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Mechanical Design of a 3D-Printed Robotic Finger with Compliant Joints

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ABSTRACT

Compliant mechanisms are mechanical systems which exploit the reduced stiffness of flexible regions for selective motion in a mechanism. Flexure joints offer several advantages over traditional rotational joints, such as ease of fabrication, no friction losses, and no maintenance. Compliant joints are already quite common in microelectromechanical systems, and in some smart materials applications. Compliant joints can also be exploited to act as passive bias mechanisms for one-way linear actuators. The challenge in this case is in designing the joints so that they have the appropriate stiffness for a given actuator force.

In this work a simplified methodology to design simple beam flexure joints for a 3D-printable robotic finger is presented. The mechanism is a 3R serial chain, with a linear force applied to the end effector via a tendon. The design process takes in inputs such as desired end effector position, end effector load, link sizes, and outputs the required flexure stiffnesses. By reconciling the calculated stiffnesses with a static analysis of the mechanism through a pseudo-rigid body model (PRBM) description, the design parameters for the compliant rotational joints can be obtained.

The validity of the joint design is investigated in this work using a variety of methods. A quasi-static model of the system is developed using the PRBM and these results are compared to finite element models with identical loading conditions. A prototype structure is 3D-printed using thermoplastic polyurethane (TPU) and tested. Agreement between the experimental results and the developed model indicates that the joints are designed to within acceptable error tolerances. In addition, this study investigates the relationship between flexure length and performance error due to deviations from the PRBM.