# Pipe Climbing Robot TAOYAKA VII

## Simplified Control of Grasping Force Using a Current Sensor


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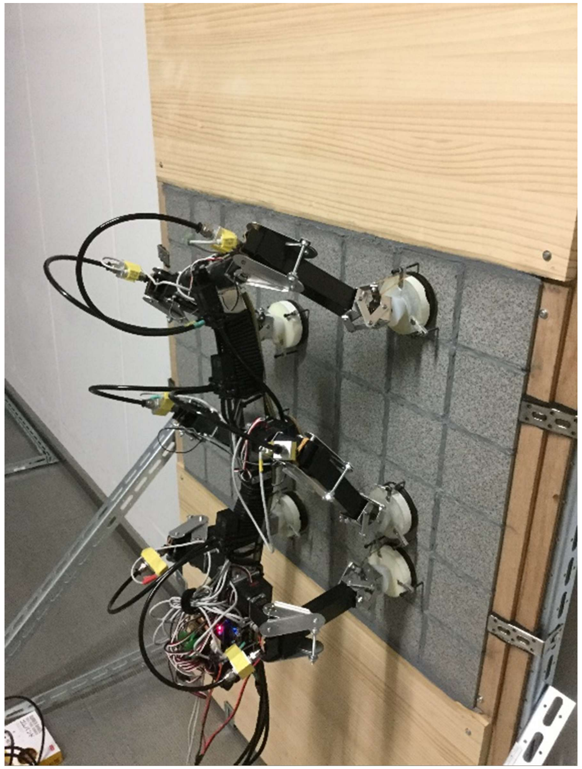
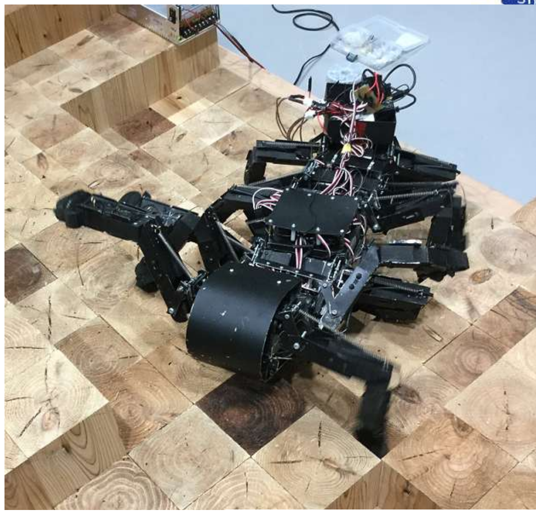




You can watch our robots on YouTube.

https://www.youtube.com/channel/UCFLo1SPFfPIIRbfKDWYtTVA

# 1. Introduction

We focus on real lower creatures,

Their bodes have many DOF.
But brains are very small.
Especially, some of them have no brain.

Nevertheless

Their behaviors are adaptive.

Questions are:

- How do they control their complex body in real-time?
- How do they adapt their behavior to unknown environments?

# 2. The hints to solve the problem

Questions are:
- How do they control their complex body in real-time?
- How do they adapt their behavior to unknown environments?

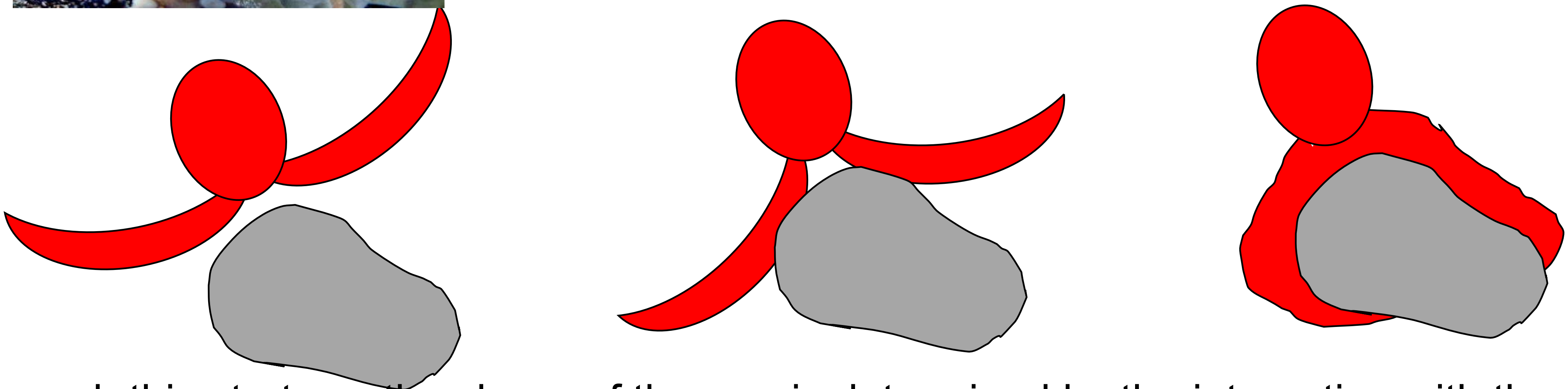
Hints:
- Interaction with the environment is key.
- Real creatures have flexible or soft bodies.
- Flexible parts of the body are passively controlled by environmental interaction.

Instead of information processing,
The mechanism of the body produces adaptive behavior using dynamics of the real world by interacting with the environment

# 3. Strategy of Octopus

The octopus can grasp various objects of unknown shapes without seeing them.

To achieve this intelligent behavior, the octopus uses a strategy in which it gradually contacts its flexible arm with the unknown object from the root to the tip.



Through this strategy, the shape of the arm is determined by the interaction with the object, allowing it to cover the object without sensing its shape.

# 4. Our previous works and goal of this study

We developed various bioinspired soft robots.

## Octopus-like manipulator

This manipulator can easily pick up objects of unknown shapes by replicating the octopus's strategy

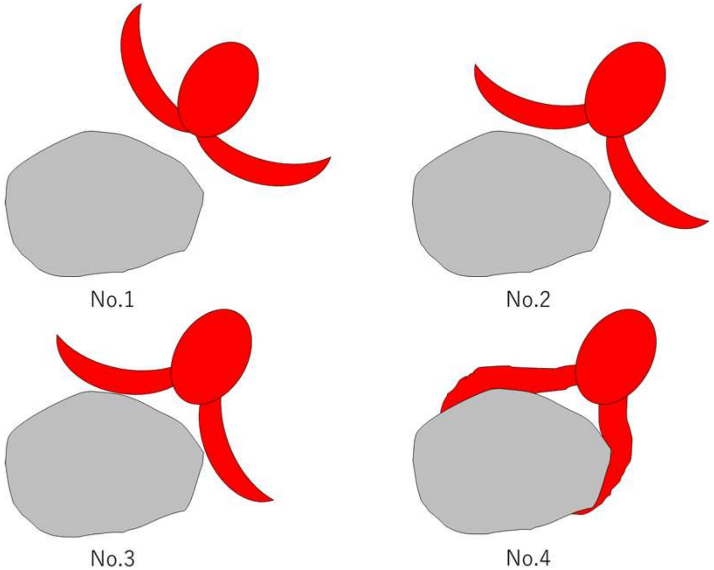
## Pipe climbing robot: TAOYAKA

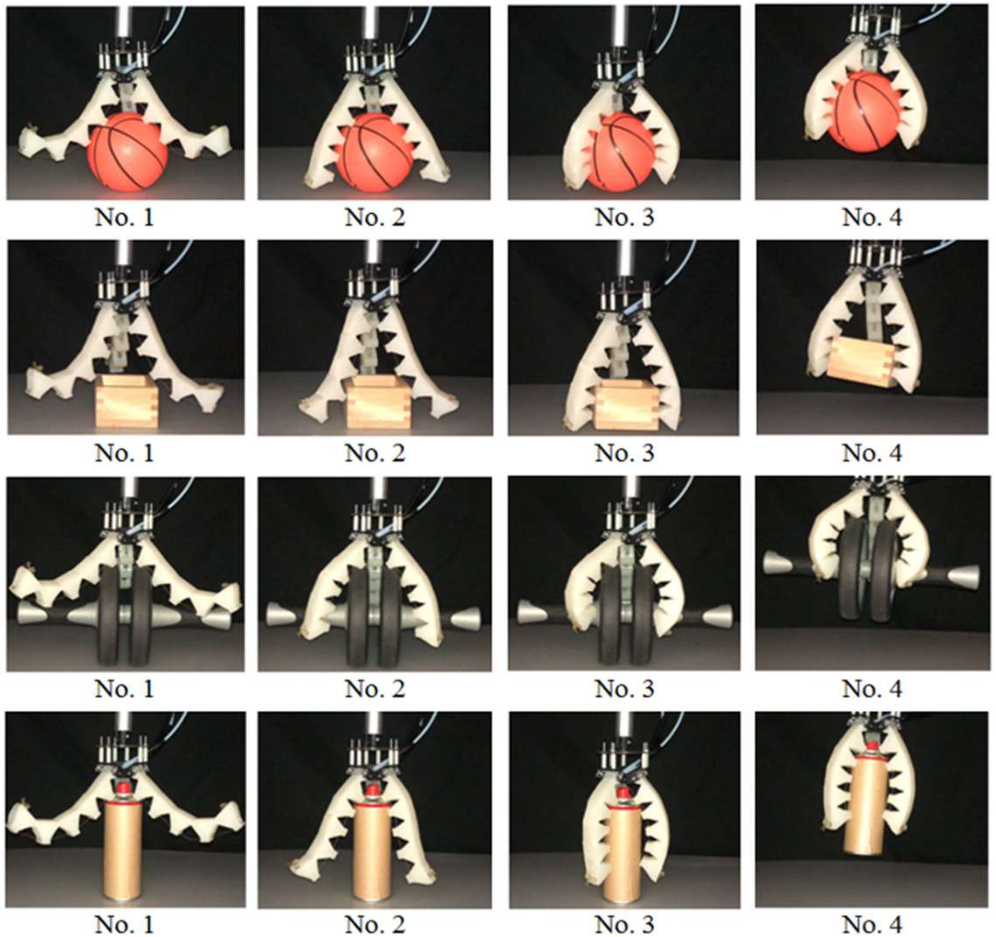
We applied grasping mechanism of the Octopus-like manipulator to a pipe-climbing robot.
However, grasping force was not controlled.

**Goal of this study**

We improve TAOYAKA VI, and add new function to control grasping force.

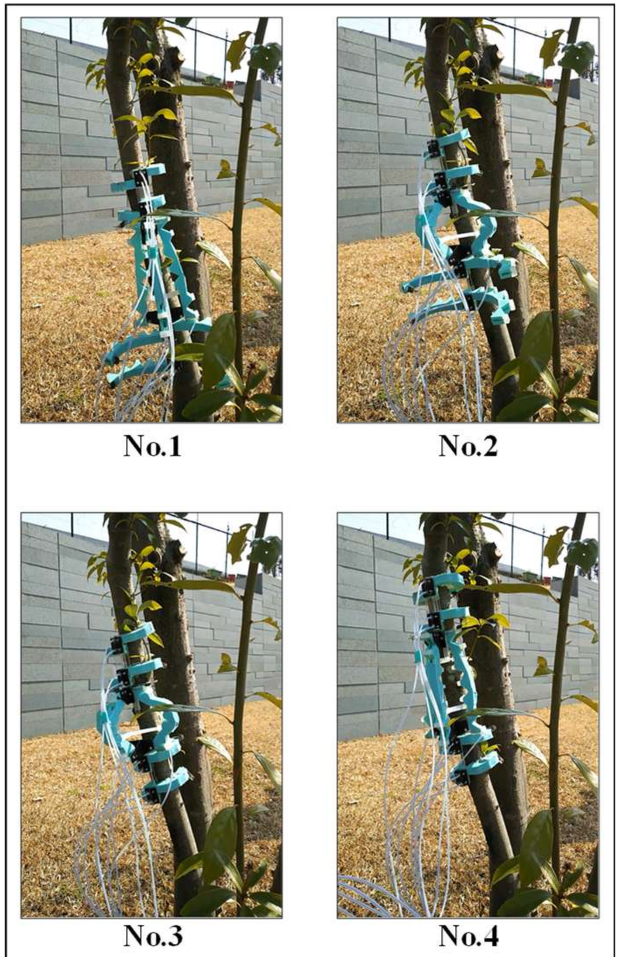
# 5. Octopus-like manipulator



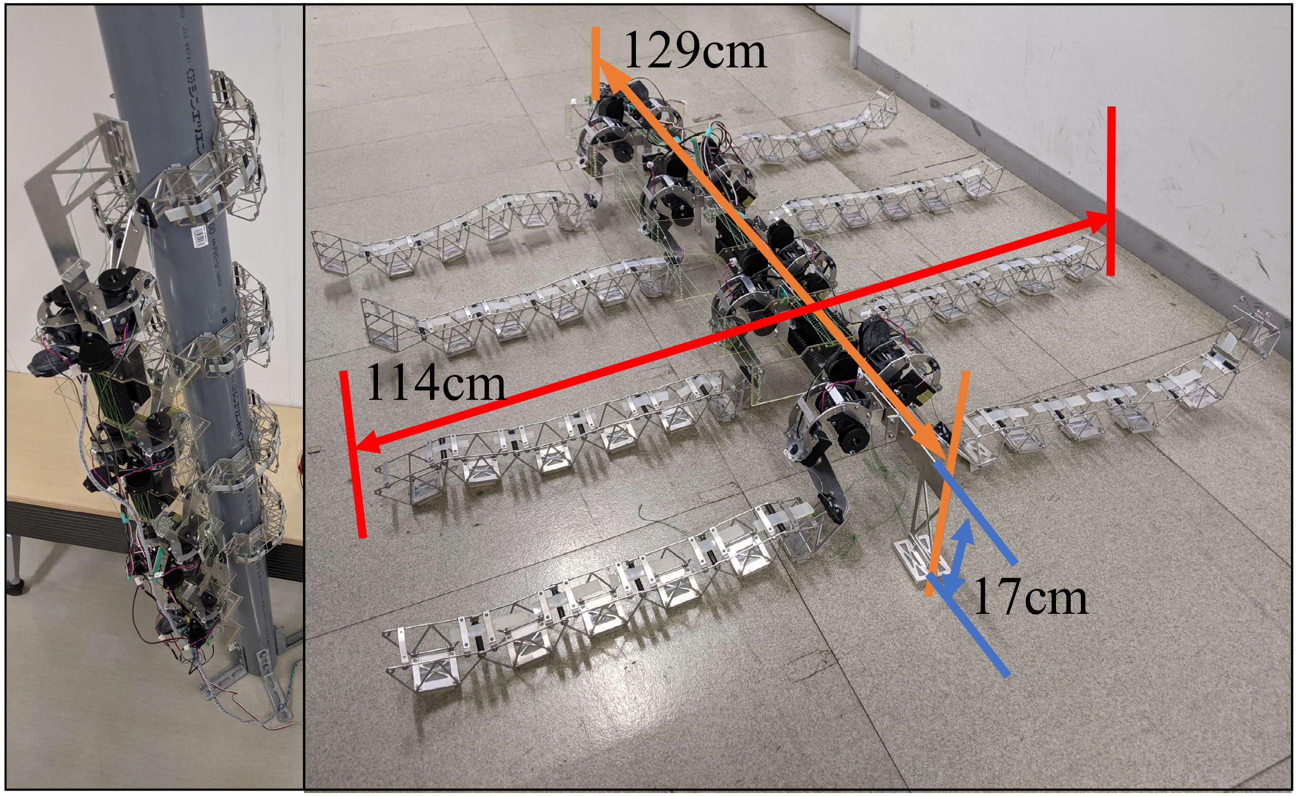




This manipulator can easily pick up objects of unknown shapes by replicating the octopus's strategy.

# 6. Pipe climbing robot TAOYAKA

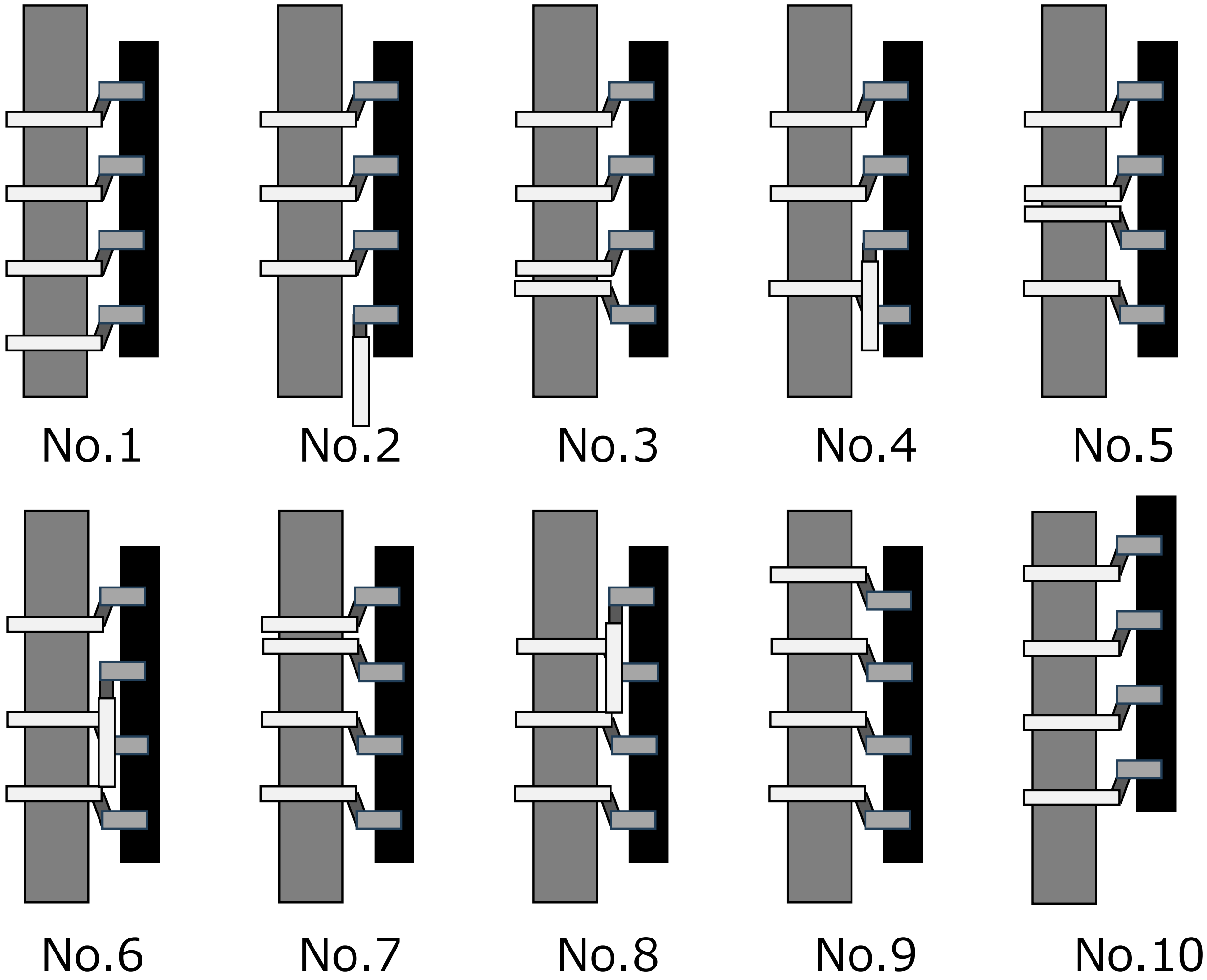



TAOYAKA-SII

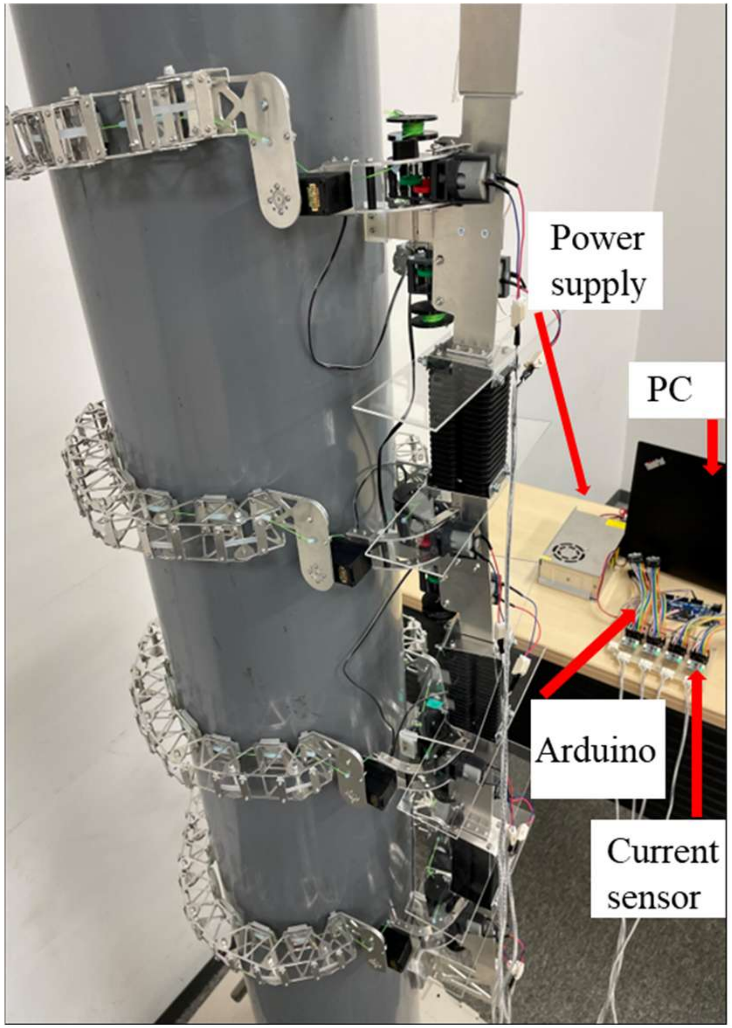


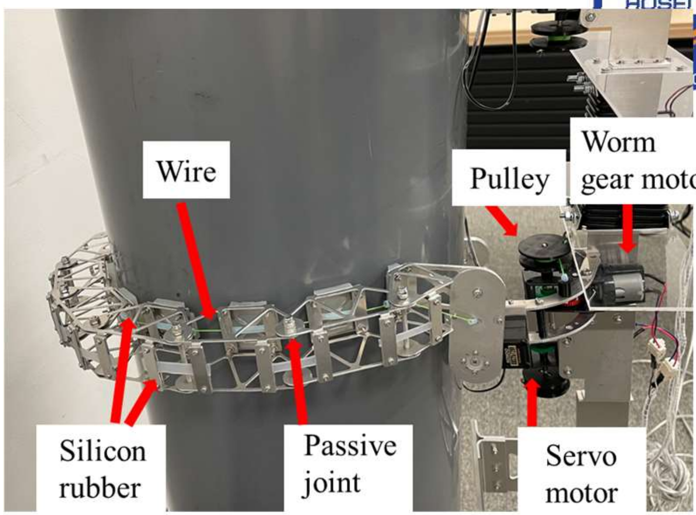

TAOYAKA V

# 7. Climbing motion



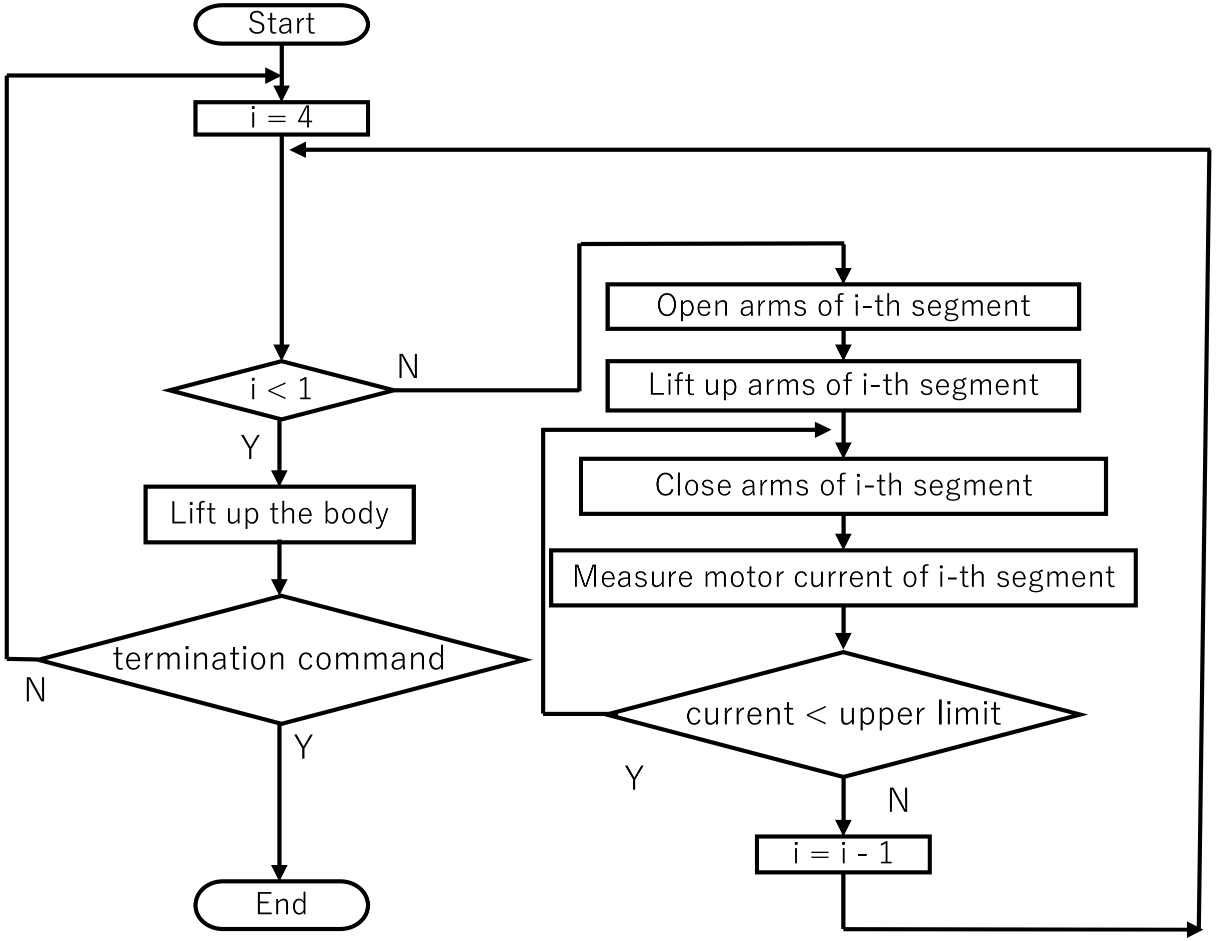
# 8. Proposed Robot: TAOYAKA VII

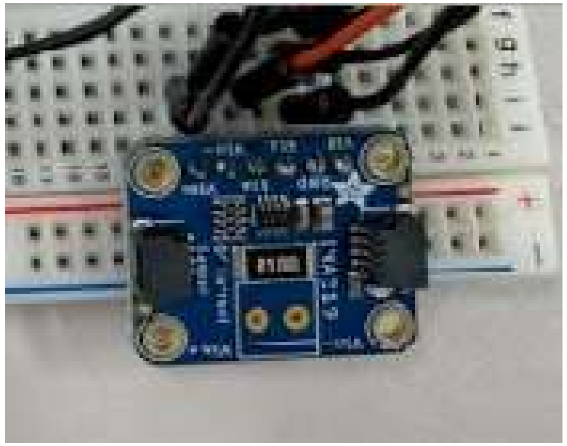



| | |
|---|---|
| Weight | 3.0 kg |
| Length | 105 cm |
| Height | 149 cm |
| Servomotor | KRS-2572HV ICS |
| Worm Gear | TAMIYA Woem Gear Box HE |
| Microcomputer | Arduino Mega 2560 |
| Power supply | DC power supply 12V25A |

# 9. Motor current control to adjust grasping force



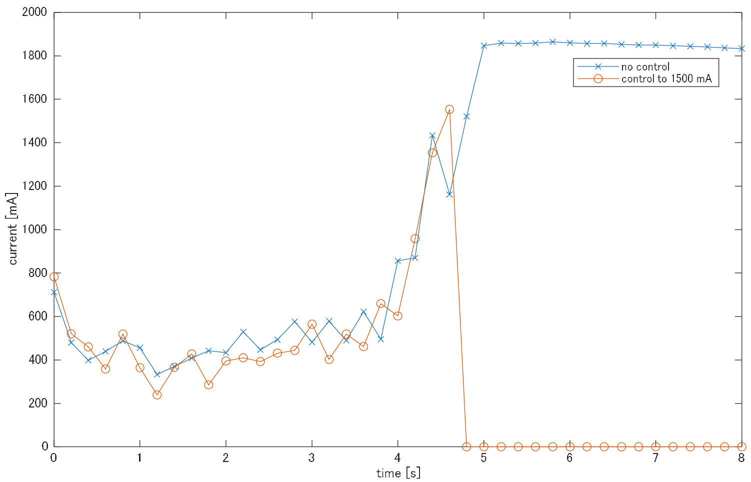
Current Sensor

We install current sensors on the motor for grasping. By monitoring these sensors, we can detect excessive torque and cut off the current.

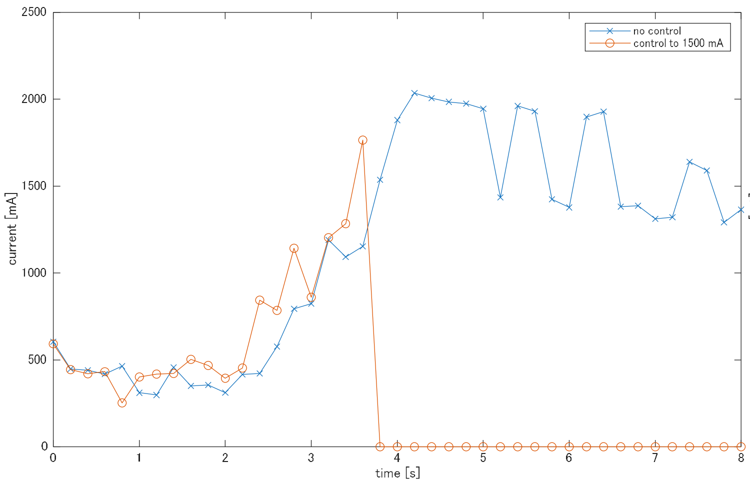
Since the motor has a worm gear, even if the electrical power is turned off, the arm remains locked, and the robot can keep holding.

# 10. Experiment

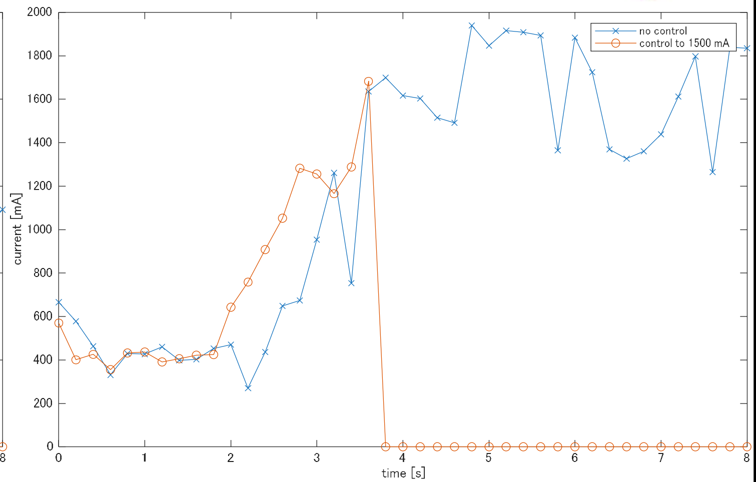
We conducted experiments to validate the proposed control scheme for grasping force. To control the grasping force, we used the motor current. We applied the same control algorithm to three pipes with different diameters.




a) Small paipe (diameter = 144 mm)



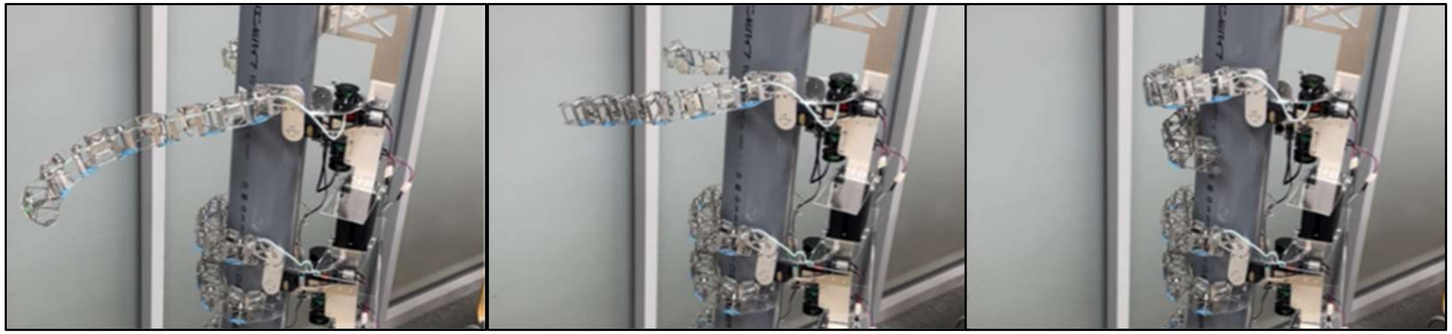

b) Medium paipe (diameter = 216 mm)




c) Large pipe (diameter = 257 mm)

In the no-control case, the current was saturated at a high level, indicating that the grasping force was too high to grasp soft objects. In contrast, in the case of the proposed control, the current was cut off around the desired value.

**Realized Motion**



No. 1 No. 2 No. 3

# 11. Conclusion

- In this paper, we focus on the adaptive mechanisms of animals and apply a passive and flexible mechanism to a pipe-climbing robot.
- We improved the previous robot by adding a function to control the grasping force using a simplified method that employs motor current sensors.
- With the proposed mechanism, the arm replicates octopus-like behavior and can grip the pipe using a preset grasping motor current.
- Our future work is to apply this robot to columnar objects with unknown dents and bumps to demonstrate the effectiveness of the proposed mechanism.