A DESIGN APPROACH TO A STANDARD MANIPULATOR

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ABSTRACT

New structures for gripping objects in robotic manipulation processes are oriented to the
new arrangement of mechanical structures using new materials and processing
technologies and innovative procedures for the implementation of contact gripping
element links to an object with a high degree of adaptively of applications together with
the ability to alter the structure of grip and limiting the intensity of the contact stiffness
variation of snap elements custody and pliability. The application of elastomeric
materials and surface finishes is important. This paper presents both a new gripper
design for robot arms but also the search of the selected materials to make an
experimental evaluation of technical parameters that are used to assess their application
potential and suitability for the targeted applications. Also the results and conclusions for
gripper testing in manipulation operations with two different robot arms are presented.

Keywords: design, gripper, robot, multimaterial, vacuum

1. Introduction

Gripping and holding of objects are key tasks for
robotic manipulators, the precise determination of the
desired trajectory for the manipulated object being
also influenced by the gripper design [4]. In some
situations when the workspace is limited and objects
are difficult to grab it is necessary to have gripper with
special design [5].

The development of universal grippers able to
pick up unfamiliar objects of widely varying shape
and surface properties remains, however, challenging.
Most current designs are based on the multifingered
hand, but this approach introduces hardware and
software complexities [2]. These include large
numbers of controllable joints, the need for force
sensing if objects are to be handled securely without
crushing them, and the computational overhead to
decide how much stress each finger should apply and
where, Brown et al. [2] has replaced individual
fingers by a single mass of granular material that,
when pressed onto a target object, that flows around it
and conforms to its shape. Upon application of a
vacuum the granular material contracts and hardens
quickly to pinch and hold the object without requiring
sensory feedback.

The idea of attaching elastic bags loosely filled
with granular material, such as small pellets or
spheres, to the gripper jaws was introduced earlier, by
Schmidt and Perovskii, as stated by Brown at al. [2].
These bags conform to the shape of any object they
press against and, by simply evacuating the gas
inside, can be turned into rigid molds for lifting the
object.

In this paper it is revised the idea of using
granular material for a universal gripper and show
that the gripping process is controlled by a reversible
jamming transition. The jamming concept has been
used to explain the onset of rigidity in a wide range of
amorphous systems from molecular glasses to
macroscopic granular materials.

Nonporous elastic bag filled with granular matter,
filled with ground coffee is compressed and deforms
around the desired object, then drawing air in the
balloon creates a vacuum and thus strengthens its
grip. When the vacuum is cancelled, the balloon
becomes soft again.

In figure 1 is represented the jamming-based
grippers that are used for picking up a wide range of
objects without the need for active feedback: (A)
Attached to a fixed-base robot arm; (B) Picking up a
shock absorber coil; (C) View from the underside; (D) Schematic of operation; (E) Holding force Fh for several three dimensional-printed test shapes (the diameter of the sphere shown on the very left, 2R = 25.4 mm, can be used for size comparison) [2]. The thin disk could not be picked up at all.

Fig. 1 - Jamming-based grippers for picking up a wide range of objects without the need for active feedback

Amend et al. [1] continued in this work. They are engaged design and manufacturing, size and reliability, error tolerance, shapes and strength, speed, placement precision, multiple object, but also shooting. There, they have developed a slightly more complex jamming gripper that interfaces with a commercial robot arm and includes a rigid collar surrounding the membrane, as well as a positive pressure port and an air filter. An assembly drawing of the design is shown in figure 2.

Fig. 2 - Assembly drawing of the positive pressure jamming gripper, including components: 1) base, 2) external collar, 3) balloon membrane, 4) coffee grains, 5) air filter, 6) vacuum line port, and 7) high pressure port. The balloon is pinched between the base and the collar producing an airtight seal

Jiang et al. [3] used a supervised learning algorithm and design both visual and shape features for capturing the properties of good grasps (Fig. 3).

The friction coefficient between two different types of rubber: neoprene and butyl, has been analyzed by several researchers: Choi and Koc [3], Rakotondrabe and Ivan [16], Stoian et al. [19], Mohd Ali et al. [11].

There are a great number of papers which describe the two major methods of exploiting the ER (electrorheological) effect in practical devices: “valve method” and “clutch method” Finio and Wood [6], Grzesiak et al. [8], Nezhad et al [14], Krishnan and Saggere [10], Drimus et al. [4, 5], Udupa et al. [20].

Microcontrollers will further use user information to control multiple servos that act as a mechanical hand inside the prosthetic gripper [17, 18]. The flex sensor is a unique component which changes its resistance according to the amount of bent [21].

There are also grippers that allow accomplishing firm and stable gripping of micro-scale objects of arbitrary shapes and orientations using a single rectilinear actuator [15].

Gillies et al. [7] examined the hierarchical structure geckos foot. In this study, vertical and pre-angled PDMS (polymethylsiloxane) microflap structures mimicking the angled setae structure of the gecko feet were manufactured using microfabrication techniques.

The paper presents the current trends search results in the development of robotics new structures gripping elements, focusing on new materials and new ways of grasping objects of complex shape. We have focused on a new gripper that should manipulate objects with complex shapes by the support of robot-vision.

2. Design of a new gripper

The new gripper design should be flexible for grasping objects of different shapes and sizes.

The new gripper has to be cheap and very practical, but also to be used in many cases, for example, in grasping of a complex shape object. For this purpose it is necessary to build a supply-driven vacuum system.

Figure 4 shows a new gripper design: completed and disassembled. The select granular material is tested and evaluated in experimental measurements. Cloth is there between body and pocket as a filter. We can easily change the gripper size (ie. the size of the pocket) by exchange of forming plate.
The material is contained in a rubber pocket. After the introduction of vacuum the gripper becomes active. In this form, it can transport an object snap to a specific location. After the cancellation of the vacuum, the gripper is inactive and allows the object snap release.

It is also possible to manufacture a gripper in the form of runner pocket by using an electrorheological fluid (Fig. 5).

The gripper uses ER (electrorheological) fluids, which is contained in the rubber pocket. This material works on the principle that the viscosity is dependent on the electric power (electric potential), or if the electric field dependence of the shear yield stress. Applying power to the ER fluid behaves as a solid. This structure is now able to transfer object strapped into place. After a power interruption to the ER fluid behaves as a liquid substance.

Testing can be performed on the material tensile machine, which measures the tensile force (N) which depends on the extension (mm).

3. Variables

Several parts are needed for implementation and subsequent experimental measurements, namely:

a) vacuum system,
b) robotic arm,
c) servocentrum,
d) robot gripper,
e) materials for testing.

Angular robot KUKA KR3 (Fig. 6) is available for testing in the Robotics Laboratory at Polytechnic University of Valencia. This type of robot is among the smallest number of industrially produced robots. It requires servocentrum and software for control being suitable for experimental measurements.

The selection of the new gripper design was influenced not only by possible attachments to an existing robot, but also the next elements. Figure 7 shows a new gripper design in composition and disassembled.

A greater number of screws were determined on the need for tightness and soundness rubber pocket, which could tear. Vacuum supply is made by fitting, which is in version for tubing. These parts are standardized and supplied by Festo Company.

A very important part is the flange (Fig. 8), which is intended to connect together the gripper and the robot. Figure 9 shows the complete set: robot with gripper and the flange.
Supply to the vacuum system is already done by the mentioned tubing system.

4. Results

A new gripper concept has been designed and manufactured by using granular material as can be seen in Figure 7.

The gripper has been tested also on a different robot arm, Scorbot Eshed Robotec™ (Fig. 10). During the experiment it was possible to grab several pieces with different geometries.

These geometries were a cube (2x2cm) and a small ball (2 cm of diameter), both made of steel, aluminum and ABS: a total amount of 6 objects. We had good grabs of all of them from different positions.

5. Discussion and Conclusions

Despite all the experiments with the pieces resulted in good results, the gripper capacity is limited to small pieces, with a diameter of 3 cm as maximum.

We had a problem with the vacuum system (tube removed easily from the connector) that was solved making a new connector, much bigger than the original one.

There are many different kinds of grippers in the industry. This gripper pretends to establish a new universal standard for grippers that could grab all kind of objects. Future investigations will try to get improvements regarding the size of the objects.

References


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