Laschi Underactuated Gripper Case Study

Sarah Chen

- **Introduce the authors**. Who are the authors? What do we know about their lab? What else have they done? (briefly)
- **Introduce the paper**. What is the goal of the paper and why is it interesting and important? This is sometimes a good place to show a preview of results so we have an idea of what is coming.
- **Related work**. What has been done in this area already? What background are they building on?
- **Specific contribution**. What is the specific gap that this paper is trying to close and what is their stated contribution?
- **Techniques**. How did the authors solve this problem? Tell us whatever is interesting to learn here in the time you have available. If there are parts that were hard to understand on first reading, go to the board or find some way to explain them to us now that you've had a chance to figure them out.
- **Results**. Show the results and help the audience sort out what is interesting and important (especially if there are endless plots).
- **Discussion**. In this section you should give your own opinion based on your study of the paper. Be sure to leave plenty of time for this section. Here are some questions to think about. Are the authors trying to solve an interesting problem in the first place? How good a job did they do? Are the results useful? To whom? What might you change or how might you solve this problem in a better way? Where do you expect the field to go from here, i.e., what important problems *didn't* the authors solve? Don't limit yourself to these questions -- just use them as a starting point to organize your own thoughts about the paper.

The Authors

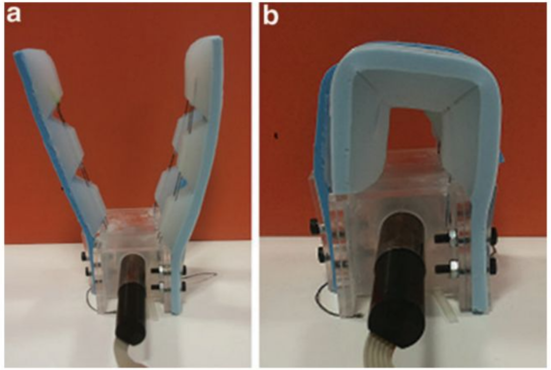
- Laschi Group from the BioRobotics Institute, Scuola Superiore Sant'Anna in Pisa, Italy.
- Cecilia Laschi
  - Professor of Biorobotics at the BioRobotics Institute.
  - Interests in Assistive Robotics, Neuro-Robotics, Neurocontrollers, Service Robots, and Soft Robotics.
- Matteo Cianchetti
  - Assistant Professor at the BioRobotics Institute.
  - Leads the Soft Mechatronics division
- Mariangela Manti
  - PhD at the BioRobotics Institute at the time, currently a Post Doc at the BioRobotics Institute
  - Involved in Soft Robotics

Previous Work

- Both Laschi and Cianchetti are both involved in the development of soft robotics
- Created an arm that mimics that of an octopus
- Uses hydrostat muscle structure to move the arm without a skeleton.

Overview

- The purpose of this paper is to create a soft gripper that is able to perform effective, stable grasps with minimal control.
- A gripper was developed using two part silicones, Dragon Skin 30 and Smooth-Sil 950, with one actuation cable running through all three fingers.
- The hand was actuated using one motor that pulled the cable.
- Able to grasps many objects, mostly circular/cylindrical objects.
- Is able to apply a maximum force of about 3 N on the object.
- Is able to resist horizontal forces of up to 15 N.
- Is able to resist vertical forces of up to 30 N.

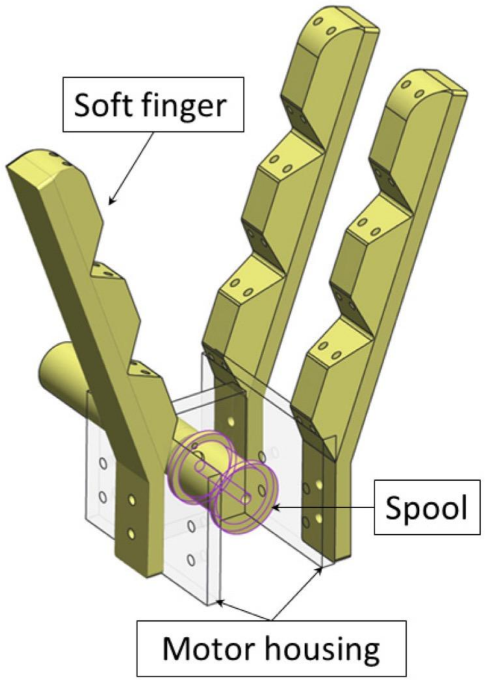


Introduction

- Traditional robotics uses rigid materials and complex control schemes or by changing actuator stiffness
    - e.g. The Salisbury and Craig ran into a lot of kinematic and control issues with their hand
- Pneumatic and hydraulic hands require large systems involving pumps and compressors outside of the hand system and also involve complex control for varying the stiffness of pneumatic actuators.
- Soft robotics can use the intrinsic properties of materials to perform grasping, such as elastic properties.
- Soft materials can undergo high deformation which helps adapt to the shape of objects being grasped.
- This paper will create a soft gripper and analyze the performance and role the material plays in the grasping actions.

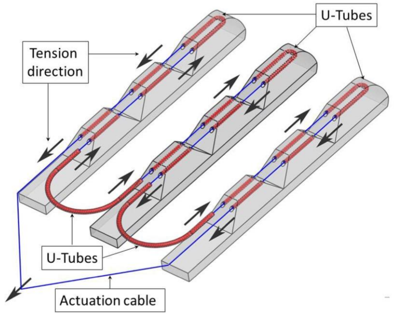
Hand Design

- Three finger gripper design.
- Entirely soft hand, does not contain any hard skeleton
- No physical mechanical joints, action is carried out by elastic energy in the soft material.
- Each finger “mimics” the human hand with the shape of each finger.
- Three phalanges are separated by 45 degree triangular cut, which allows maximum bending of 90 degrees between each phalanx.

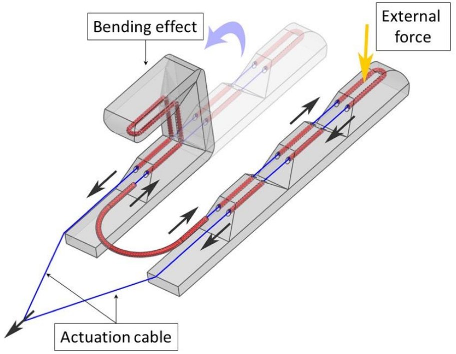


Hand Design (cont.)

- Uses an underactuated system to control the fingers.
- One cable runs through all the fingers as shown in the diagram.
- The cable is then attached to the motor and when run, it reduces the length of the cable which produces bending in the finger.
- Due to the finger design, each phalanx can bend up to 90 degrees.
- Due to the underactuated design, external forces can be applied to each finger and it will stop bending wherever it hits the object.



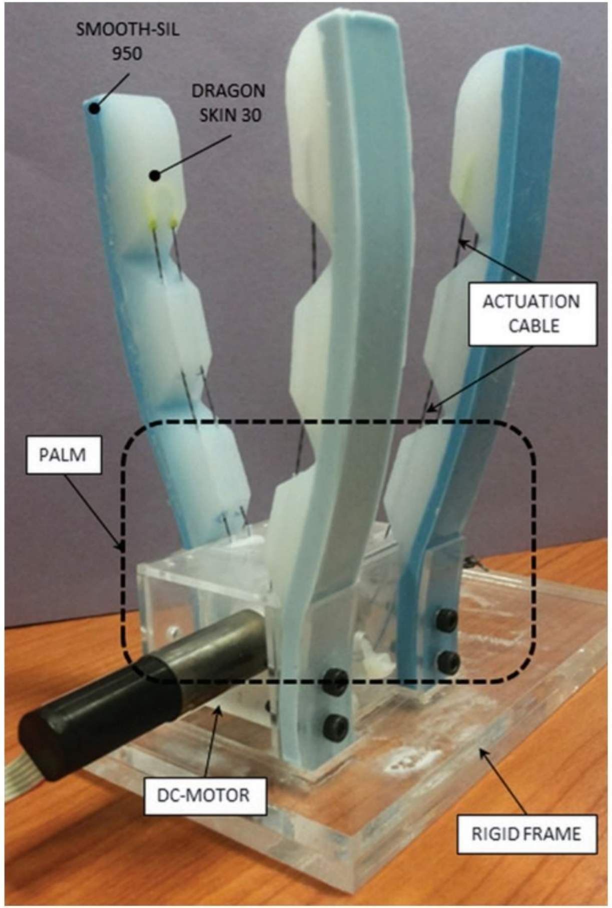
(a) Routing scheme for the actuation cable



(b) Adaptability mechanism

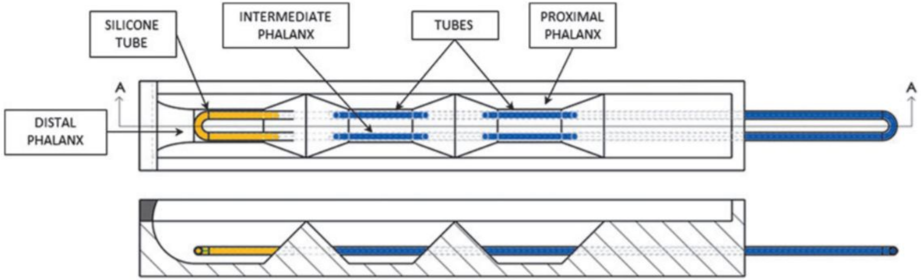
Manufacturing/Fabrication

- Two types of silicone are used: Dragon Skin 30 and Smooth-Sil 950
- The Dragon Skin 30 is used for the interaction with the object.
    - Elastic Modulus of 1MPa
    - More elastic to conform to the objects shape better.
- The Smooth-Sil 950 was used mainly for its material properties as an elastic spring, to extend the fingers.



Manufacturing/Fabrication (cont.)

- A mold was created with a silicone tube inside to create a path for the string to move. The Dragon Skin and Smooth Sil were then cast.
- The silicone tube in the mold was then removed.
- Another silicone tube was inserted to decrease the friction between the cable and the fingers.

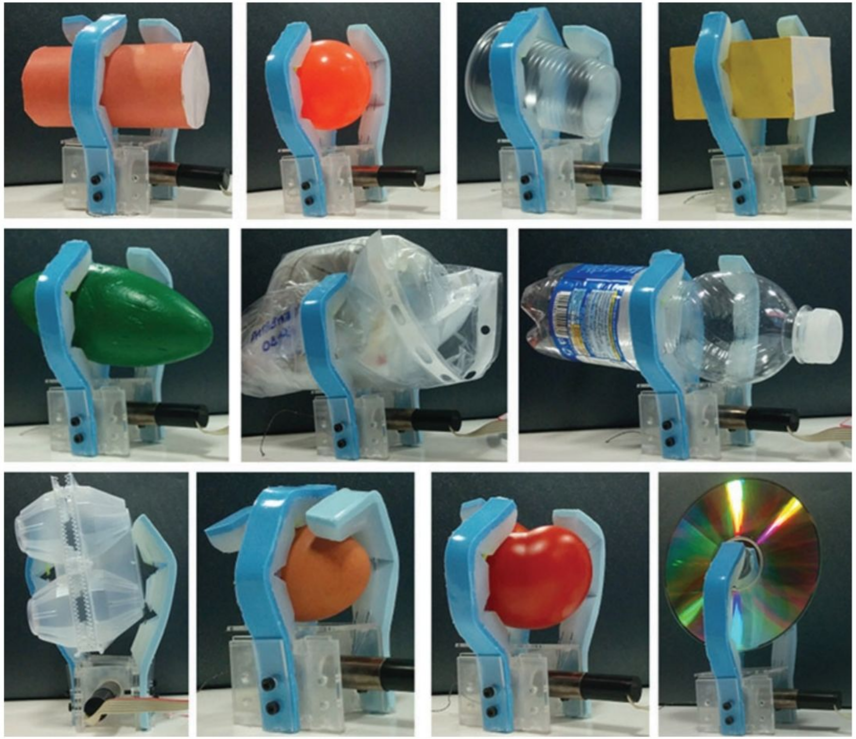


Manufacturing/Fabrication (cont.)

- Previous iterations (1 and 2) were made up of either entirely Dragon Skin 30 or Smooth-Sil 950.
- The first iteration used Dragon Skin 30 for the fingers and an embedded elastic spring.
- The second iteration used only Smooth-Sil 950 and removed the need for an elastic spring.
- The third iteration combined both materials

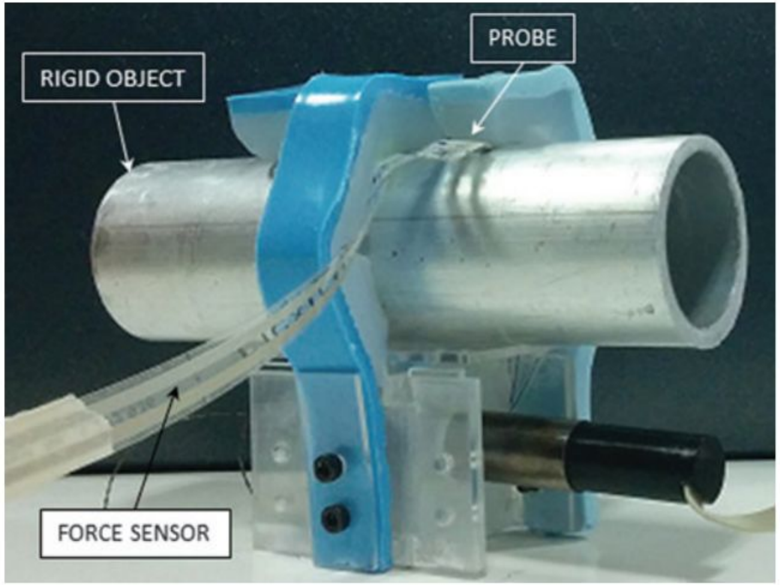
Results, Grasping

- Due to the design of the gripper and the symmetrical nature of the movement of the fingers, the hand was expected to mostly perform power circular grasps.
- This was true for most of the objects tested
- Was also able to perform precision circular grasps but with reduced grasping force
- These grasps were performed with a human in the loop controlling the motor power.



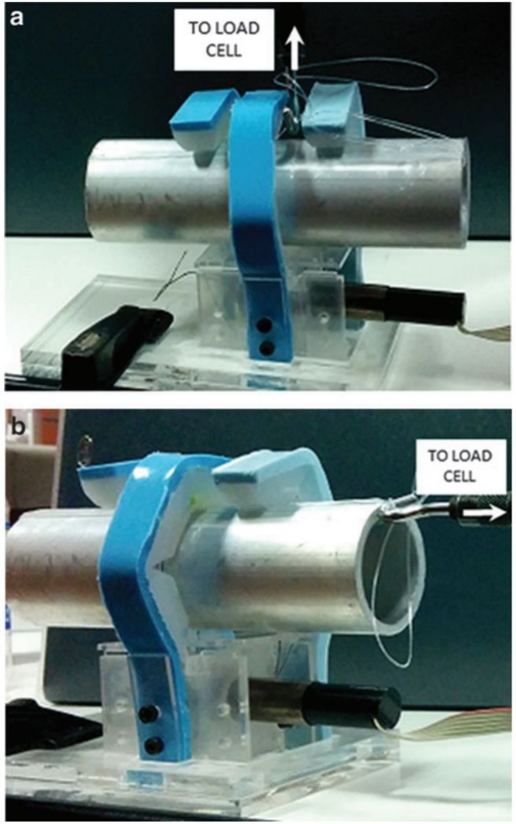
Results, Force

- Performed testing to get information about how much force this gripper can apply.
- Used a cylinder as the test object.
- For grasping force, a force sensor was placed under a finger and maximum force without rotation of the finger was recorded.



Results, Force

- Calculated the maximum horizontal and vertical forces it can withstand using a nylon string attached to the finger/object interface.
- The horizontal force was measured using a load cell on a slide.
- The vertical force was measured using an Instron machine.



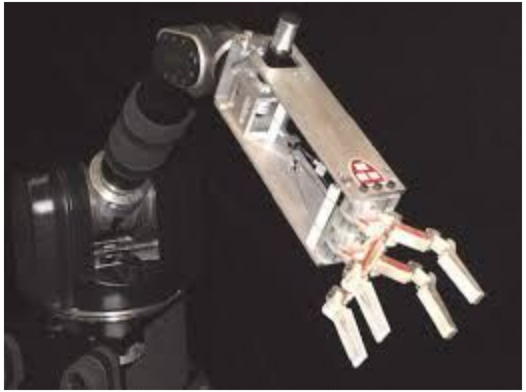
Results, Force

TABLE 1. FEATURES AND PERFORMANCES OF EACH SOFT GRIPPER

	Soft gripper 1	*Soft gripper 2*	*Soft gripper 3*
Overall dimensions		$40 \times 55 \times 135\ mm^3$	
Weight (excluding the DC motor)		110 g	
Tip to tip distance (@ rest position)		40 mm	
Tip to tip distance (@ max opening)		200 mm	
Maximum grasping force (N)	3	2.3	3.5
Vertical resistive force (N)	25	27.56	34.51
Horizontal resistive force (N)	8.05	4.03	15

How it Compares

- i-HY Hand
  - 3 fingers 5 motors
  - Underactuated System
  - Weighs 1.35 kg
- SDM Hand
  - 4 Fingers 1 Motor
  - Similar finger size to this gripper
  - Fingers weigh 39g



Conclusions

- Although this gripper is not able to perform many tasks, it is able to grasps effectively given the simple actuation, control and design.
- This gripper is able to grasps objects of large weight given the grippers size and weight.
- The soft materials of the gripper allow it to conform to objects that are not exactly circular and still be able to grasp them well.
- The soft material also lets the gripper grasp more delicate objects like tomatoes and CDs without damaging them.

Discussion

- Impact: Was this hand groundbreaking?
- How does it compare to other hands we’ve seen?
- Is a soft hand better than a rigid hand?