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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 gab 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.

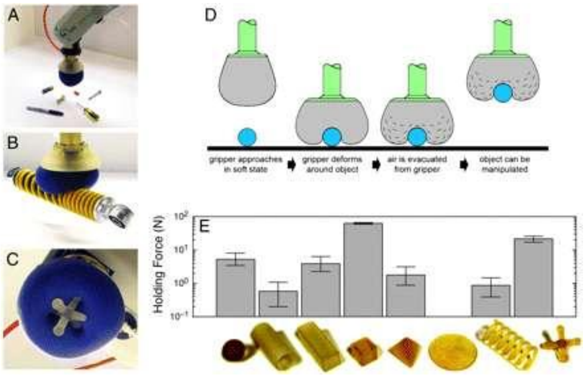

Fig. 1 - Jamming-based grippers for picking up a wide range of objects without the need for active feedback

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.

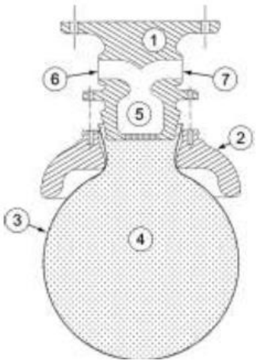

Fig. 2 - Assembly drawing of the positive pressure jamming gripper, including components: 1) base, 2) external collar, 3) balloon membrane, 4) coffee grains, 5) air filter, 6) vacuum line port, and 7) high pressure port. The balloon is pinched between the base and the collar producing an airtight seal

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].

Fig. 3 - Gripper used by Jiang et al. (a) selected conceptual model; (b) assembled gripper; (c) gripper attached to a robot

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 (polydimethylsiloxane) microflap structures mimicking the angled setae structure of the gecko feet were manufactured using micro-fabrication 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.

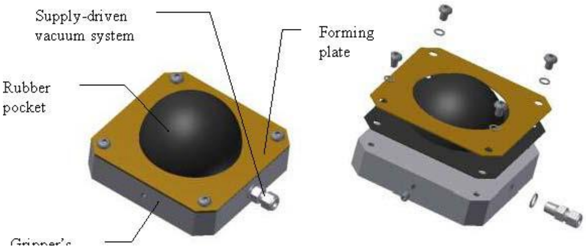

Fig. 4 - The new gripper with granular material

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).

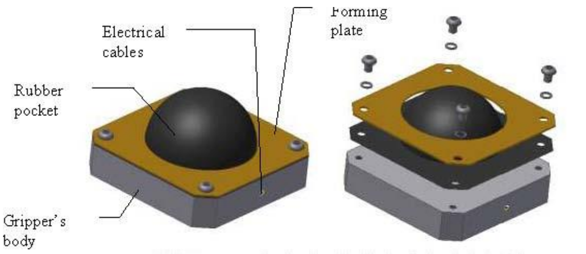

Fig. 5 - The new gripper using the electrorheological fluid

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.

Fig. 6 – The angular robot KUKA KR3

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.

Fig. 7 - The new concept based on the pocket with granular material: in an assembled and disassembled state

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.

Fig. 8 - The flange

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.

Fig. 9 - The complete set: robot, gripper and 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^{TM} (Fig. 10). During the experiment it was possible to grab several pieces with different geometries.

Fig. 10 - The Scorbot Eshed Robotec^{TM}

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

[1] Amend, J.R., Brown, E., Rodenberg, N., Jaeger, H. M. and Lipson, H. (2012), A Positive Pressure Universal Gripper Based on the Jamming of Granular Material, *IEEE Transactions on Robotics*, 28(2), pp. 341-350.

[2] Brown, E., Rodenberg, N., Amend, J., Mozeika, A., Steltz, E., Zakin, M. R., Lipson, H. and Jaeger, H.M. (2010), *Universal robotic gripper based on the jamming of granular material*, Proceedings of the National Academy of Sciences of the United States of America 107 (44), pp. 18809-18814.

[3] Choi H. and Koc M. (2006), Design and feasibility tests of a flexible gripper based on inflatable rubber pockets, *International Journal of Machine Tools & Manufacture*, 46, pp. 1350–1361.

[4] Drimus, A., Kootstra, G., Bilberg, A. and Kragic, D. (2011), *Classification of rigid and deformable objects using a novel tactile sensor*, IEEE 15th International Conference on Advanced Robotics: New Boundaries for Robotics, ICAR 2011, pp. 427-434.

[5] Drimus, A. and Bilberg, A. (2011), *Novel approaches for bio-inspired mechano-sensors*, Intelligent Robotics and Applications, Springer Berlin Heidelberg, 7102, pp. 12-23.

[6] Finio, B.M. and Wood, R.J. (2011), Optimal energy density piezoelectric twisting actuators, IEEE *International Conference on Intelligent Robots and Systems*, pp. 384-389.

[7] Gillies, A.G. and Fearing, R.S. (2011), Shear adhesion strength of thermoplastic gecko-inspired synthetic adhesive exceeds material limits, *Langmuir* 27 (18), pp. 11278-11281.

[8] Grzesiak, A., Becker, R. and Verl, A. (2011), The Bionic Handling Assistant: A success story of additive manufacturing, *Assembly Automation* 31 (4), pp. 329-333.

[9] Jiang, Y., Amend, J., Lipson, H. and Saxena, A. (2012), *Learning Hardware Agnostic Grasps for a Universal Jamming Gripper*, to appear in IEEE International Conference on Robotics and Automation (ICRA), St. Paul, MN.

[10] Krishnan, S. and Saggere, L. (2012), Design and development of a novel micro-clasp gripper for micromanipulation of complex-shaped objects, *Sensors and Actuators: A. Physical*, pp. 110-123.

[11] Mohd Ali, A.M., Ismail, M.Y. and Abdul Jamil, M.M. (2011), *Development of artificial hand gripper for rehabilitation process*, IFMBE

Proceedings 35 IFMBE, pp. 785-788.

[12] Moldovan, L. (2008), *Trajectory Errors of The 6-PGK Parallel Robot,* First International Conference on Complexity and Intelligence of the Artificial and Natural Complex Systems. Medical Applications of the Complex Systems. Biomedical Computing. Published by the IEEE Computer Society, pp. 31-37.

[13] Moldovan, L. (2008), *Geometrical Method for Description of the 6-PGK Parallel Robot's Workspace*. Complexity in Artificial and Natural Systems. "Petru Maior" University Publishing House, Tirgu Mures, Romania, pp. 23-30.

[14] Nezhad, A.S., Stiharu, I., Packiricamy, M. and Bhat, R.B. (2012), Modelling of adhesive forces in nanotweezer, *Advanced Materials Research*, 403-408, pp. 1122-1129.

[15] Petterson, A., Ohlsson, T., Caldwell, D.G., Davis, S., Gray, J.O. and Dodd, T.J. (2010), A Bernoulli principle gripper for handling of planar and 3D (food) products, *Industrial Robot* 37 (6), pp. 518-526.

[16] Rakotondrabe, M. and Ivan, I.A. (2011), Development and force/position control of a new hybrid thermo-piezoelectric microgripper dedicated to micromanipulation tasks, *IEEE Transactions on Automation Science and Engineering* 8 (4), pp. 824-834.

[17] Sam, R. and Nefti, S. (2011), *A novel, flexible and multi-functional handling device based on Bernoulli principle*, Proceedings of 2011 IEEE International Conference on System Engineering and Technology, ICSET 2011, pp. 166-171.

[18] Sam, R. and Nefti, S. (2010), *A new design approach of robotic gripper for reducing operating cost for handling food product*, 2010 IEEE 9th International Conference on Cybernetic Intelligent Systems, CIS 2010, pp. 1-5.

[19] Stoian V., Ivanescu M., Popescu D., Popescu A. N. and Popescu D. (2004), *The Control of a Multifingered Hand Actuated with ER Fluids*, Proceedings of the WSEAS and IASME Conferences Corfu, Greece, pp. 488-438.

[20] Udupa, G., Sreedharan, P. and Aditya, K. (2010), *Robotic gripper driven by flexible microactuator based on an innovative technique*, 2010 IEEE Workshop on Advanced Robotics and Its Social Impacts, ARSO 2010 - Conference Proceedings, pp. 111-116.

[21] Yu, J., Chary, S., Das, S., Tamelier, J., Pesika, N.S., Turner, K.L., and Israelachvili, J.N. (2011), *Gecko-inspired dry adhesive for robotic applications*, Advanced Functional Materials 21 (16), pp. 3010-3018.