A Novel System for Grasping and Handling Flat and Deformable Objects

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Presented by:

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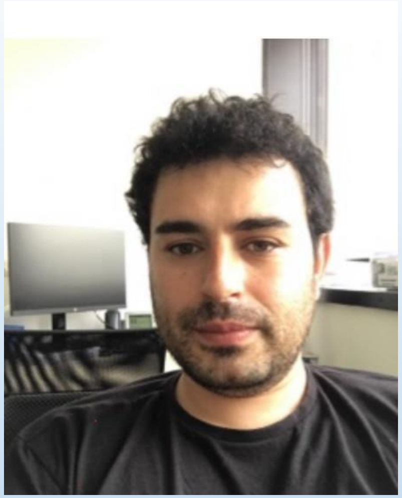
RESUME

Claudio Gloriani obtained his Master's Degree in Mechanical Engineering at University of Cagliari in 2016. After his graduation, he sought for a career in Research and Development in Robotics as Fellow Researcher at Italian Institute of Technology. In 2018 he started his PhD at University of Bergamo in collaboration with Italian Institute of Technology. He is currently working on his PhD Thesis, in the field of Robotic Grasping and Manipulation for Flat and Deformable Objects.



Introduction

Manipulation and grasping of rigid objects is a mature field in robotics but the study of deformable objects is not so extensive in the robotics community.

Deformable objects are very complicated to manipulate because they have infinite degrees of freedom [1].

A lot of Industries are interested in manipulation of Flat and Deformable Objects (FDOs) as for example:

- Garments
- Fabrics Textile
- Clothes
- Etc.

They require a strong skills in handling and for this reason are performed mainly from humans [2].

[1] F. Guo, Huan Lin, and Y. Jia, “Squeeze grasping of deformable planar objects with segment contacts and stick/slip transitions,” in 2013 IEEE International Conference on Robotics and Automation, May 2013, pp. 3736–3741.
[2] P. N. Koustoumpardis, K. X. Nastos, and N. A. Aspragathos, “Underactuated 3-finger robotic gripper for grasping fabrics,” in 2014 23rd International Conference on Robotics in Alpe-Adria-Danube Region (RAAD), 2014, pp. 1–8.

Motivations

The industries have a great need of simple, reliable, versatile and overall low cost grippers for grasping and handling Flat and Deformable Objects [3] [4].

There are several reasons, for industries, to invest money in this systems: for instance [5] [6]:

- Reduction of labor cost
- Reduction of phisical burdens
- Increase of productivity

[3] S. Tokumoto, Y. Fujita, and S. Hirai, "Deformation modeling ofviscoelastic objects for their shape control," in Proceedings 1999 IEEE International Conference on Robotics and Automation (Cat. No.99CH36288C), vol. 1, May 1999, pp. 767–772 vol.1.
[4] R. Buckingham, A. Graham, H. Arnarson, P. Snaeland, and P. Davey, "Robotics for de-heading fish - a case study," Industrial Robot: AnInternational Journal, vol. 28, 08 2001, pp. 302–309.
[5] J. Acker and D. Henrich, "Manipulating deformable linear objects: characteristicfeatures for vision-based detection of contact state transitions," in
[6] Proceedings of the IEEE International Symposium onAssembly and Task Planning, 2003., July 2003, pp. 204–209. M. Rambow, T. Schauß, M. Buss, and S. Hirche, "Autonomous manipulation of deformable objects based on teleoperated demonstrations," in 2012 IEEE/RSJ International Conference on Intelligent Robots and Systems, Oct 2012, pp. 2809–2814.

State of the art

The idea for developing this new gripper starts from some papers which deal about manipulation of FDOs using a parallel gripper that has two rotational wheels on the fingertips [7] and exploiting some ideas used to pick up fabrics textile from layers exploiting friction [8] [9].

[7] T. Kabaya and M. Kakikura, “Research on a service robot for housekeeping —handling of clothes—,” Transactions of the Japan Society of Mechanical Engineers Series C, vol. 64, 01 1998, pp. 1356–1361.[4] R. Buckingham, A. Graham, H. Arnarson, P. Snaeland, and P. Davey, “Robotics for de-heading fish - a case study,” Industrial Robot: AnInternational Journal, vol. 28, 08 2001, pp. 302–309.
[8] E. Ono, K. Kitagaki, and M. Kakikura, “On friction picking up a piece of fabric from layers,” vol. 4, 01 2005, pp. 2206 – 2211 Vol. 4.
[9] E. Ono and Kunikatsu Takase, “On better pushing for picking a piece offabric from layers,” in 2007 IEEE International Conference on Robotics and Biomimetics (ROBIO), Dec 2007, pp. 589–594.

State of the art

The choice of using microspines (or flexible needles) in our gripper is given by the fact that, in this research [10], results very reliable for grasping and handling flat and deformable materials. The different approach used, in our Research, exploits intrusive method using microspines but also non intrusive method, retracting the microspine inside the wheel, exploiting the friction of the wheels or to combine them together when possible (it depends on the FDO treated). The main purpose of this research is to increase the reliability of the grip of an FDO but at the same time the gripper has to be adaptable.

[10] A. Karakerezis, Z. Doulgeri, and V. Petridis, “A gripper for handling flat non-rigid materials,” in Automation and Robotics in Construction XI: Proceedings of the Eleventh International Symposium on Automation and Robotics in Construction (ISARC), D. A. Chamberlain, Ed. Brighton, UK: International Association for Automation and Robotics in Construction (IAARC), May 1994, pp. 593–601.[

State of the art

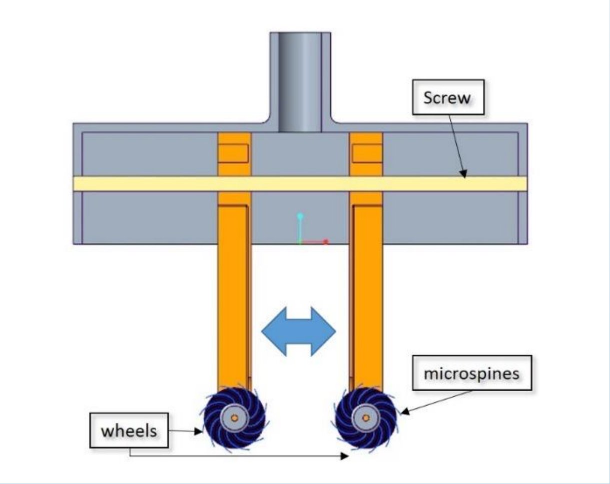
A big inspiration for making the new gripper comes from an interesting work [11] where, in the Jet Propulsion Laboratory (JPL), a lightweight robot which is able to climb Rough Surface using wheels with microspines has been developed. The interactions between microspines and asperities of rough surface generates the movement of the robot and therefore the idea is to exploit this principle in order to grasp FDOs.

[11] K. Carpenter, N. Wiltsie, and A. Parness, “Rotary microspine rough surface mobility,” IEEE/ASME Transactions on Mechatronics, vol. 21, no. 5, Oct 2016, pp. 2378–2390.

DESCRIPTION OF THE NOVEL GRIPPER

The grasping system chosen is a parallel gripper, widely used for handling in industries, which is simple to build it but very reliable and useful for pinching the object to be manipulated. This idea of gripper was thought with these basic but important components:

- A Body
- Two Fingers
- Two wheels
- Microspines



DESCRIPTION OF THE NOVEL GRIPPER

Inside these two wheels there are placed the microspines, equally distributed, which can be extended or retracted rotating the reel where are wrapped the wires of the microspines.

DESCRIPTION OF THE NOVEL GRIPPER

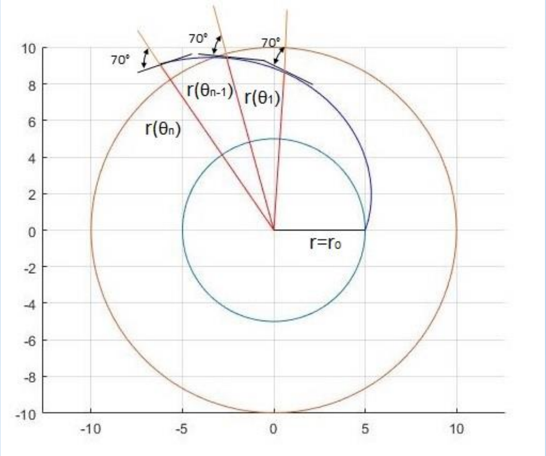
The wire of each microspine follow a logarithmic spiral path, inside a hole of the wheel, which has the Cartesian coordinates expressed in the following parametric form:

$$\begin{cases} x(\theta) = r(\theta)(\cos(\theta)) \\ y(\theta) = r(\theta)(\sin(\theta)) \end{cases}$$

Where θ is the angle expressed in radians and $r(\theta) = r_0 e^{b\theta}$ is its polar equation.

DESCRIPTION OF THE NOVEL GRIPPER

The terms of the polar equation are: $\boldsymbol{r_0}$ which is the radius where the logarithmic curve starts and $\boldsymbol{b}$ is a parameter for determining the rate of increase of the spiral. The parameter $\boldsymbol{b}$ is expressed in radians because $\boldsymbol{b} = \mathbf{cot}(\boldsymbol{\psi})$ where $\boldsymbol{\psi}$ is the angle between $\boldsymbol{r}(\boldsymbol{\theta})$ (and the respective tangent of the curve. The Figure shows an example when $\psi = 70^{\circ}$ and the interesting aspect is that this angle remains constant so it means that does not depend on the values of $\boldsymbol{\theta}$ and $\boldsymbol{r_0}$.



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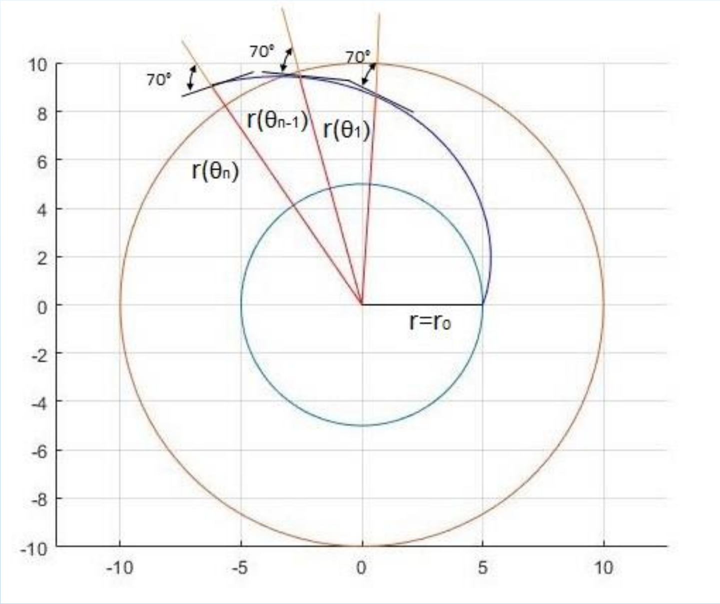
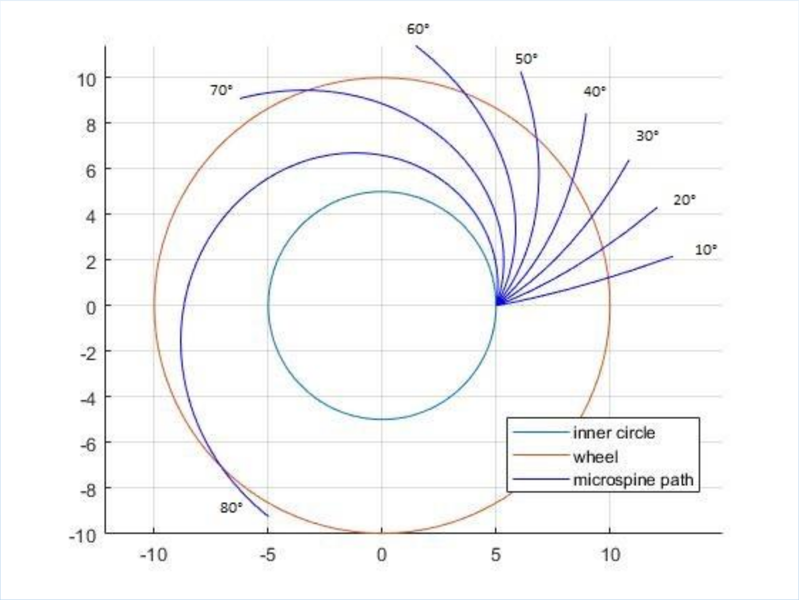


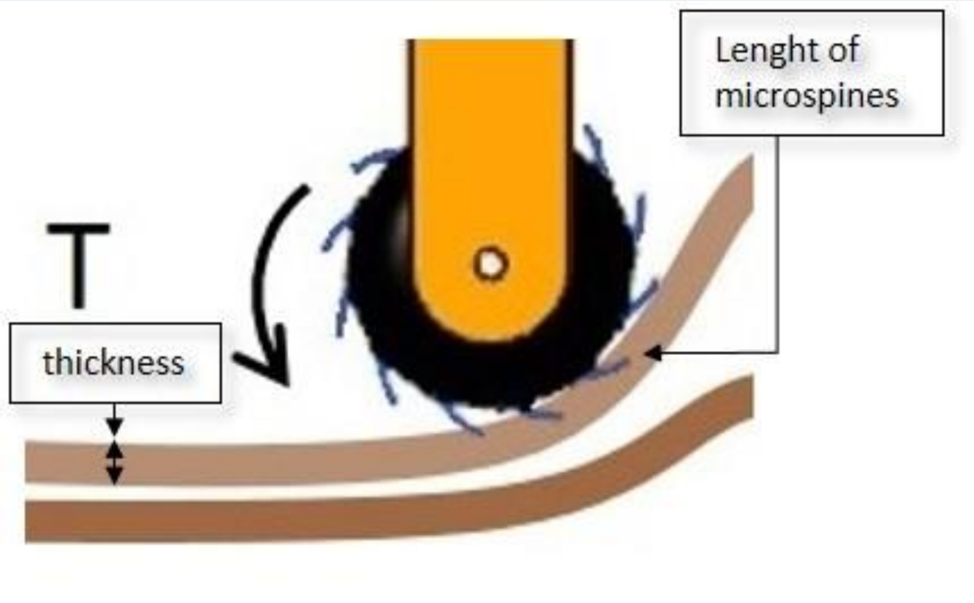
DESCRIPTION OF THE NOVEL GRIPPER

The Figure shows different paths as the $\boldsymbol{\psi}$ angle changes. The variable $\boldsymbol{\theta}$ instead is very useful in order to compute the total length of the spiral.



DESCRIPTION OF THE NOVEL GRIPPER

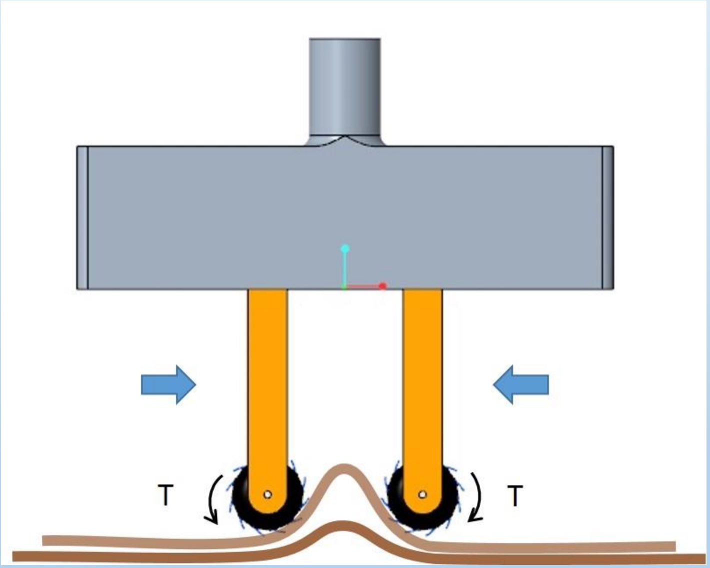
These aspects are very important because it is possible to test the microspines with different angles and length in order to have an optimal interaction with the FDO to be grasped and manipulated as shown in the Figure.



METHODOLOGIES FOR GRASPING

First Method:

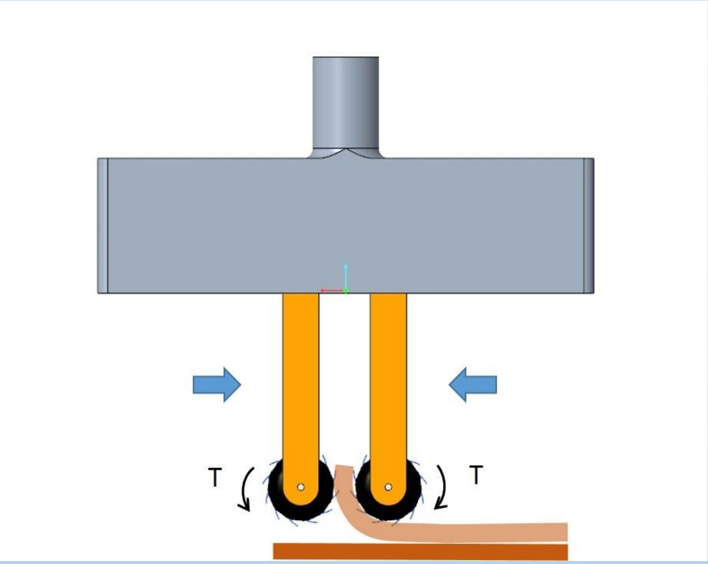
It is very useful when it is not possible to grasp the FDOs at the boundary. Before to start any operation the thickness of the FDO should be known to be able to manipulated it in order to regulate the right length of the microspines which has to penetrate into the material as shown in the Figure. The buckling generated from the torque of the wheels depends on the material considered and it is related to the flexibility of the FDO.



METHODOLOGIES FOR GRASPING

Second Method:

The second method, shown in the Figure , is quite similar to the first one but there is a difference with the grasping point of the material. Such point is placed quite near to the boundary. This can be an advantage when it is impossible to grasp it in a different place and furthermore it is possible to engage less material during the grasping. The choice of methodology depends on the task that needs to be performed.



CONCLUSION AND FUTURE WORKS

CONCLUSION:

In this work, we have explained different methodologies that will be used, in our gripper, for grasping and manipulating flat and deformable objects (FDOs). In particular we focused on the study of the geometry for realizing the microspines.

FUTURE WORKS:

In the future, it will be studied also other important aspects such as, for example, the choice of the proper microspines material, its size, etc. This is just a preliminary idea of gripper and, in future, it will be studied and developed more, adding all the necessary components useful to produce a prototype able to work in a reliable way. After, it will be tested in a real scenario using different kind of FDOs in order to check its performance.

Thanks for your attention.