NEW SCISSOR-GRASPING TOOL FOR PARALLEL GRIPPERS, ENSURING STROKE ENHANCEMENT

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1. Introduction

In the framework of national contract no. 22 PCCDI /2018, project entitled "Autonomous robot systems for waste management in the context of smart city" (acronym SIRAMAND), the idea is to build a mobile robotic system carrying a *x-y-z* robotic manipulator or a Delta parallel robot, equipped with an electric parallel gripper, as schematized in Fig.1. The gripper is the end-effector tool responsible for grasping various waste objects from the ground and to manipulate them to a box container placed on the mobile robot.

Fig. 1. Overall scheme of SIRAMAND mobile system.

The overall actuation of this mobile/autonomous robotic system must be performed using only 24 VDC, technological constraint which led us to the choice of a FESTO *x-y-z* robotic manipulator, composed of planar surface gantry EXCM-30-700-510 for $x+y$ actuation, plus an electrical slide EGSK-26-200-2P for actuation on *z*-axis. In fact, this is one of the few robotic systems capable of carrying 2-3 kg of load, considering the 24 VDC voltage limitation.

In order to collect waste objects, the mobile robotic system must be equipped with a rotary electric gripper, using 24 VDC actuation, not too heavy, but providing enough stroke and gripping force for grasping as much types of waste objects as possible.

2. Festo HGPLE electric parallel gripper

For full compatibility of the overall robotic system, a FESTO electric parallel gripper has been selected. More precisely, the solution of a *FESTO parallel gripper HGPLE-14-60 [1], plus a rotary drive ERMO-16, has been selected*. So, our HGPLE-14-60 gripper provides a total stroke of 120 mm and a gripping force varying between 104 N (for 5 mm/s closing speed), up to 173 N (for a closing speed of 10 mm/s) [1[.

Of course, numerous various electric in-house grippers has been proposed in the literature. For example, Barbieri et al. [2] proposed an underwater robotic arm with an adaptive rotary gripper, having two fingers with an anthropomorphic kinematic structure. Each finger is composed of two phalanges. Due to the special parallel structure of the first/proximal phalanx (incorporating a helical elastic spring), when it comes in contact with the grasped object, its rotation is blocked, but the actuation enables still the rotative closure of the second/intermediate phalanx (until it comes also in contact with the object). Moreover, the intermediate phalanx is naturally continued with a distal phalanx having the form of a FinRay pattern structure, patented by FESTO. The current FESTO product based on this FinRay pattern structure are the adaptive gripper fingers DHAS [3]. When such a gripper grasps an object by closing its two fingers, this flexible FinRay bionic structure of DHAS fingers [3] has the property of adapting to the shape of the object, thus significantly increasing the contact surface between the fingers and the object.

Another in-house gripper is proposed by Bonello et al. [4], mounting in parallel a 2-finger mechanical gripper and a vacuum cup, respectively. Combining classical grasping using friction with the supplementary vacuum aspiration, this versatile gripper is able to successfully grasp objects of different shapes, sizes and weights [4].

In order to be able to grasp larger objects and to improve the grasping, we propose to replace the classical or the adaptive fingers of HGPLE-14-60 gripper with the following innovative stroke enhancement adapter, inspired from the operating mechanism of scissors.

3. New scissor-grasping tool

This paper's contribution is to present a new scissor-grasping tool to be mounted on the FESTO HGPLE-14-60 gripper, equipping the x-y-z robotic system conceived for grasping waste objects. This innovative scissor-grasping tool represents an alternative to classical rigid BUB-HGPL fingers or to adaptive gripper fingers DHAS-GF [3], provided by FESTO as gripper grasping tools.

The idea is to study a different type of grasp, the proposed innovative scissor-grasping tool fulfilling also the role of stroke enhancement adapter. Fig. 2 shows a frontal view of the scissor-grasping tool, indicating all the geometrical design elements needed to express the scissor equations.

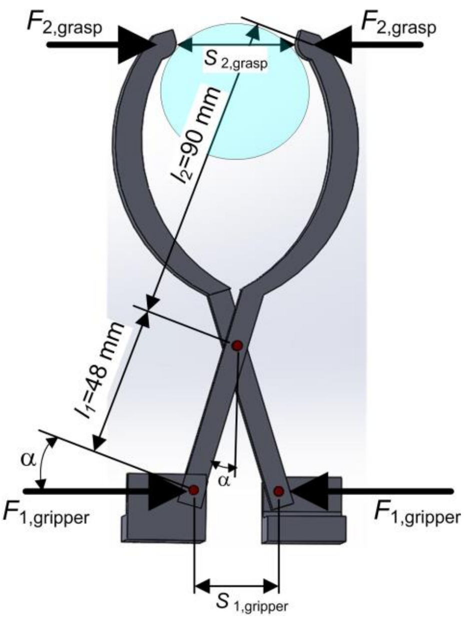

Fig. 2. Frontal view of scissor-grasping tool.

The scissor-grasping tool is characterized by the following torque transmission equation:

$$F_{1,gripper} l_1 \cos\alpha = F_{2,grasp} l_2 \cos\alpha \qquad (1)$$

to which must be added the geometrical condition:

$$\frac{s_{2,grasp}}{s_{1,gripper}} = \frac{l_2}{l_1} = \frac{90\text{ mm}}{48\text{ mm}} = 1.875 \qquad (2)$$

So, our scissor-grasping tool is a stroke enhanement adapter, able to almost double the stroke. For example, considering a gripper total stroke $s_{1,gripper}$ of 100 mm (for safety reasons, it is recommended to avoid working in the proximity of 120 mm maximum stroke), one obtains a grasping effective stroke $s_{2,grasp}$ = 187.5 mm. The only drawback, but acceptable, is that the grasping force will be 1.875 times smaller than the force provided by the gripper: $\frac{F_{2,grasp}}{F_{1,gripper}} = \frac{l_1}{l_2} = \frac{1}{1.875} = 0.53$.

4. Conclusion and further validation

A new scissor-grasping tool has been proposed, being also a stroke enhancement adapter. This innovative tool has been already manufactered by classical 3D printing, using PLA filament material. Grasping tests will be further performed on cylindrical glass bottles, cylindrical plastic bottles and cubic wood pieces. Another further issue is to cover the interior side of the scissor with anti-skidding material, in order to increase the frictional force and thus the graspable object weight.

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