Characterization of Fabrication Processes for Soft Robots

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Abstract

Soft robots can be quickly fabricated using molds and curable polymers. However, this process results in fabrication errors and variations between designs. We will replicate published molding methods for various soft-robotic actuator designs. We will fit the actuators with the most intuitive "fingernails" (wedge-like pieces which slide underneath an object to assist in lifting it up) for manipulating and sliding underneath objects. Furthermore, we will create a base to hold the actuators along with the pneumatic system needed to operate them.

Introduction

The aim of this project is to successfully design and fabricate pneumatic actuators for soft-robotic grippers. In contrast to rigid robots, the light-weight, compliant materials used in soft-robotics allow robots to adaptably and carefully manipulate objects that might otherwise be damaged.

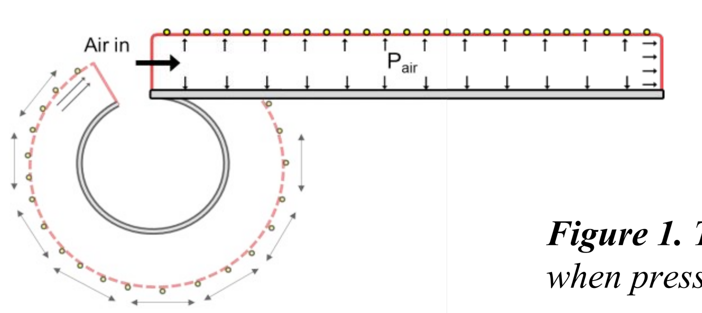
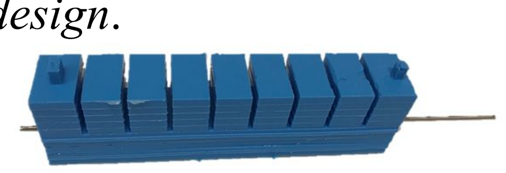


Figure 1. *The motion of a pneumatic actuator when pressurized with air (Polygerinos et al.).*

Specifically, the two designs that were examined and fabricated were the *fiber-reinforced design* and the *bellows design*.



Bellows Design

Fiber-Reinforced Design

Materials

Bellows

The molds for the actuator and meltable core were constructed from laser-cut acrylic. Ribbon was used as the inextensible layer. The actuator itself was made from Ecoflex™ 30, while the meltable core was made from a glycerol-gelatine mixture. The tubing used to connect the actuator to the air supply was silicone-based tubing.

Fiber-Reinforced

The mold for the fiber-reinforced actuator was 3D-printed. The core for molding the actuator was an aluminum half-round rod. Ribbon was used as the inextensible layer. High-strength thread was used to provide structure. The actuator was cast out of Dragon Skin™ 30. Vented screws were attached to the actuators to allow them to be connected to an air supply. Laser-cut acrylic pieces and screws were used to create a connector for the "fingernails."

Fiber-Reinforced Method

1) Prepare the mold for the inner layer and the aluminum-rod core

2) Cast the inner layer out of an elastomer

3) Attach the inextensible layer (ribbon) and wrap it in string to reinforce it

4) Cast the outer layer of the actuator

5) Once cured, demold the actuator, wrap the end in Teflon tape, and cap the end with an elastomer

6) Insert the vented screw through the capped end

7) To finish, attach the "fingernail" connector to the other end of the actuator so that the "fingernail" pieces can be attached

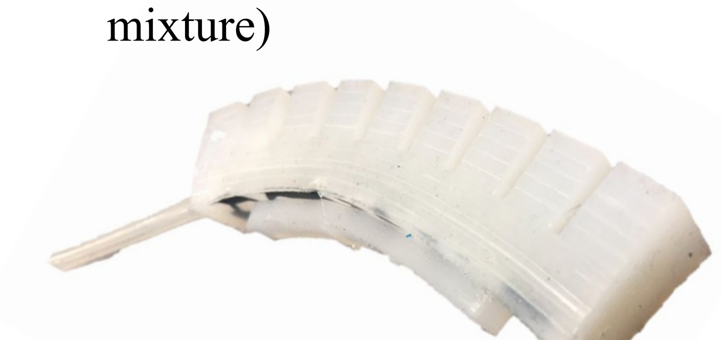
Bellows Method

1) Prepare the molds for the actuator and core

2) Cast the core out of a meltable material (e.g. glycerol-gelatine mixture)

3) Once the core has cured, set it in the actuator mold and use the mold to cast the actuator out of an elastomer

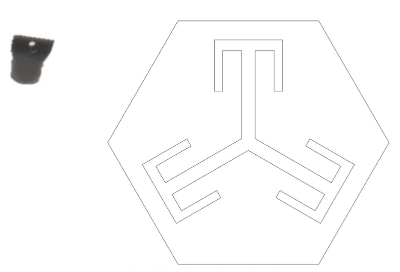
4) After the actuator has cured, set it in an oven to melt the core, and then remove the liquid



5) To finish, cap one end of the actuator and attach tubing to the other end so air can enter

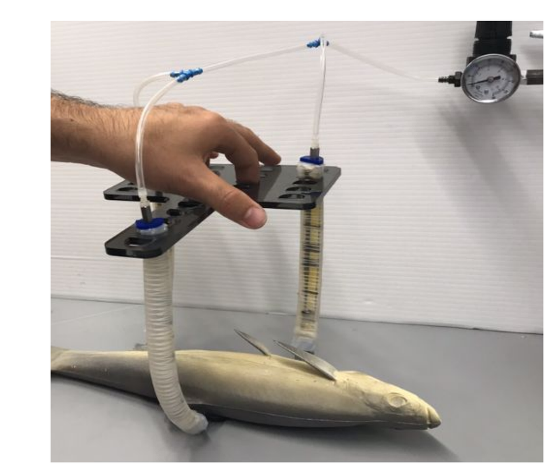
Results

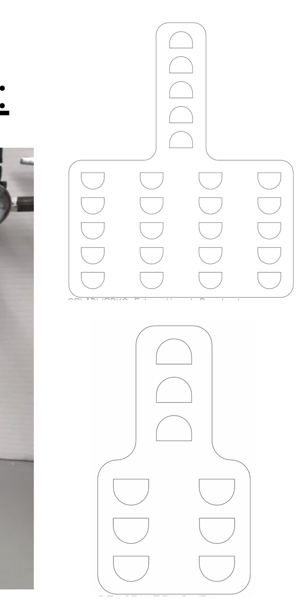
Final Fingernail Designs:



Hexagonal Gripper:

Large Parallel Gripper:





Small Parallel Gripper:

Conclusion

The improvements to the fabrication process, such as mold design, can be used in the future to minimize the time and effort required to make soft-robotic actuators. The interchangeable "fingernail" design increases the customizability and adaptability of an actuator. In future research, each gripper "palm" and "fingernail" should be quantitatively tested to determine the most effective design for gripping objects of various shapes and textures. Furthermore, research into new and different designs will continue, such as a design which uses a 3D-printed skeleton to provide structure instead of the high-strength thread used in the fiber-reinforced design.

References

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