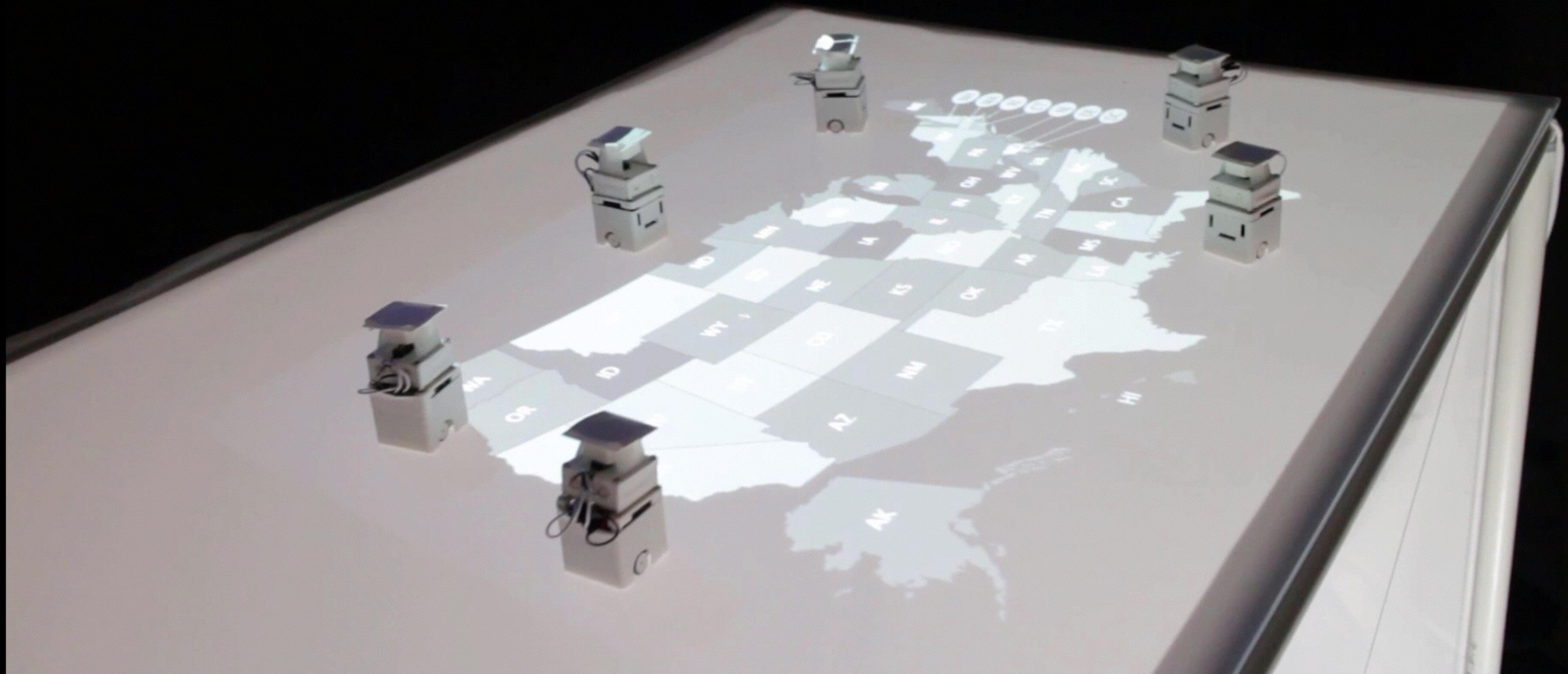


Dynamic Data Physicalization

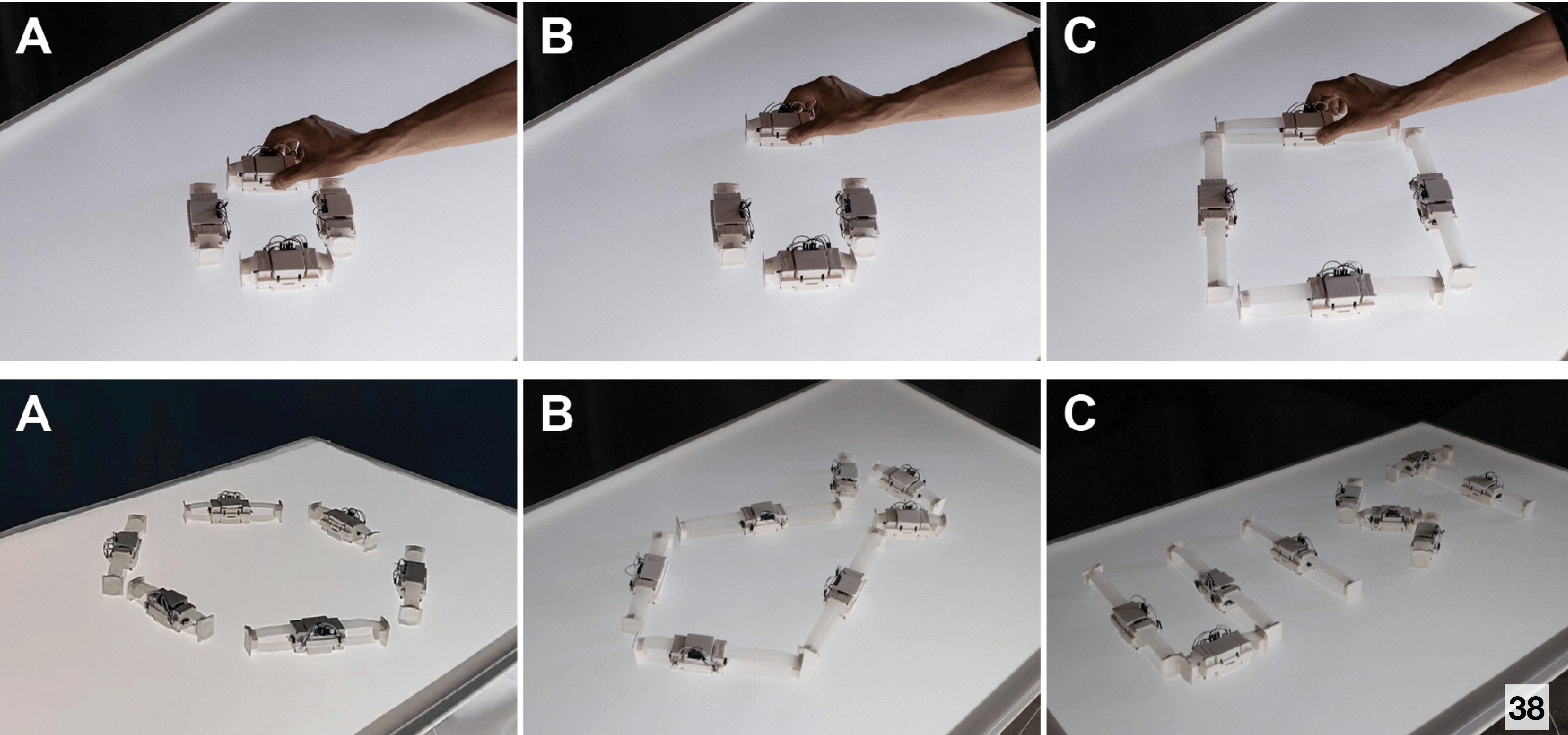




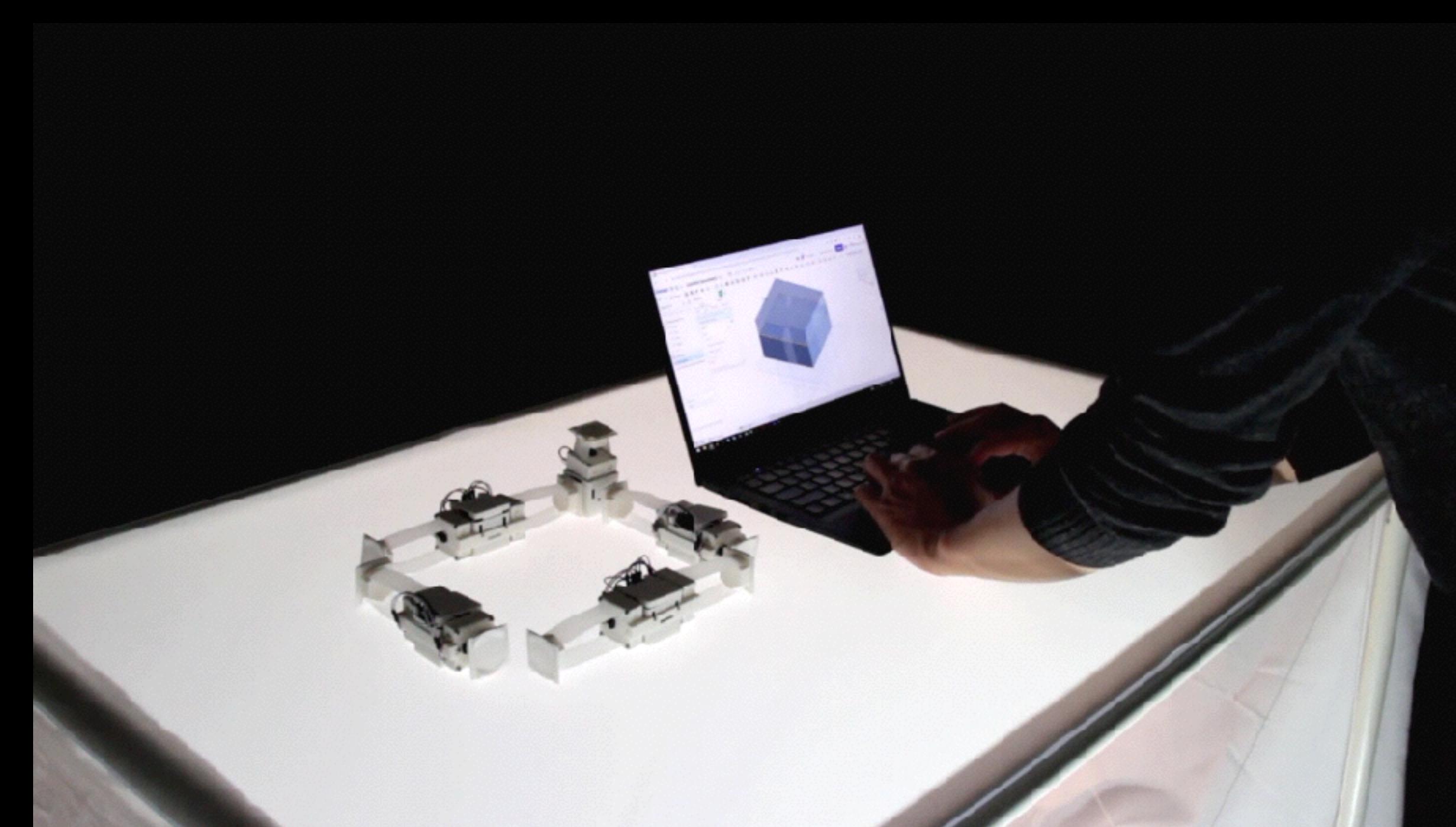
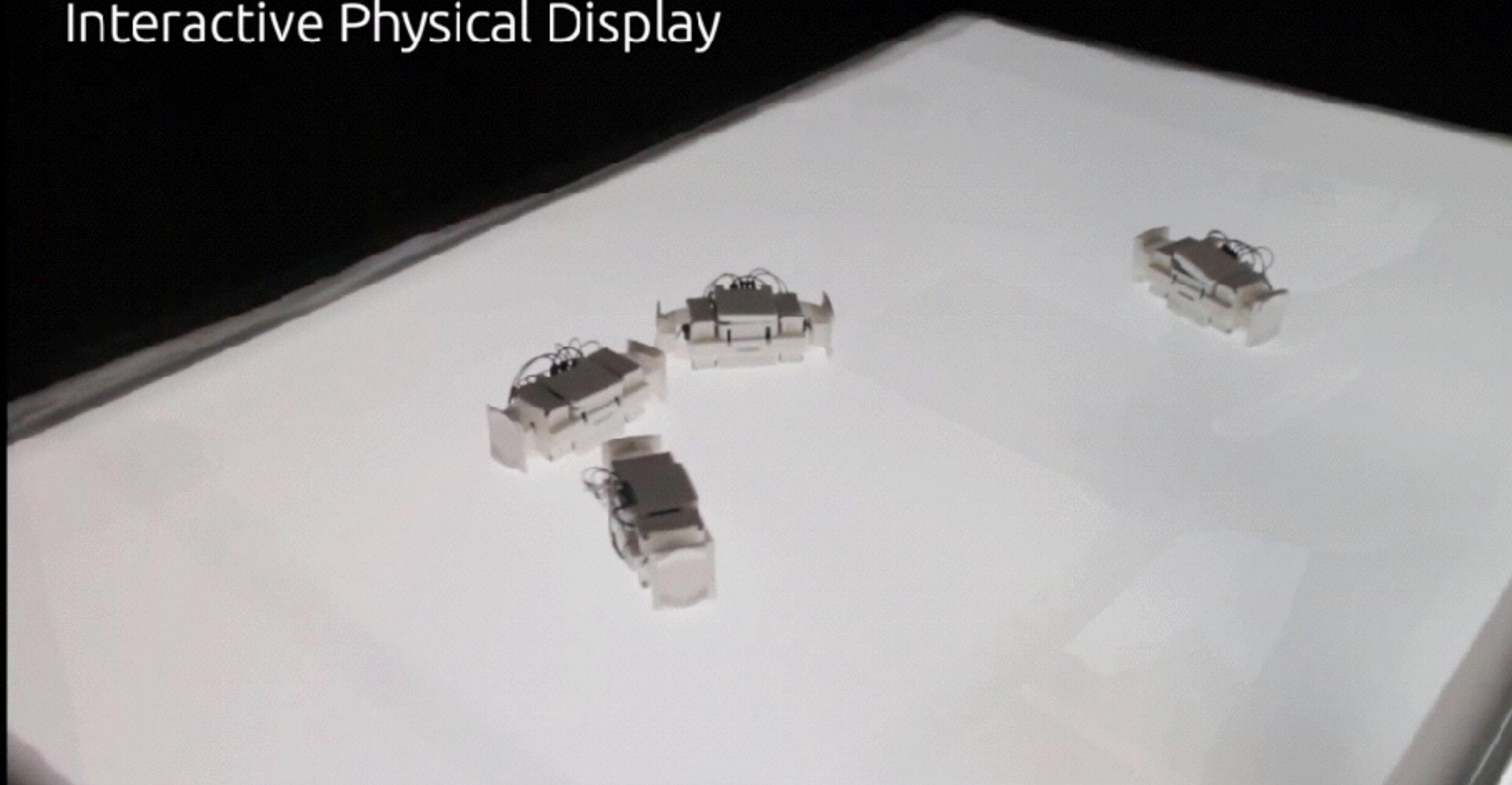
Embedded Data Physicalization



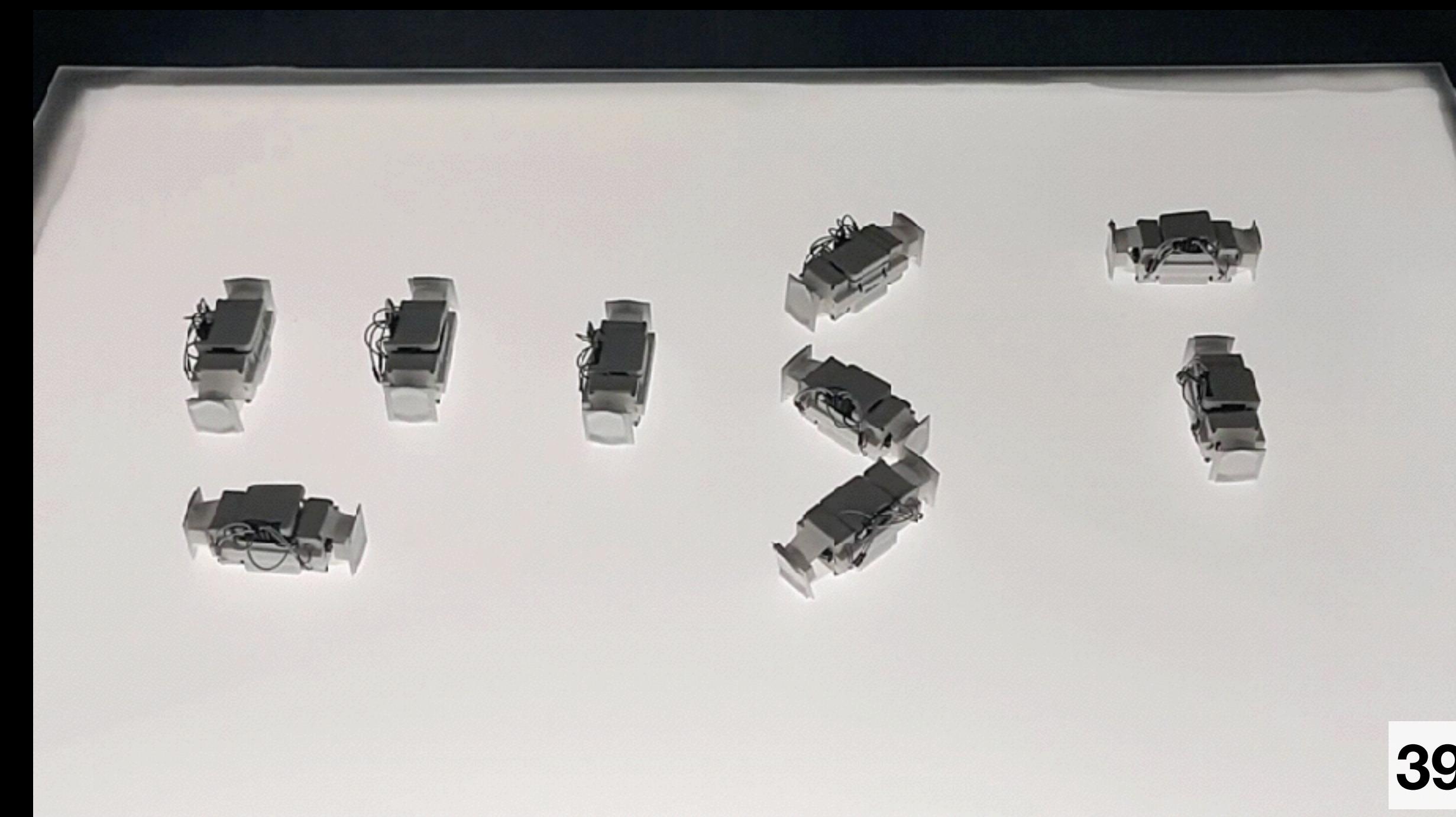
Interactive Information Display

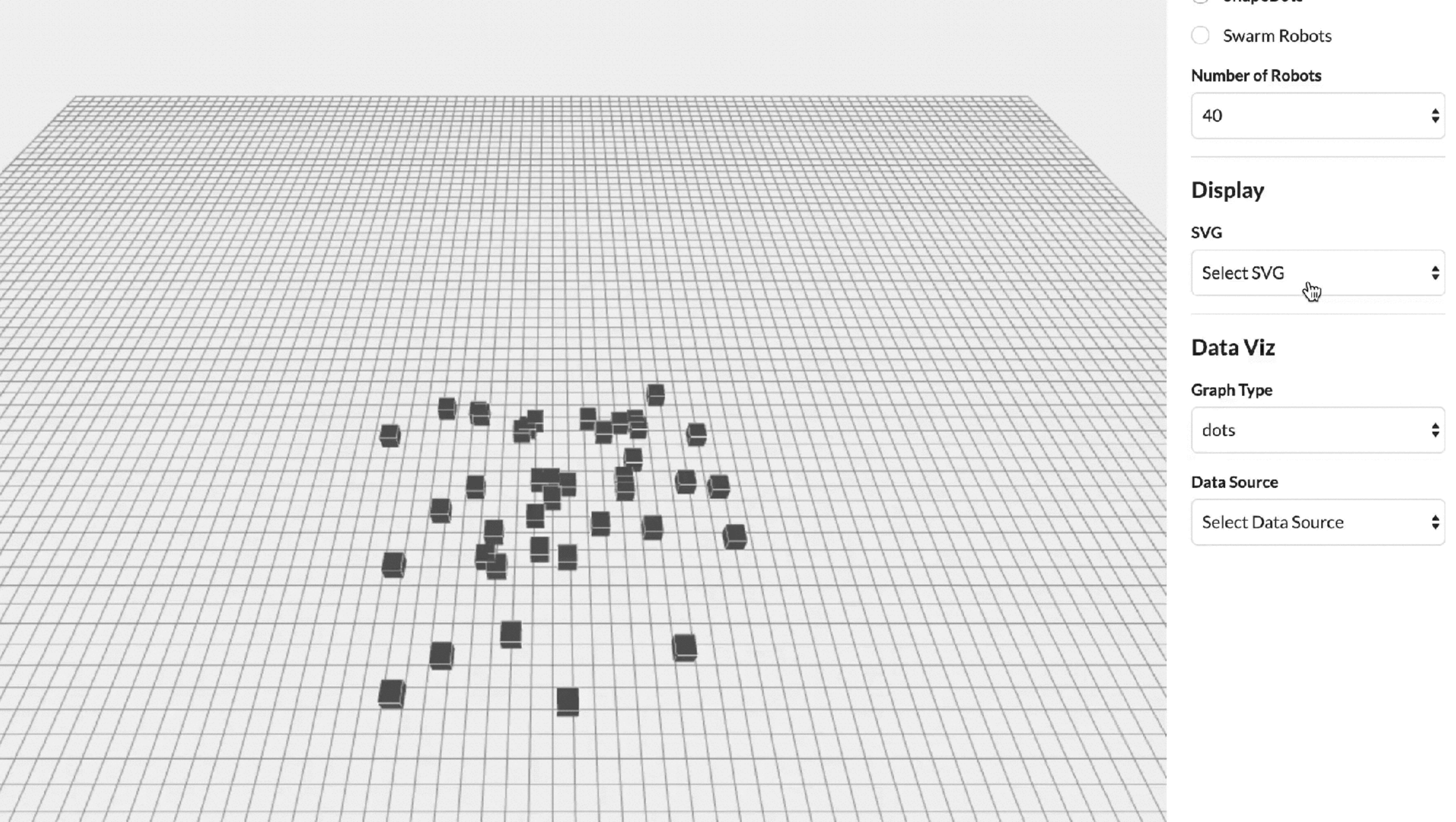


Interactive Physical Display



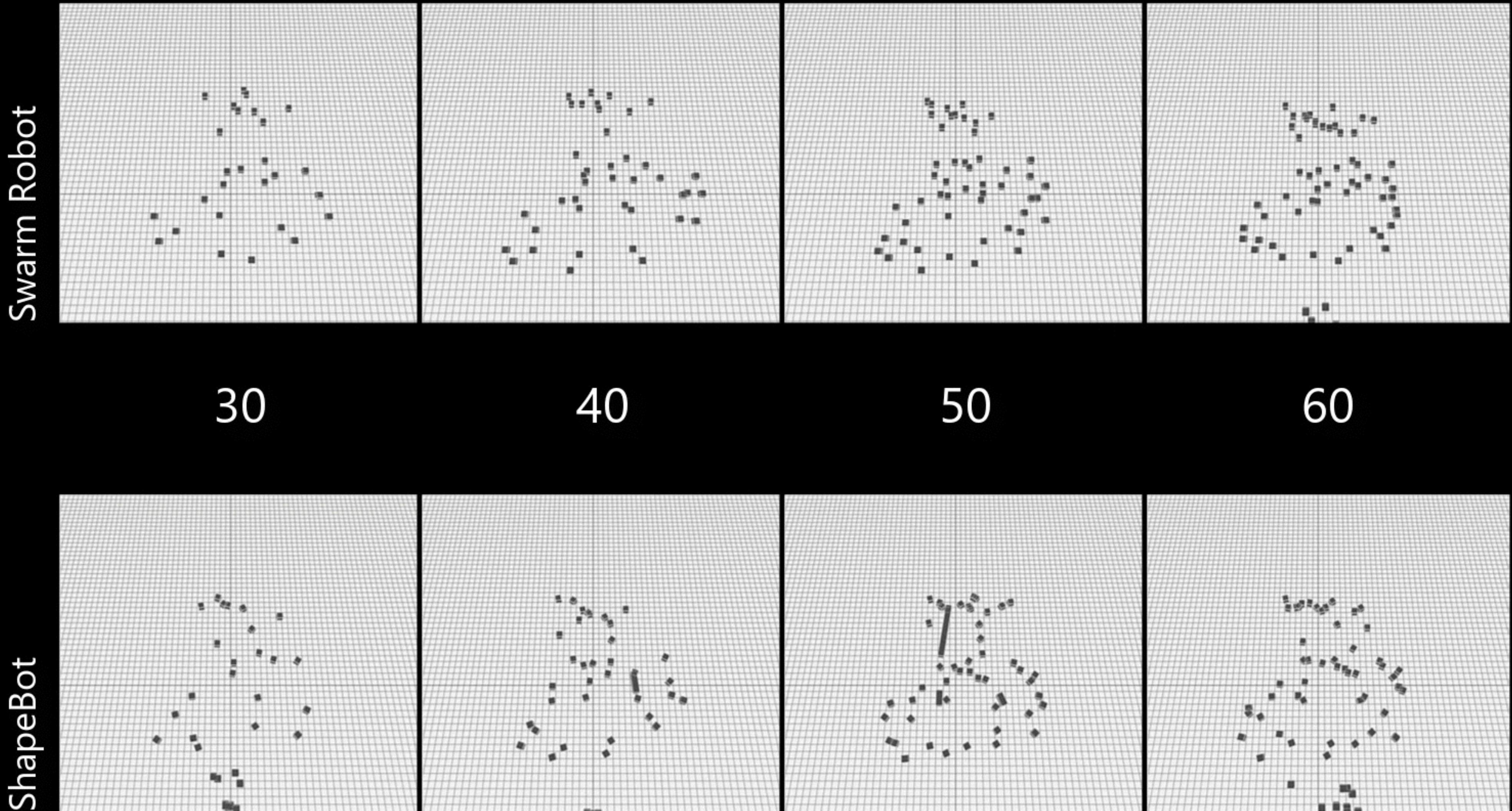
Dynamic Shape Construction



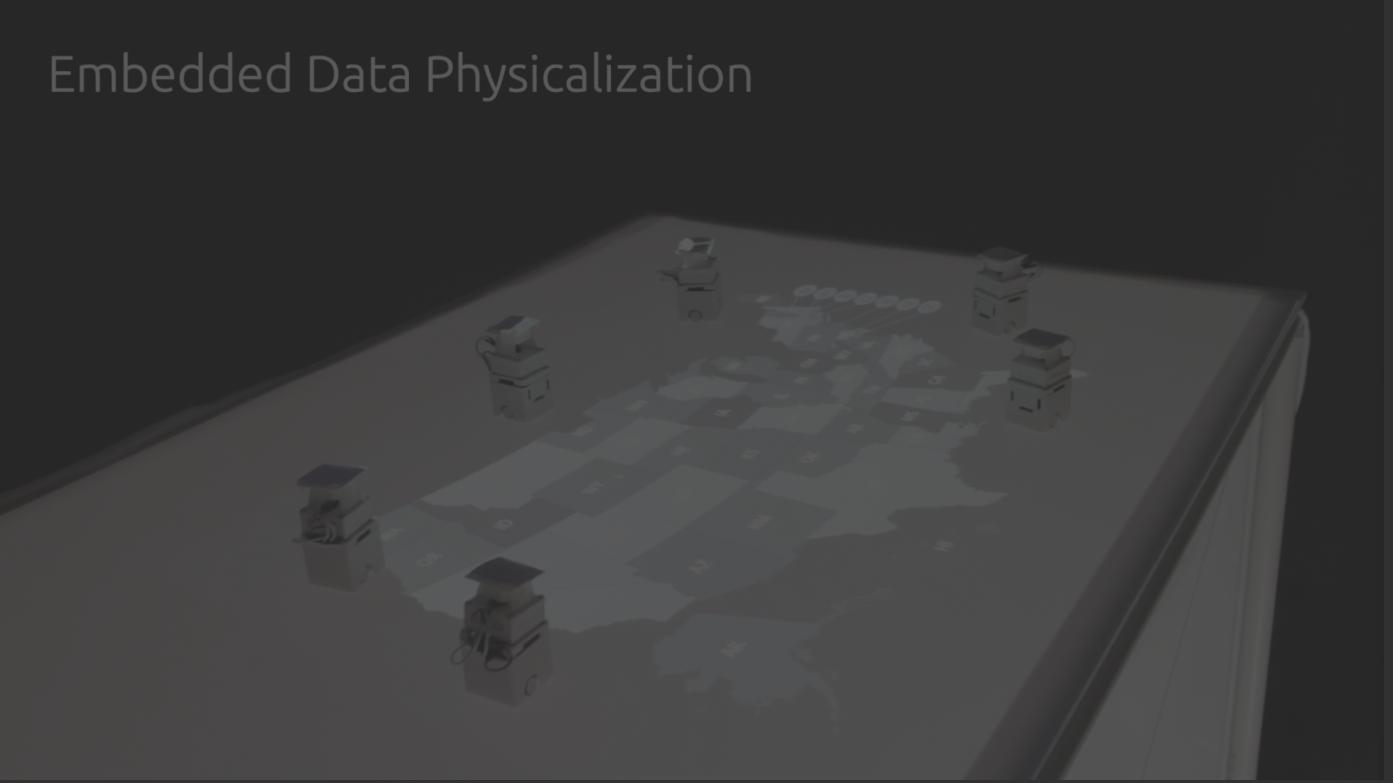
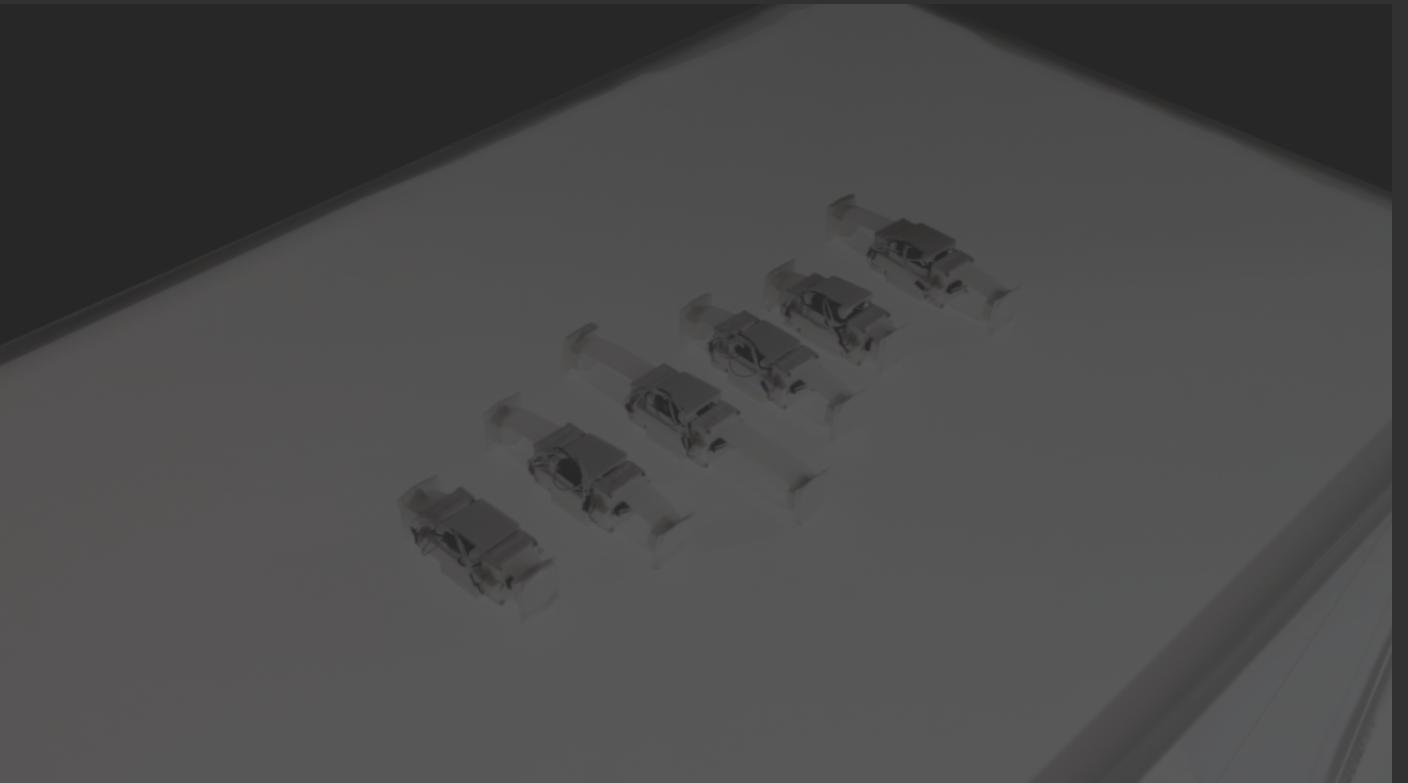




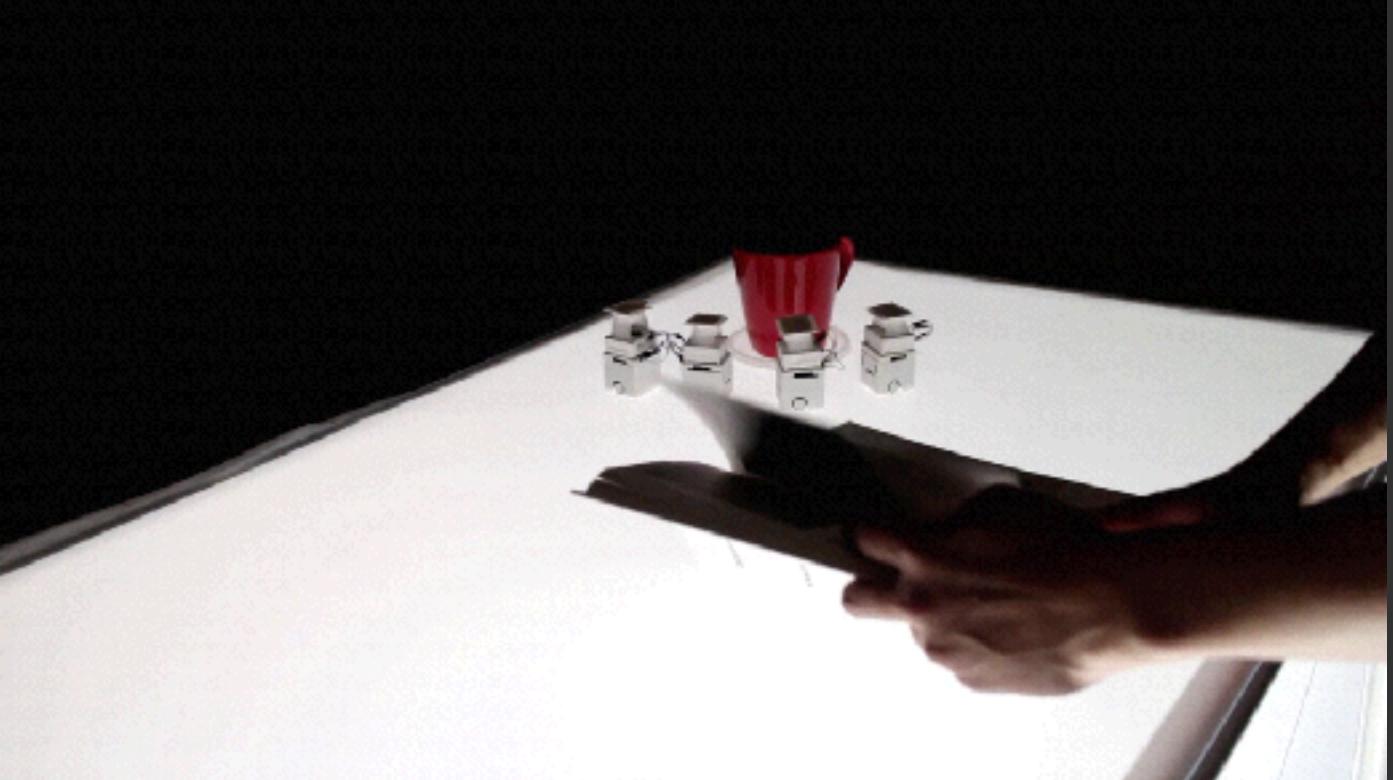
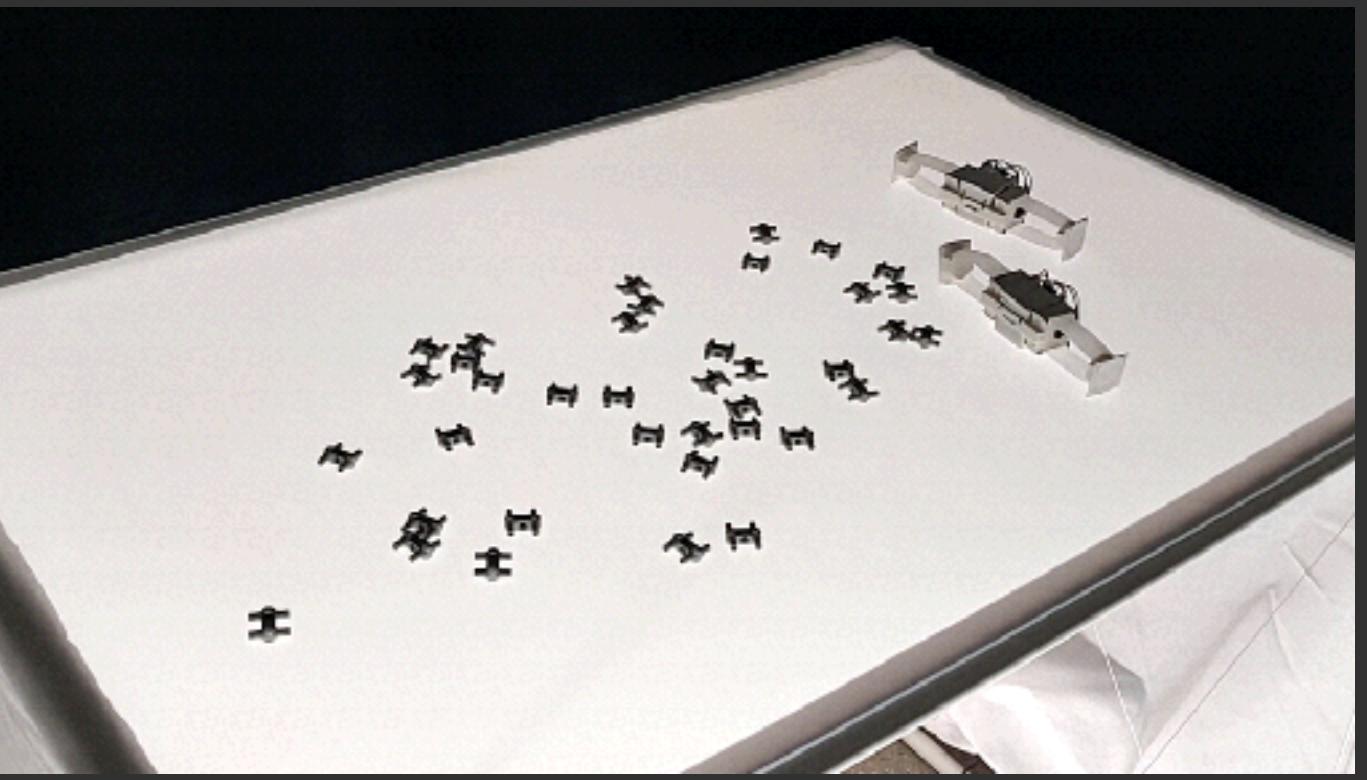
Input SVG



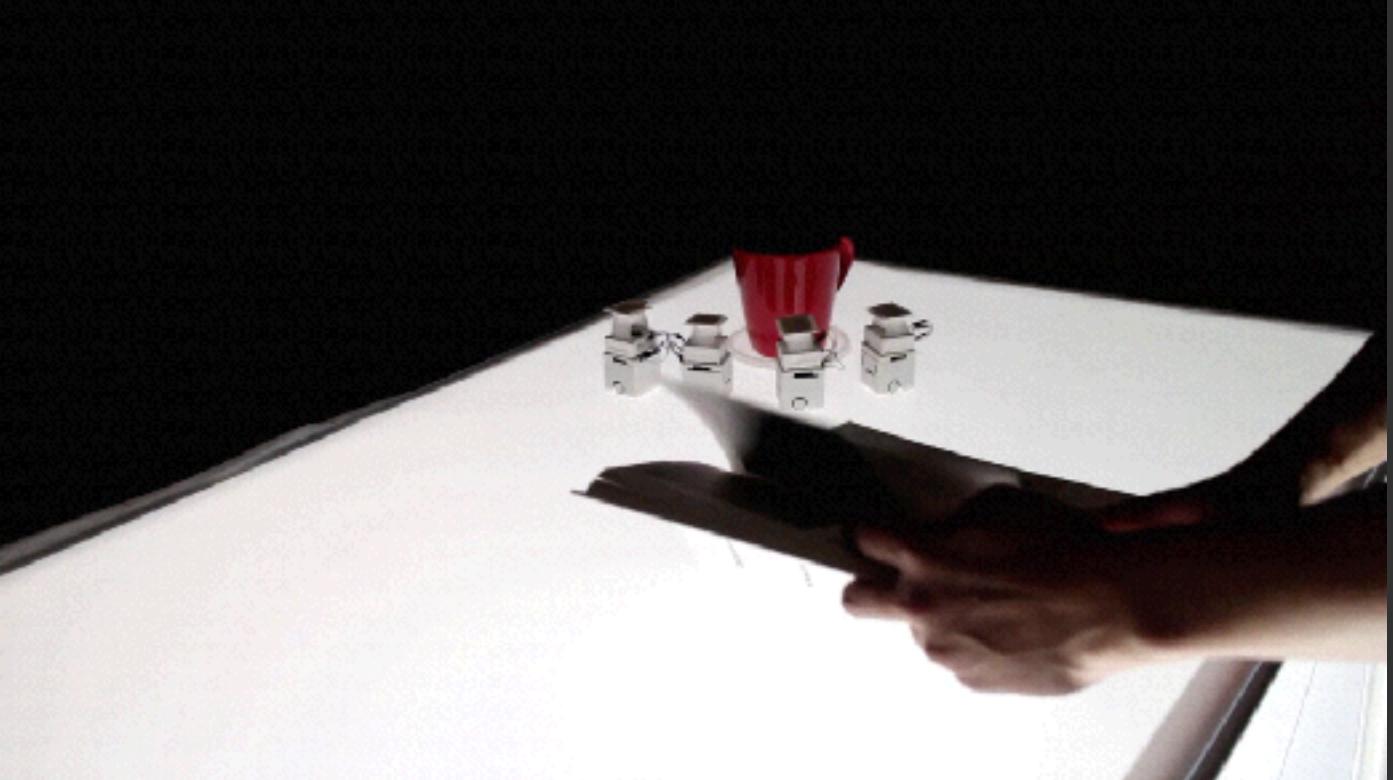
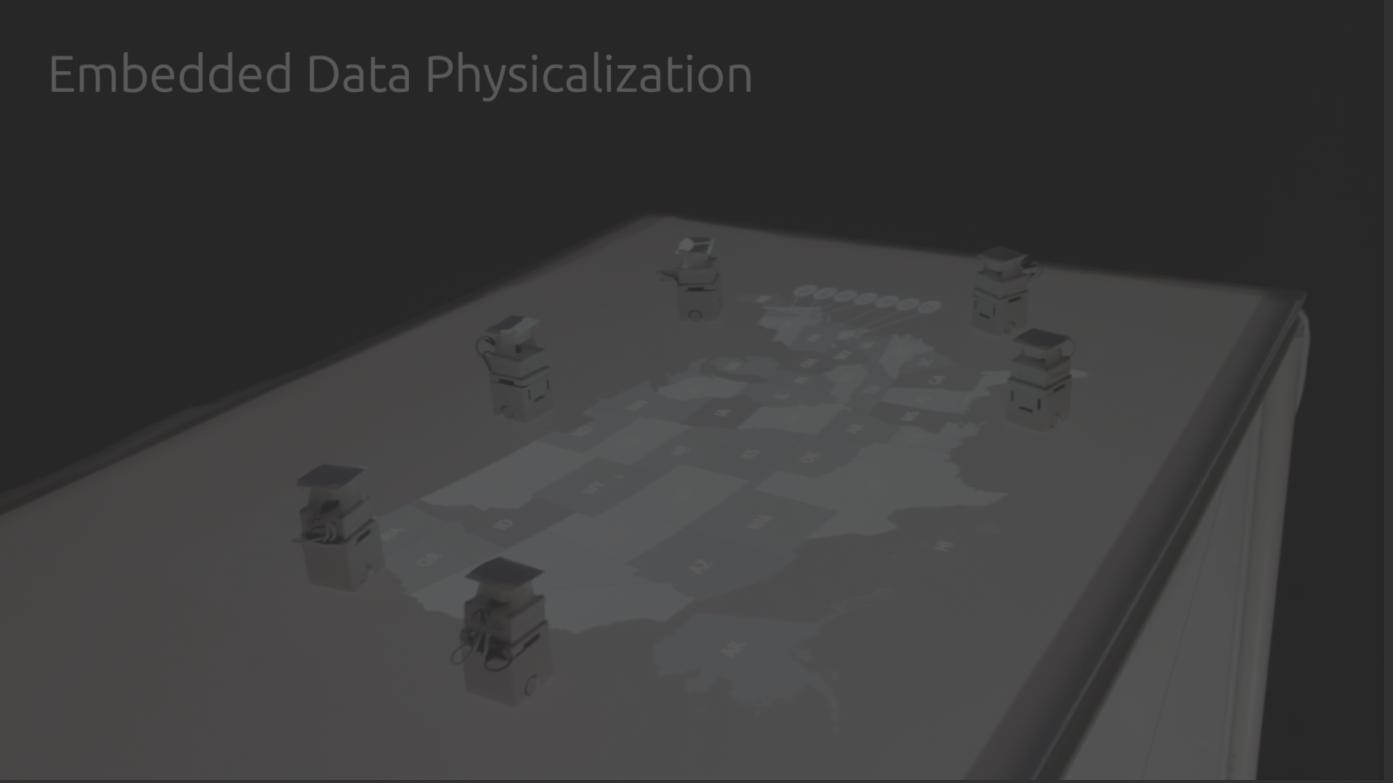
Tangible Media



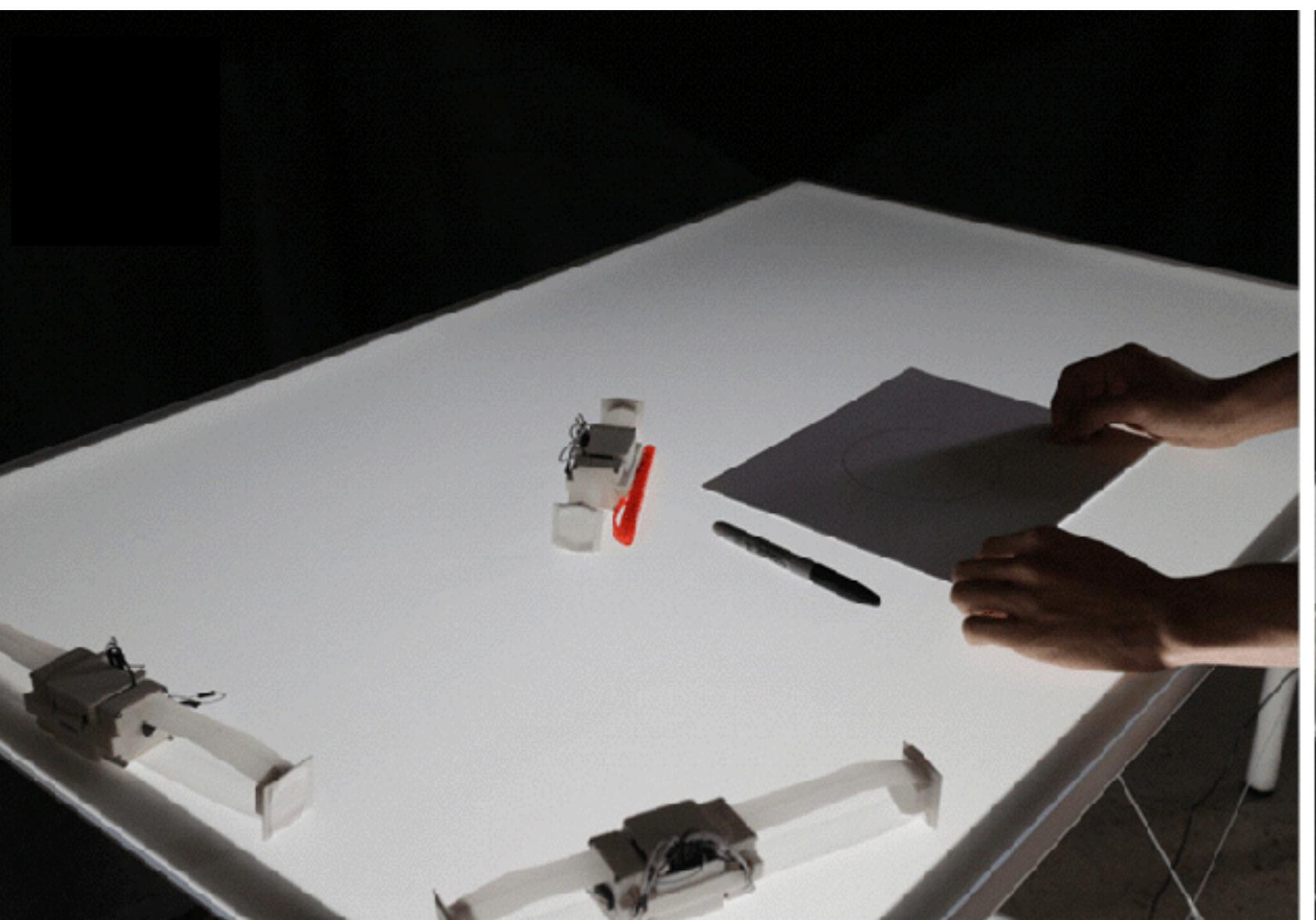
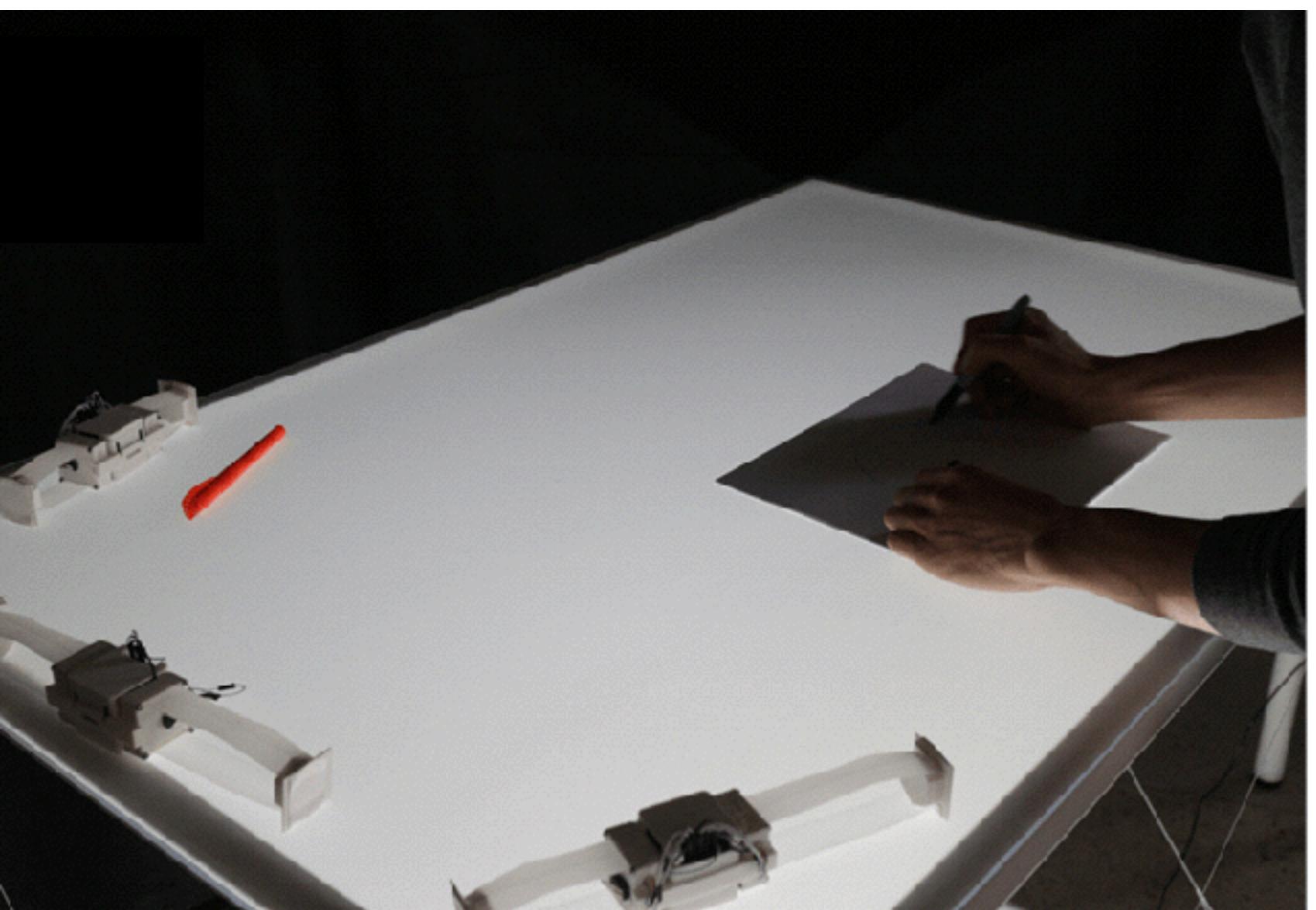
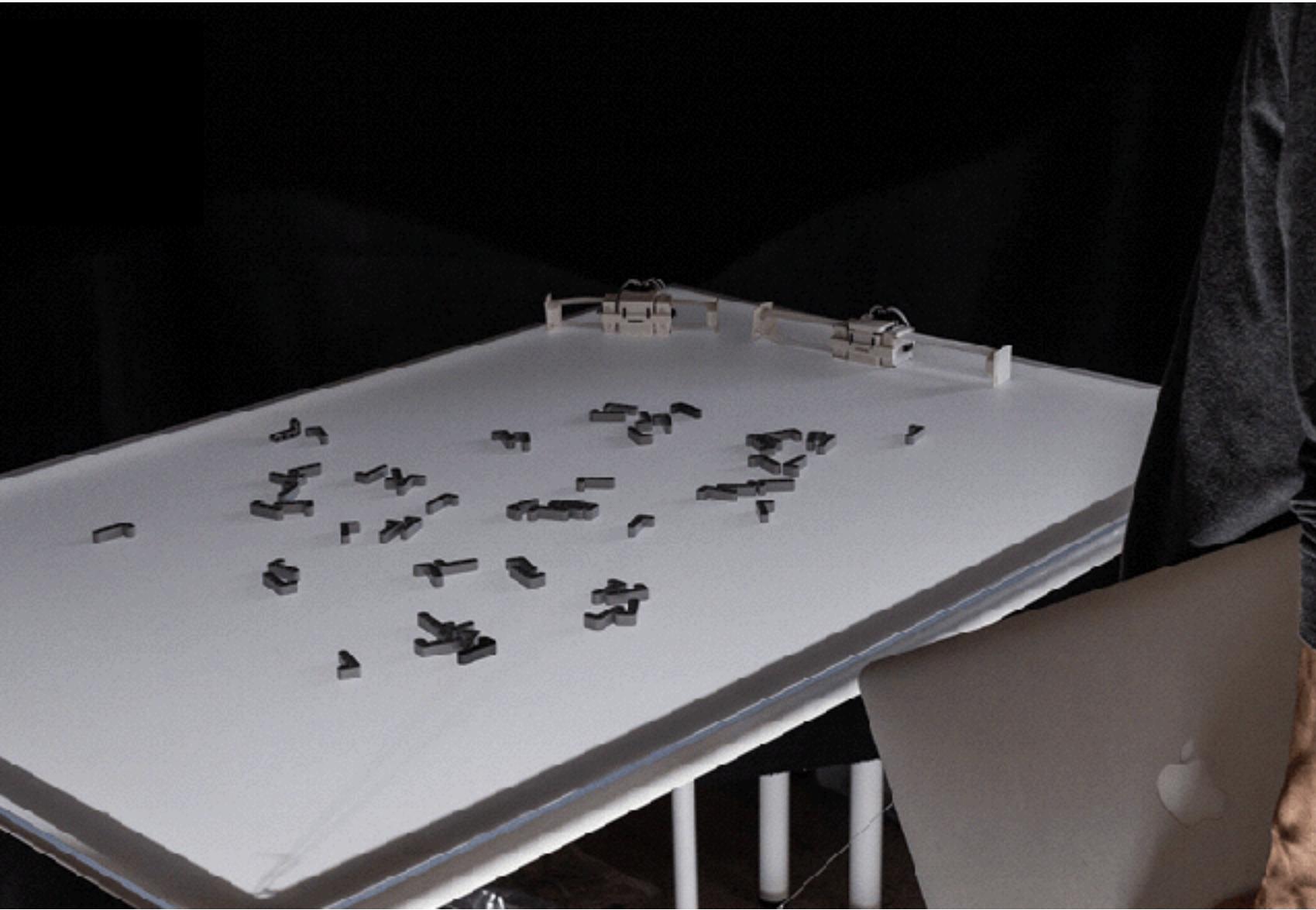
Everyday Assistant



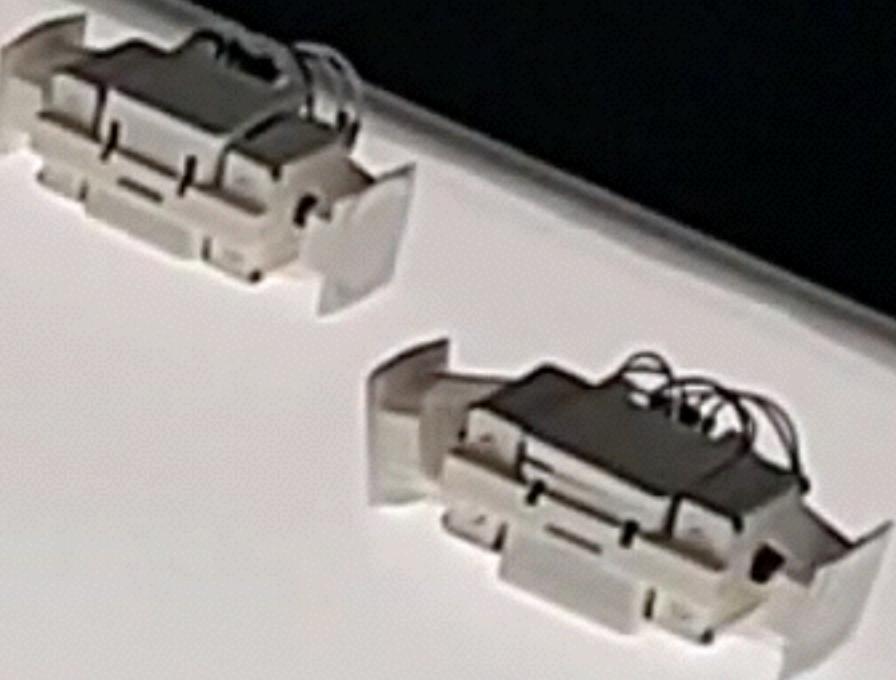
In-situ Physical Assistants



Everyday Assistant



Cleaning Robots

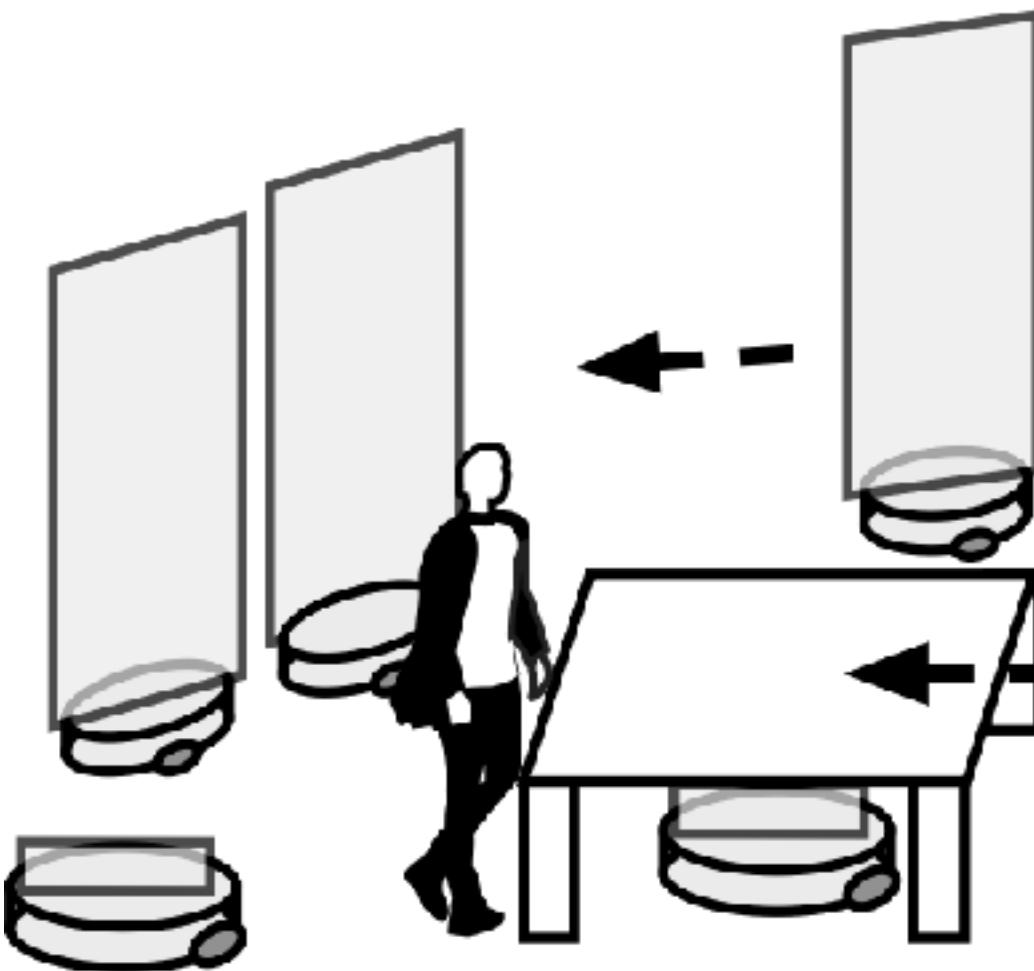




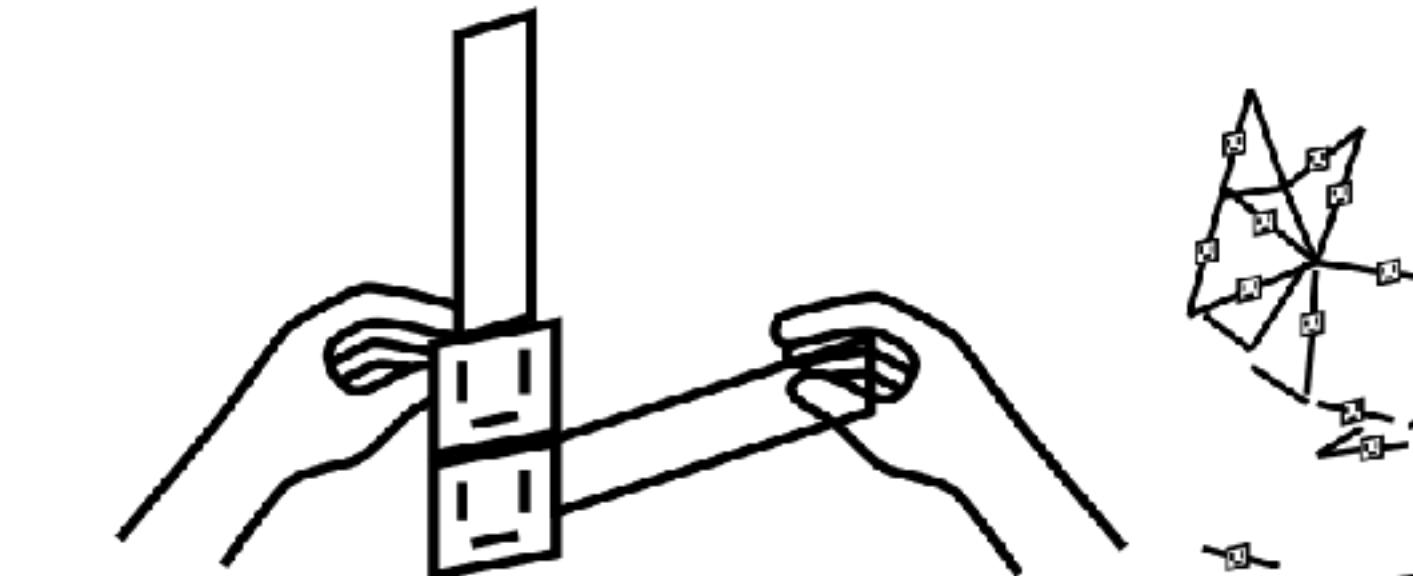
In-situ Physical Assistants



Design Space and Future Opportunities



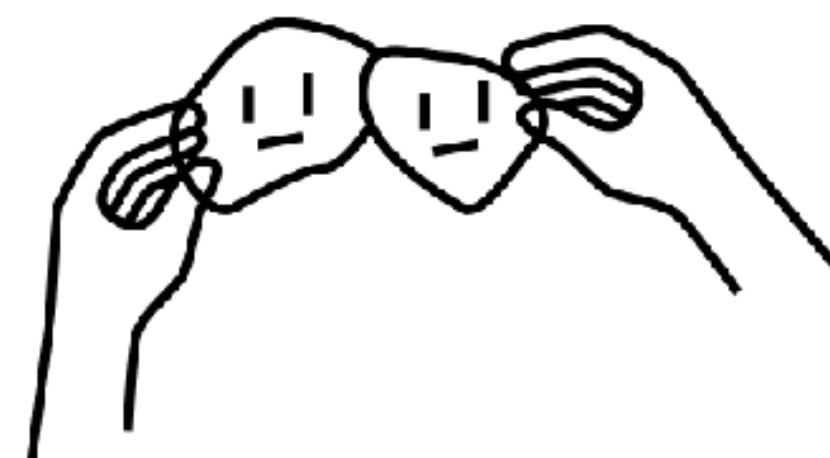
Size of Elements
e.g., Room-scale
robots



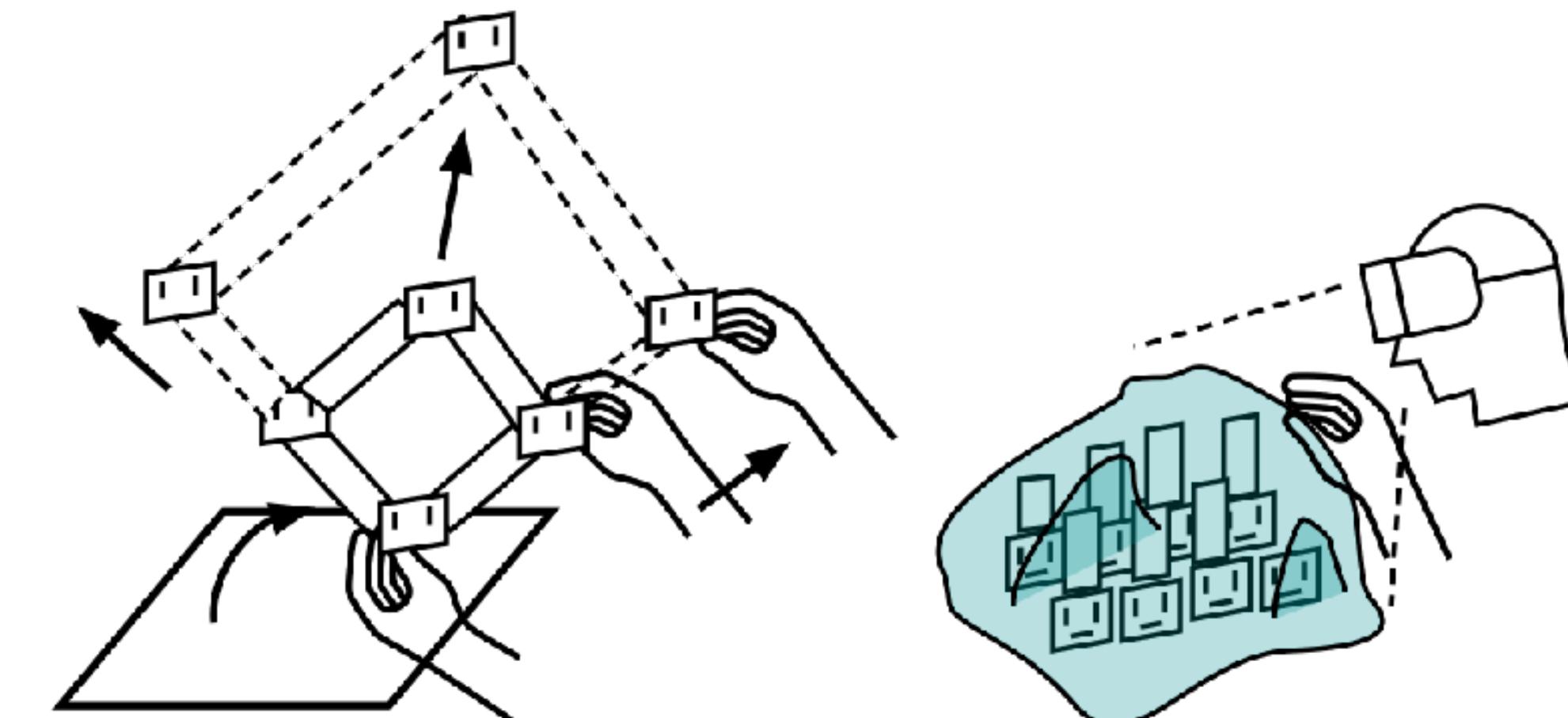
Input Capability
e.g., Deformation
and construction



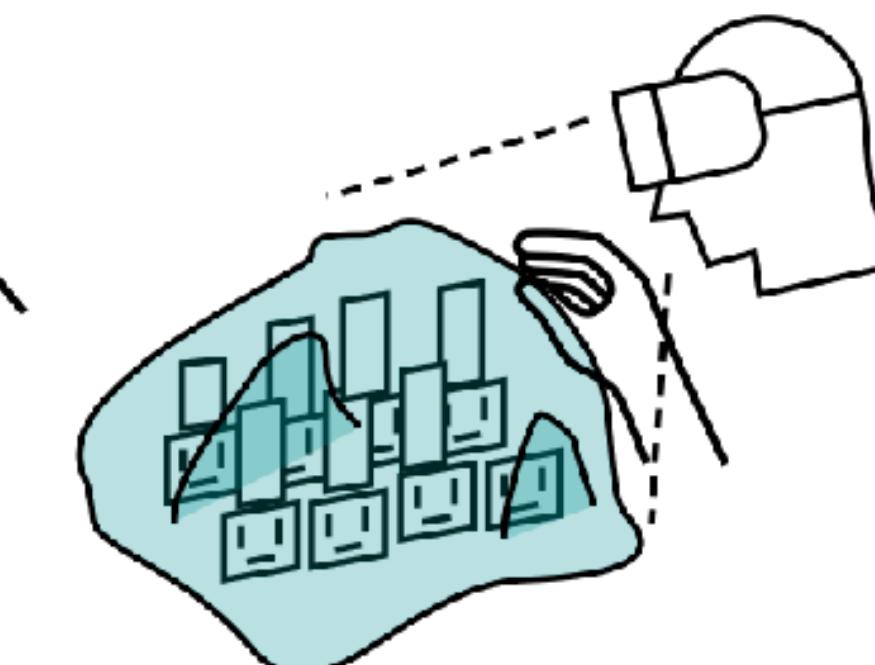
Locomotion Capability
e.g., Shape-changing
drones



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



Connectability
e.g., Connected for
graspable objects

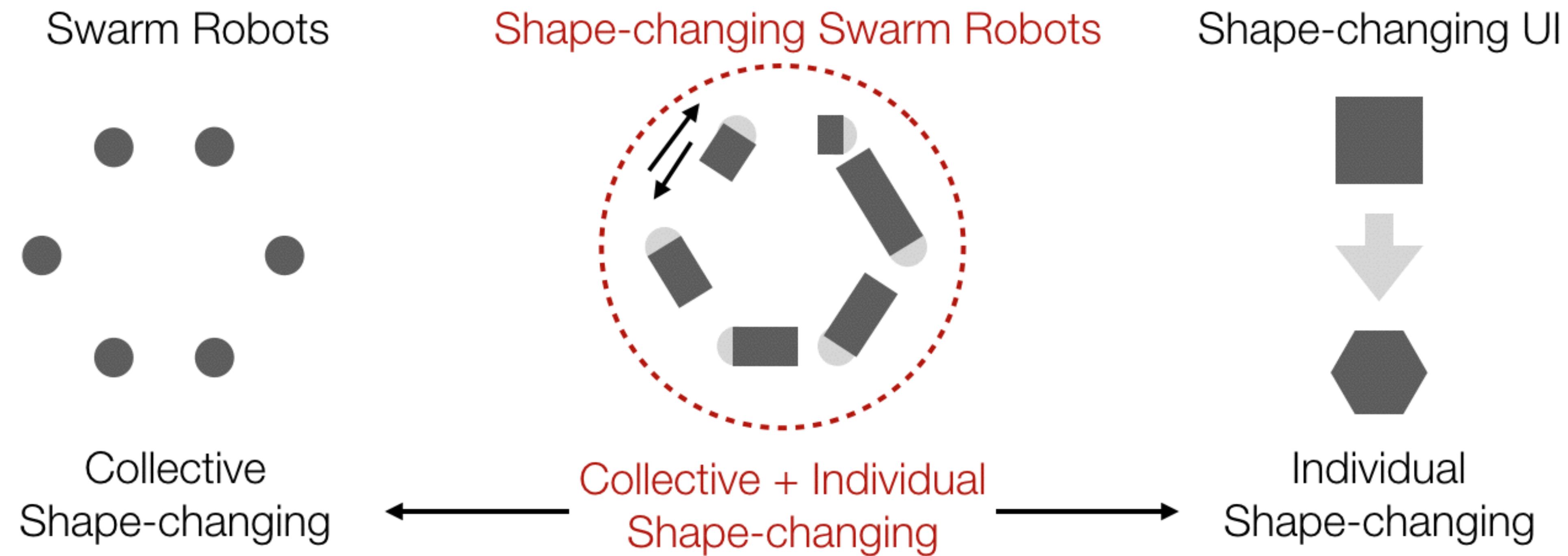


Representations
e.g., Haptic proxy for
AR

Conclusion

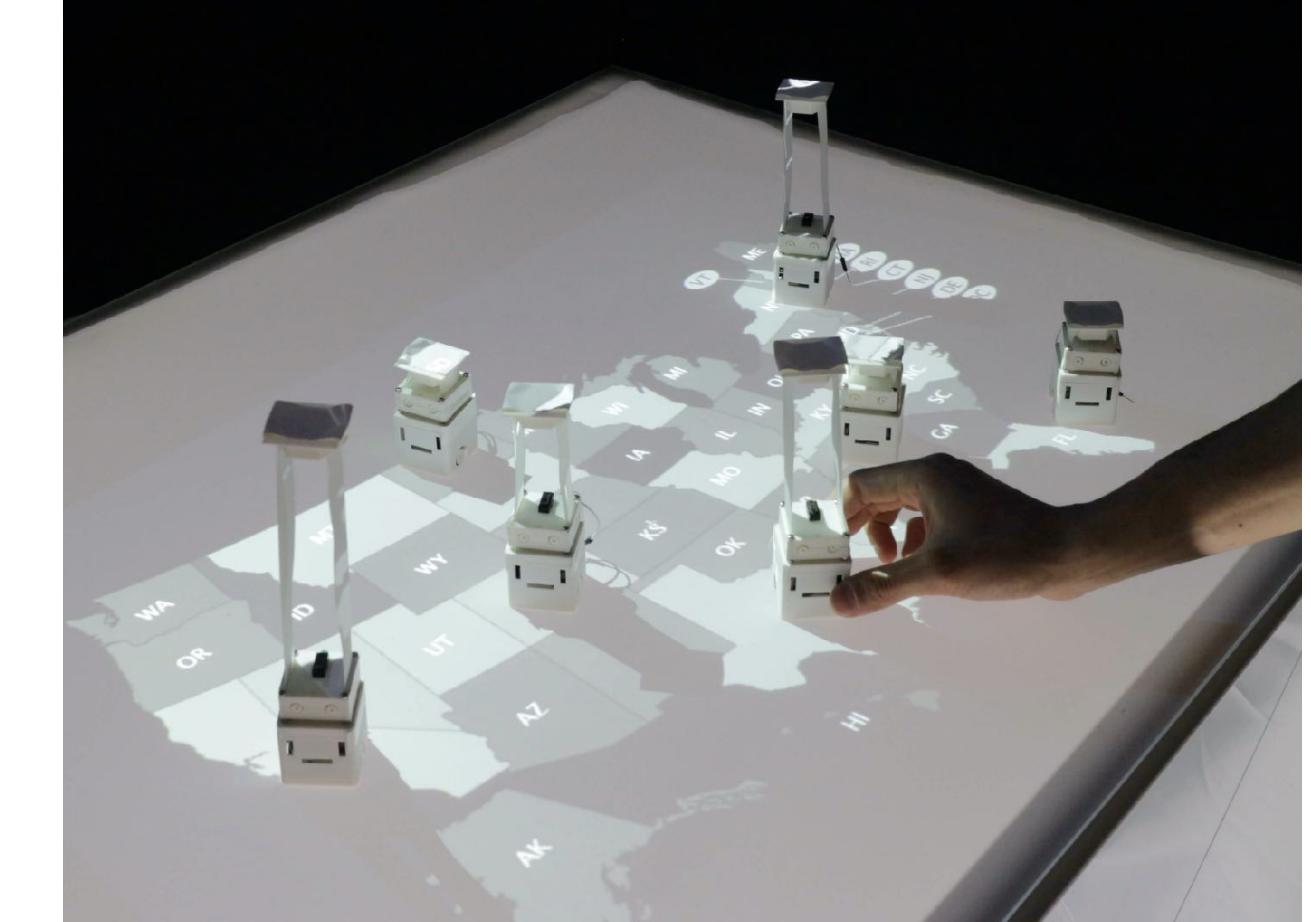
Contributions

1. Concept of shape-changing swarm robots



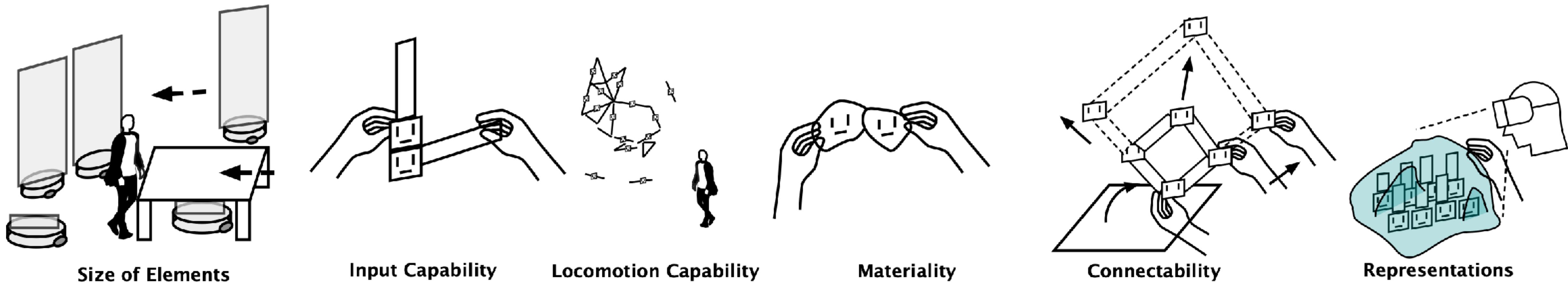
Contributions

2. ShapeBots design and applications



Contributions

3. Design space exploration for future research opportunities



ShapeBots

Shape-changing Swarm Robots

Ryo Suzuki

Clement Zheng

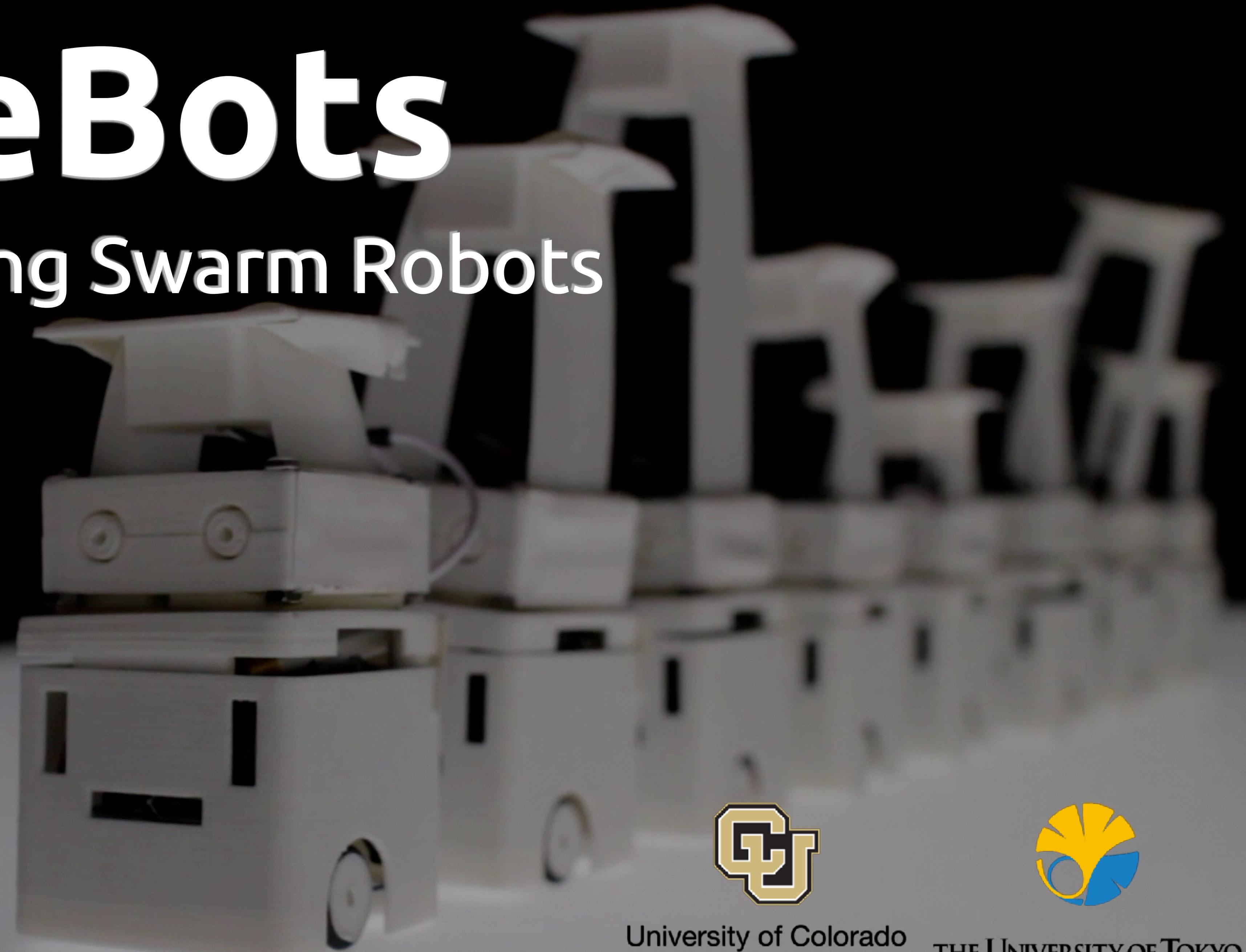
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