Soft Drag Gripper - a soft simultaneous multiple object gripper designed to work in rectangle boxes

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***Abstract*— In the field of logistics, humans have the ability to grasp multiple objects simultaneously. This paper presents a hardware solution in the form of the Soft Drag Gripper, that demonstrates excellent capabilities for grasping multiple objects simultaneously. The drag design enables efficient emptying. of rectangular boxes.. Simple strategies can be employed to increase the number of picks per grasp, thereby reducing time and costs. A benchmark compares SDG to exiting design solution showing higher pick rate than other designs.**

I. Introduction

For certain tasks in logistics, especially bin picking and packing, humans resort to a strategy of grasping multiple objects simultaneously [1], thus reducing picking and transport time. In contrast, robotic systems mainly grasp only one object per picking action, which leads to inefficiencies that could be solved with a smarter gripping hardware and strategies. Development of new manipulators, robotic hands, hybrid or specialized grippers [2], can already consider such challenges for multi-object grasping in the design stages. This paper [3]introduces different hardware solutions and tests possible grasp strategies for the simultaneous grasping of multiple objects (SGMO). Four hardware solutions presented at Frontiers: an under-actuated Constriction Gripper, Linear Scoop Gripper suitable for deform-able object grasping, Hybrid Compliant Gripper equipped with mini vacuum gripper on each fingertip, and a Two-finger Palm Hand with fingers by simulation in pybullet for maximum in-hand manipulation workspace. The benchmark on these grippers showed possible improvement in rectangular boxes, which are often used in industrial environments. Also the space needed to come between object should be reduced. The now presented soft drag gripper shows improved simultaneous multi-object grasping, and works also in rectangular boxes. Due to its design collecting of more objects after the first grasp is possible, similar as present for the Two Finger Palm Hand [3].

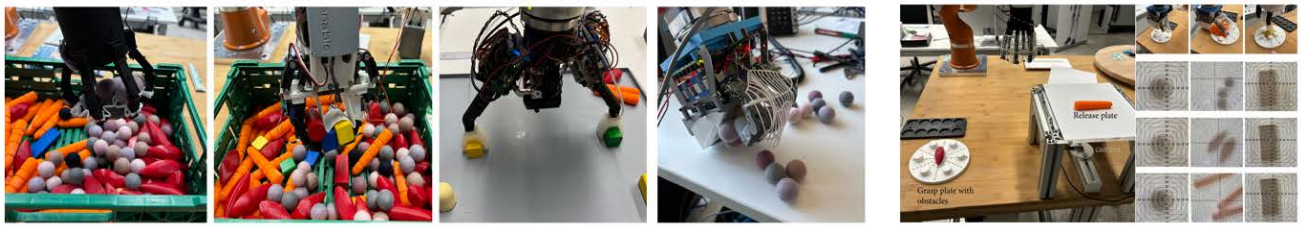

Fig. 1: Left: Multi-object grasping with different end-effectors. From left to right: Constriction Gripper, Linear Scoop Gripper, Hybrid Compliant Gripper, and Two Finger Palm Hand. Right: Benchmark Setup

II. Design

In figure 1 right the design of four different grippers was tested. Other designs [4],[5] were also analyzed and all designs show weakness if a top grip is used near the corners of a box to empty it. This comes mostly from the form of the gripper. Without improving this disadvantage, the gripper will reach a lower performance of picks per grasp. For the new design following requirements are set.

- The gripper should grasp successful object near corners.
- Small contour of the fingers to come easy between full boxes.
- Improved SGMO capability to best value out of [3]
- Soft structure for less damage of object
- Work with exiting electronic concept.

A. Kinematic of SDG

In order to find a proper kinematic, following ideas were explored. First reach a high inner volume, if the gripper is closed. Second have a soft material, which can deform, while the finger is moved between the object. A closed double drag shows a good inner volume, but has not a small contour during opening. Hence the idea was to form two sheets to get in close condition a double drag form. To close the sides of the drag tendons are used as show in figure 2. The gripper mainly slide under the object to generated a cage grasp, which reduce the loads on the object. The gripper has a manual tool changer to be used on a robot or with a handle to learn grasping strategies by demonstration.

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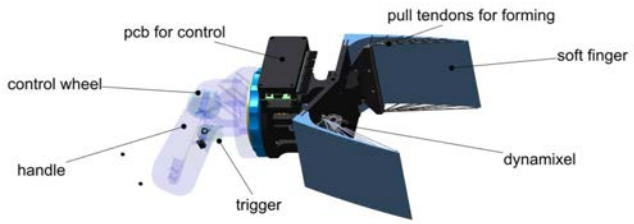

Fig. 2: Design of the Soft Drag Gripper with handle to learn strategies by demonstration

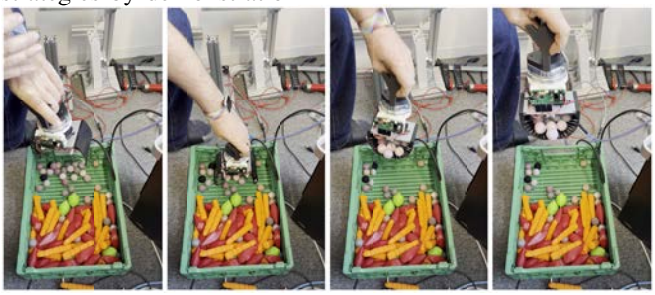

Fig. 3: Grasping small balls by human demonstrations. For this first test a simpler handle was used without direct control

B. Hardware

The SDG are made of 3D printed TPE, with an optimzied shape to form a nice drag profile. Each drag is acutated by a dynamixel XC330-M288-T servomotor, which pulls the drag over two tendons, which are connected to the end of the drag into the middle. Extra tendons, which are connected evenly distributed to the side of the drag, are closing the side of the drag in close position and help to form the drag shape. In open condition the tendons are without pretension and allow the flat drag to bend during pregrasp. A third dynamixel is changeing the base opening of both drags. The dynamixel are controlled over the PWM interface by a CLASH [6] electronic.

III. Experiments

To test the performance of SDG, the simultaneous grasping of multiple object is evaluated based on the benchmark out of [3]. Compared to the constriction gripper, which showed the highest score, SDG could improve the performance for example for cherry tomatoes from 8 to 16.

A. Multiple object grasping by human demonstration

The goal of these tests was to grasp multiple objects and found tactics, which can then be implemented at the robot. Figure 3 shows the grasping of small ball, by a simple top grasp tactic.

Figure 4 shows the collection strategy. The handle allows different closing modes to be set. The pre-close mode is controlled by the trigger: first, the drag at the handle; then, at 50 per cent of the trigger signal, the second drag closes, as does the position relative to the other drags. This mode allows you to pick up nearby objects in one step and then individual objects in the next step, reducing the robot's transfer motion to the release goal.

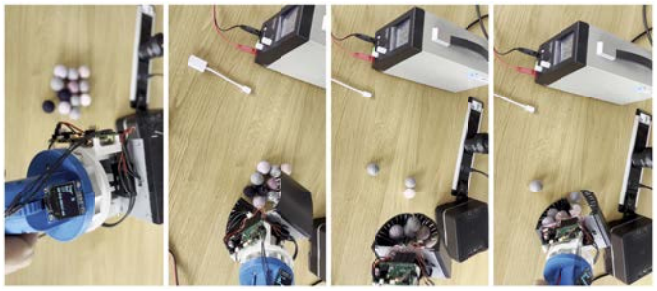

Fig. 4: Collect strategy: first step: choose pre close mode, second step: grasp as much objects possible in one pick, third step: tilt gripper back to arrange objects in the close drag, fourth step; grasp more objects with the open drag.

Fig. 5: Pull grasping strategy by robot to collect more objects

B. Robot grasping tests

The found tactics are used to test if they are practical on a robot. For that purpose another found strategy was the pull strategy, this is shown in figure 5. The goal of this strategy is to arrange object in one direction and reduce free space between objects to increase the number of objects per grasp. The gripper is for this initial tilt at around 30 degree. Then the drag nearer to surface is placed near the object. Then a linear motion of the robot, push the objects together. The gripper is then tilted back to grasp the objects.

IV. Conclusion

The paper presents the design of the new DLR Soft Drag Gripper, a soft simultaneous multiple object grasping gripper with an increased grasping capability also in rectangle boxes. Initial testing with gripper shows an improved performance against older designs. In a next iteration the position of the drag forming actuators will be optimised to increase the drag volume and to have no moving parts inside the drag. Furthermore a ego motion camera on the handle could help to generate data for machine learning.

V. Acknowledgment

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