Title	Reflexive-Driven Gripper Mechanism
Author(s)	Shimizu, Shoya; Tadakuma, Kenjiro; Abe, Kazuki et al.
Citation	The 11th International Symposium on Adaptive Motion of Animals and Machines (AMAM2023). 2023, p. 130-131
Version Type	VoR
URL	https://doi.org/10.18910/92302
rights	
Note	

Reflexive Driven Gripper Mechanism
Contact counter element inspired from the mechanism by which the Venus Flytrap snaps shut

○Shoya Shimizu[1], Kenjiro Tadakuma[1], Kazuki Abe[1], Masahiro Watanabe[1],
Satoshi Tadokoro[1], 1.Tohoku University
*Corresponding author: Kenjiro Tadakuma (*email: tadakuma@rm.is.tohoku.ac.jp*)

1 Abstract

There have been many studies on reflex-based motion generation, such as the lateral inhibition of a snake robot by Hirose[1] and a walking robot by Hosoda[5], that have focused on reflexive action. We regard soft robotics as a design science of super-underactuated robot, and have been consistently engaged in research from the viewpoint of mechanism, including reflexively driven omni-directional curved arm mechanisms [2] and Omnidirectional Expanding Torus Mechanism [3]. This paper is a study of the contact counter function of the Venus flytrap, which is shown in the next chapter, in consideration of the robot hand.

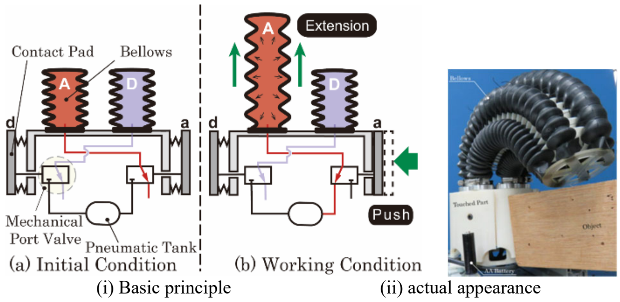

Figure 1 : reflexive Driven Arm [2]

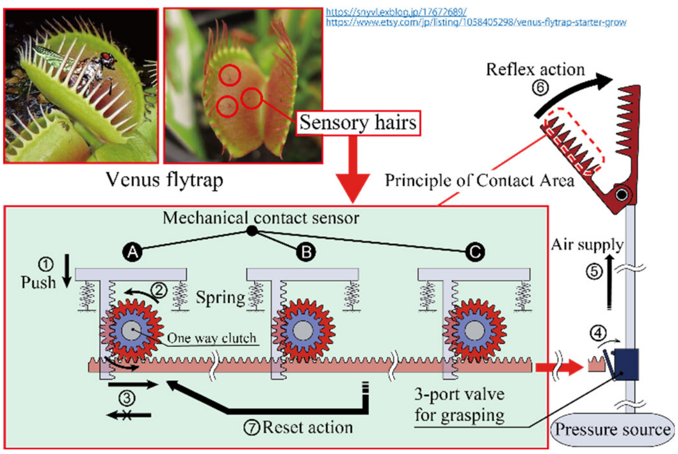

Figure 2 : Mechanization of the contact counter mechanism of the Venus flytrap

2 Mechanism of the trap snapping shut

Venus flytrap (*Dionaea muscipula*) is a kind of carnivorous plants. It catches its prey, chiefly insects with a trapping structure formed by the terminal portion of each of the plant's leaves It is known that the leaf does not close after a single stimulus, but after multiple contacts, the Ca+ concentration in the body exceeds a threshold level and the leaf starts to close. [7]-[9]. In the field of MEMS, there is an example of this reflexive drive method using optical stimulation [4], but as far as we know, there is no example of a fully mechanical contact counting system such as gears or flow circuits. If this system can be implemented, it will be effective, for example, for work in high-radiation environments where it is difficult to use electrical sensors or circuits, whether contact or non-contact. Furthermore, this technology can be highly effective in preventing opening and closing operations from being initiated by accidental contact with the outside world, and in teleoperating robot hands in environments where visibility is obscured by smoke or other factors.

3 Basic principle

Figure 3 shows a fluidic type that realizes the contact counting function. One unit consists of a small syringe that pushes out fluid by external force and is placed between two check valves. These contact-sensitive parts are exposed on the outside of the gripping part to facilitate verification of the principle in the figure and in the actual device, but it is possible to fit all the structures in the hand mechanism, depending on the design, such as miniaturization of the syringe part.

The reset part could be a valve that activates when a certain amount of fluid is accumulated, which is equivalent to the counter mechanism described above. To further simplify the structure, a valve with an aperture is opened to the outside in the flow path directly connected to the large syringe. A spring for restoring the large syringe is mounted to achieve a reset operation.

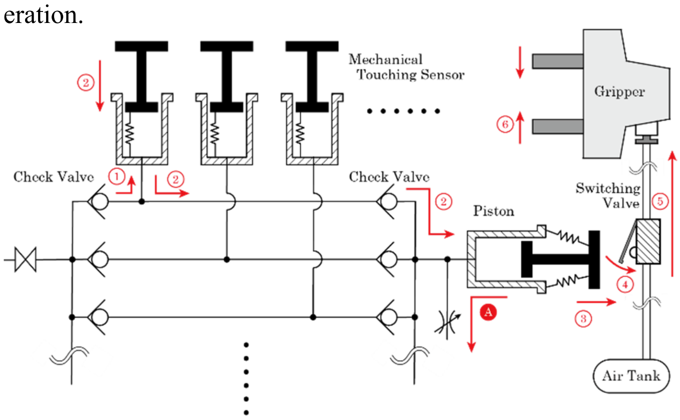

Figure 3 : Pneumatic circuit diagram of fluid system of contact counter containing mechanism

4 Prototype development

Based on the proposed principle, the prototype was designed and realized using the fluid system.

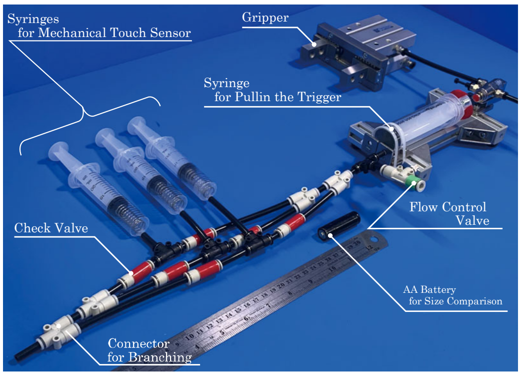

Figure 4 : Actual appearance of reflection-driven hand mechanism with contact counter

The number of times the hand closes at contact can be adjusted by changing the amount of aperture and the relative distance between the large syringe (piston) and the contact-type switching valve for initiating the hand-closing action.

5 Basic experiments

Experiments were conducted using the actual system embodied in the proposed basic principle.

5.1 reset operation

A reset operation experiment was conducted to see if the counts (accumulation) would gradually decrease and return to the initial state again as the Venus flytrap do. Figure 5 shows the experiment in action. As shown in ①-③, even if the large syringe is extended to the right in the figure by multiple inputs to the contact-sensitive part, it will return to its original position as shown in ④-⑥ unless the switching valve for the closing operation is pressed.

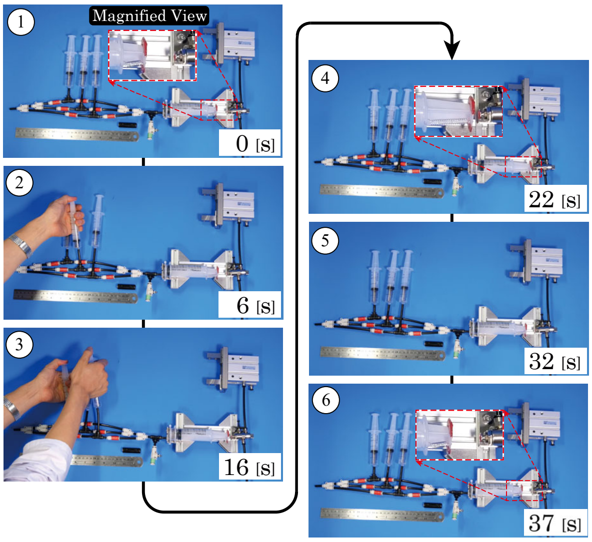

Figure 5 : A basic experiment of reset operation

5.2 Contact count/closing operation

An experiment was conducted to confirm the function that the number of counts accumulates and leads to the start of grasping. Figure 6 shows the experiment. As can be seen in the figure, regardless of how many times, and which syringe in the contact-sensitive part was pressed, all counts were gradually accumulated in the inner volume of the large syringe and extended in the right direction in the figure, and finally the button-type switching valve as a trigger was pressed to perform the hand-closing action.

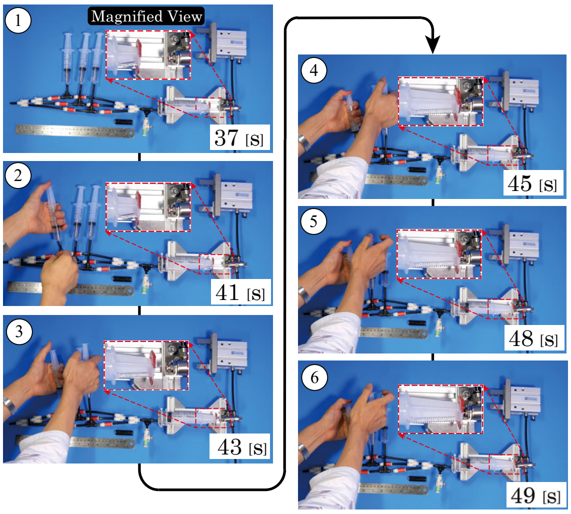

Figure 6 : Grasp initiation by contact counting function(https://youtu.be/NSZwZ3Z00Qc)

6 Conclusion

In this paper, we further develop our previous concept of a reflexive driven robot mechanism and propose and realize a complete mechanization of the hand mechanism and the contact counting element that is based on the mechanism of trapping initiation in the Venus flytrap. Through experiments using actual prototype, we confirmed the basic validity of the proposed principle, such as the reflexive drive including the contact counting function.

In the future, we will systematically extend this mechanism from the viewpoint of intelligent robot through the creation of principles and the realization of actual robots.

References

[1] Shigeo Hirose, Yoji Umetani, “Kinematic Control of Active Cord Mechanism with Tactile Sensors”, ociety of Biomechanism Japan Vol. 1, No. 1, pp. 25-28, 1972.

[2] Eri Takane, Kenjiro Tadakuma, Tomonari Yamamoto, Kazunori Ohno, Masashi Konyo, Satoshi Tadokoro, “A mechanical approach to realize reflexive omnidirectional bending motion for pneumatic continuum robots”, ROBOMECH Journal, Article number: 28, 2016.

[3] Kenjiro Tadakuma, Hirone Komatsu, Masahiro Fujita, Akito Nomura, Eri Takane, Satoshi Tadokoro, “Omnidirectional Expanding Torus Mechanism for Edible Robotics” , Conference on Robotics and Mechatronics, Fukushima, Japan, May 10-13, 2017.

[4] Owies M. Wani, Hao Zeng & Arri Priimagi, "A light-driven artificial flytrap", Nature Communications volume 8, Article number: 15546, 23 May 2017.

[5] Kenichi Narioka, Koh Hosoda, “Study on Locomotion of Musculoskeletal Humanoid” , The Robotics Society of Japan, Vol. 30(1), pp. 8-13, 2012

[6] Jennifer Böhm, Sönke Scherzer, Elzbieta Krol, Ines Kreuzer, Katharina von Meyer, Christian Lorey, Thomas D. Mueller, Lana Shabala, Isabel Monte, Roberto Solano, Khaled A.S. Al-Rasheid, Heinz Rennenberg, Sergey Shabala, Erwin Neher, Rainer Hedrich, "The Venus Flytrap Dionaea muscipula Counts Prey-Induced Action Potentials to Induce Sodium Uptake," Current Biology, vol. 26, no. 3, pp. 286-295, 8 Feb. 2016, doi: 10.1016/j.cub.2015.11.057.

[7] Hiraku Suda, Hiroaki Mano, Masatsugu Toyota, Kenji Fukushima, Tetsuro Mimura, Izuo Tsutsui, Rainer Hedrich, Yosuke Tamada, Mitsuyasu Hasebe, "Calcium dynamics during trap closure visualized in transgenic Venus flytrap," Nature Plants, vol. 6, pp. 1219-1224, 5 Oct. 2020, doi: 10.1038/s41477-020-00773-1.

[8] Hiraku Suda, "The memory system of Venus flytrap mediated by calcium ions," the 86th Annual Meeting of the Botanical Society of Japan., 2aSB02, Nagoya (Online), 20 Sep. 2021.