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Compliant passive gripper design with automatic switching gripper motion

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***Abstract*— Differently from active grippers, compliant grippers focus on passive movements using kinematic structures or soft materials, which allows for effective grasping and releasing of objects. The most common gripper configuration consists of two parallel fingers, akin to a crab's claws. Similar to a person picking an object from the floor with their hands, conventional compliant grippers typically undergo four steps to grasp and release objects. The first step is opening two fingers to match the width of objects, by spreading two fingers, it is ready to grasp. And the second step is moving downward. If the object is on the floor, the gripper should move toward it. The third step is closing two fingers, indicating that an object is grasped, and the last one is moving upward for lifting and moving another place. Although these steps are intuitive, controlling them can be complex and time-consuming. To overcome and improve previous disadvantages, the concept of two steps operation and automatic switching is proposed in this paper. Based on armrest and leverage principles, the actions of opening and descending are combined, as are closing and ascending. Thus, when the proposed gripper descends, it makes contact with the object's surface, prompting the fingers to spread out to match objects' width. Subsequently, as it ascends, it simultaneously grasps and lifts the object. From building concepts and idea, kinematic analysis, spring displacement and grasping force calculations were conducted in this paper. Through simulation and experiments, verifying on various weights and widths of objects were conducted.**

I. INTRODUCTION

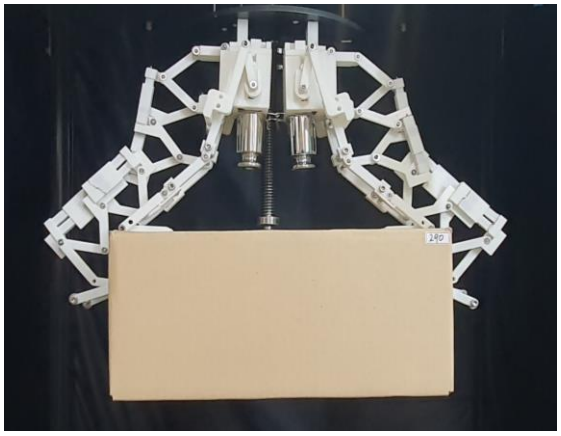
Differently with actuated gripper, in order to role actuator in underactuated system, springs, wires and soft materials have been widely used[1]. The conventional underactuated grippers have been studied for grasping and releasing based on four control steps and two parallel fingers[2], [3]. The conventional processes for grasping an object are follows. The first step is opening two fingers to match the width of objects, by spreading two fingers, it is ready to grasp. And the second step is moving downward. If the object is on the floor, the gripper should move toward it. The third step is closing two fingers, indicating that an object is grasped, and the last one is moving upward for lifting and moving another place. Although these steps are intuitive, controlling them can be complex and time-consuming. To overcome and improve previous disadvantages, the concept of two steps operation and automatic switching is proposed in this paper. In this study, we employed closed linkage systems[4], spring, stopper, etc. However soft materials or wires were not employed in this study due to the complexity and uncertainty.

II. CONCEPT AND EVALUATION

A. Concept

The main concept of proposed gripper is to grasp and release based on two steps, and switch between grasping and releasing mode automatically. To achieve, armrest principle is adopted. The armrest principle is a common method for switching two modes sequentially based on the same movement, such as push and pull. The similar principle is like click pen principle. Two parallel fingers are also employed in this paper, but they approach an object with fingertips, allowing two fingers to make contact with the top surface of an object, and fold to match the object's width. Based on aforementioned concepts, leverage principle, stoppers, springs and kinematical structures, the proposed gripper can open its two fingers while moving downward without requiring additional control, enabling it to grasp and lift simultaneously. Fig.1 shows the proposed gripper holding the objects. As aforementioned explanation, the parts based on the armrest principle is mounted the top part of the gripper, and no actuator was used for fabrication the gripper.

Figure 1. The proposed gripper in grasping status with an object



B. Evaluation

Modeling and simulations were conducted to check the configuration of parts, and whether they fold and moves as intended. Through simulations, scenarios were set for idle status, bending and folding status, grasping and lifting status, releasing status and recovering status. In terms of experimental evaluation, various weights and widths of objects were prepared. The proposed gripper was mounted on the lifter, which moves only upward and downward. Therefore, finger

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movements such as folding, grasping and releasing are solely determined by kinematical structure and aforementioned principles employed in this paper. There were three outcomes: ‘grasping only’, ‘grasping and releasing’ and ‘grasping failure’. These outcomes were determined by the weight and width of objects, friction coefficient, and gripper's dimensional information.

III. EXPERIMENTS

A. Experiment

The main purposes of these experiments are to verify whether the gripper is folded well or not as intended, and the grasping and releasing mode is switched automatically or not. Moreover, to measure the range of width and weight which the proposed gripper can afford. So to do that, several hexahedral boxes and weights are prepared like Fig2.

Figure 2. Various weights and width of objects

Three conclusions were obtained from the experimental results. The first was “grasping only” the second was “grasping and releasing” and the last was “grasping failure”.

Consequently, the proposed gripper only performed automatic switching between grasping and releasing in a width range between 220mm and 270mm, within a weight range of 400g and 900g. Except for these regions, half of the area where the experiment was conducted was the grasping-only region, and the other half was the grasping-failure region.

IV. CONCLUSIONS

A. Conclusion

The proposed gripper incorporates the concepts of two-steps for grasping and releasing, as well as automatic mode switching. To embody these concepts, armrest principles, kinematical structure were employed. Consequently, within a certain range of widths and weights of prepared objects, automatic switching between grasping and releasing was detected. When the proposed gripper moved downward, its two fingers opened, and when it moved upward, it automatically grasped an object. However except for the range ‘grasping and releasing’, it grasped an object but failed to release, and it failed to grasp because objects are too light or weight.

REFERENCES

[1] T. Yoshikawa, “Multifingered robot hands: Control for grasping and manipulation,” Annual Reviews in Control, vol. 34, no. 2, pp. 199–

[2] Y. Yan, S. Guo, C. Lyu, D. Zhao, and Z. Lin, “Sea-based humanoid finger-functional parallel gripper with two actuators: Pg2 gripper,” IEEE Transactions on Instrumentation and Measurement, vol. 72, pp. 1–13, 2022.208, 2010

[3] T. Hattori and T. Omata, “Multifunctional parallel gripper with three actuators,” IEEE/ASME Transactions on Mechatronics, vol. 27, no. 3, pp. 1391–1402, 2021.

[4] S. R. Kashef, S. Amini, and A. Akbarzadeh, “Robotic hand: A review on linkage-driven finger mechanisms of prosthetic hands and evaluation of the performance criteria,” Mechanism and Machine Theory, vol. 145, p. 103677, 2020.