

Hand structure and dexterity

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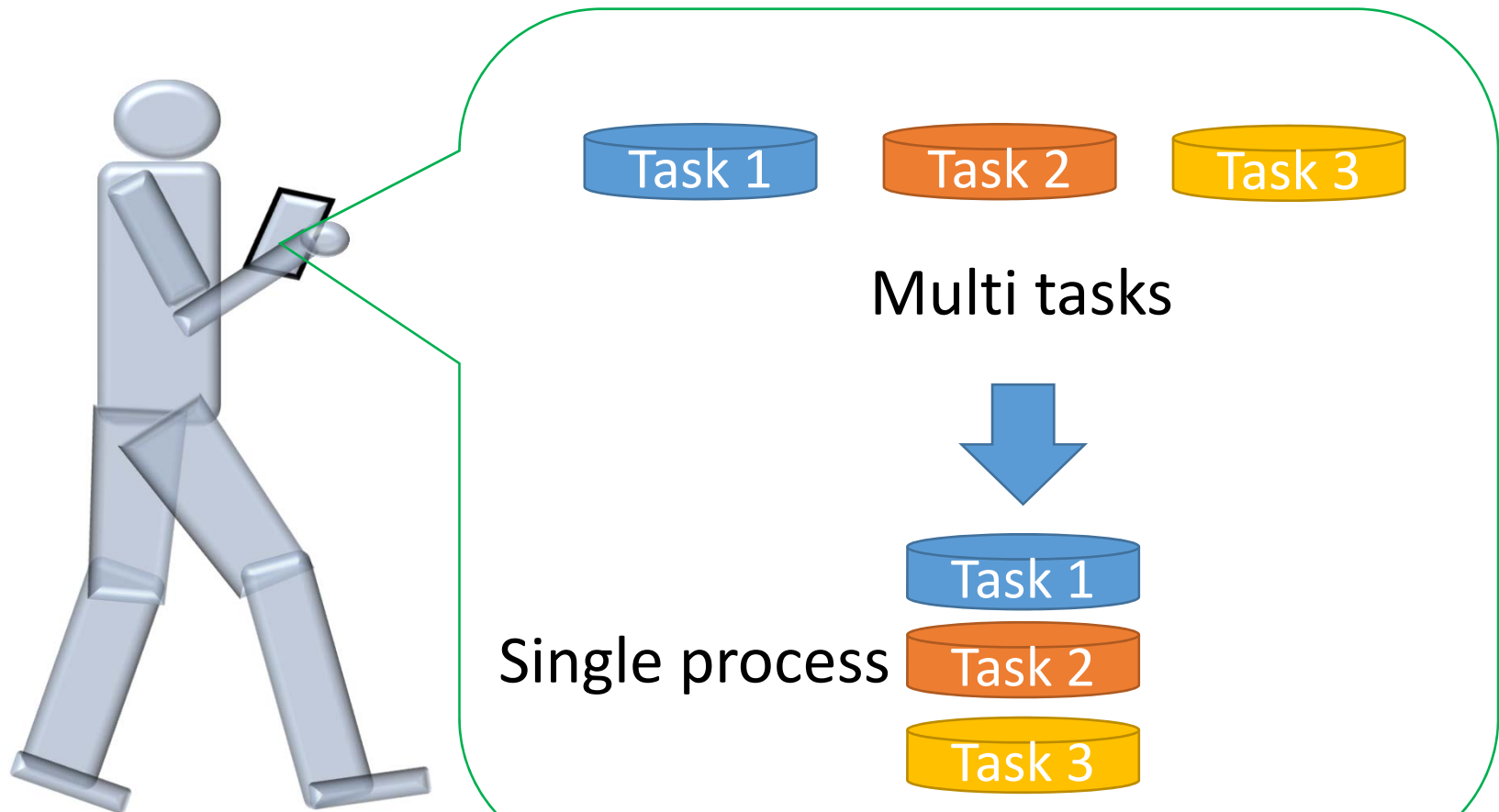
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6. Summary

Human can perform only one thing at a time

Except for the unconscious processes at cerebellum



Human can perform only one thing at a time.

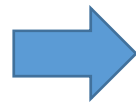
Human can perform only one thing at a time

Assumption

Robotic hand is an unfamiliar tool for human



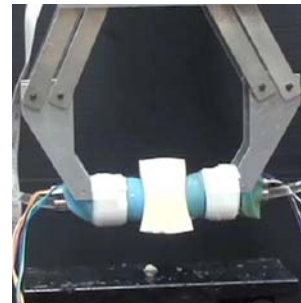
Grasping
manipulation
Motion planning



One kind on
motion at a time



Sorry



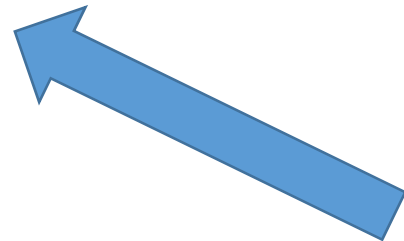
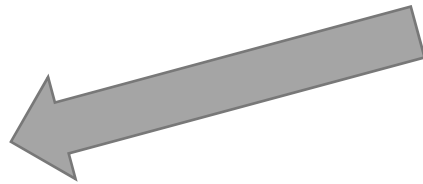
Xu et al. [ICRA2016]

Maruyama et al. [IROS2013]

How to acquire dexterity at robotic hand

How should we apply this concept to robotic hand ?

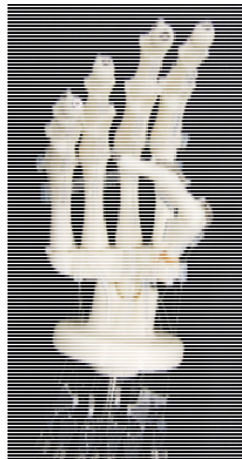
Candidate 1



Multiple operators: synchronization is difficult!

How to acquire dexterity at robotic hand

Candidate 2



Sorry

- **Open/Close: main motion** \Leftarrow Freely operated
- Rotation and bending: **Ratchet, e.t.c.**
 \Leftarrow Mainly fixed

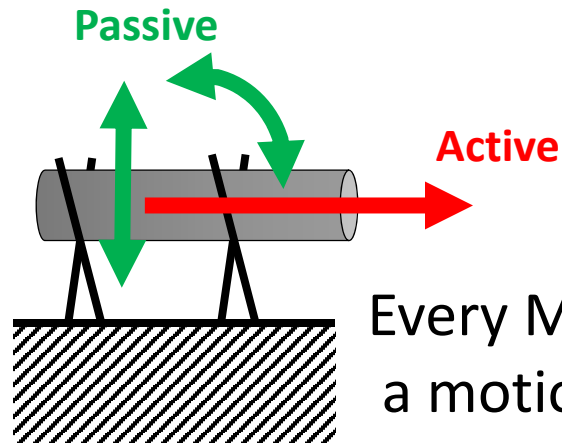
Operator only has to manipulate in a specified direction at a time!

How to acquire dexterity at robotic hand

Candidate 2

Sorry

- **Open/Close: main motion** \Leftarrow Freely operated
- Rotation and other motions: **Ratchet**
 \Leftarrow Mainly fixed



Every Motion becomes a motion in active direction

- Software base
 - ✓ Muscle synergy
 - ✓ Eigen grasp
- Hardware base

Sorry

Sorry

Jamming gripper

PISA-IIT Hand

Sorry

Sorry

Velo gripper

Our gripper

Underactuated soft gripper with Variable grasping modes

Sorry

Sorry

Sorry

(a) Parallel gripper

(b) Pinching grasp

(c) Enveloping grasp

- Open/Close: main motion
 - ⇐ Freely operated
- Mode change: by contact with an environment
 - ⇐ Mainly fixed by ratchet

Underactuated soft gripper with Variable grasping modes



Sorry

Underactuated soft gripper with Variable grasping modes

Sorry

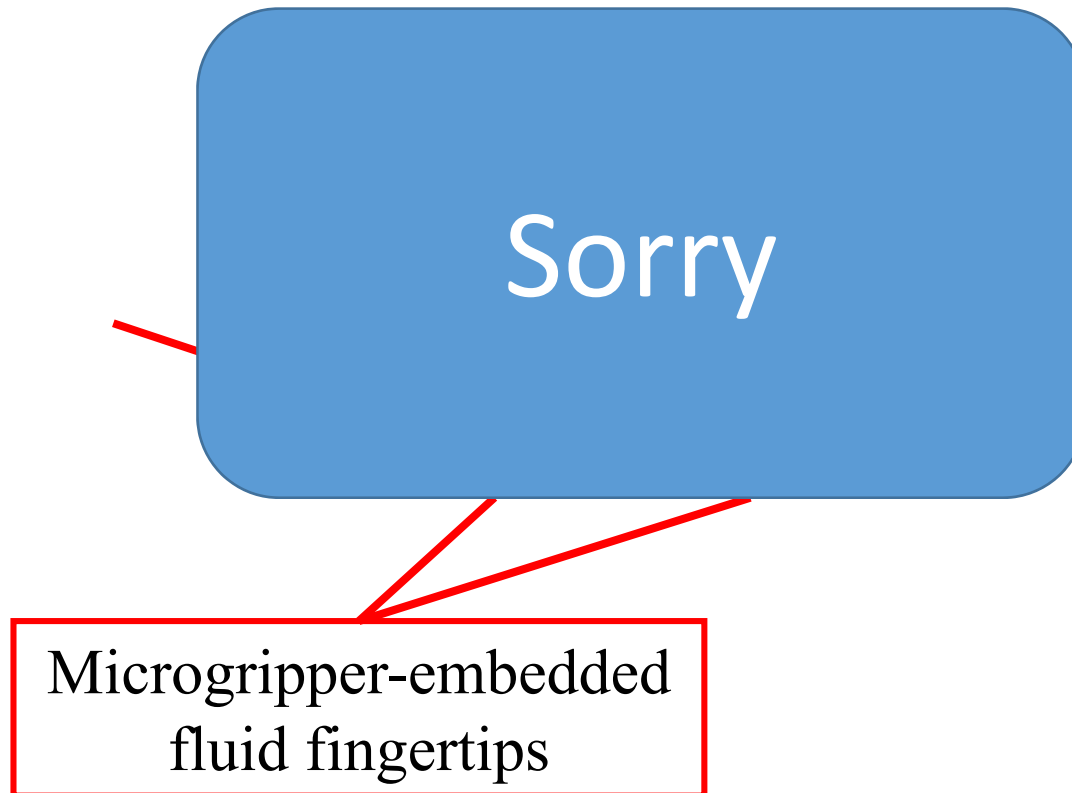
- Rotated joint angle by contact with an environment is fixed by the ratchet.
- The ratchet is released by fully opening.

Underactuated soft gripper with Variable grasping modes



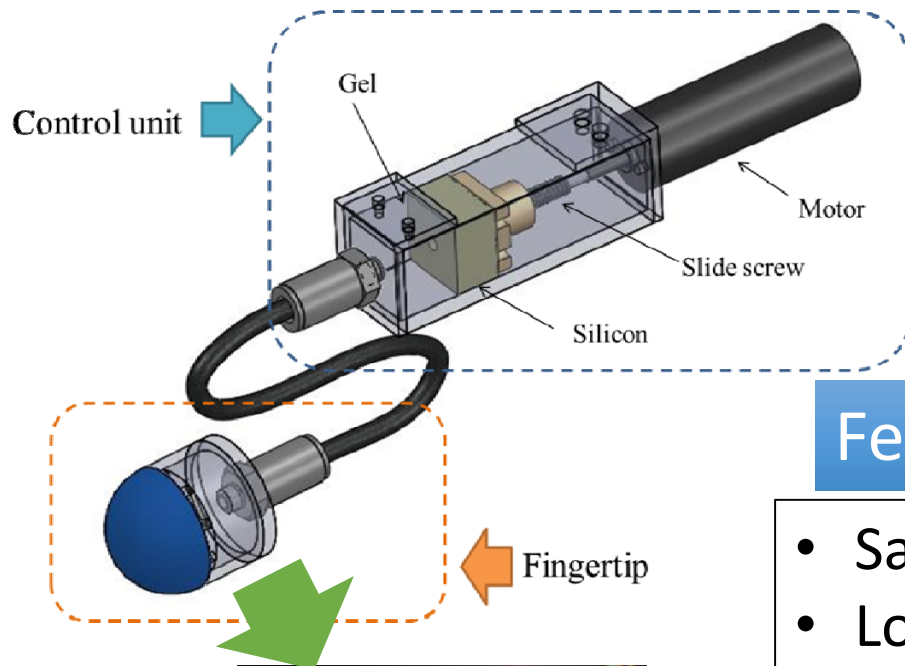
Sorry

Underactuated soft gripper with Variable grasping modes



Softness produces robust grasping

Microgripper-embedded fluid fingertips



Fluid fingertips

Features

- Safe interaction
- Low contact impact
- Adaptation to object shape
- High friction
- Uniform contact pressure
- Local passive compliance
- Heavy object cannot be grasped

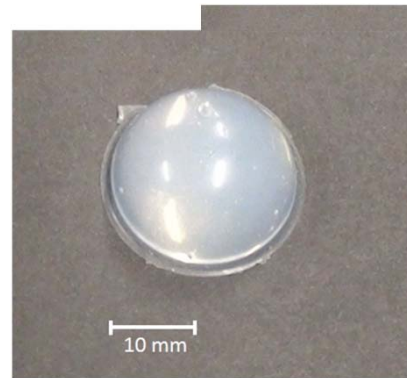
Robustness

Softness produces robust grasping

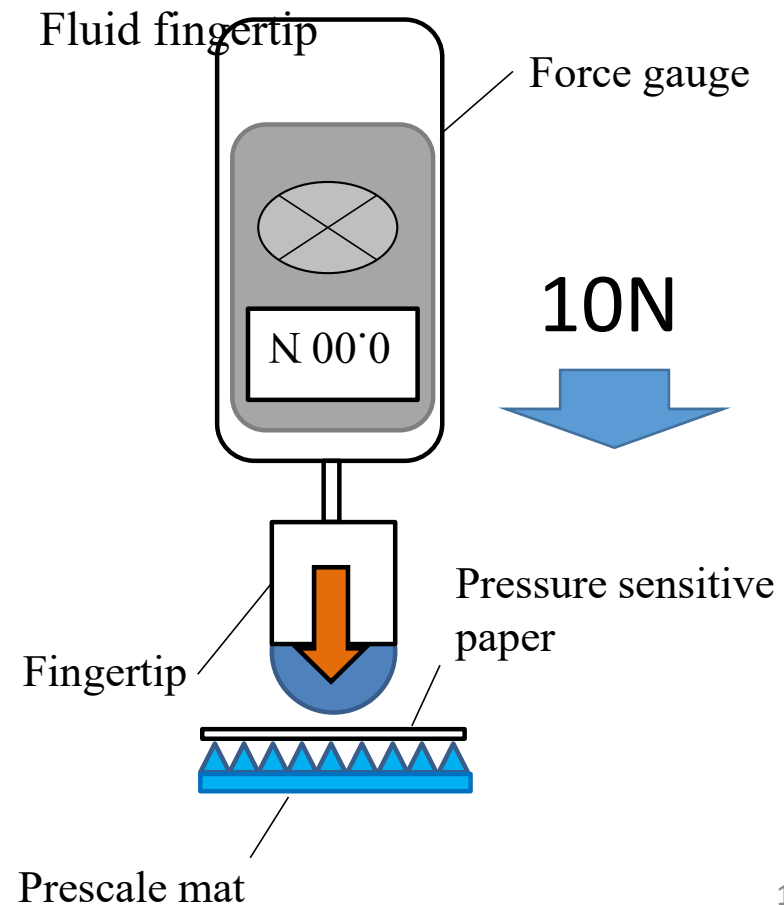
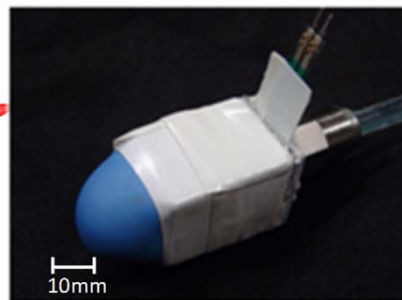
【 Experiment 】

We measured the contact pressure distribution
⇒ Pressure-sensitive paper.

Silicon fingertip



Gel layer fingertip

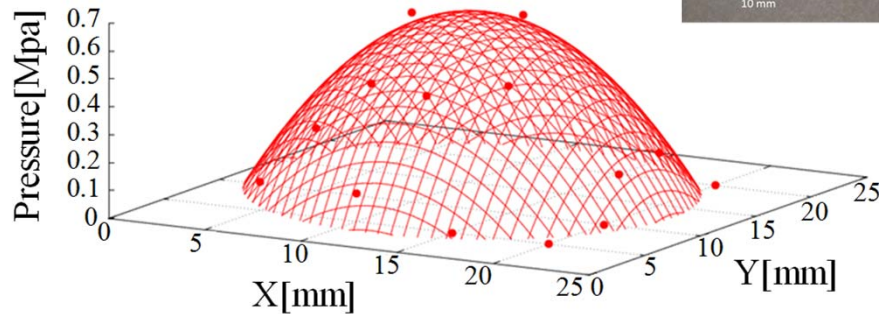
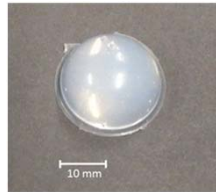


Softness produces robust graspi

【 Experiment 】

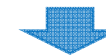
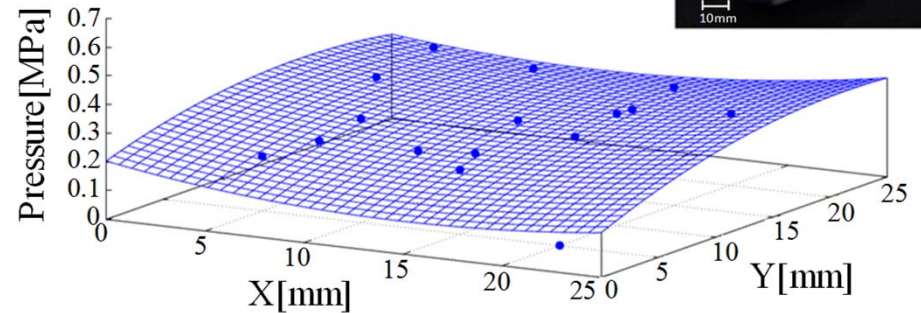
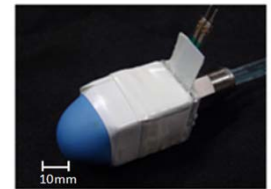
We measured the contact pressure distribution
⇒ Pressure-sensitive paper.

Silicon fingertip



Pressure is concentrated in the center

Fluid fingertip



Pressure profile is almost uniform

Fluid fingertip



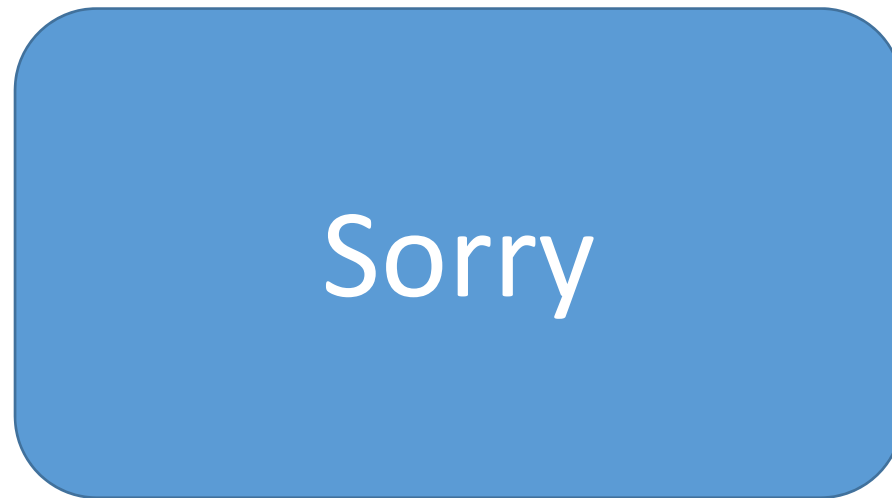
: Can grasp objects without producing high local pressures

It is effective when grasping a fragile object.

Softness produces robust grasping

Microgripper-embedded fluid fingertips

Elastic surface



Torsion spring

Softness produces robust grasping
Three types of contact modes

Sorry

Held by the two arms of micro-gripper



Large grasping force can be applied

Softness produces robust grasping
Structure: Dimension of microgripper-embedded
fluid fingertips



Sorry

Belt

Stopper

Mode (1) ...fluid part

Fragile

Potato chip

Egg

Sorry

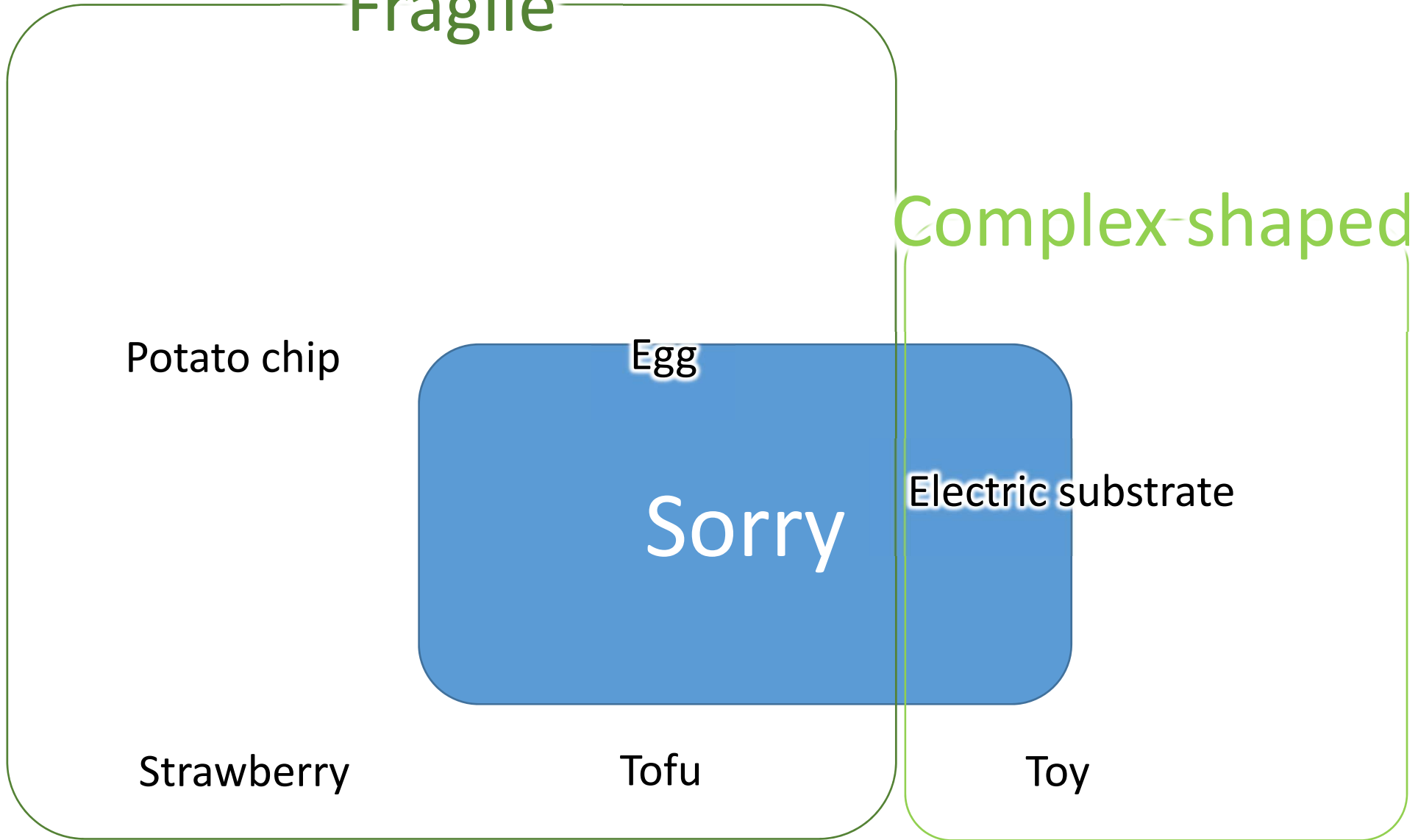
Complex-shaped

Electric substrate

Strawberry

Tofu

Toy



Mode (2) ... Pinched by micro-gripper

Heavy

Sorry

Fixture (600g)

Weight (2.5 kg)

Mode (3) ...Held by two arms

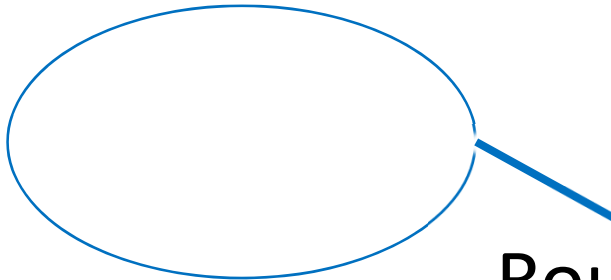
Heavy

Sorry

Book (2kg)

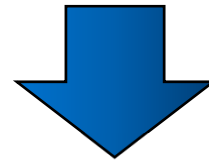
Pet bottle (2L)

Intermediate styles



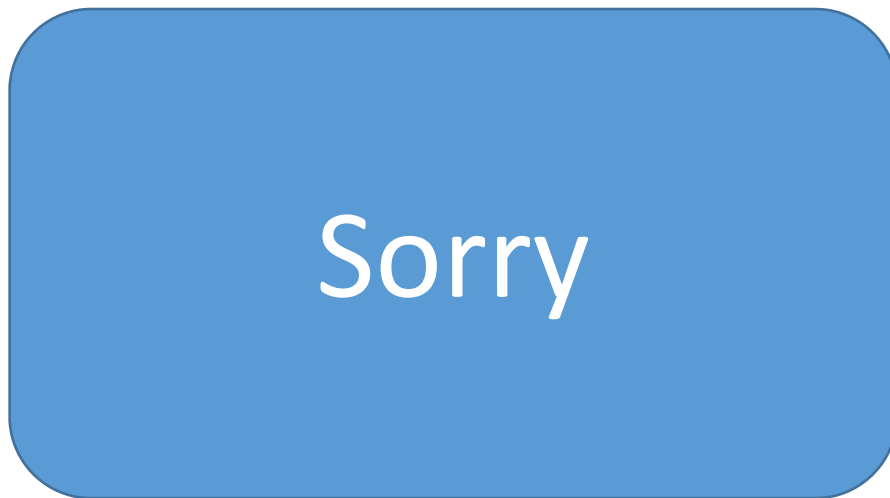
Rough area was used

Sorry



Between the modes (2) and (3)

Dexterous manipulation by underactuated soft gripper



- Utilization of Environment



Extend grasping and manipulation

Dexterity

Summary

- Dexterity acquisition at robotic hand design was presented
- Dexterous Motion=main one DOF motion + variable modes \Rightarrow Apply to Robotic hand design
- Another keys for dexterity are softness and environment.
 - Softness provides robust grasping
 - Utilization of environment extends grasping and manipulation.