

AirTouch

3D-printed Touch-Sensitive Objects Using Pneumatic Sensing

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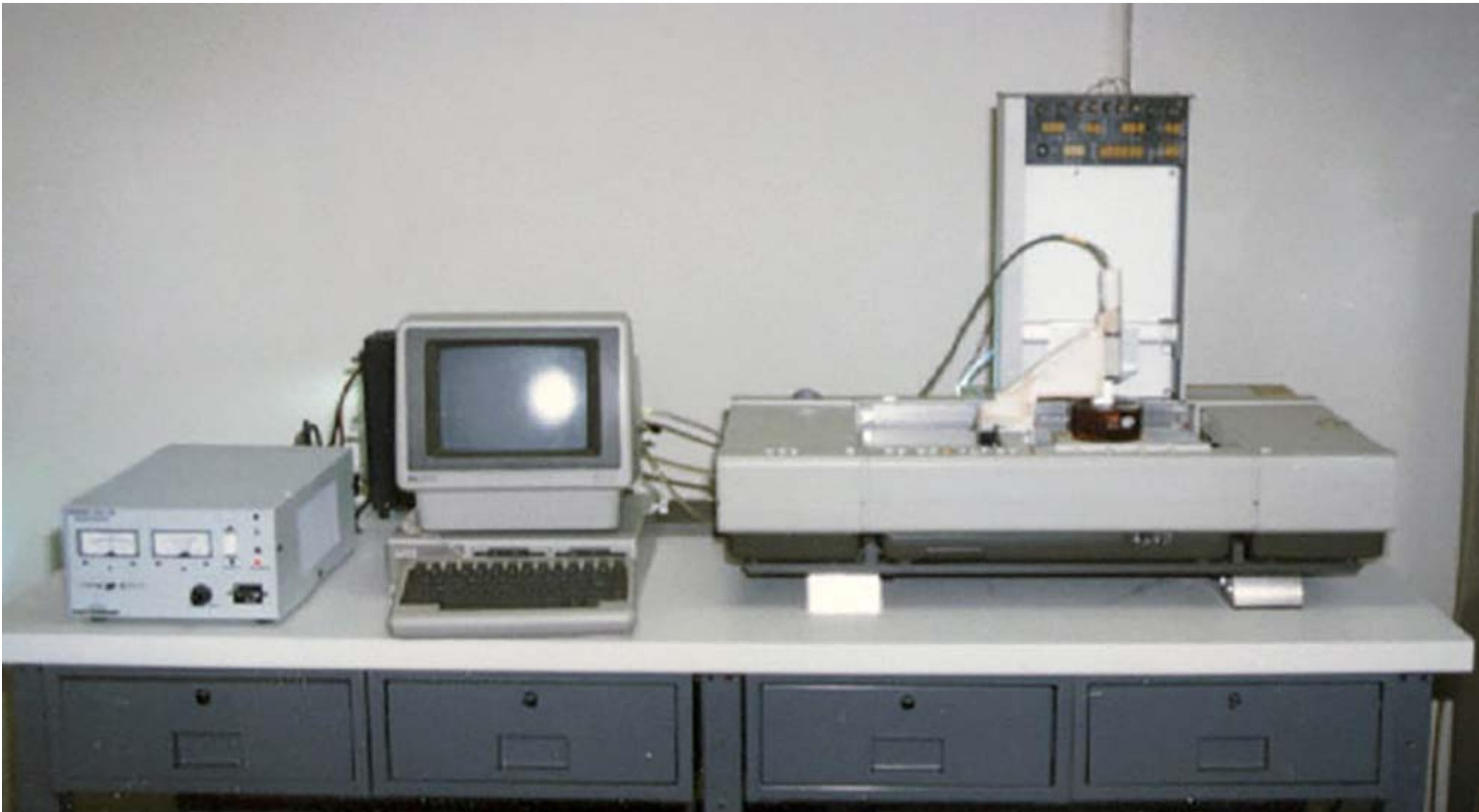


Sebastian Boring
Aalborg University

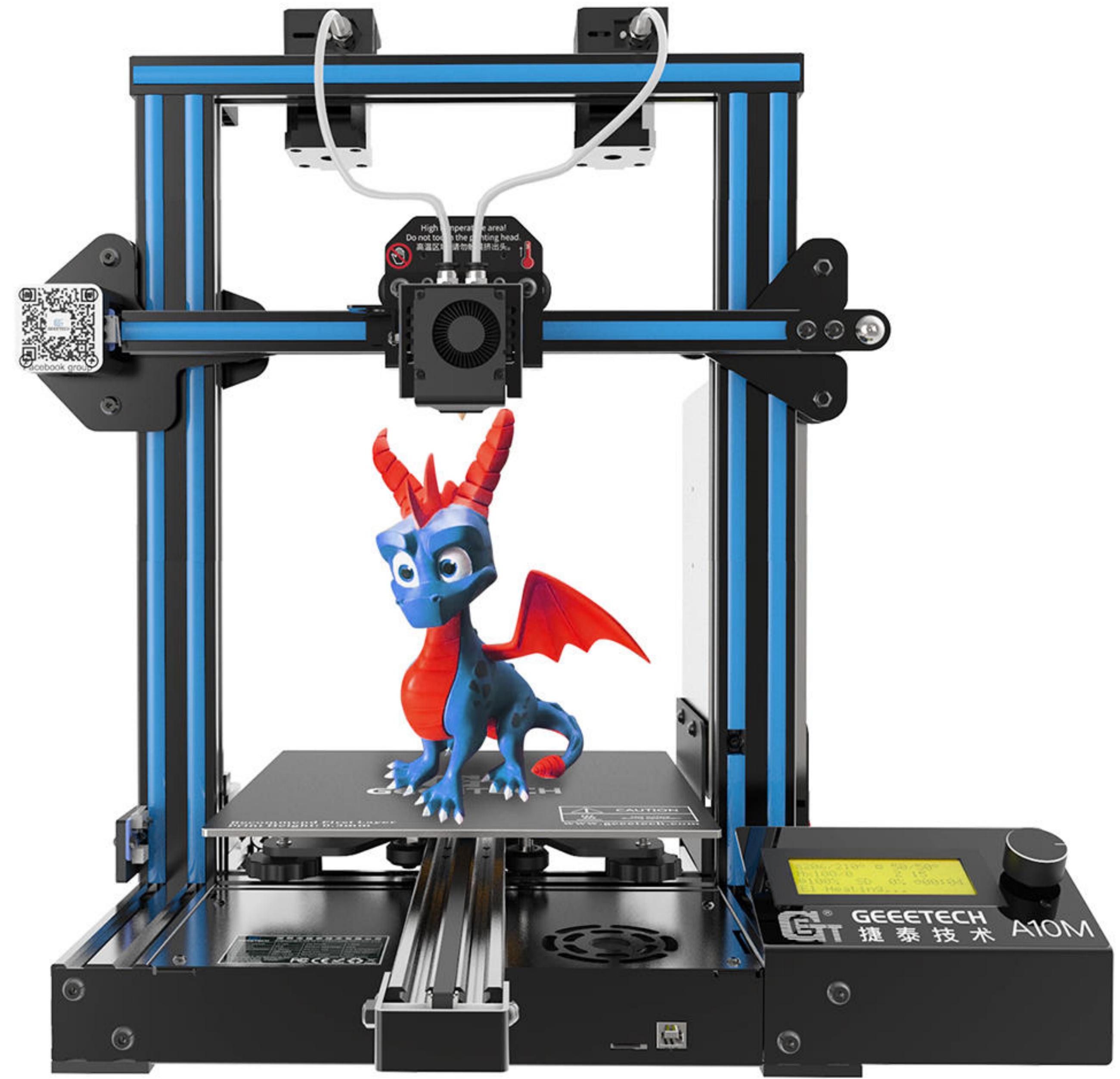


Daniel Ashbrook
University of Copenhagen





The first 3D printer: The SLA-1 from 3D Systems







Passive
Can't be interacted with

From static to interactive

Assembly

Calibration

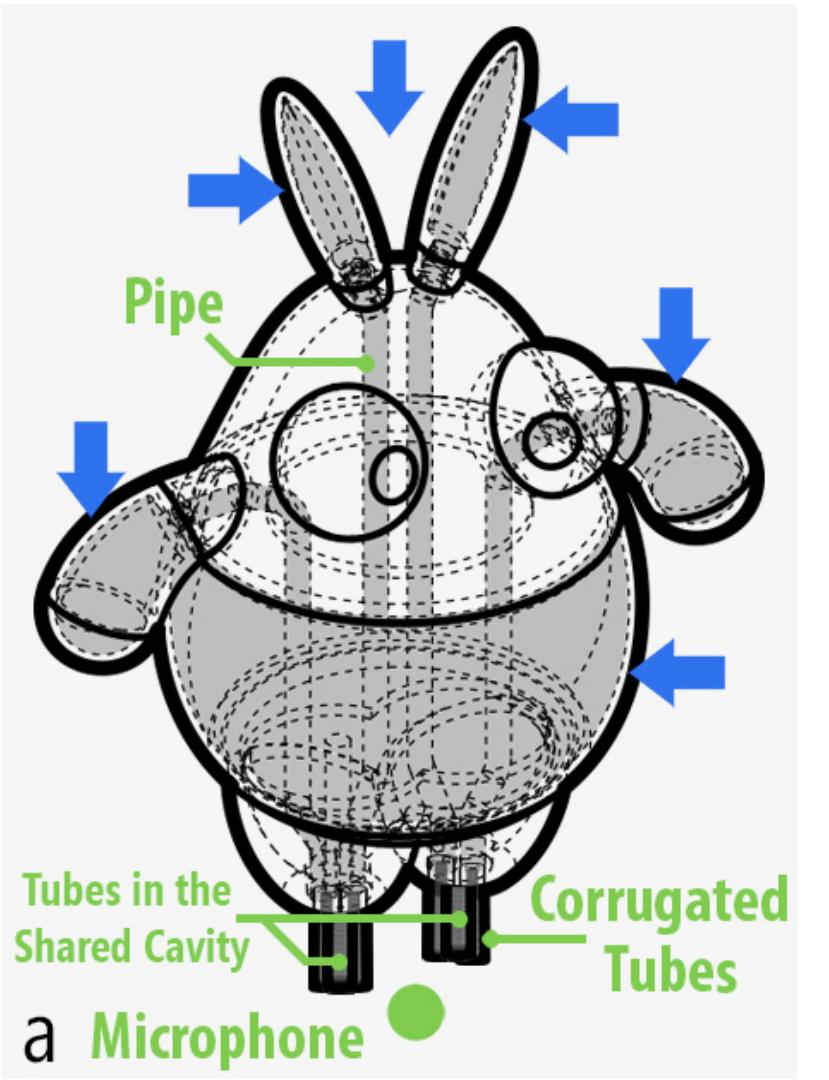
Use limitations

Assembly

Calibration

Use limitations

Assembly



Le et al.

TEI '17

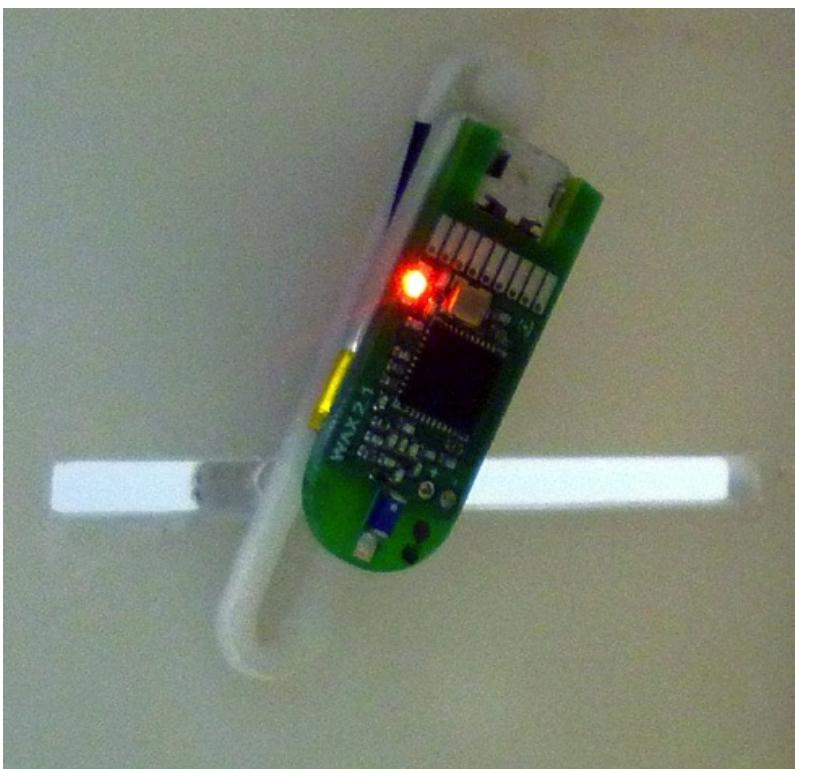
Calibration



Savage et al.

UIST '13

Use limitations



Hook et al.

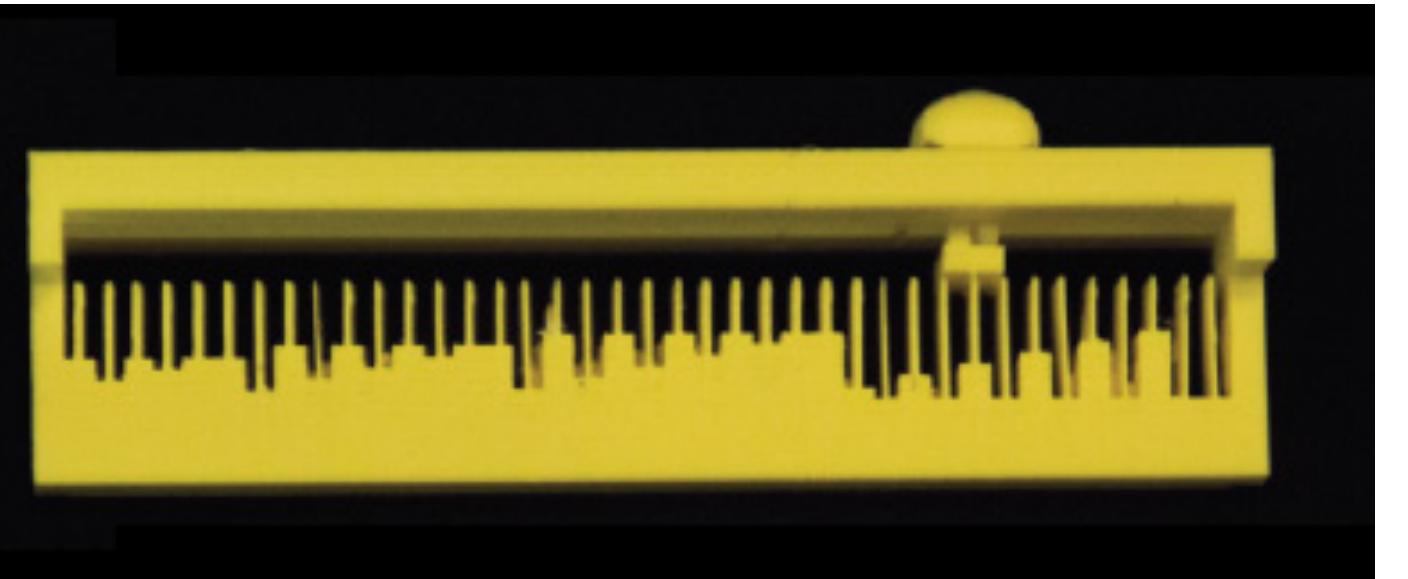
CHI EA '14

Assembly

Calibration

Use limitations

Assembly



Savage et al.

CHI '15

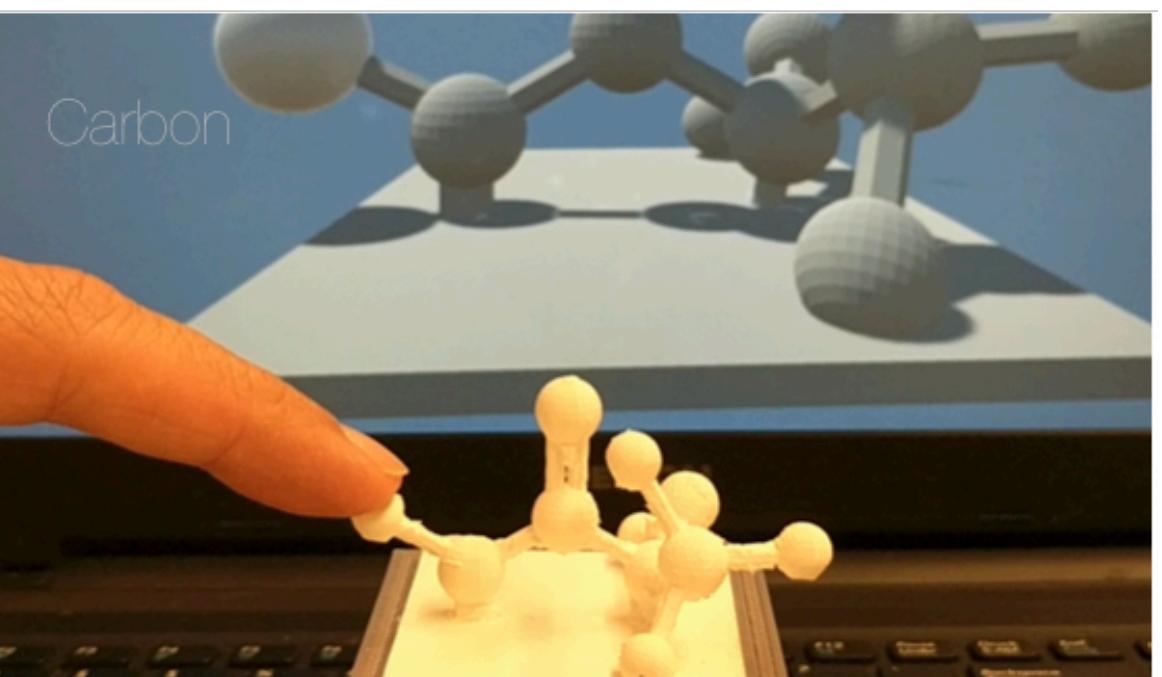
Calibration



Laput et al.

CHI '16

Use limitations



Schmitz et al.

CHI '19

Assembly

Calibration

Use limitations

Assembly



Hudin et al.

CHI EA '15

Calibration



Tejada et al.

GI '18

Use limitations



Shi et al.

CHI '16

AirTouch



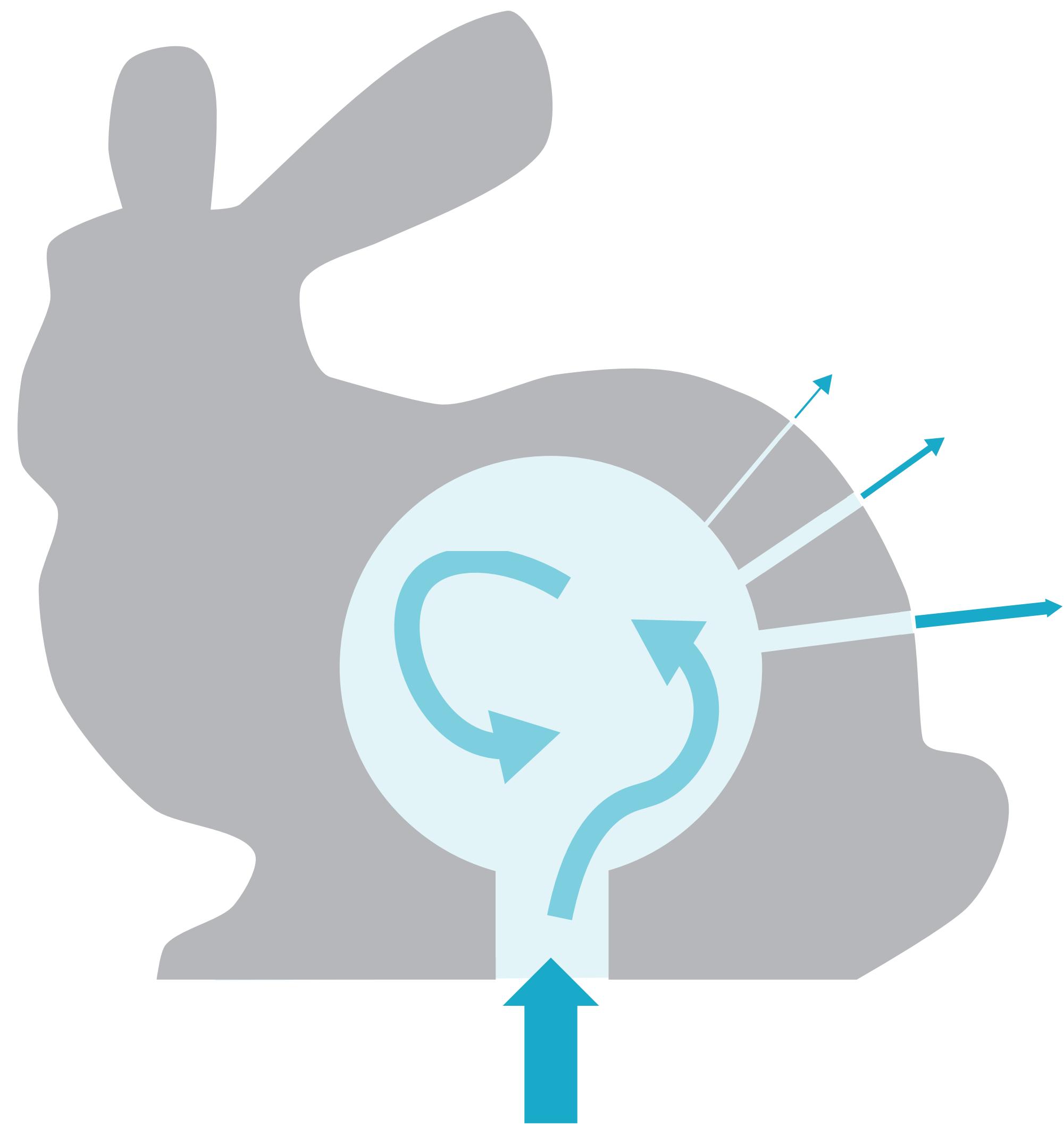
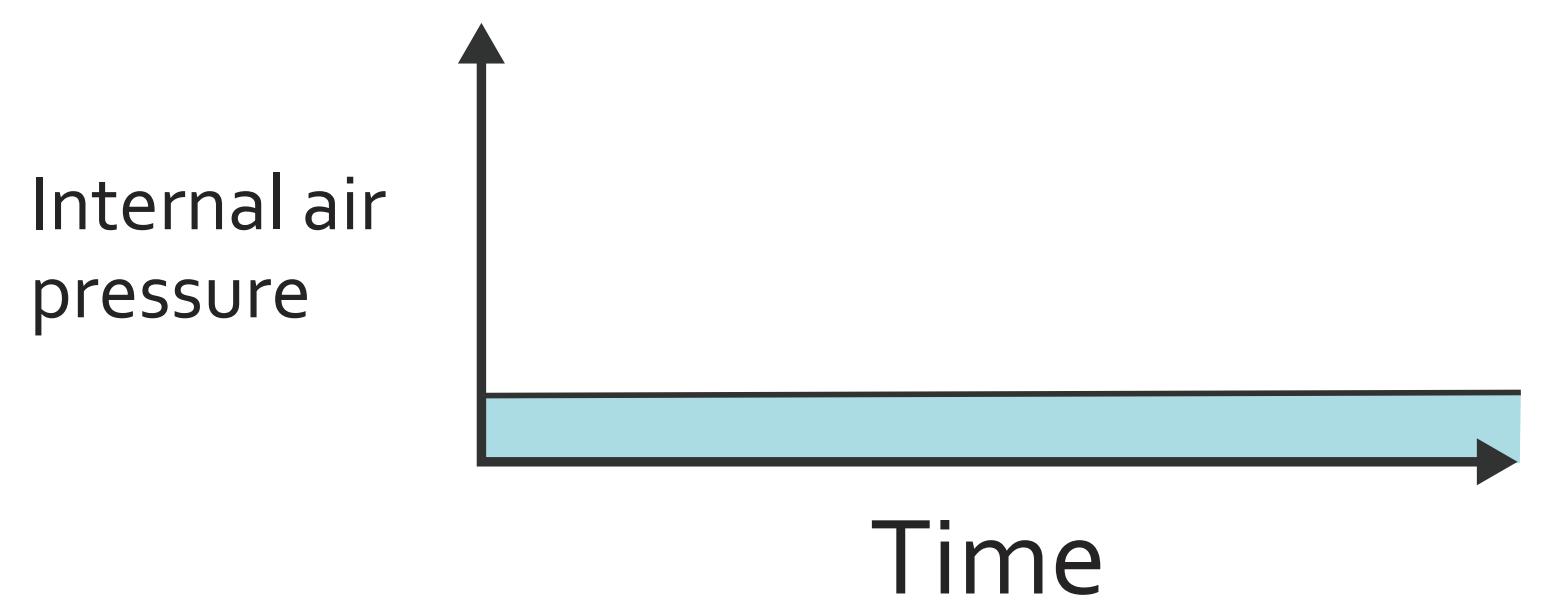
AirTouch

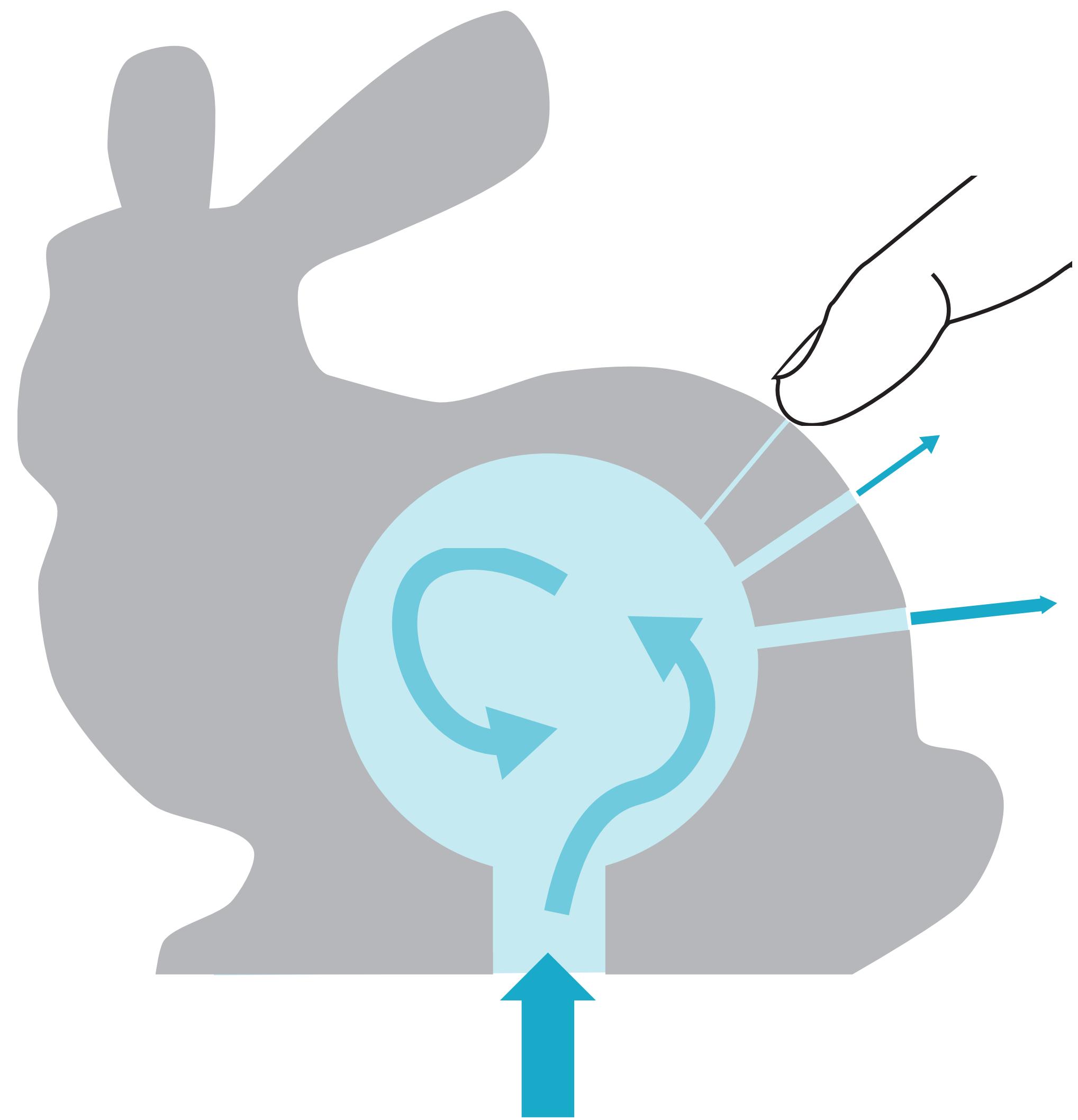
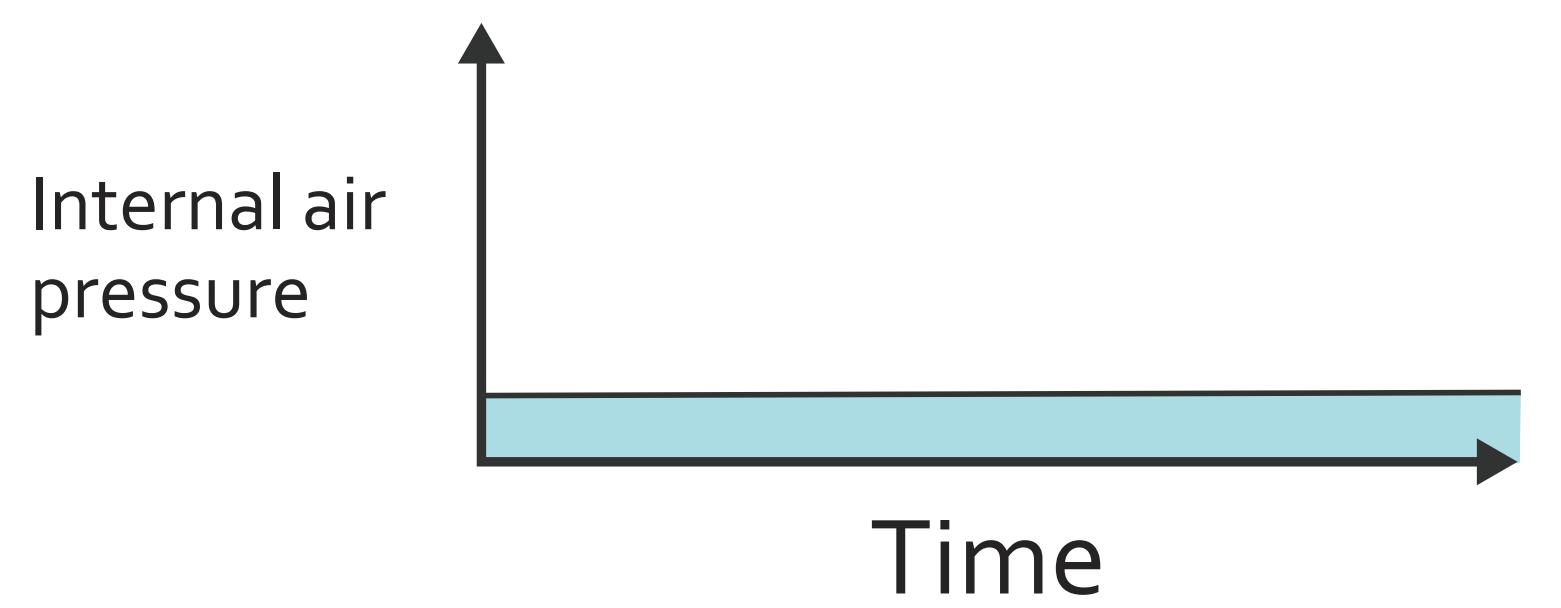
- No assembly of parts or circuits.
- No calibration.
- Single material, consumer-level 3D-printers.
- Minimal disruption of original geometry.

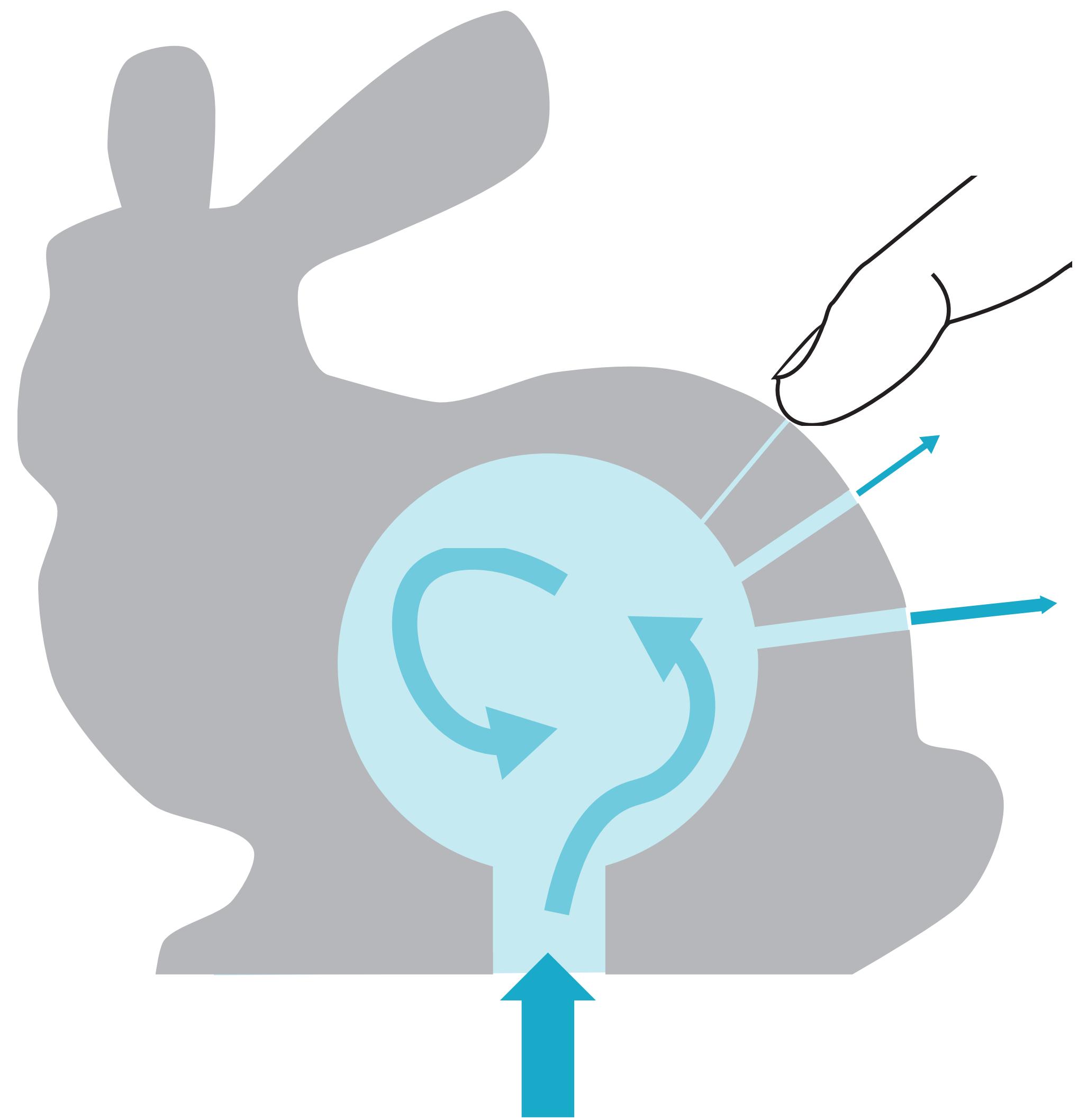
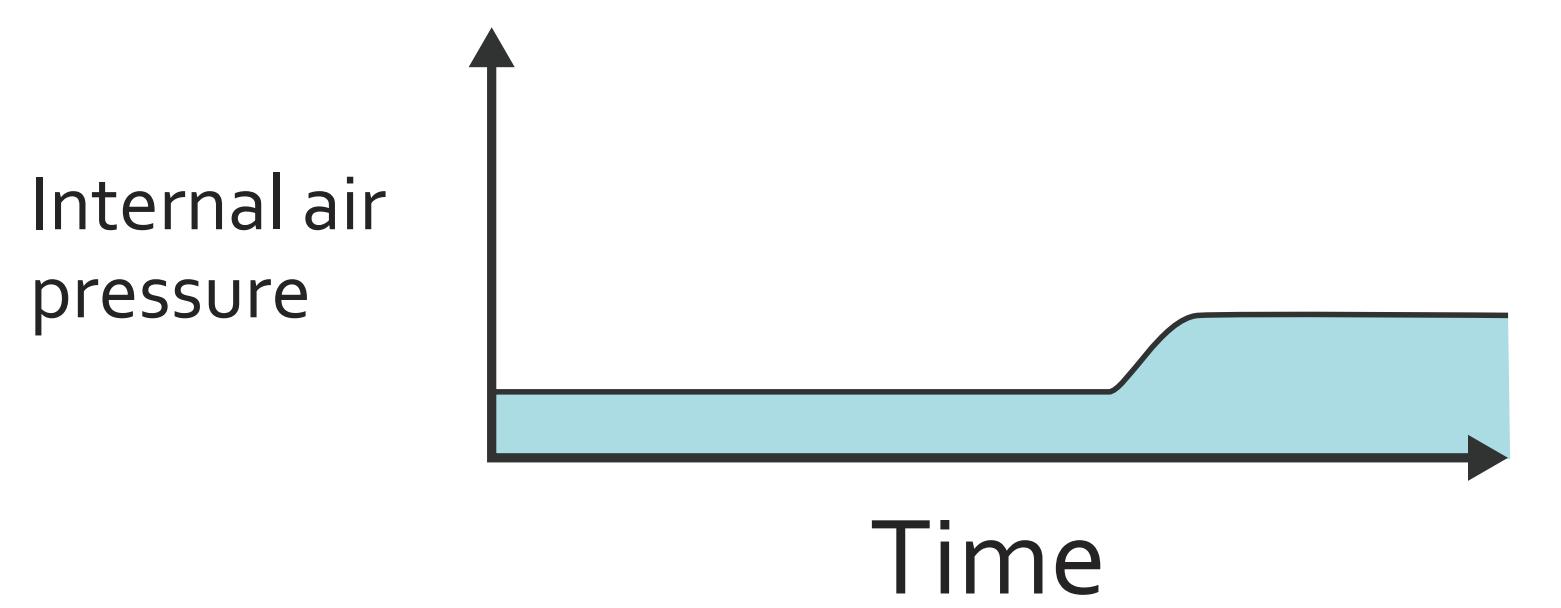


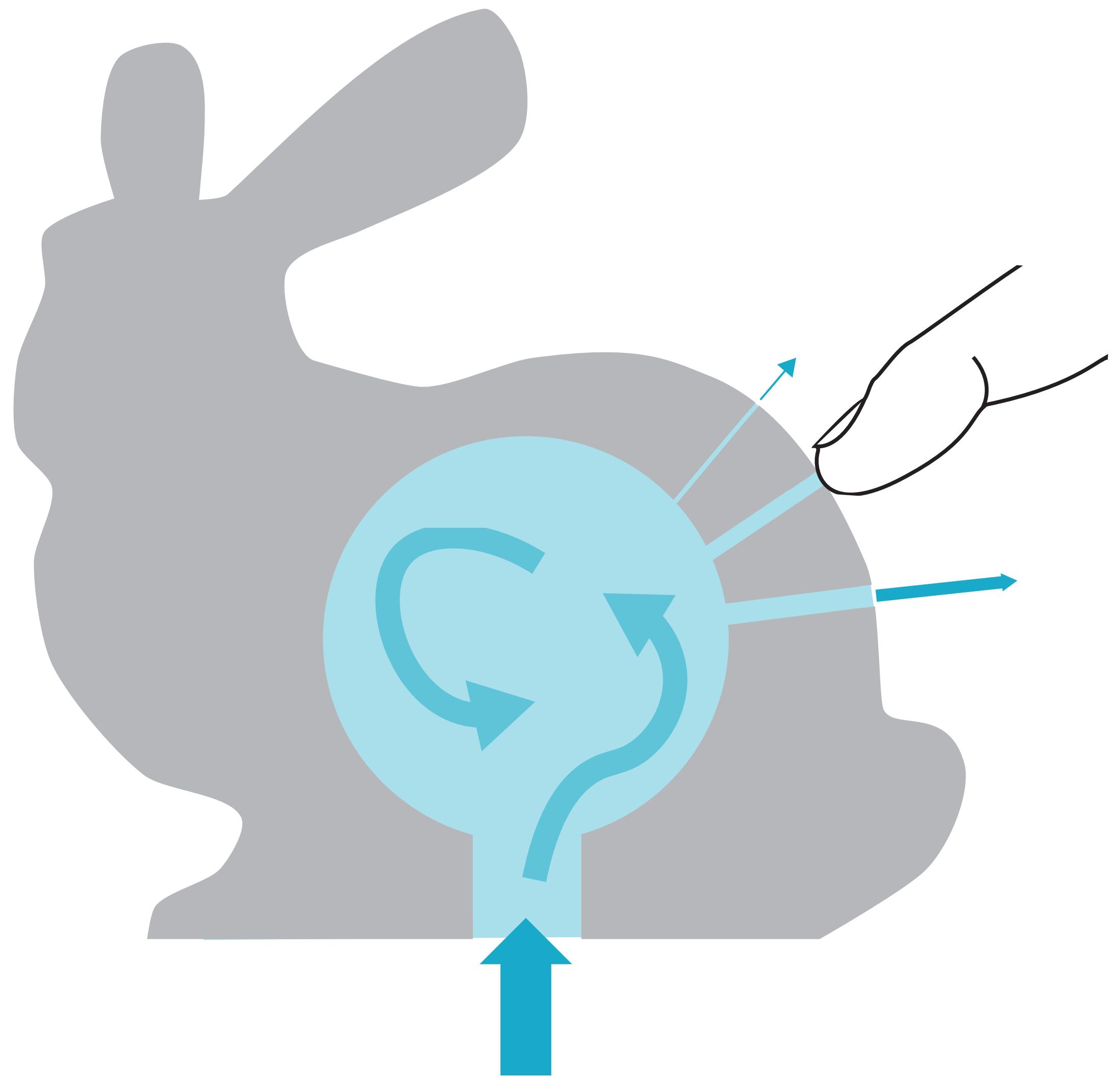
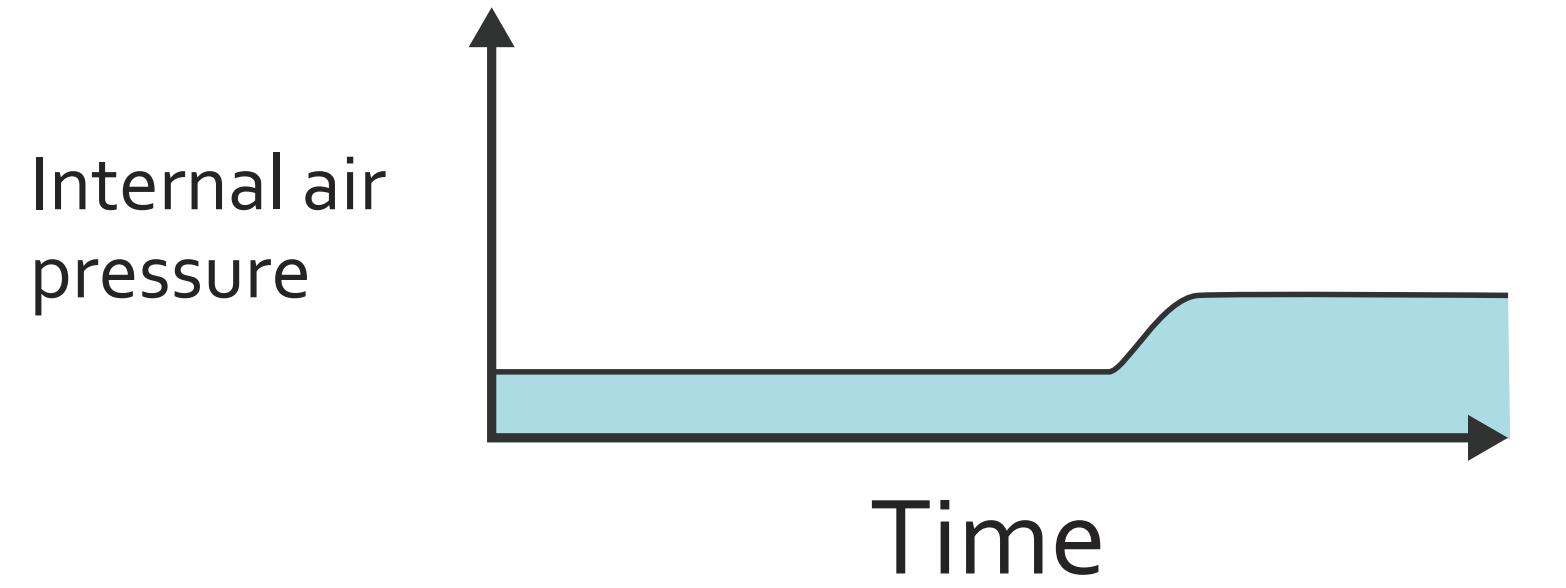
How does it work?

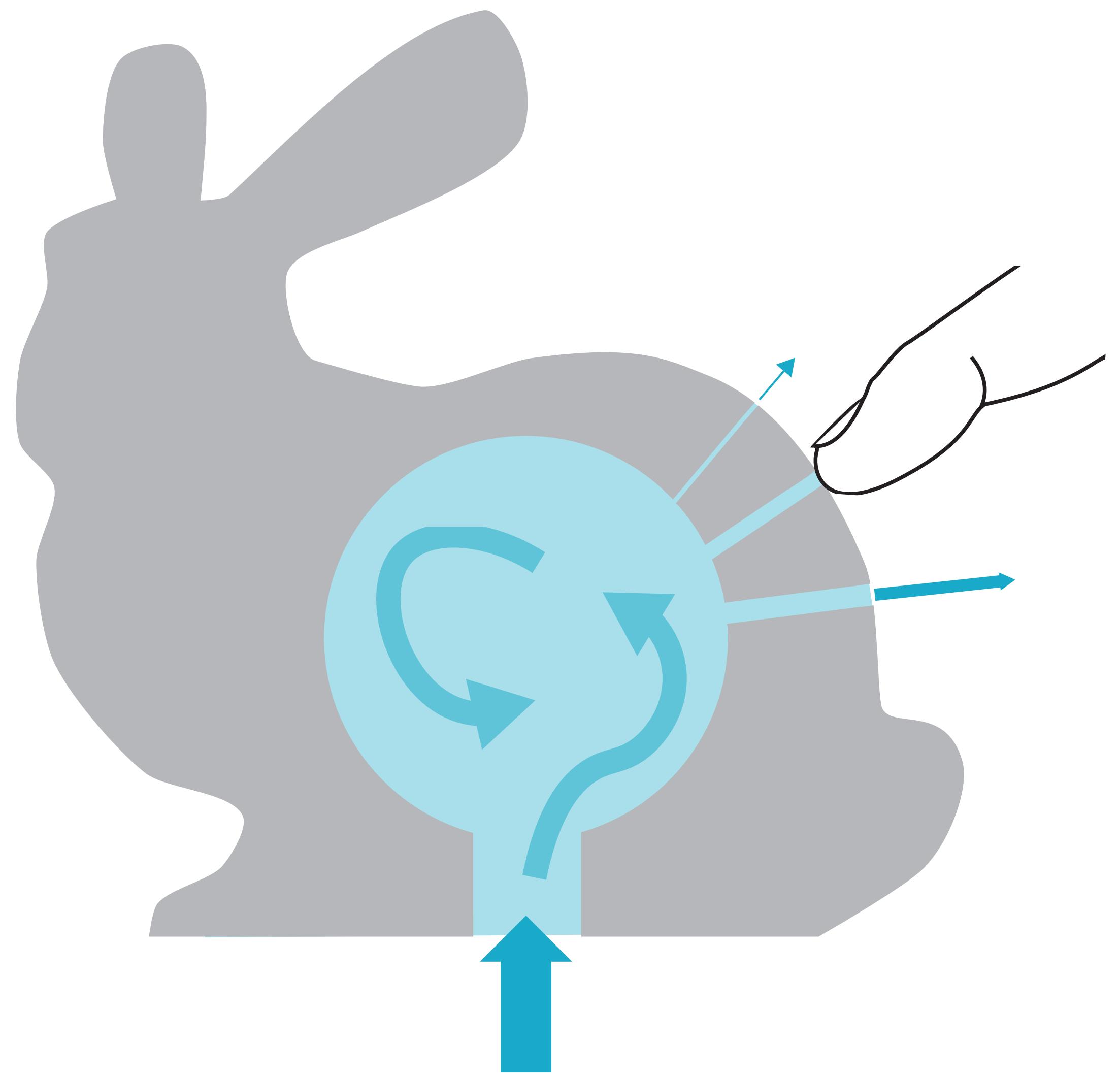
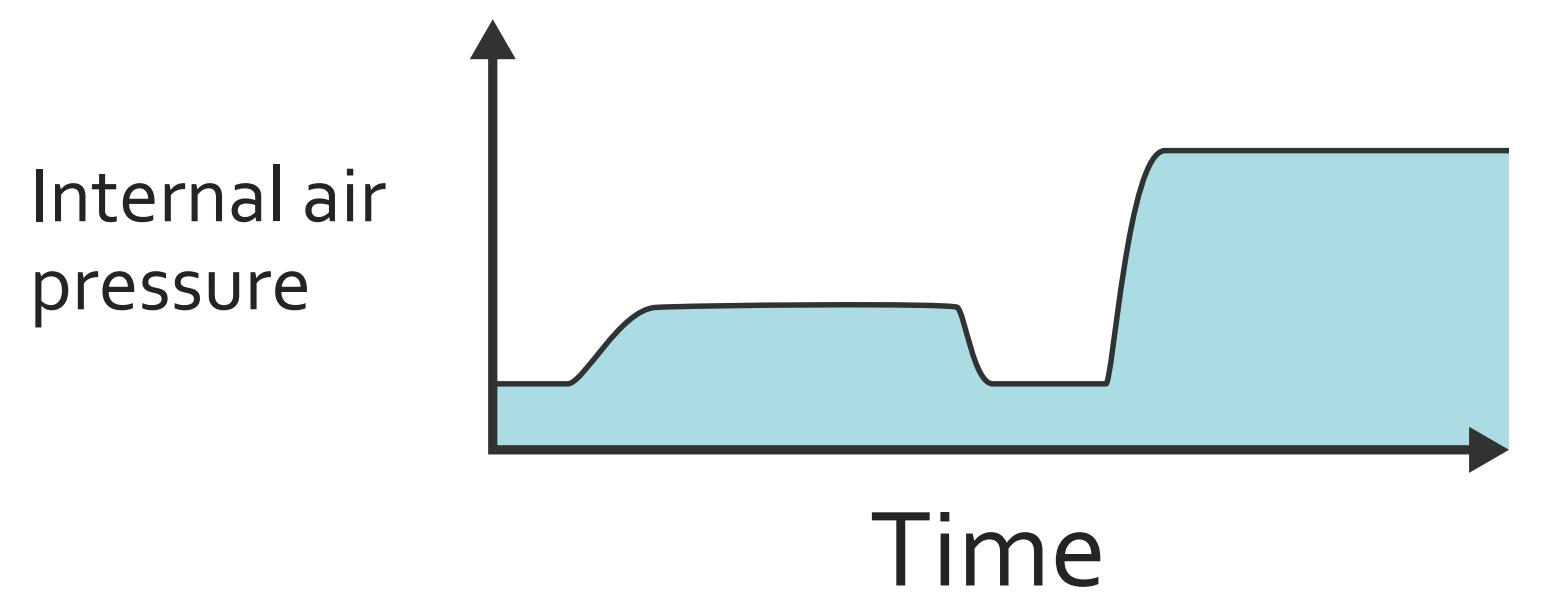












How does it work?

- Principle of fluid continuity.
- Bernoulli's principle.

$$\Delta P_x = \frac{(\sum A_i)^2 \Delta P}{(\sum A_i - A_x)^2}$$

- Change in size of openings → Change in pressure.

How does it work?

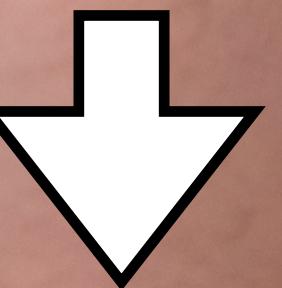
- Assumptions:
 - Incompressible fluids.
 - Perfectly shaped outlets and structures.
- Reality:
 - Air is compressible.
 - 3D-printed objects are not perfect.
 - Complex internal geometries.

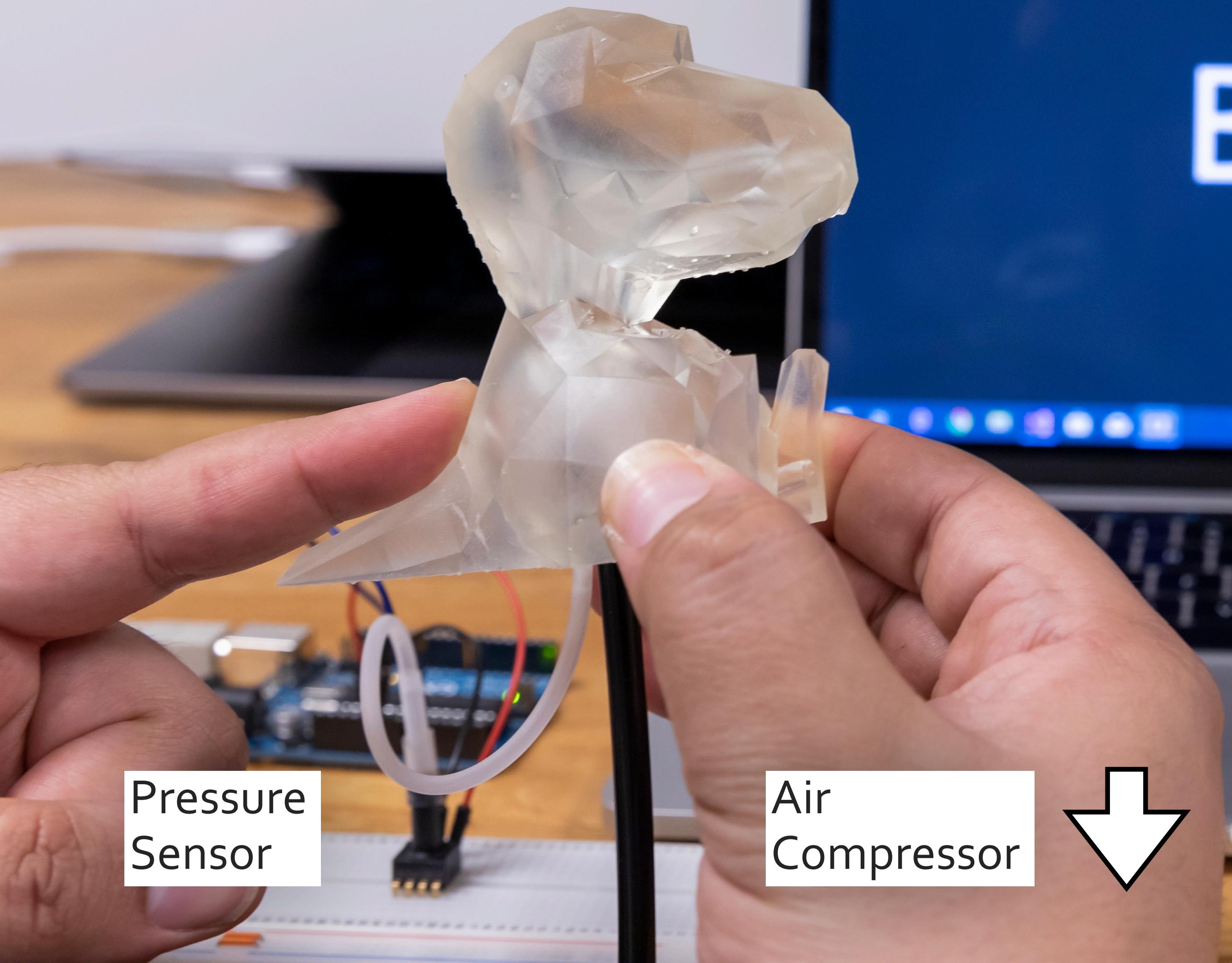
Setup

Back

Back

Air
Compressor





Pressure
Sensor

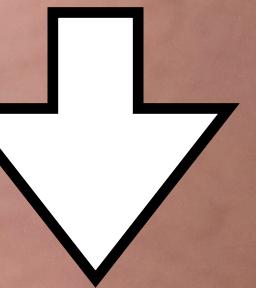
Air
Compressor

Computer

Back

Pressure
Sensor

Air
Compressor







AirTouch



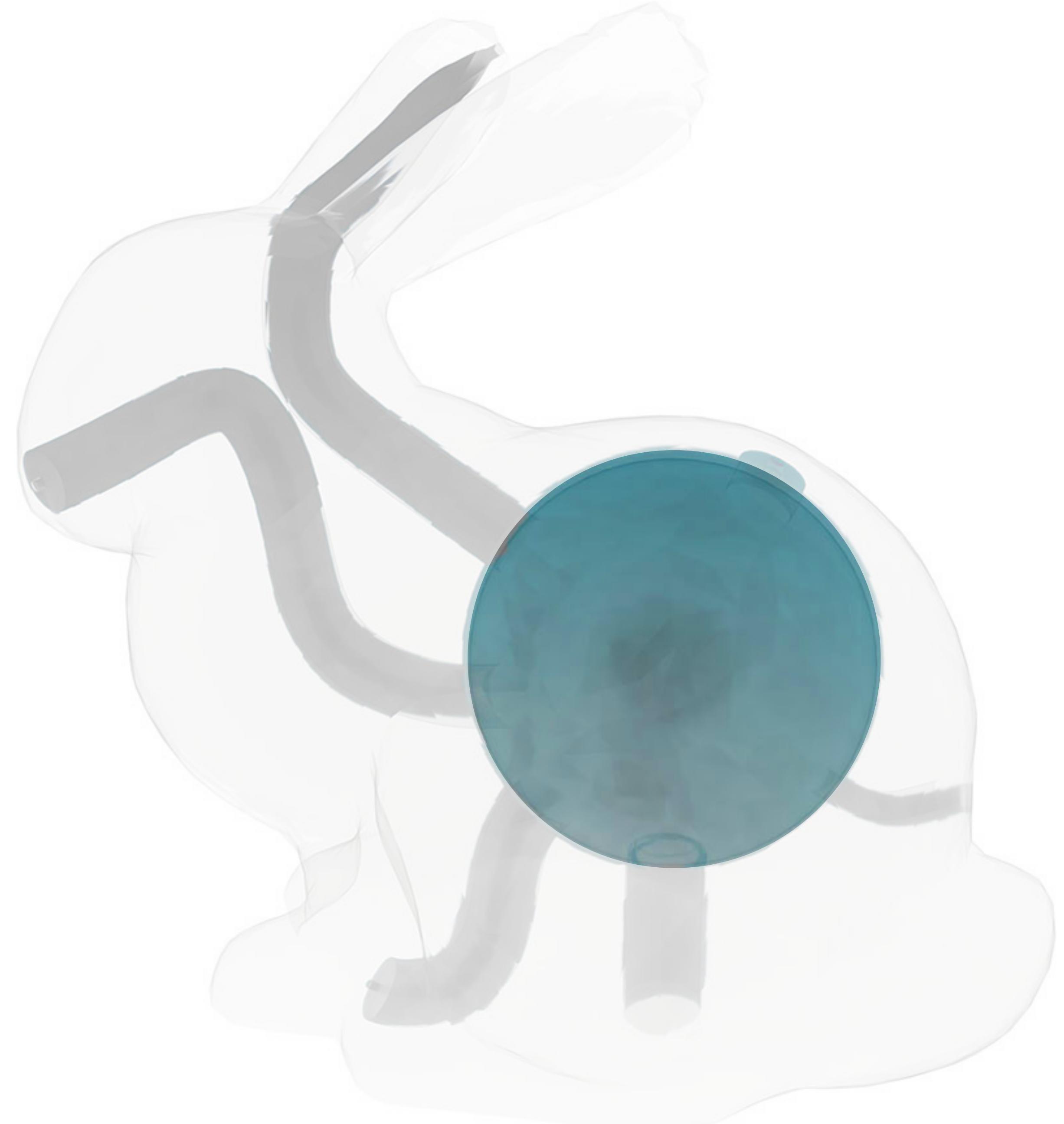
AirTouch

- Cavity
- Tubes
- Outlets



Cavity

- Spherical cavities.
- 30 mm in diameter.
- Shared cavity size between all objects.
 - Shared machine learning model.



Tubes

- Cylindrical tubes.
- 5mm in diameter.
- Compromise between printability and size.



Outlets

- Outlets are placed on touch locations.
- Very small.
- Pressure increase depends on the area of outlet.

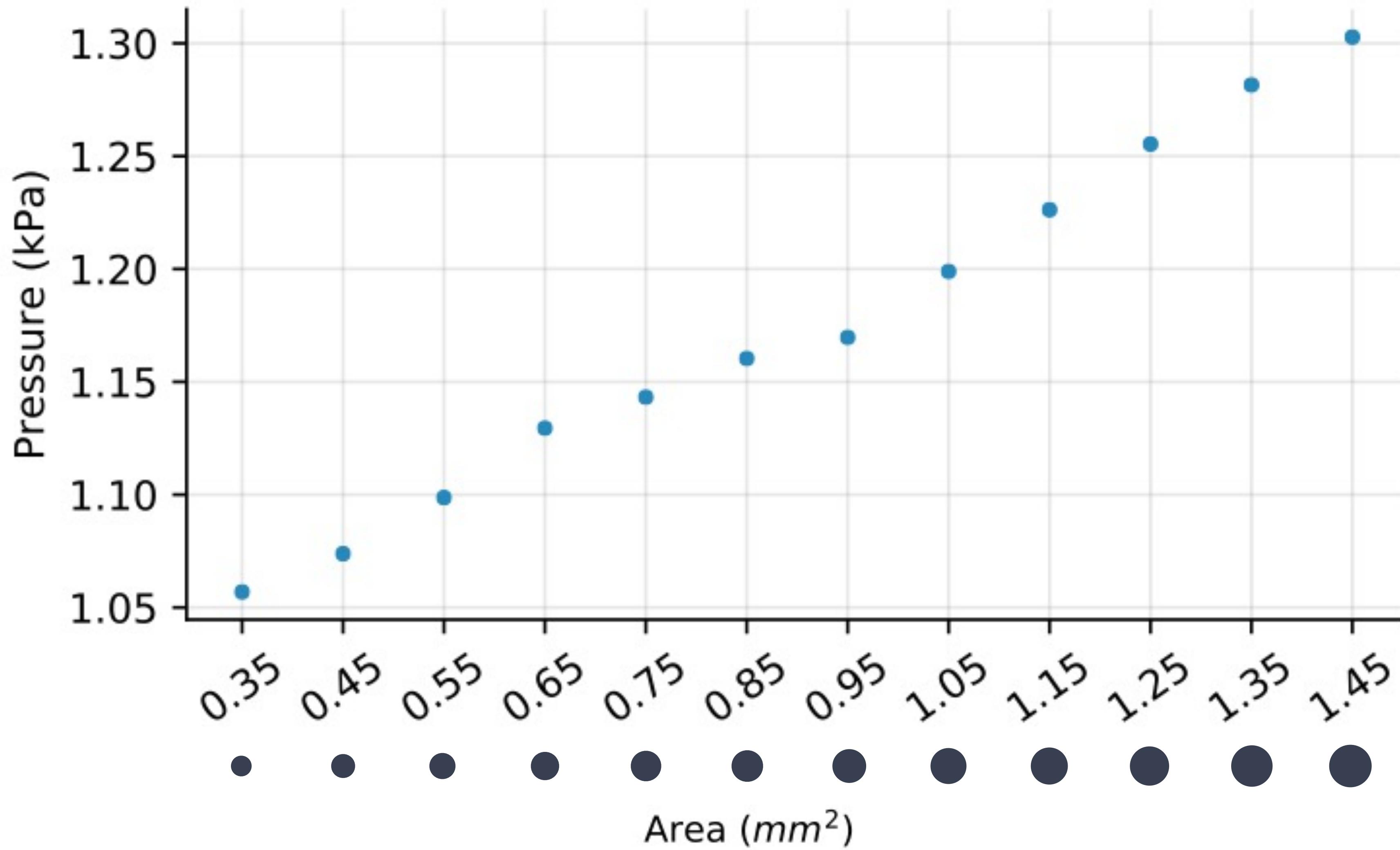


Final outlet dimensions



Outlet area, in mm²

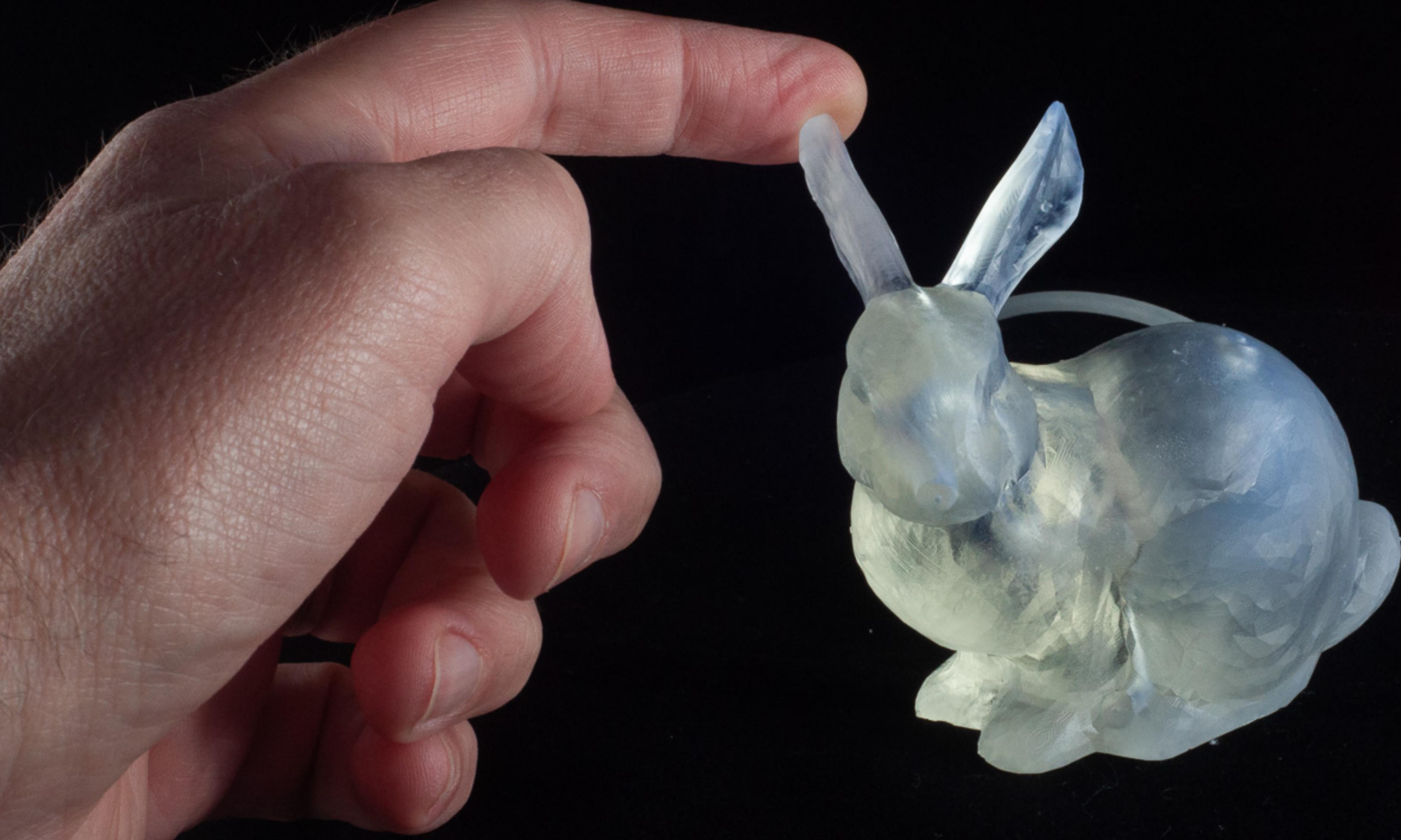


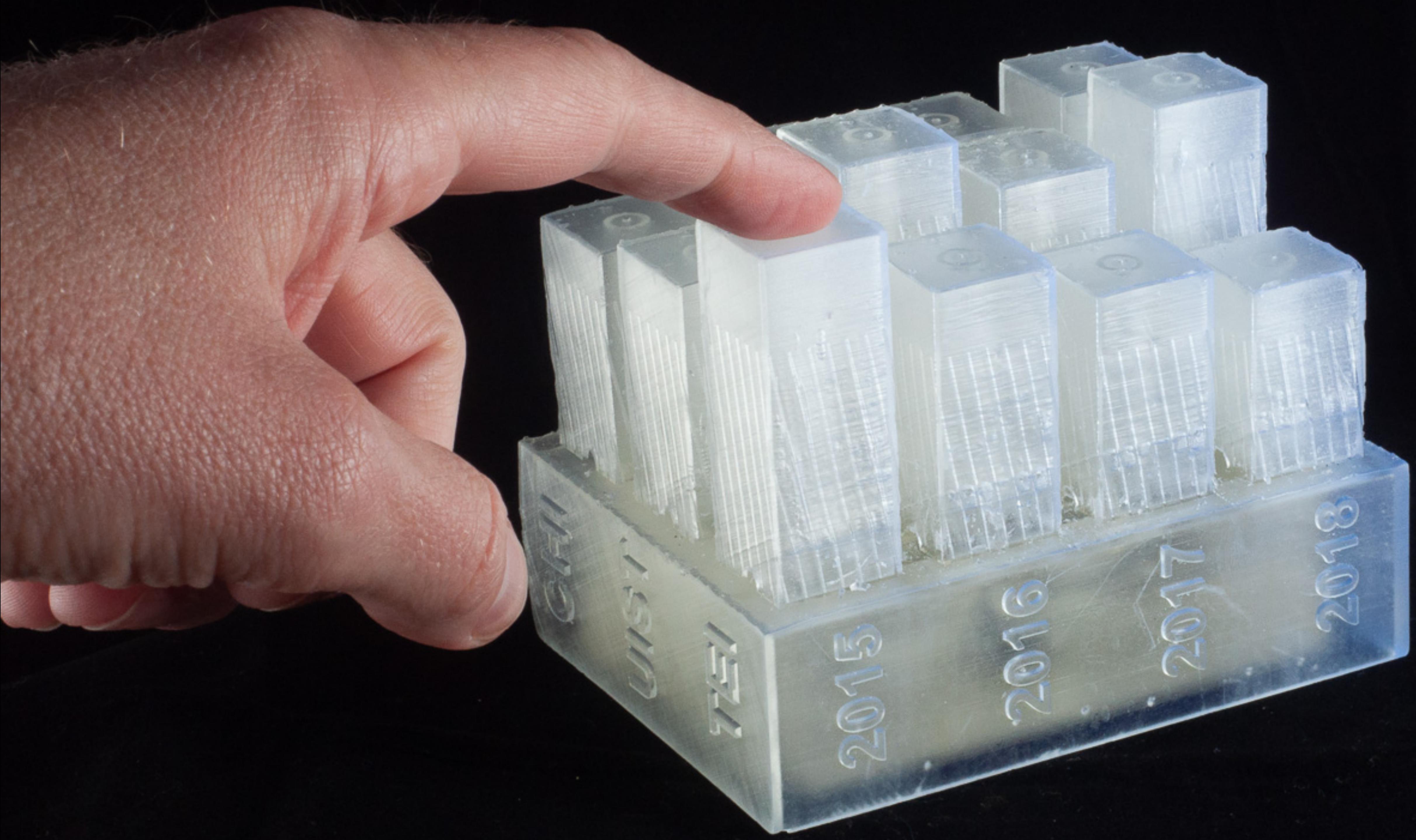


Performance Testing

Performance Testing

- Printed four objects.
- Pre-trained a machine learning model.
 - One instance per touch.
- Cycled through all touch locations.
- Repeated four times per object.

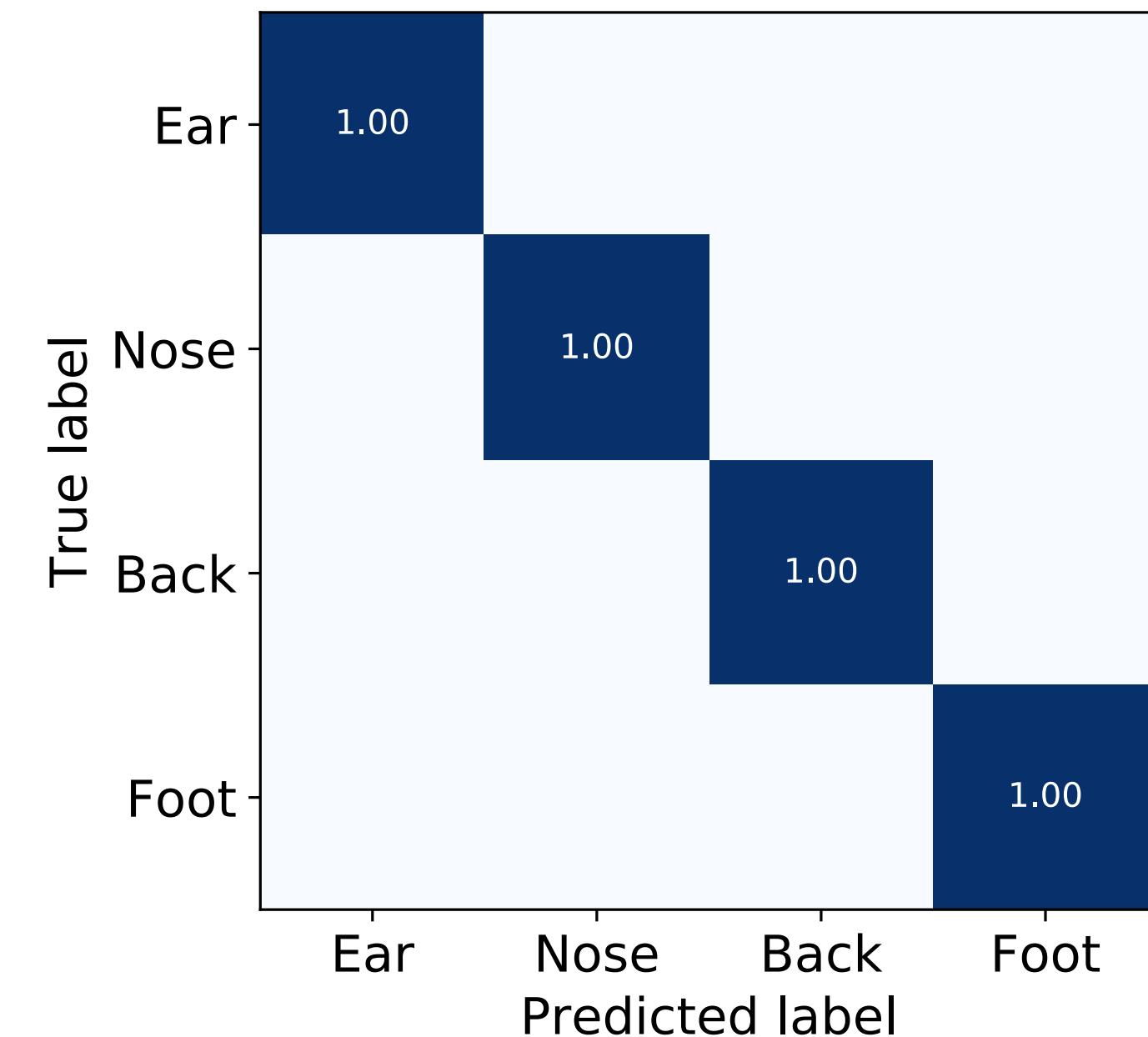






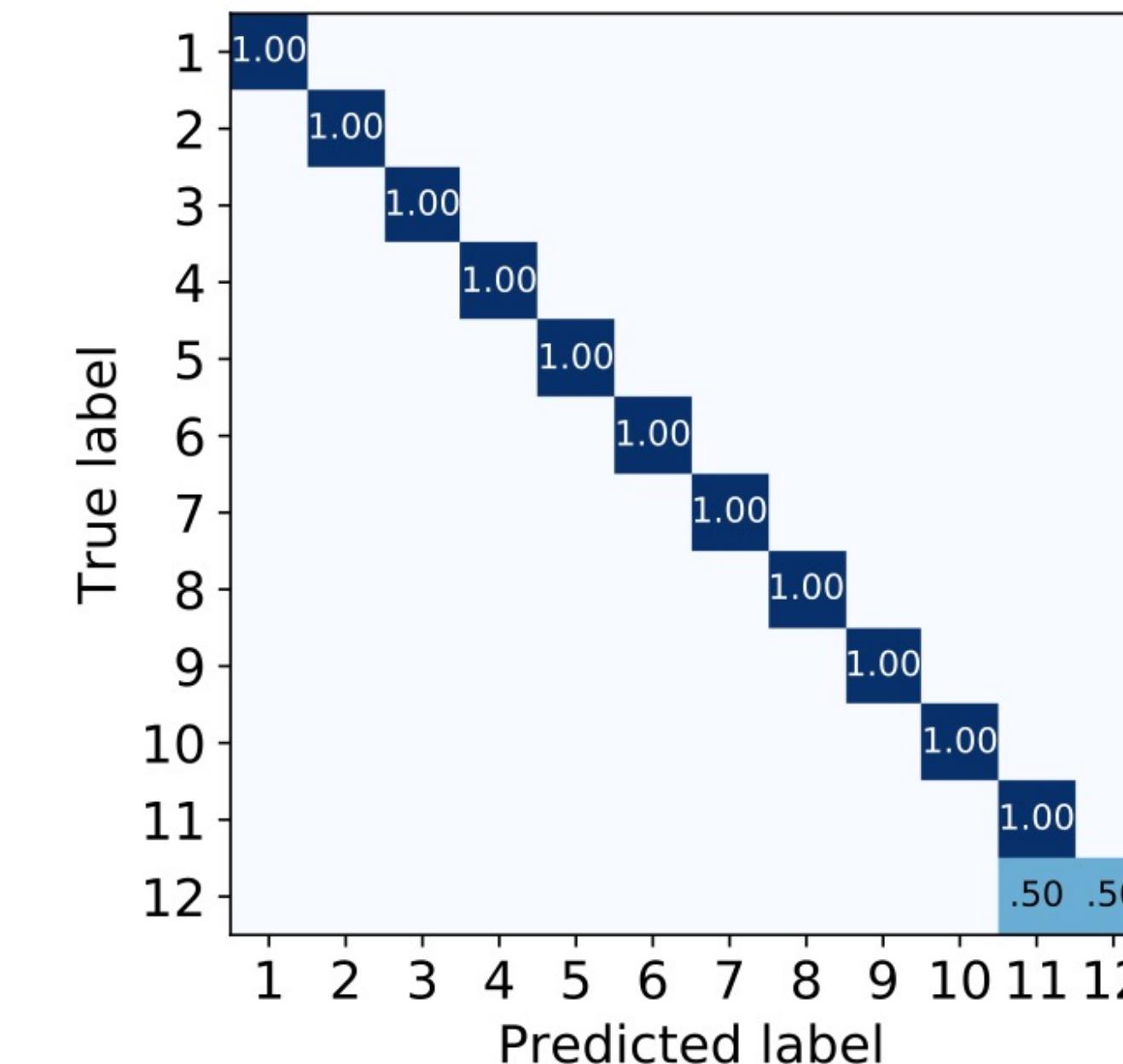


Stanford Bunny



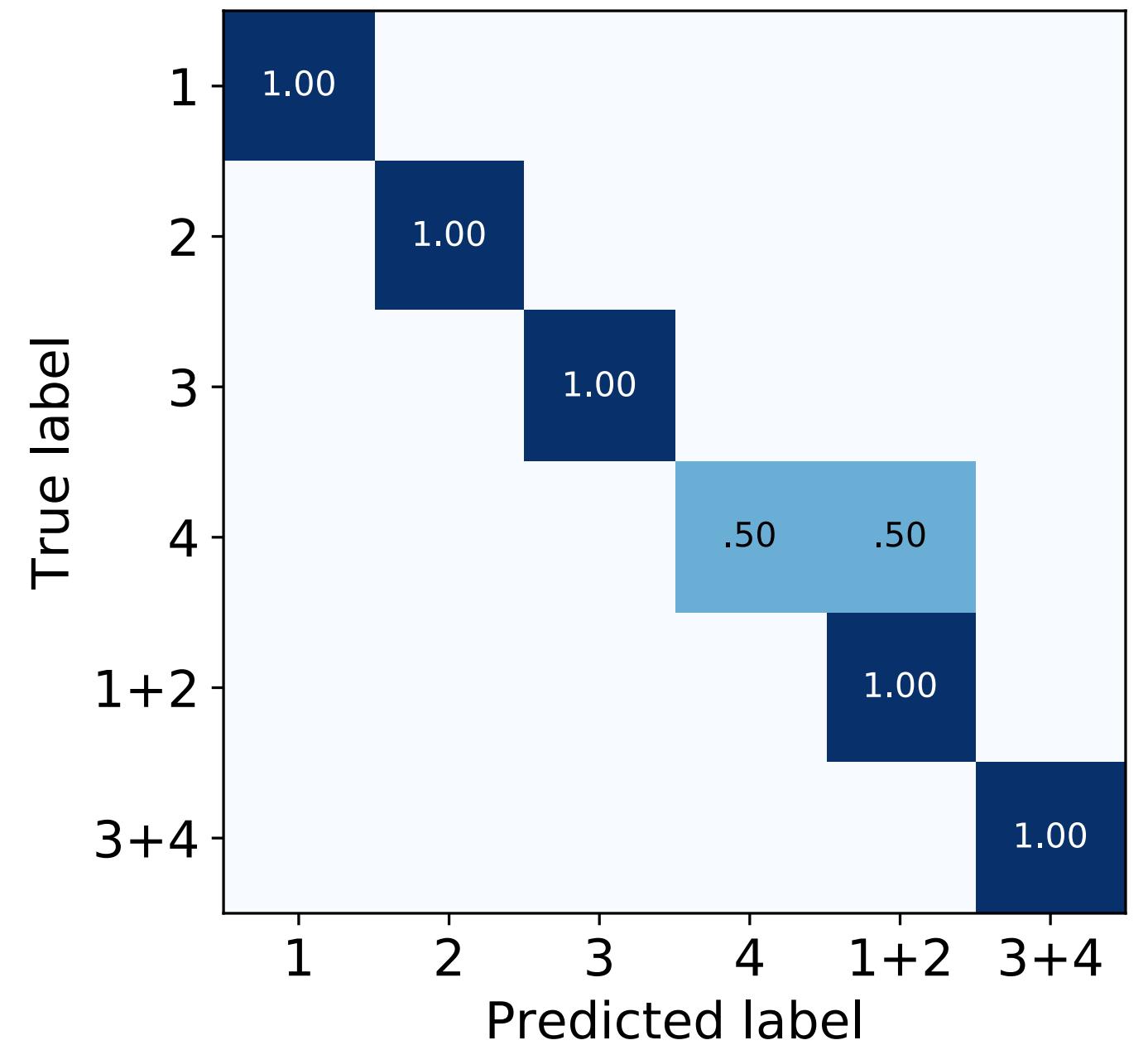
100%

Interactive Bar Chart



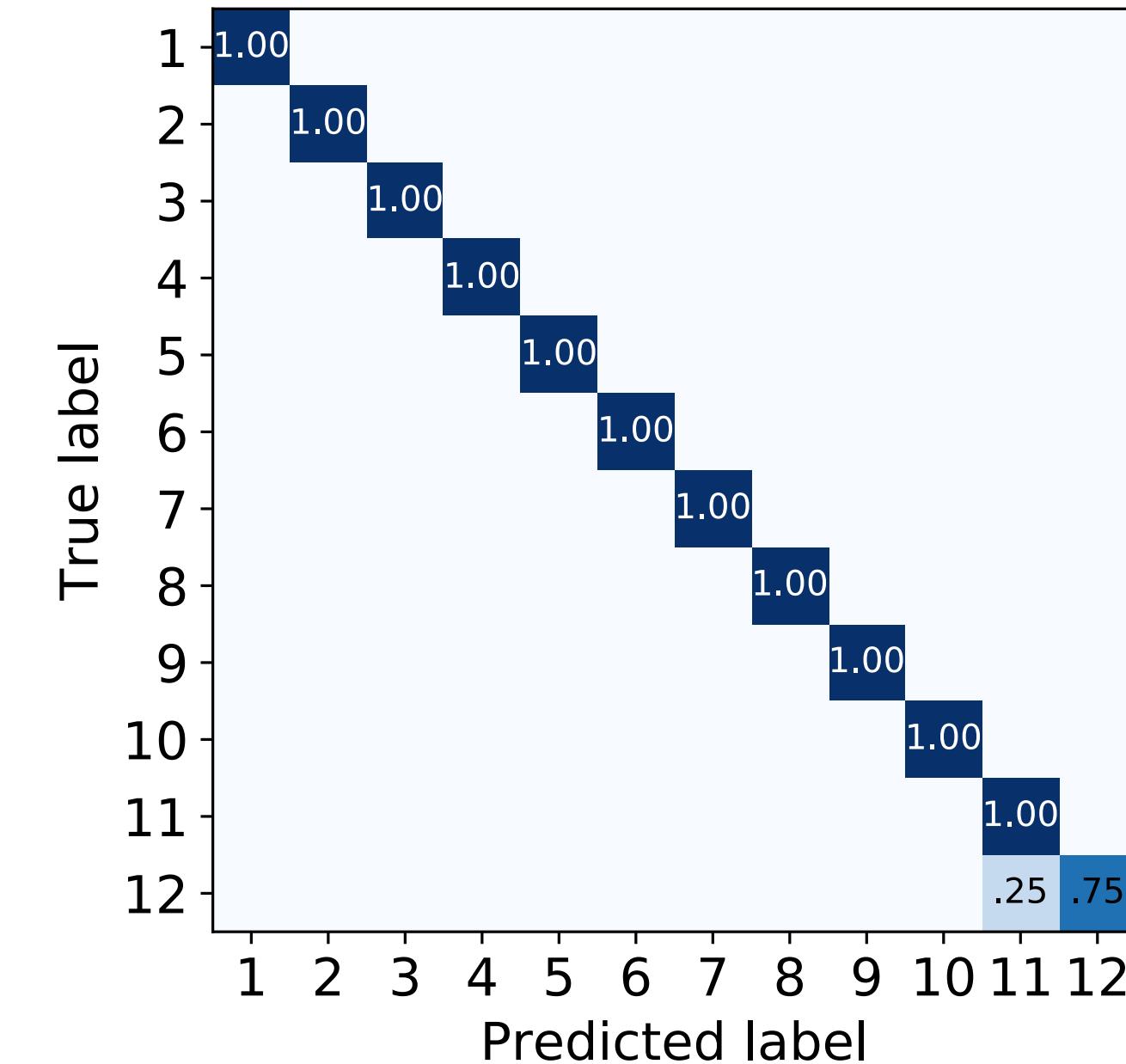
95.50%

Grasping Sphere



91.60%

Color Hue Selector



97.75%

Example Applications

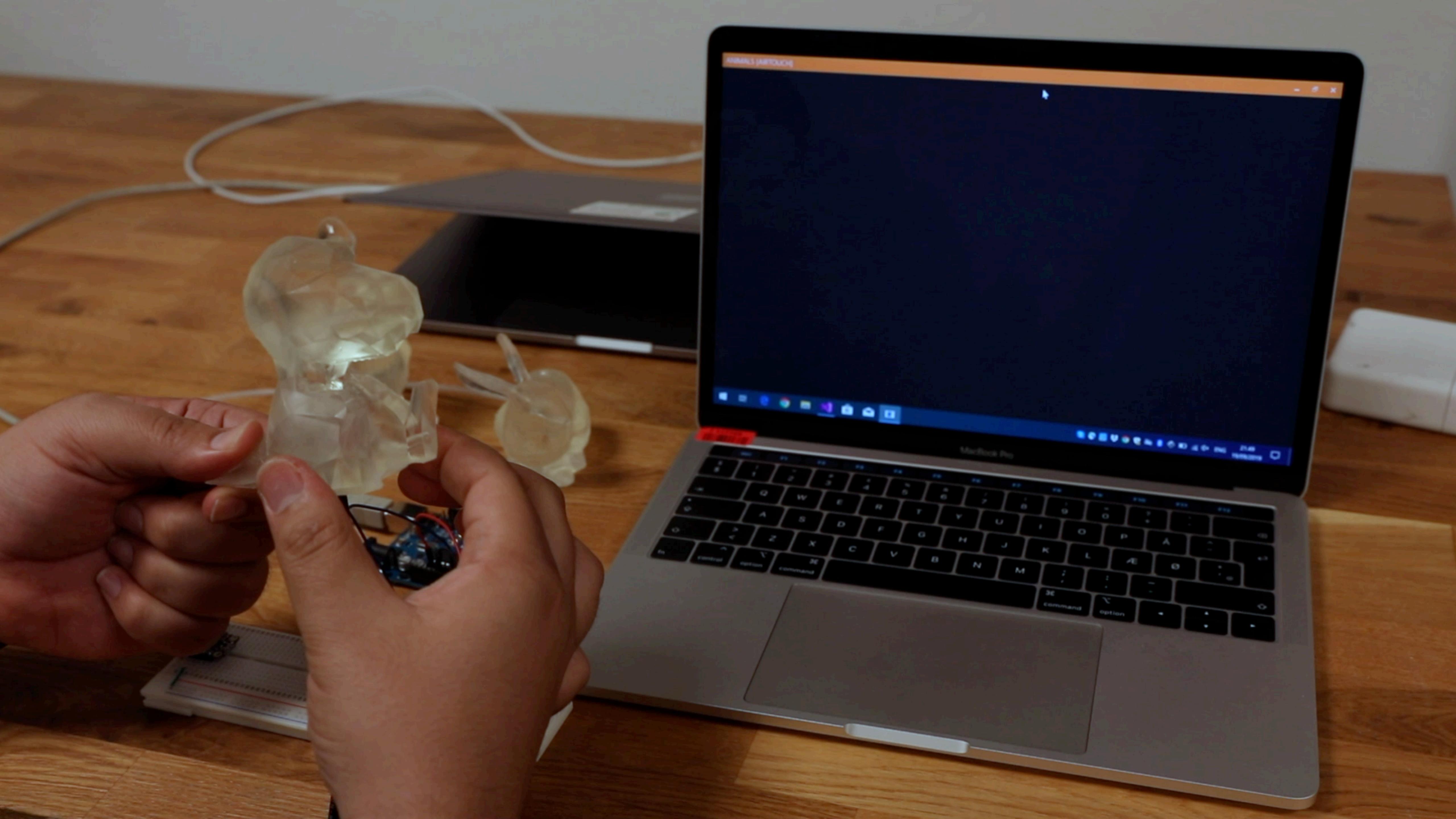


Accepted

Rejected







Limitations





Atmospheric Pressure Changes

Takeaways

Takeaways

- No assembly of parts or circuits
- No calibration
- Single material, consumer-level 3D-Printers
- Minimal disruption of original geometry

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Looking for Postdoc positions, early 2021!

