MorphIO

Keio University

University of Colorado Boulder

The University of Tokyo

Entirely Soft Sensing and Actuation Modules for Programming Shape Changes through Tangible Interaction

Ryosuke Nakayama*

Ryo Suzuki*

Satoshi Nakamaru

Ryuma Niiyama

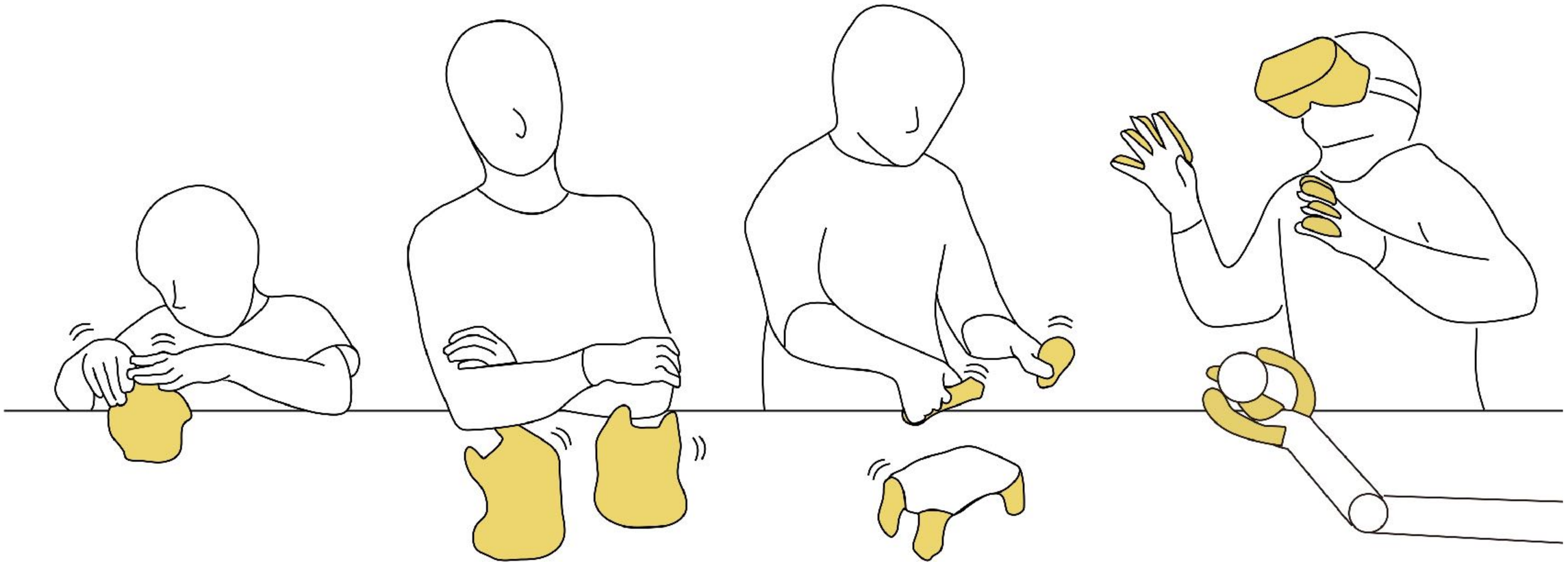
Yoshihiro Kawahara

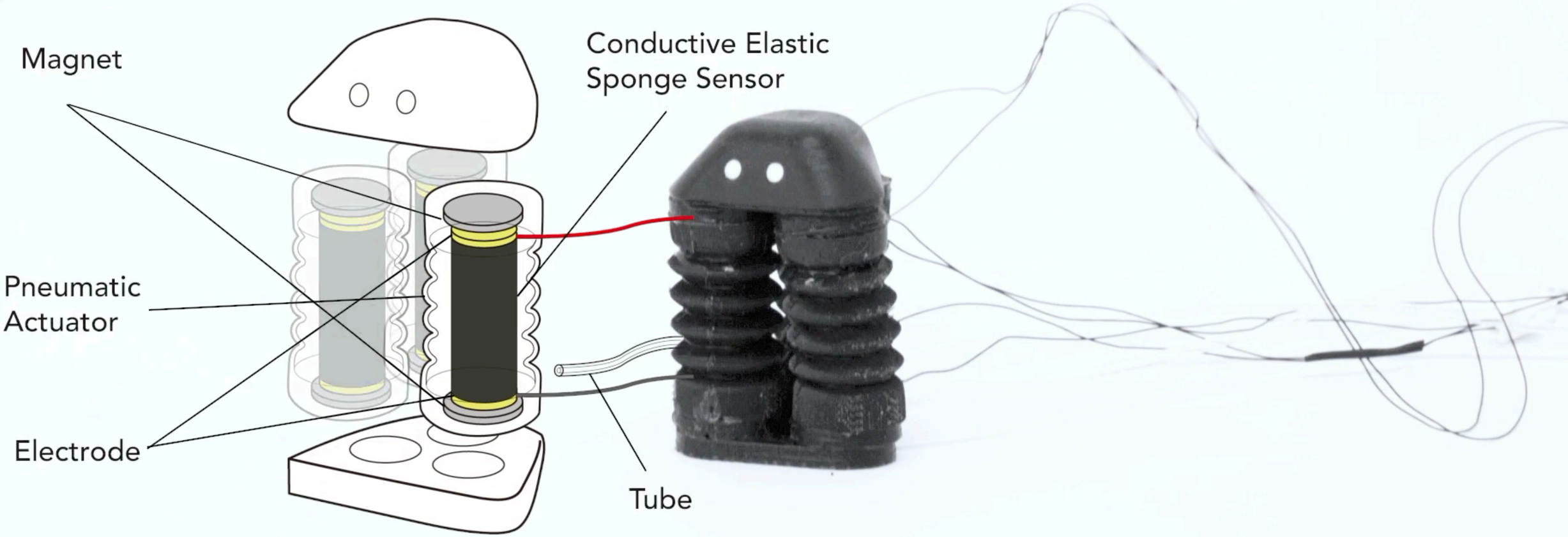
Yasuaki Kakehi

Programmable Soft Materials

Programming of Soft Materials is **Hard**

Our Vision




Magnet
Conductive Elastic
Sponge Sensor
Pneumatic
Actuator
Electrode
Tube

Contributions

1. **Entirely soft** sensing and actuation unit

Contributions

1. **Entirely soft** sensing and actuation unit

2. MorphIO, **programming by demonstration** environment

Contributions

1. **Entirely soft** sensing and actuation unit

2. MorphIO, **programming by demonstration** environment

3. **Applications** and user **study**

1. Summary

2. Related Work

3. MorphIO: System and Implementation

4. User Study

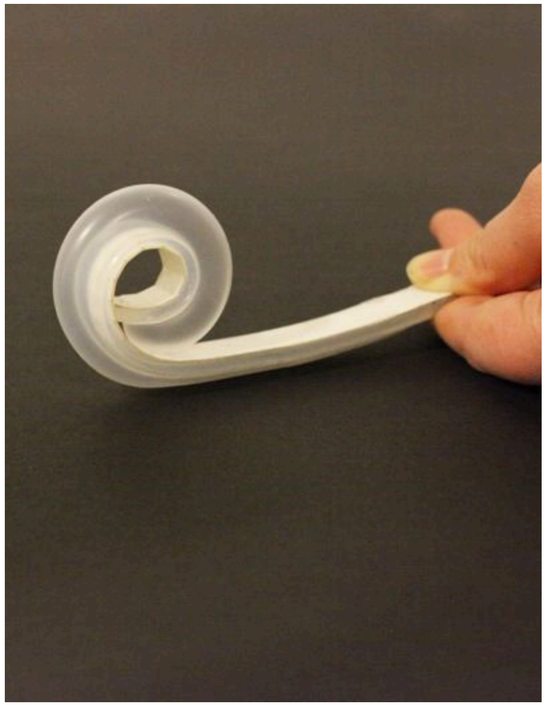
5. Conclusion

Programming by Demonstration

Topobo
[CHI 2004]

Bosu
[TEI 2010]

Shape-changing UI with Soft Materials



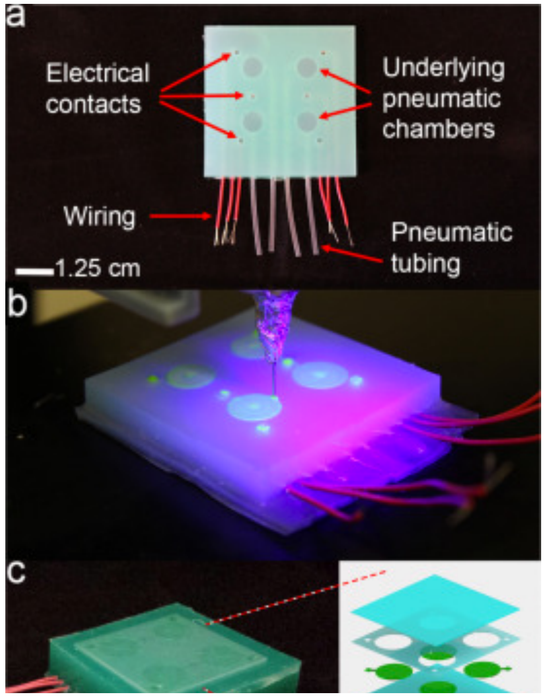
PneUI
[UIST 2013]

Jamming UI
[UIST 2012]

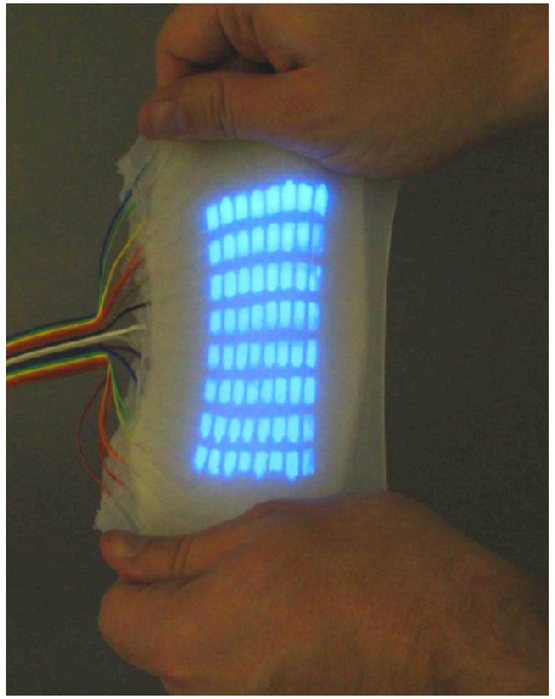
FoamSense
[UIST 2017]

COLORISE
[TEI 2018]

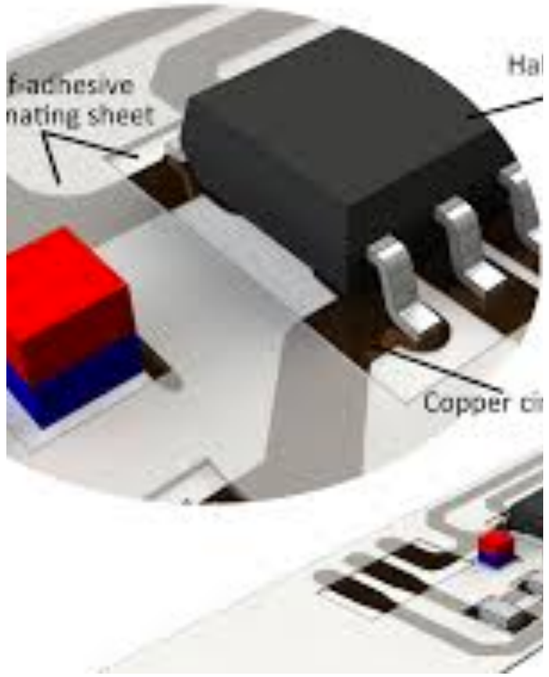
Integrated Soft Sensor + Actuator



Direct Ink Writing
[EML 2015]



Capacitive
[Science 2016]



Magnetic
[ICRA 2016]

Optical
[Science 2016]

1. Summary
2. Related Work

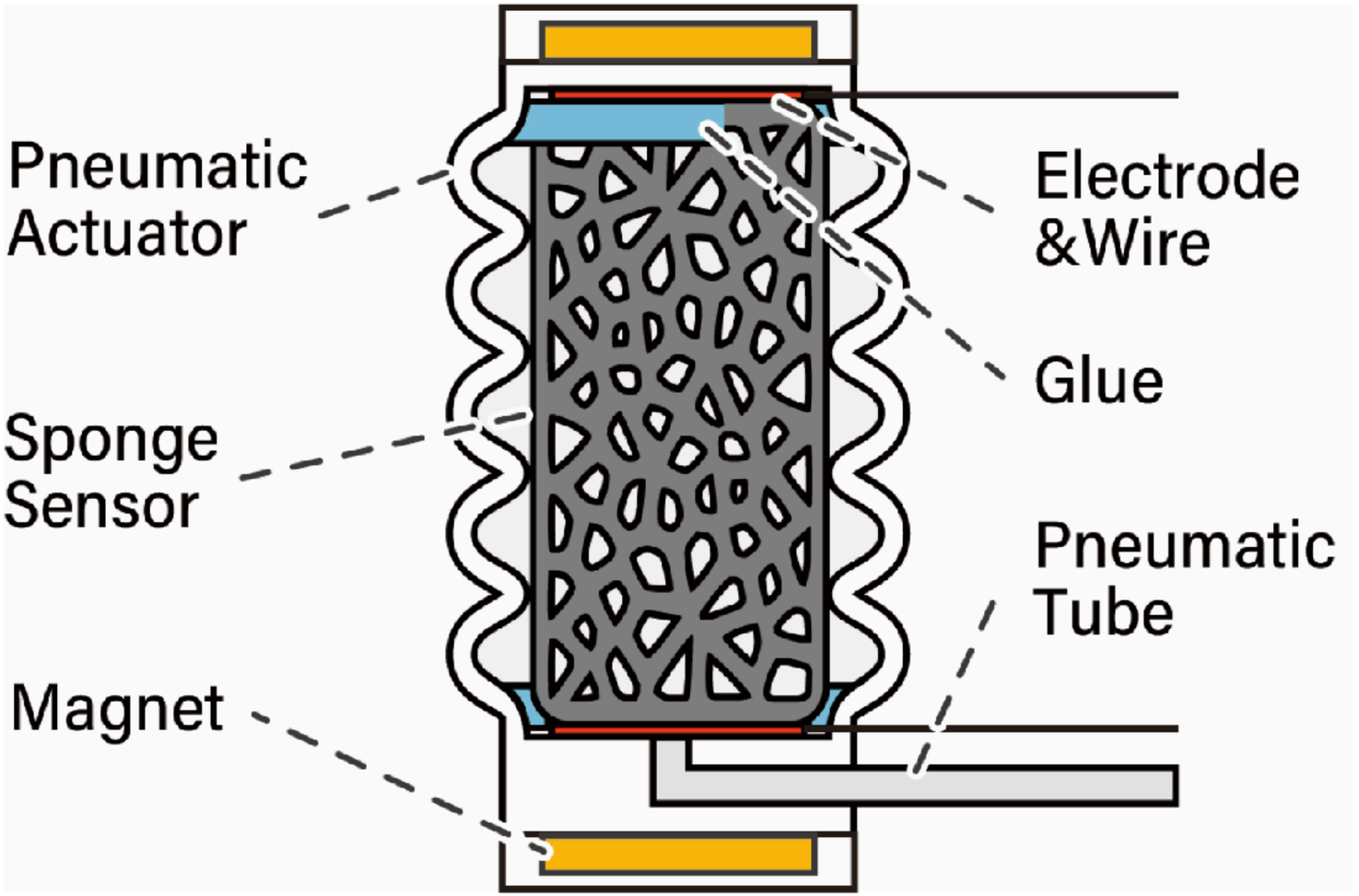
3. MorphIO

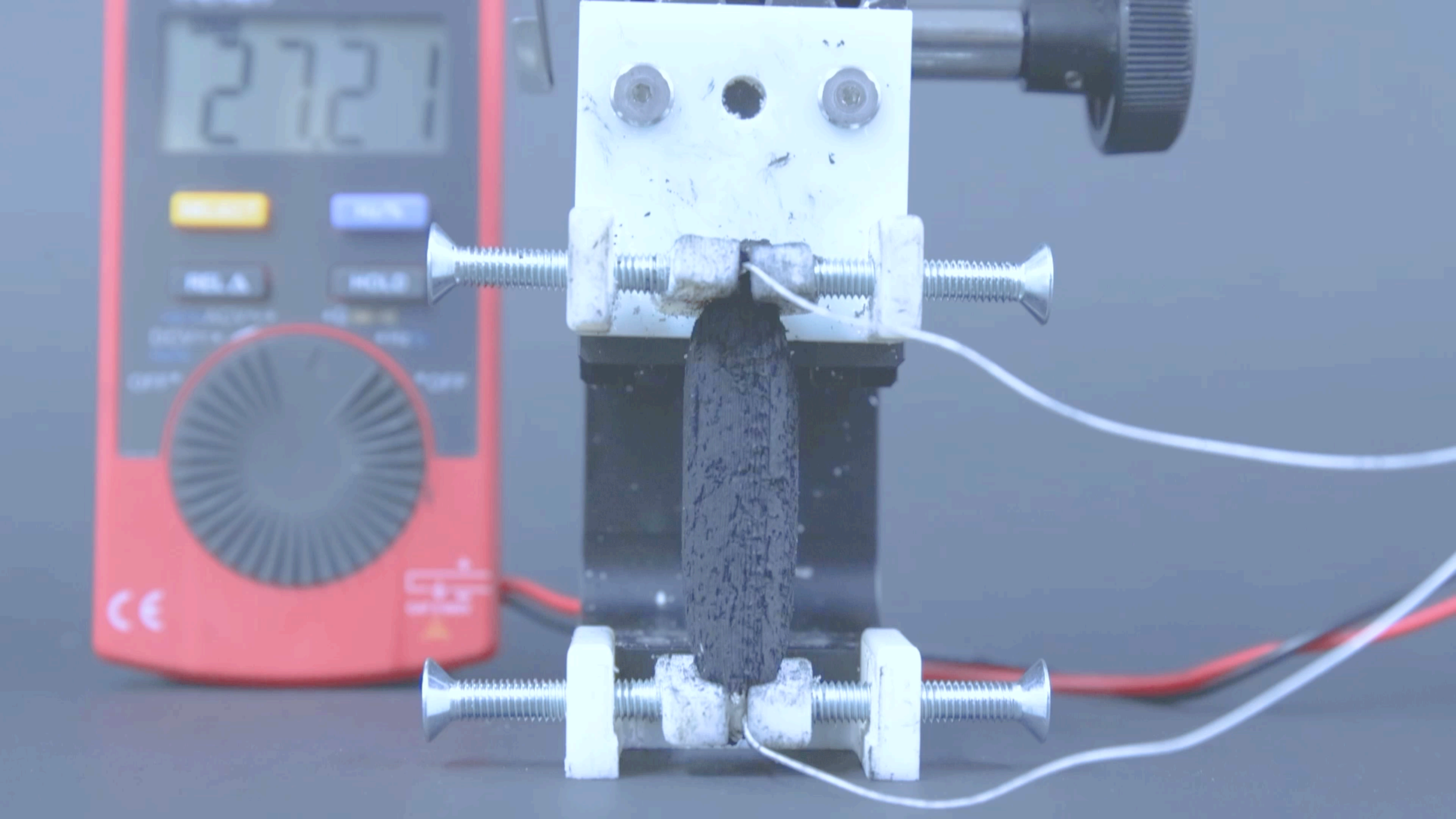
4. User Study
5. Conclusion

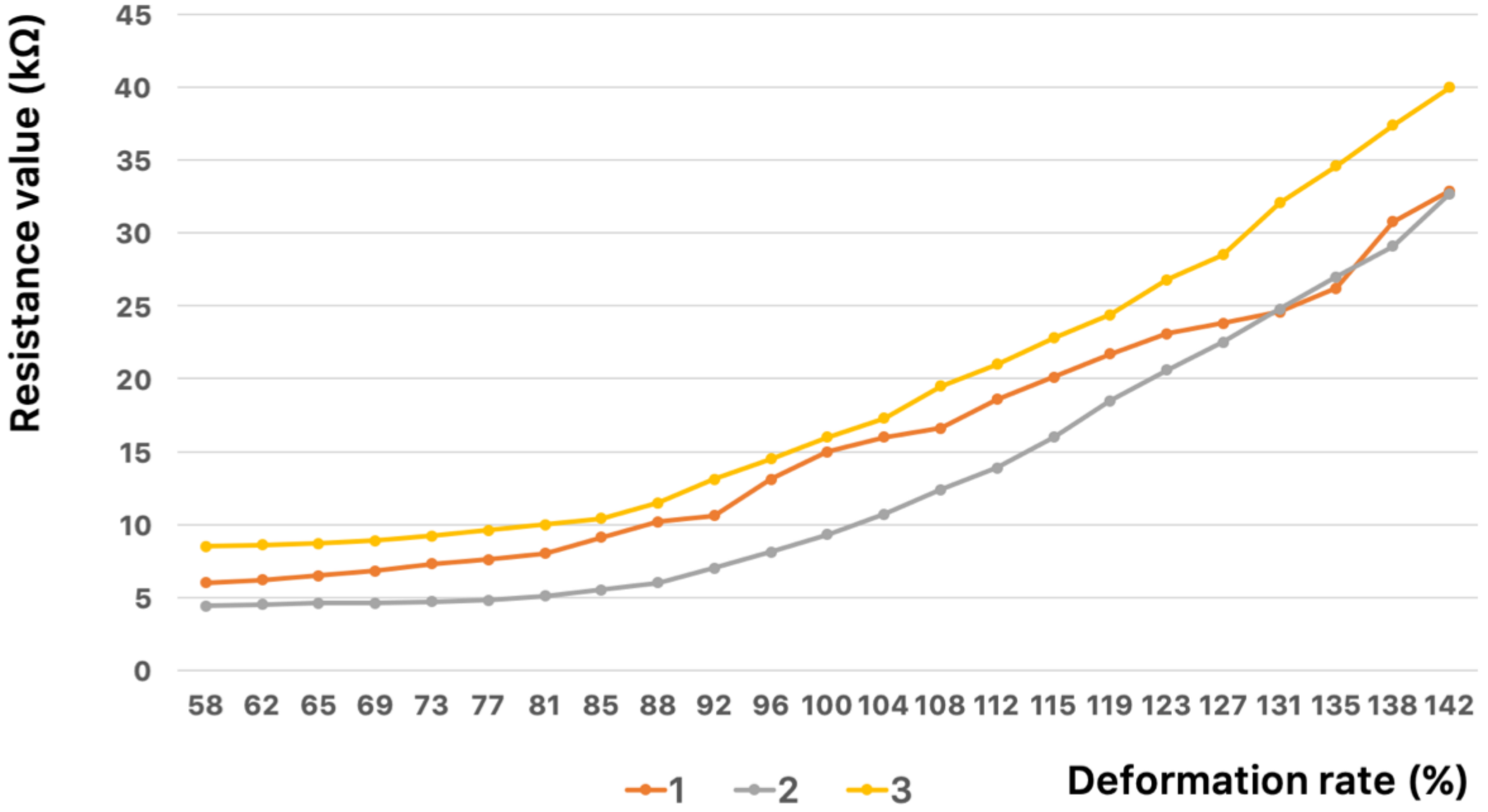
Programming Method

Record & Playback

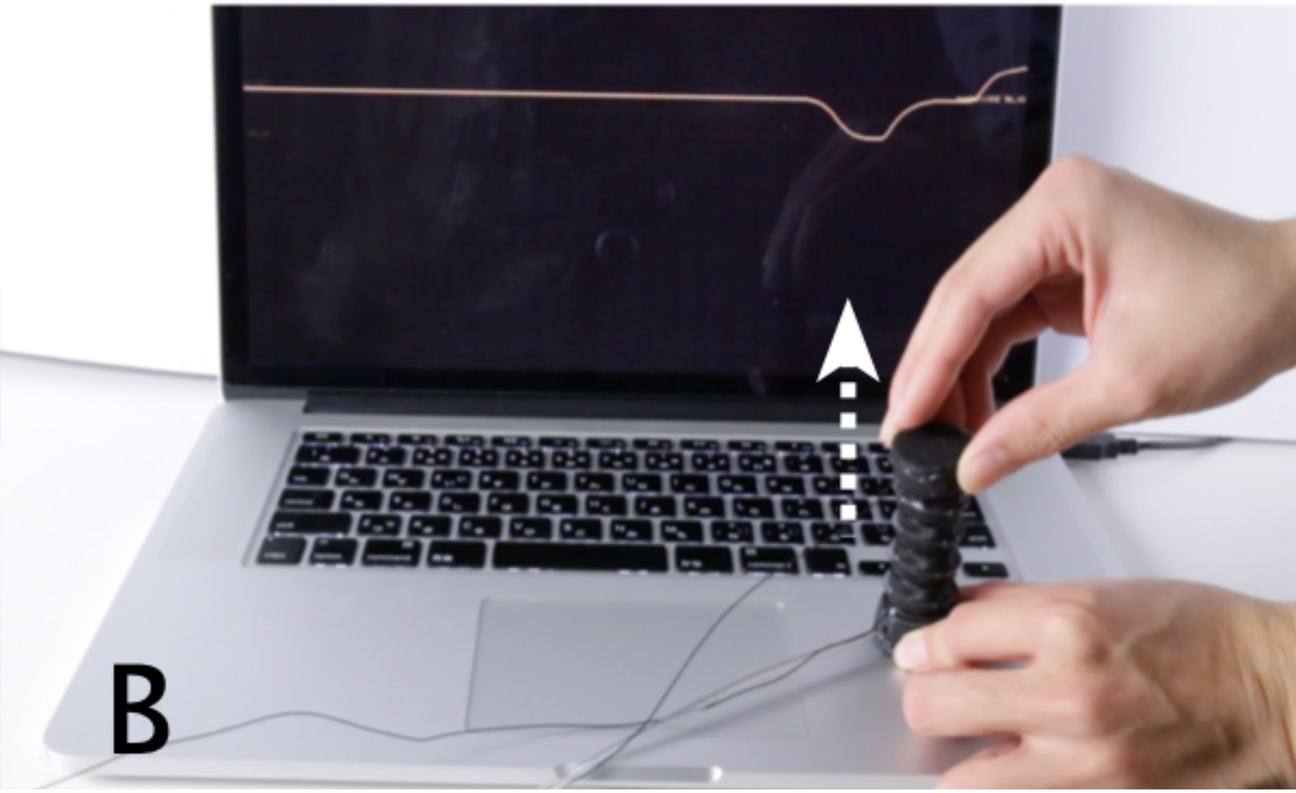
Entirely Soft I/O

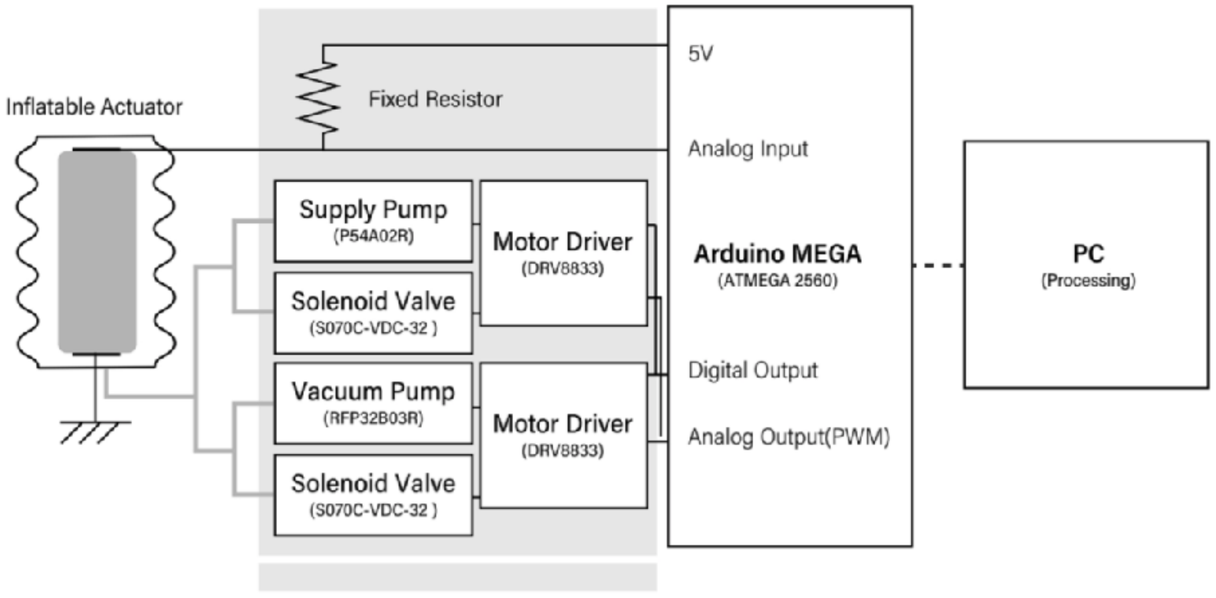

Pneumatic
Actuator
Sponge
Sensor
Magnet
Electrode
&Wire
Glue
Pneumatic
Tube

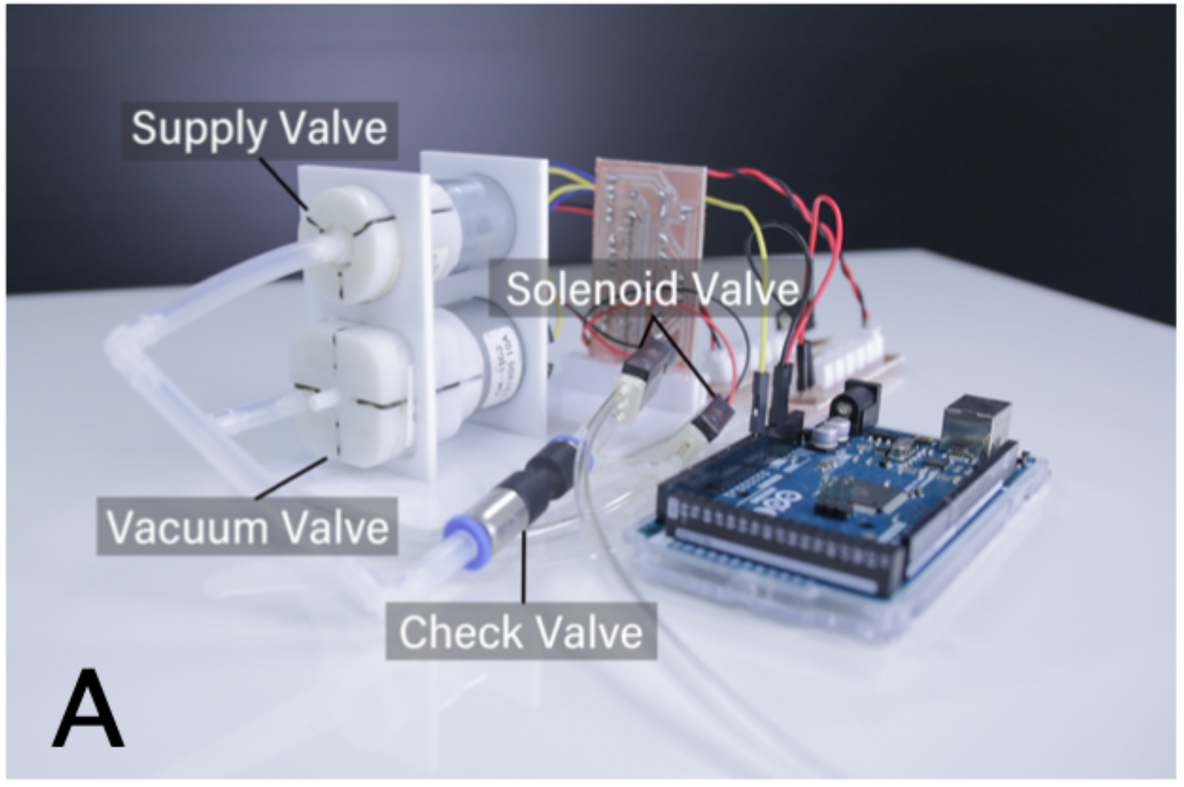

2721

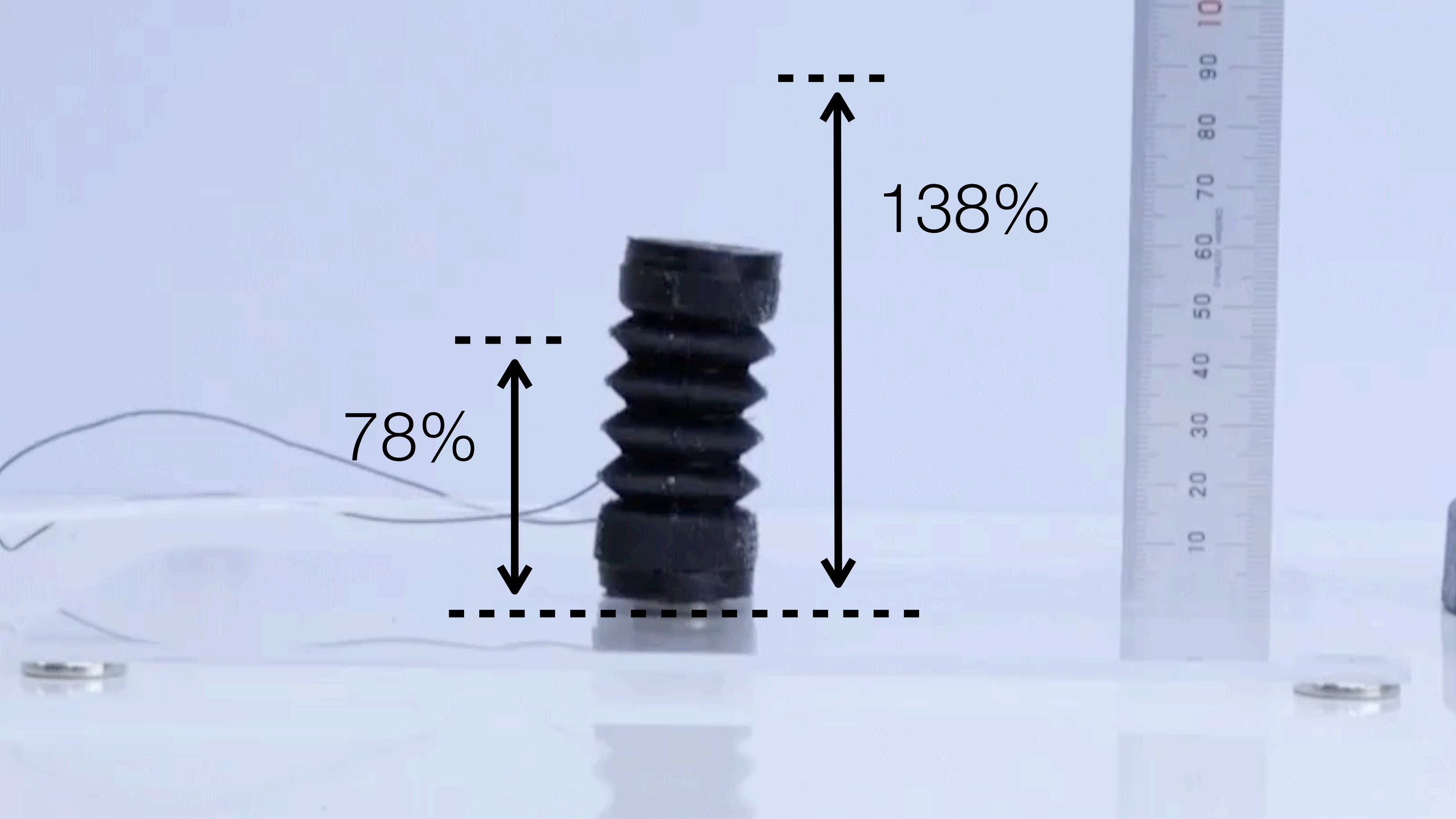

Resistance value (kΩ)
45
40
35
30
25
20
15
10
5
0
58 62 65 69 73 77 81 85 88 92 96 100 104 108 112 115 119 123 127 131 135 138 142
1
2
3
Deformation rate (%)

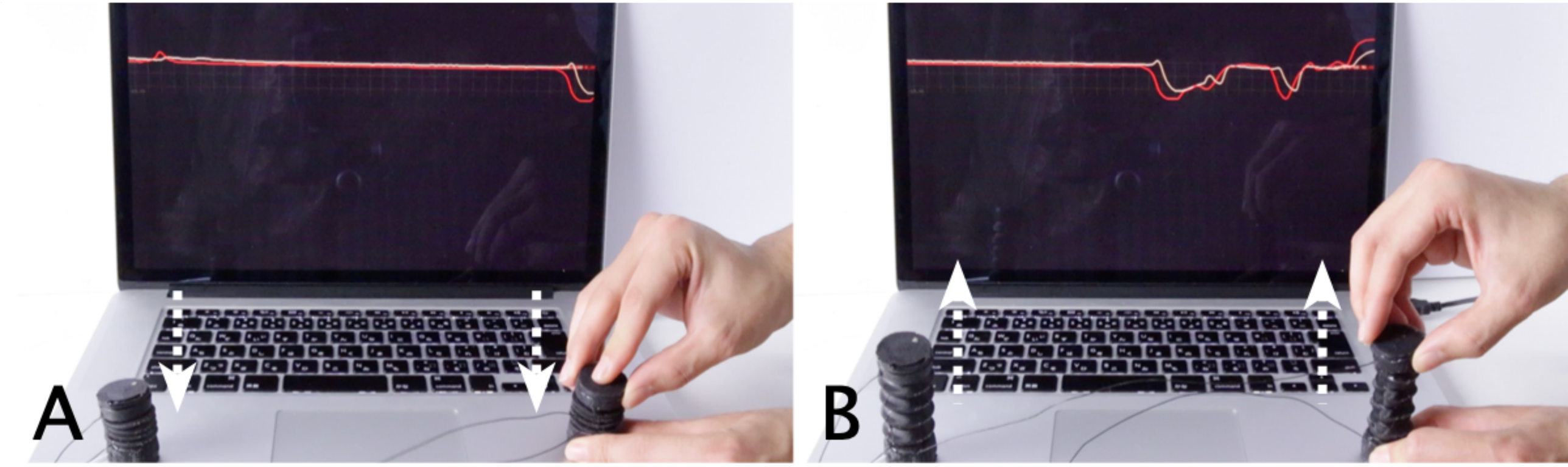

A


B


Inflatable Actuator
Fixed Resistor
Supply Pump
(P54A02R)
Solenoid Valve
(S070C-VDC-32)
Vacuum Pump
(RFP32B03R)
Solenoid Valve
(S070C-VDC-32)
Motor Driver
(DRV8833)
Motor Driver
(DRV8833)
5V
Analog Input
Arduino MEGA
(ATMEGA 2560)
Digital Output
Analog Output(PWM)
PC
(Processing)


Supply Valve
Solenoid Valve
Vacuum Valve
Check Valve
A

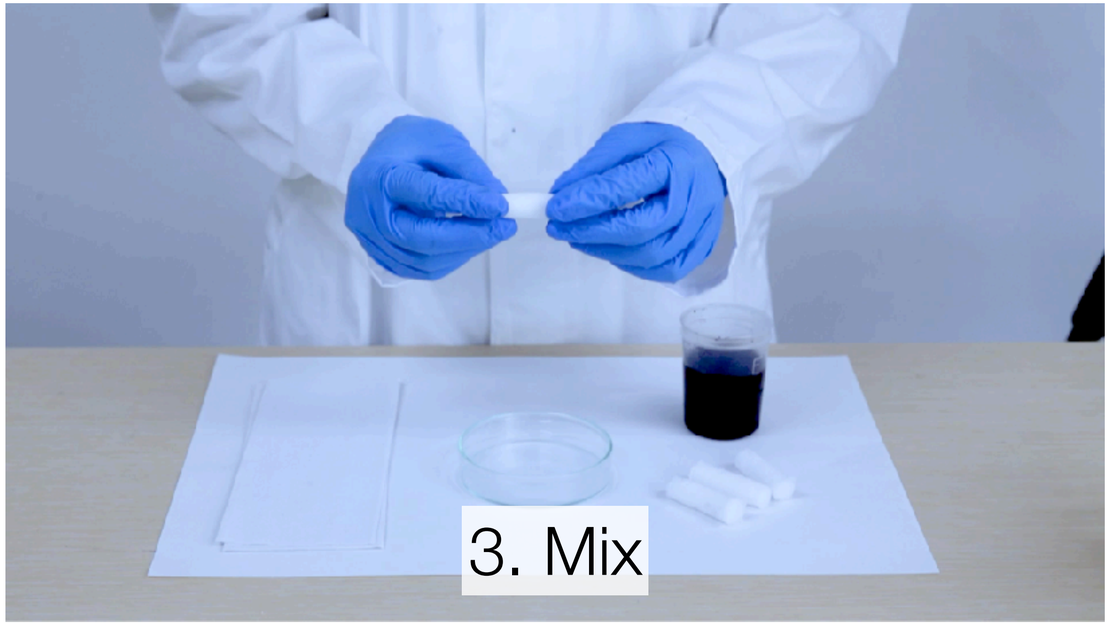

138%
78%

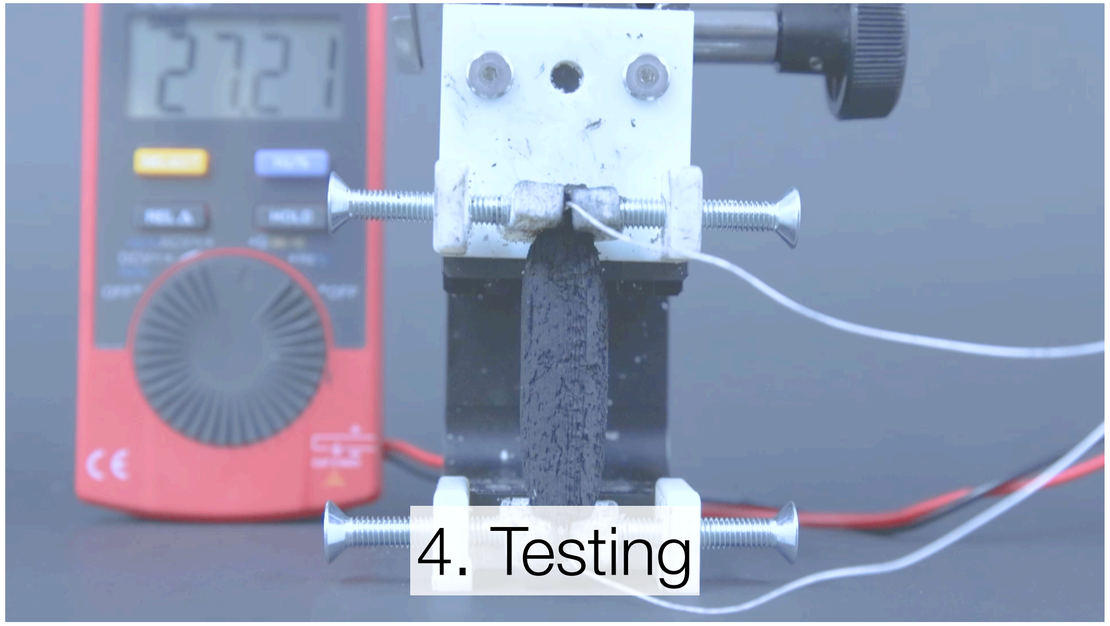

A
B

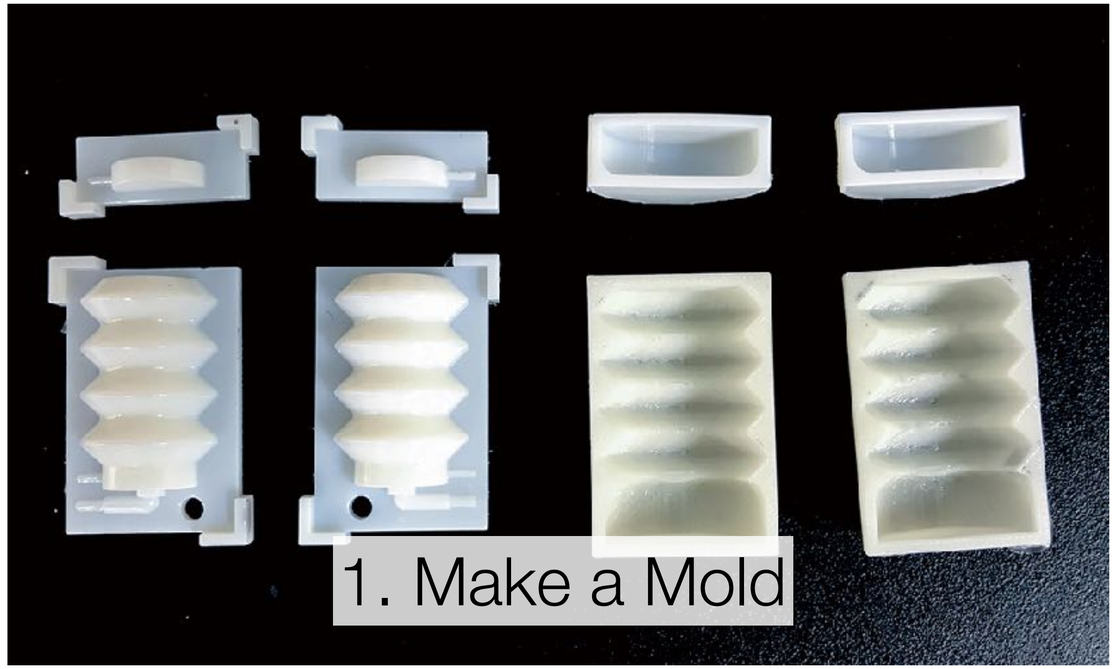
Fabrication Process

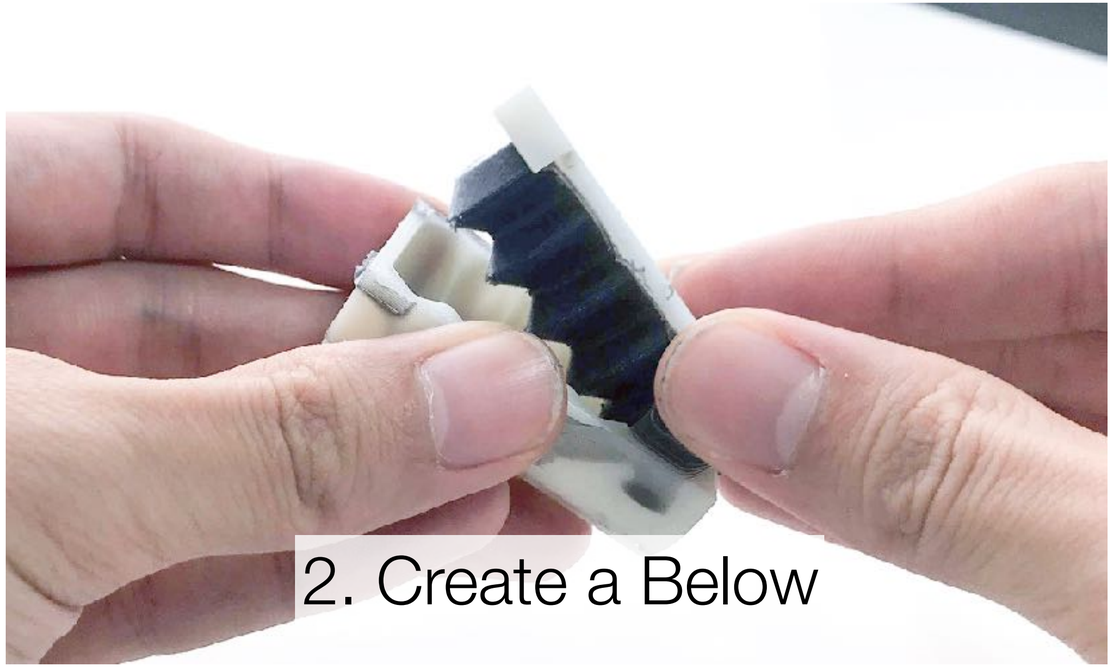

1. Make an Elastic Foam


2. Make a Conductive Ink

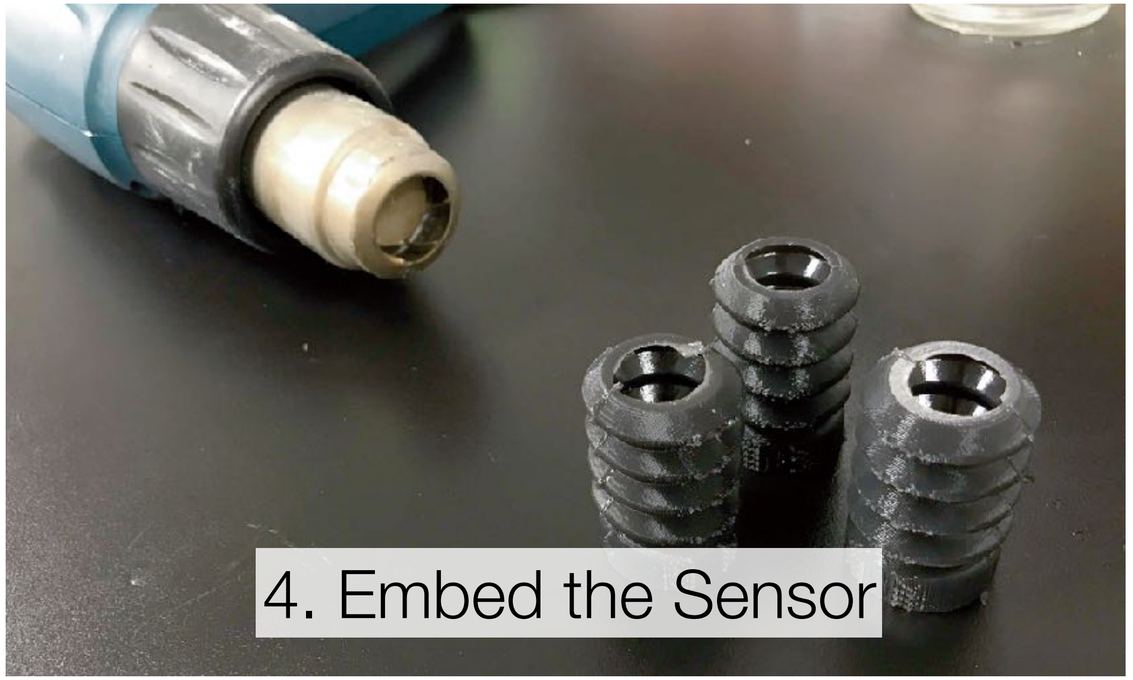

3. Mix

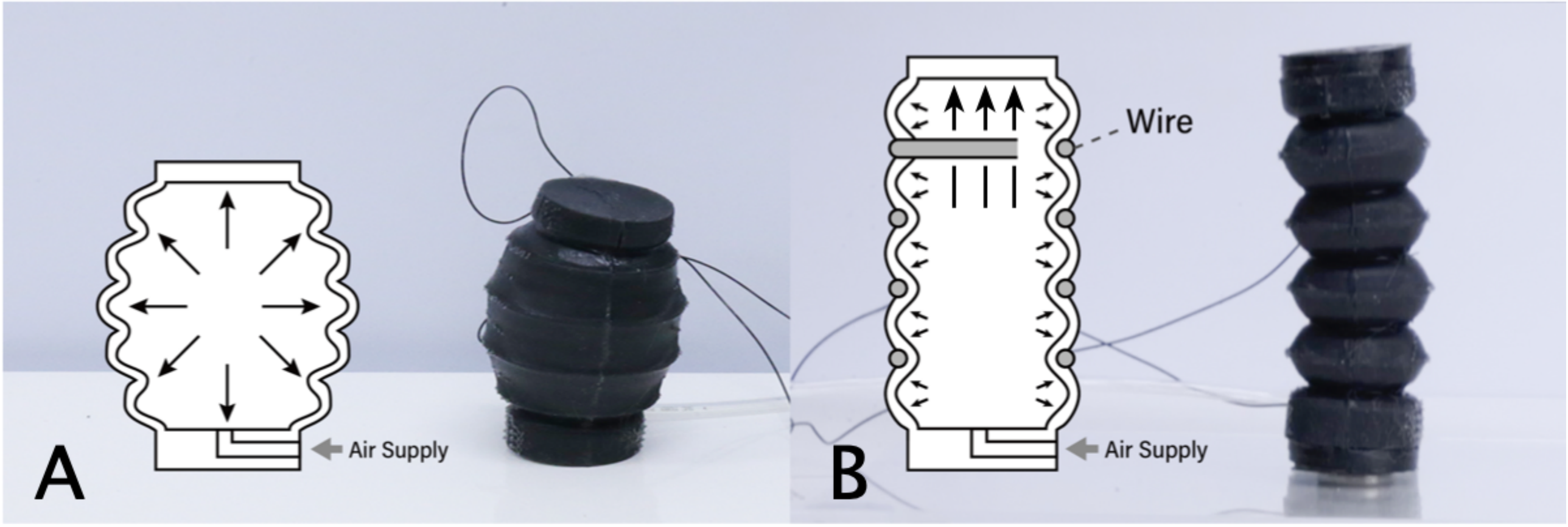

4. Testing


1. Make a Mold


2. Create a Below


3. Repeat Casting

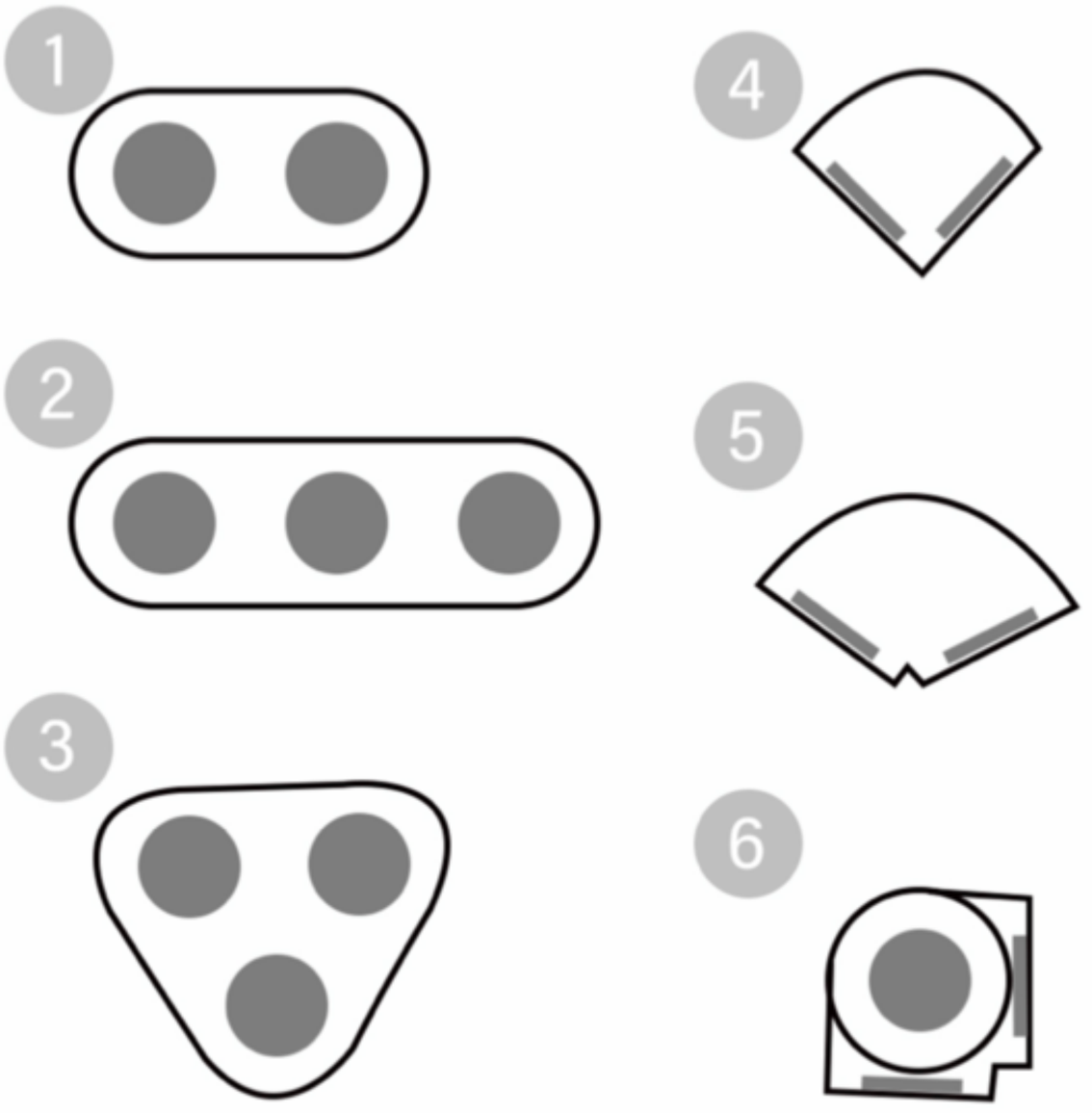

4. Embed the Sensor


A
Air Supply
B
Wire
Air Supply

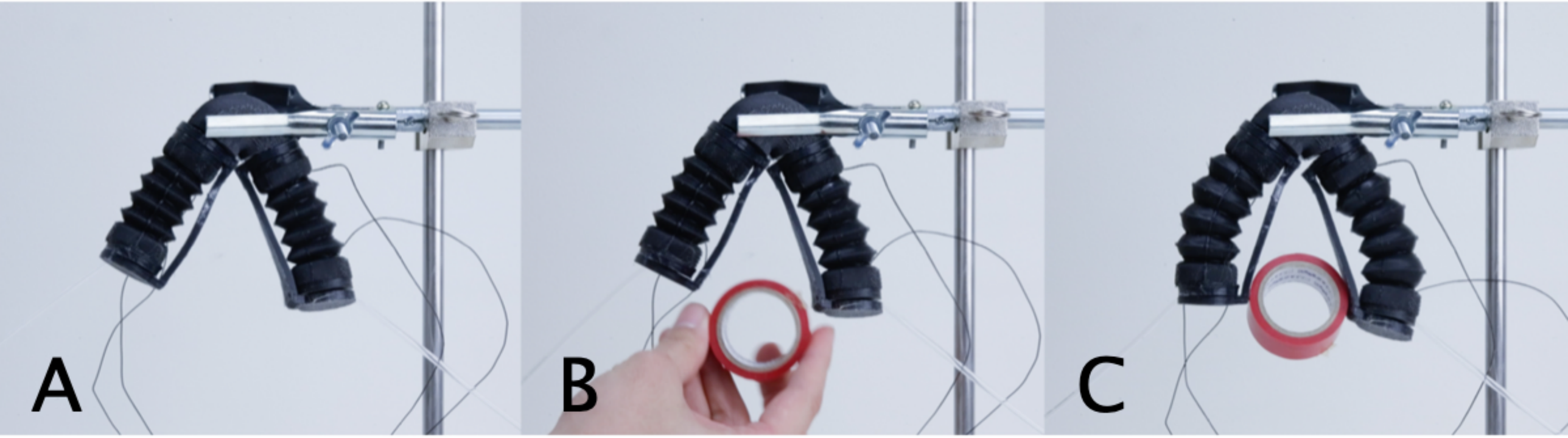
Modular Design


A
B
C

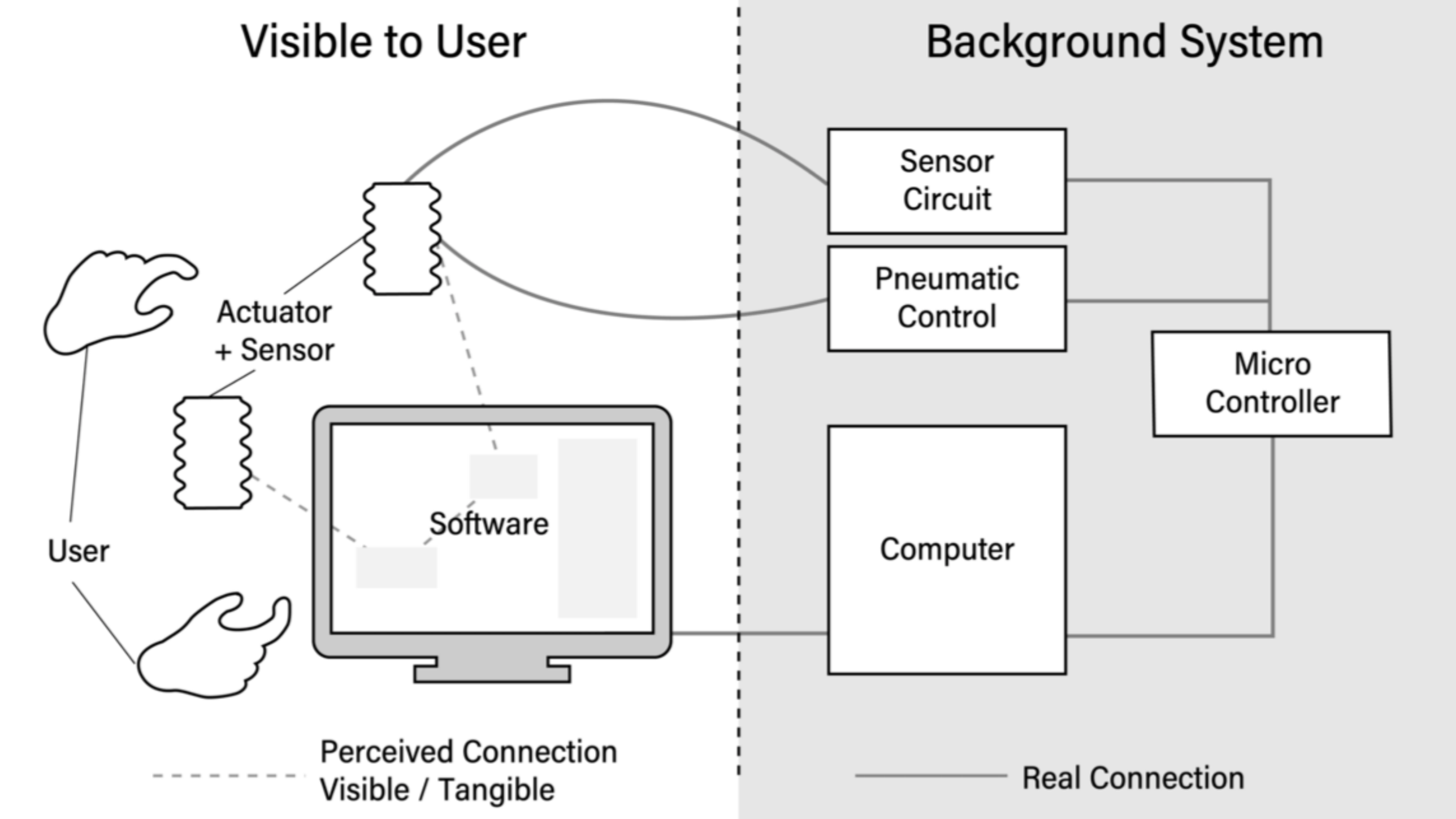

1
4
2
5
3
6

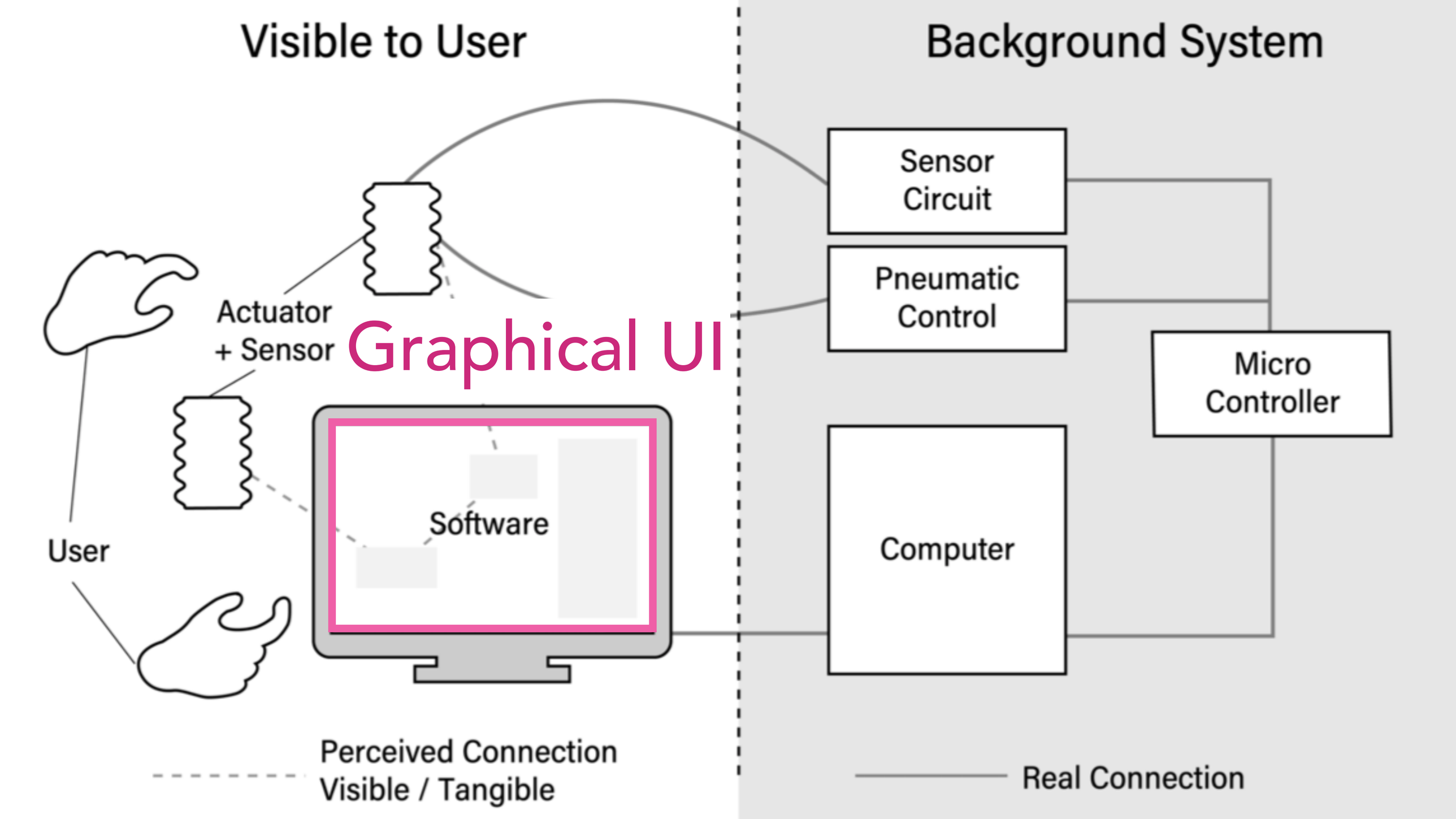

1
4
2
5
3
6

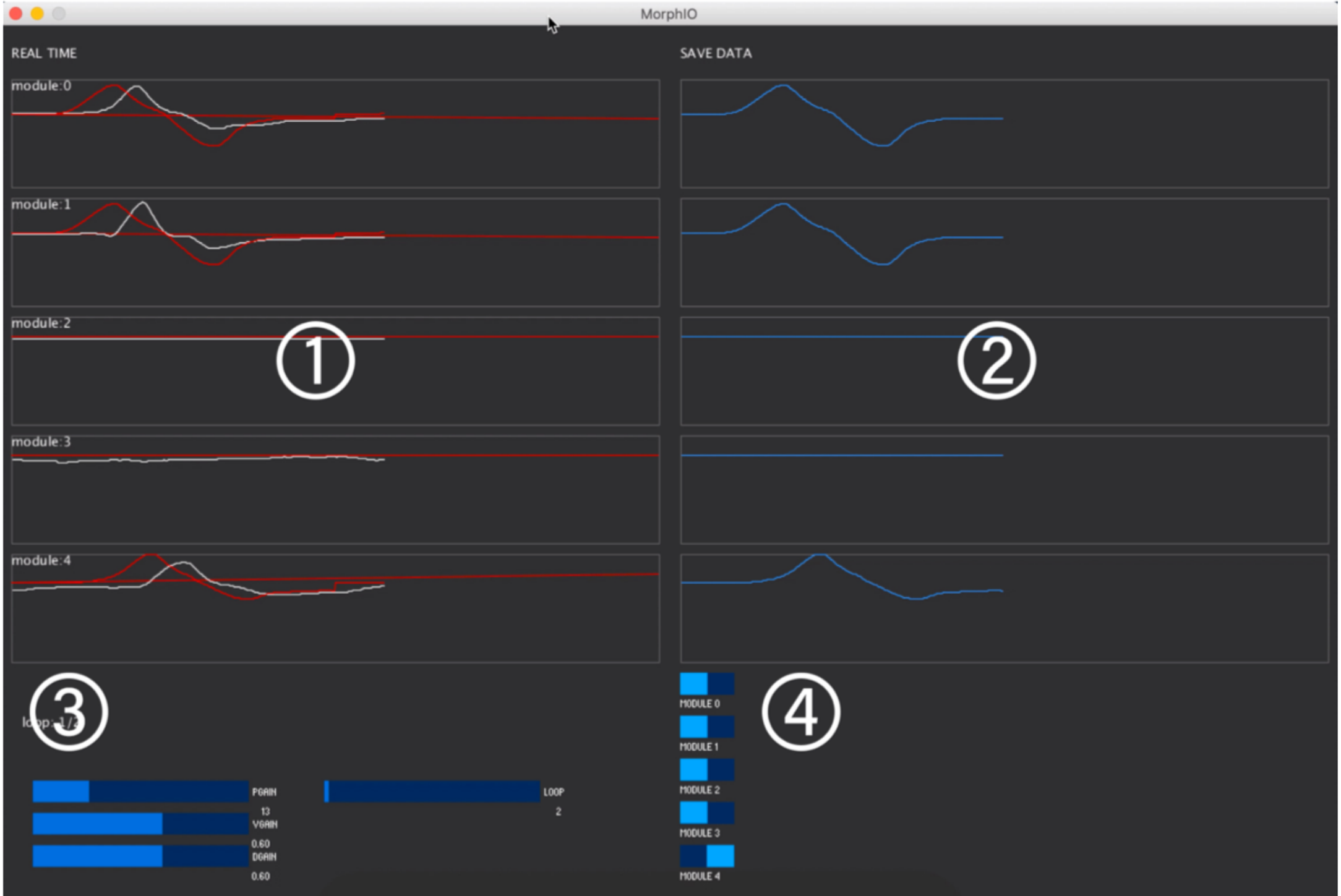
10
20
30
40
50
60
70
80
90

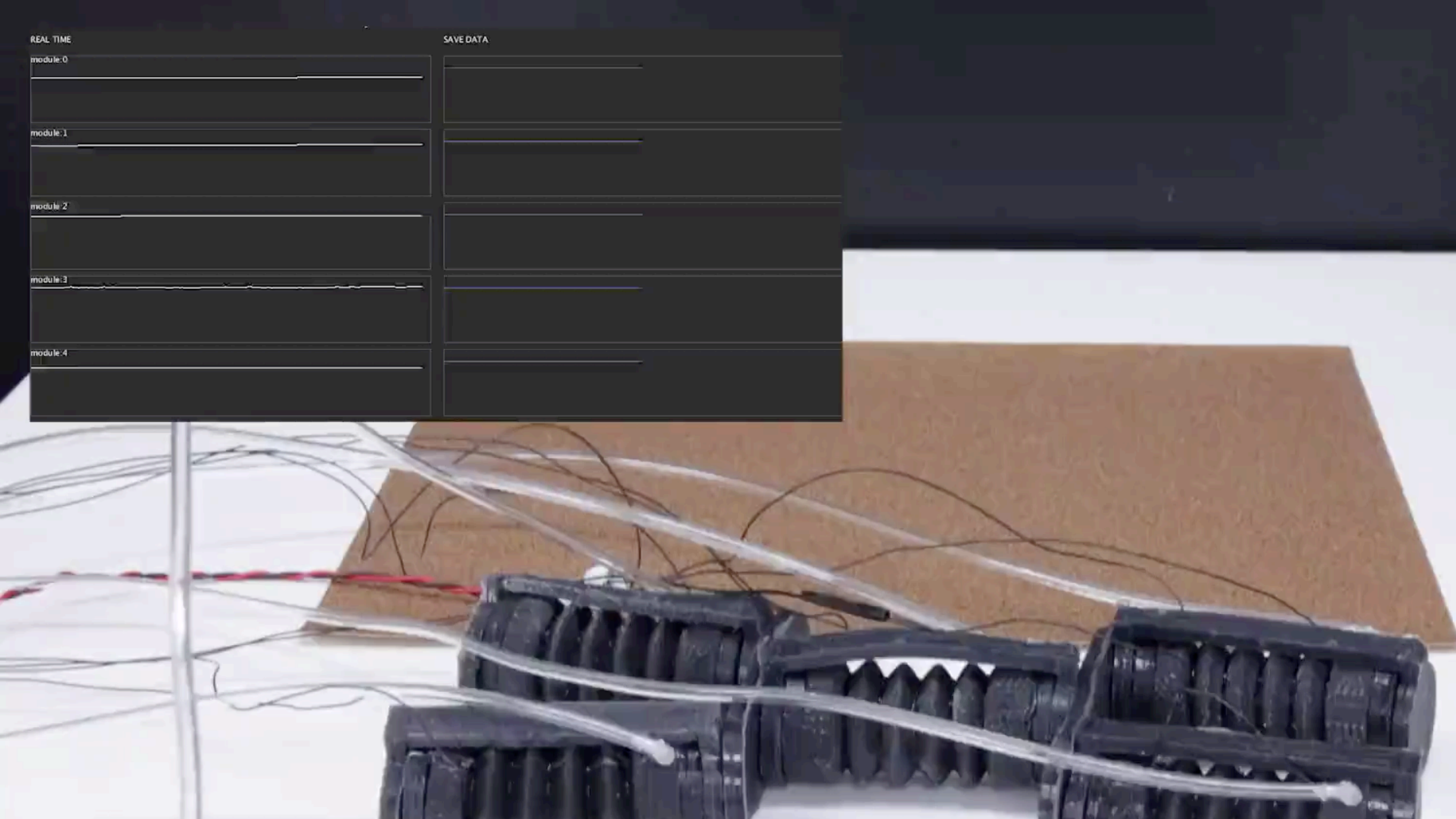

A
B
C

Software System


Visible to User
Background System
Sensor Circuit
Pneumatic Control
Micro Controller
Computer
Actuator + Sensor
Software
User
Perceived Connection
Visible / Tangible
Real Connection


Visible to User
Background System
Sensor Circuit
Pneumatic Control
Micro Controller
Computer
Actuator + Sensor
Graphical UI
Software
User
Perceived Connection
Visible / Tangible
Real Connection

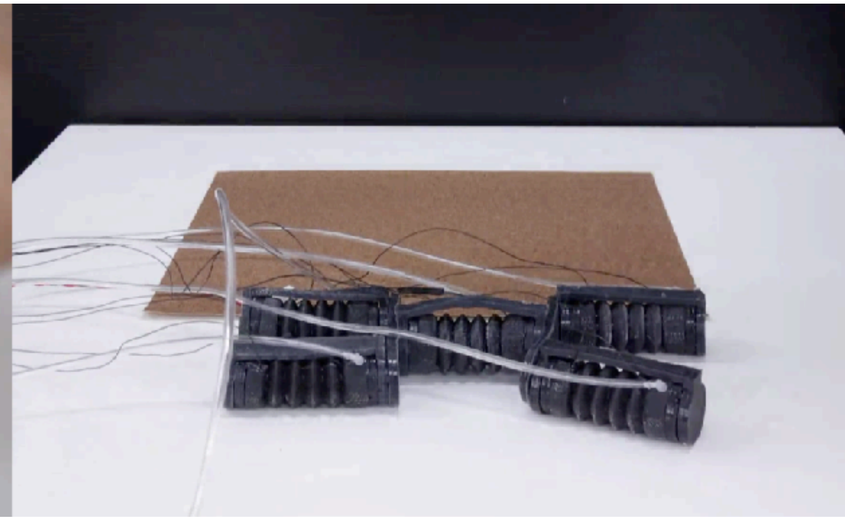

MorphIO
REAL TIME
SAVE DATA
module:0
module:1
module:2
module:3
module:4
①
②
③
④
PGAIN
13
VGAIN
0.60
DGAIN
0.60
LOOP
2
MODULE 0
MODULE 1
MODULE 2
MODULE 3
MODULE 4


REAL TIME
SAVE DATA
module:0
module:1
module:2
module:3
module:4

Applications

Tangible Character Animation

Animating Static Objects



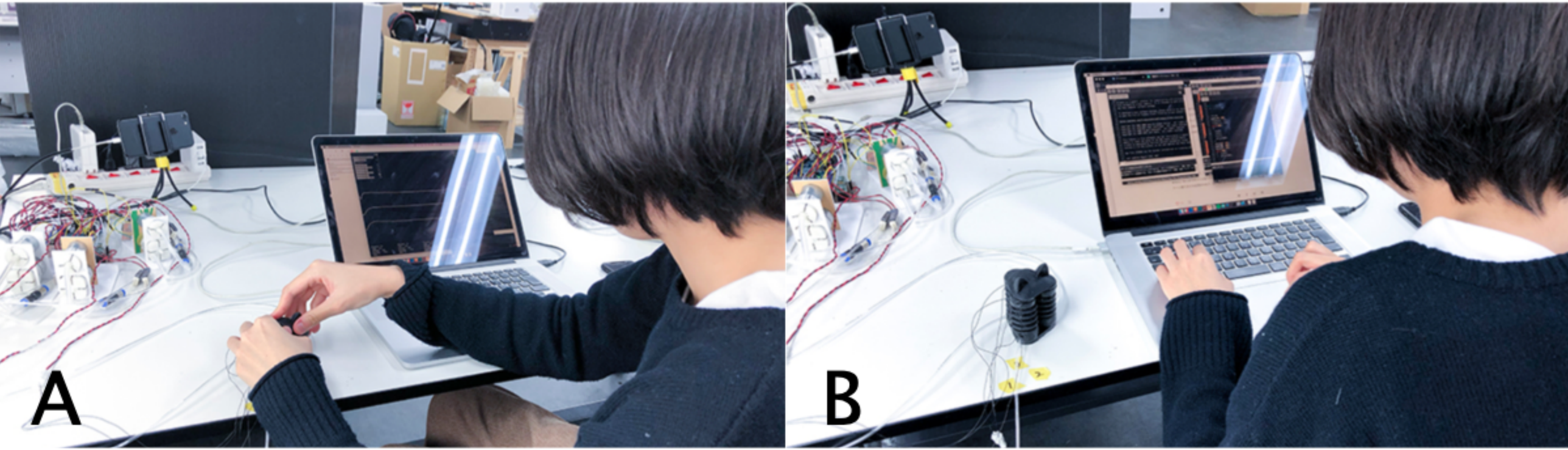
Quick Experiment for Soft Robots

1. Summary
2. Related Work
3. MorphIO: System and Implementation

4. User Study

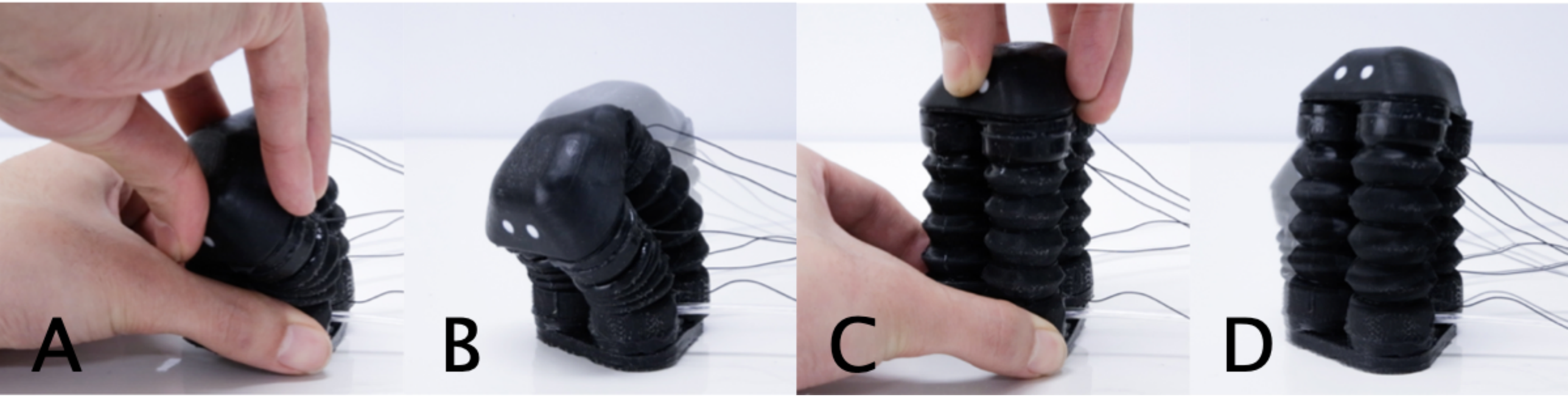
5. Conclusion

Control Experiment



MorphIO vs Arduino IDE

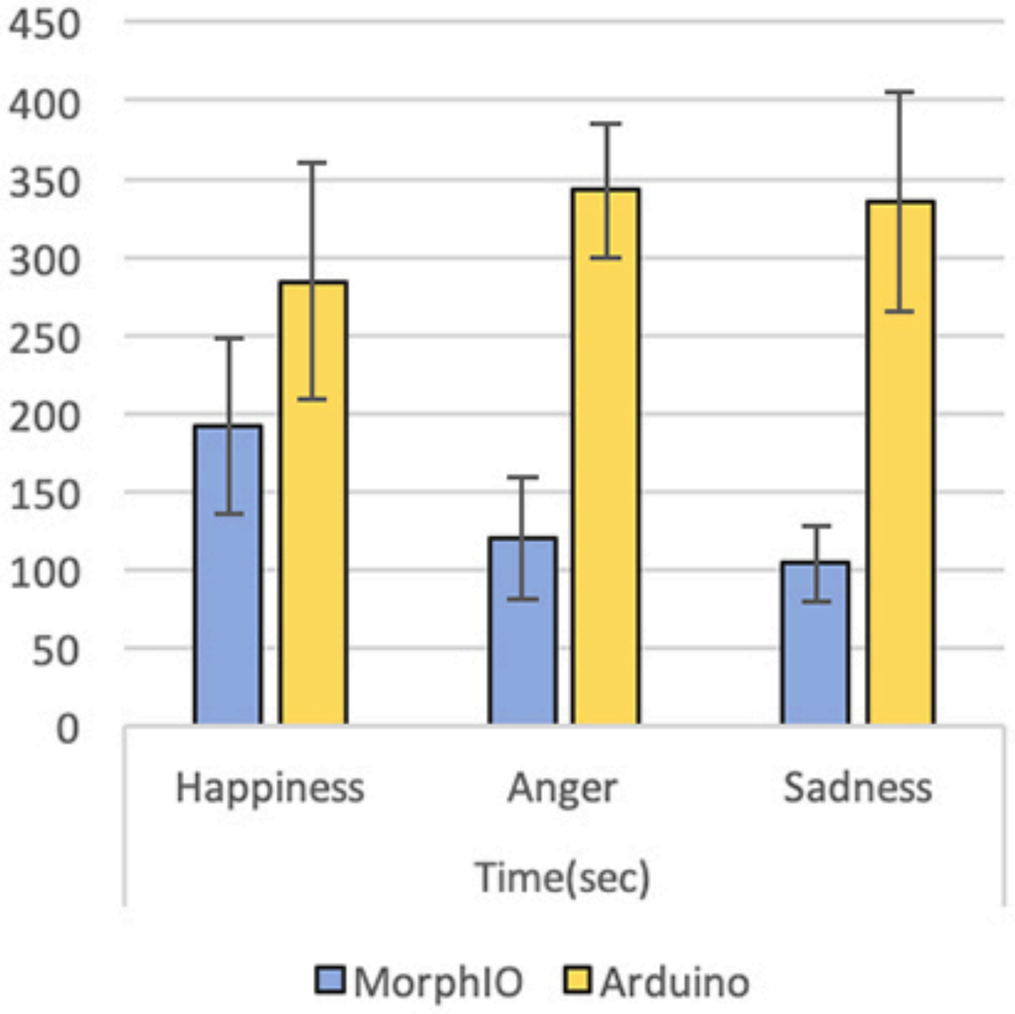
Task

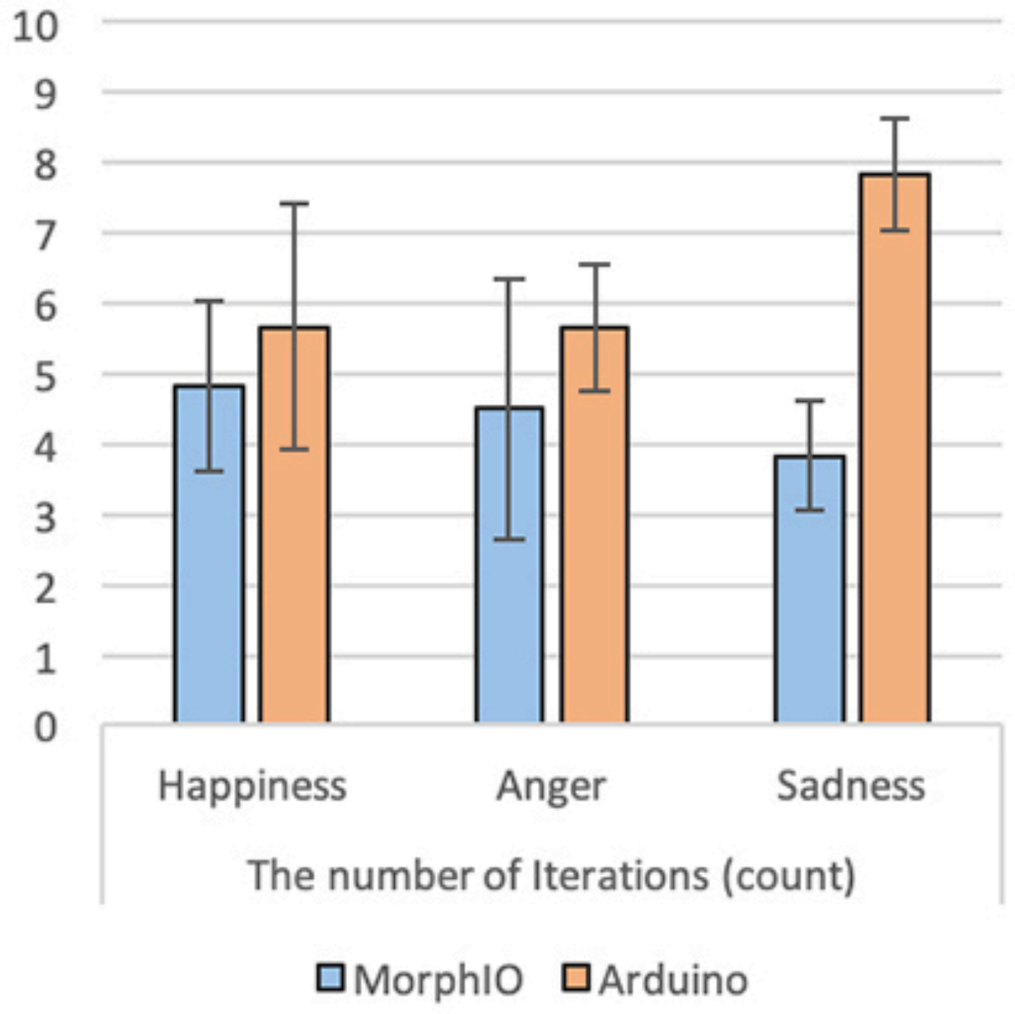


happy angry sad

RQ1: Does MorphIO save **time** and reduce **the number of iterations** to program the target behavior, compared to the existing approach?

RQ2: Does MorphIO increase the **expressiveness** of the motion?


450
400
350
300
250
200
150
100
50
0
Happiness
Anger
Sadness
Time(sec)
MorphIO
Arduino


10
9
8
7
6
5
4
3
2
1
0
Happiness
Anger
Sadness
The number of Iterations (count)
MorphIO
Arduino

RQ1: Does MorphIO save **time** and reduce **the number of iterations** to program the target behavior, compared to the existing approach? → **Yes**

RQ2: Does MorphIO increase the **expressiveness** of the motion? → **No**

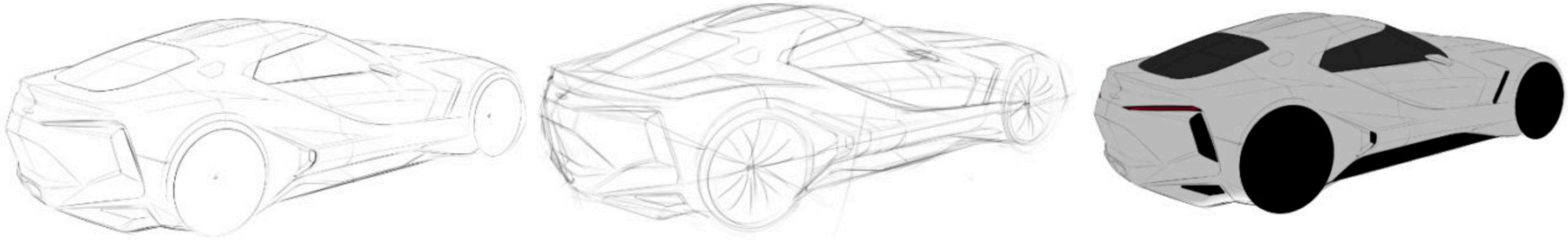
Insights

tangible interactions are suitable for sculpting **rough motion**,

on the other hand…
programming allows for fine-tuning for more **precise adjustments**.

Future Research Question

Can we leverage the **both** advantages?



rough ⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯▶ tuning

e.g. can we apply this to programming practice?

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2. Related Work
3. MorphIO: System and Implementation
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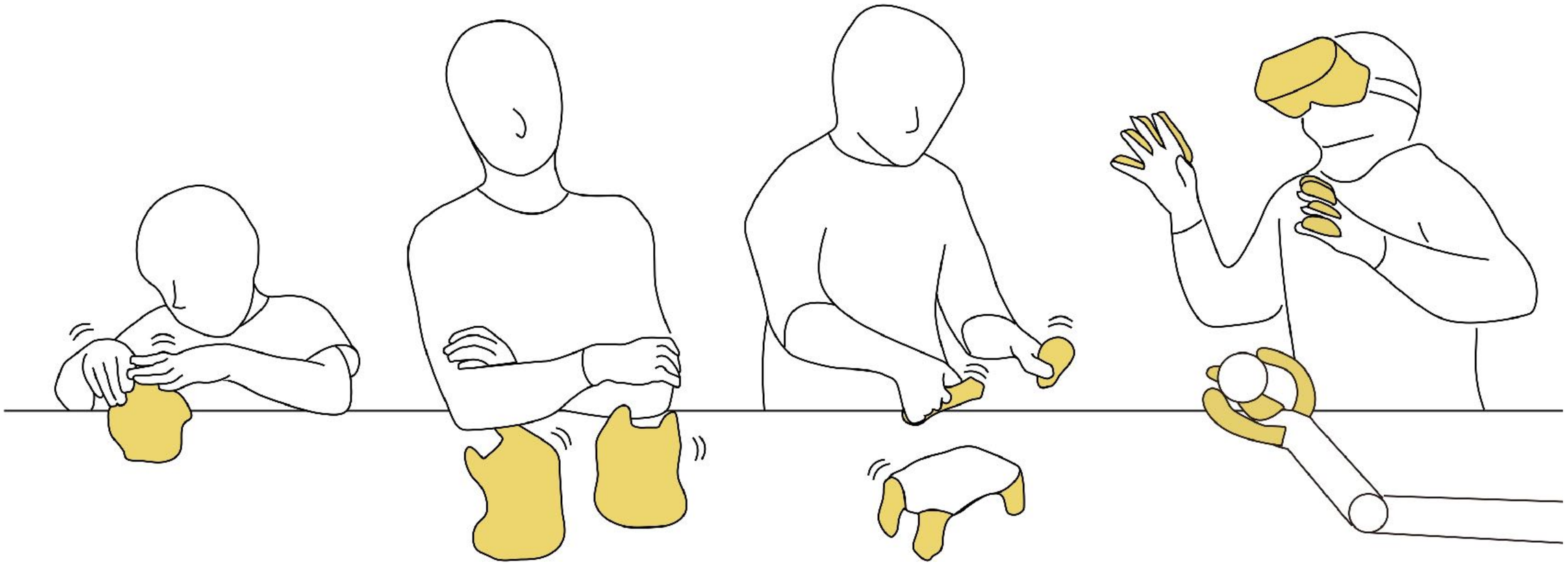
5. Conclusion

Contributions

1. **Entirely soft** sensing and actuation unit
2. MorphIO, **programming by demonstration** environment
3. **Applications** and user **study**

Future Vision



MorphIO

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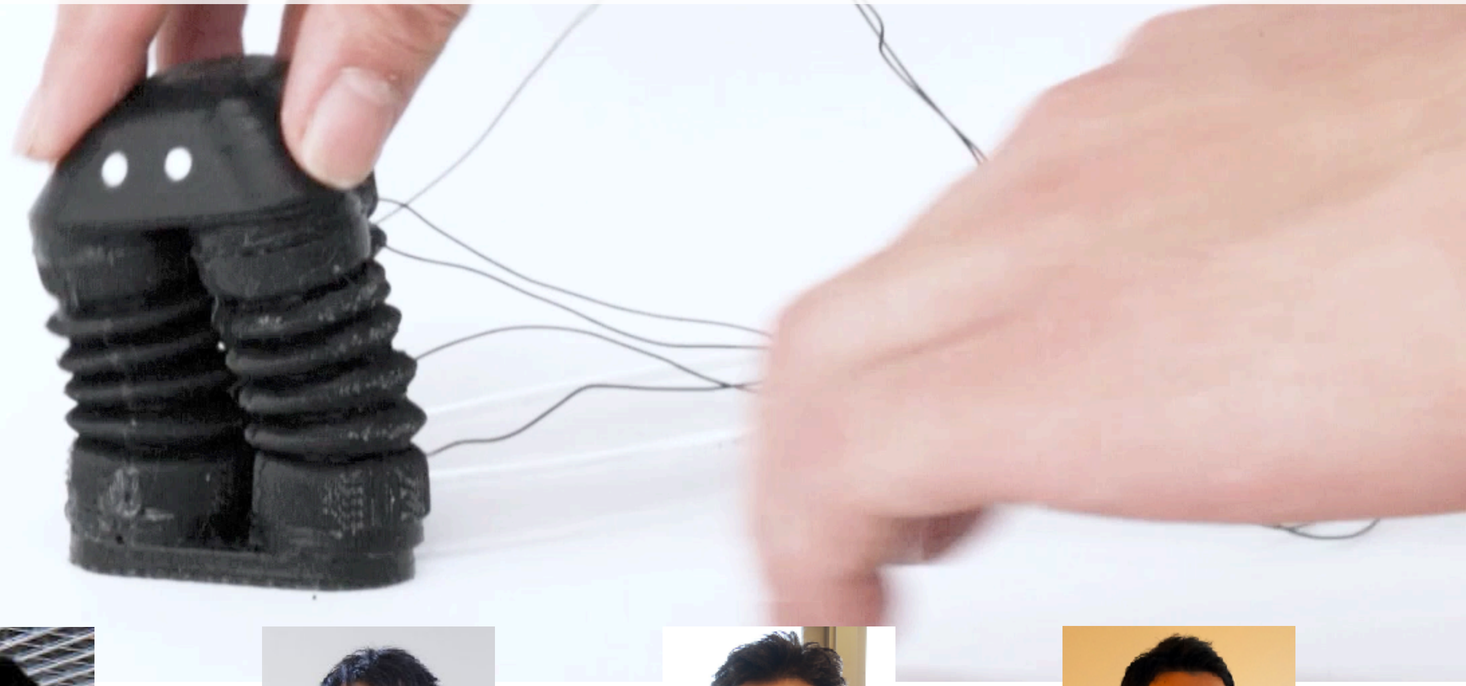
THE UNIVERSITY OF TOKYO

ERATO川原万有情報網プロジェクト
ERATO Kawahara Universal Information Network Project

Entirely Soft Sensing and Actuation Modules for Programming Shape Changes through Tangible Interaction

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