Compliant soft linear mechanism for use in soft robotic applications

Introduction

Traditional robots use rigid structures articulating about hinges and joints, making their actuation path predictable and easy to control. The past two decades has seen a rise in robotic research that centred around incorporating of soft materials into robot design. Soft robots are a type of robotic system that are constructed using compliant and deformable materials. Unlike traditional rigid robots, soft robots are characterized by their ability to undergo large deformations and interact safely with humans and delicate objects. The use of compliant mechanisms in soft robotics is still in its early stages but has the potential to revolutionize the way robots are designed and used. In this paper we explore how such a mechanism could be used and the advantages of it against already existing solutions.

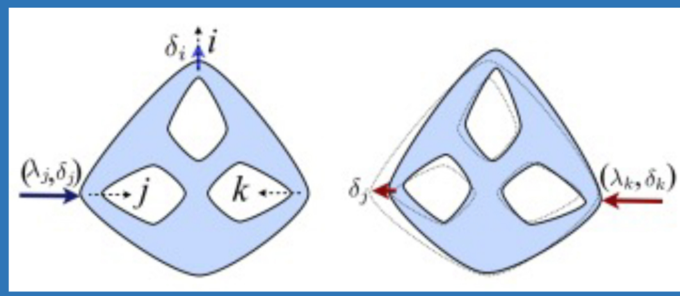

Figure 1: Compliant coupling that influenced this research idea [1]

Aims and objectives

- Identification of existing soft robotic actuation solutions.
- Design of a soft linear coupling mechanism where the actuator is situated further from the activation area.
- Describing possible application for such a mechanism.
- Highlighting the gaps available for further work.

Related work

Most existing solutions for the actuation of soft robotics usually utilize pneumatic, hydraulic, electroactive polymers; these solutions while effective and repeatable, usually require substantial amounts of resources to design and fabricate a working design. Pneumatic and hydraulic systems require pumps, compressors, tubing, etc. There has been research around cable/tendon driven soft robots. The Twisted String Actuator-Driven Soft Robotic Manipulator [3] is a great example of how a fairly inexpensive actuator such as a DC motor can be used to actuate a soft robot reliably. There have been however, few attempts at producing a manipulator that produces a pushing force using DC motors.

Design

The design was inspired by the manipulator mechanism in Figure 1. The design utilized flexures that act as hinges to create this compliant mechanism. Being made out of TPU, this mechanism has enough rigidity to impart force, but still be deformable. This mechanism acts as a small, inline lever that transmutes the force from rotation of motors situated below it into upwards linear motion. Simulating the actuation resulted in about a 10% extension from the original shape.

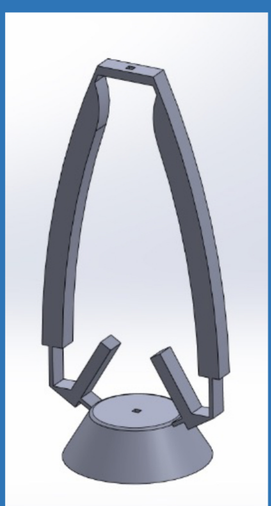

Figure 2: Compliant Manipulator 3D model

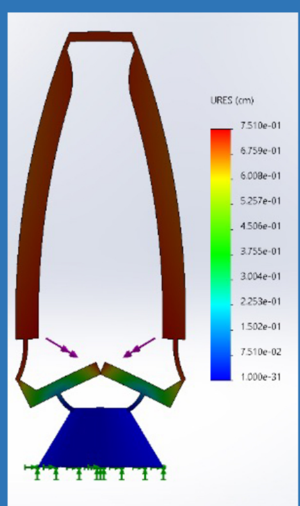

Figure 3:Compliant Manipulator Displacement Simulation

Applications

The applications for such a manipulator vary . This mechanism works best as part of a system of different actuating parts. one such instance would be bringing a bistable passively closing gripper to the open stable state [2]. This would automate the opening and grasping functions of the gripper. One advantage of such a system is retains the soft robotic aspect of the gripper. This allows it to be deployed in delicate medical and production applications.

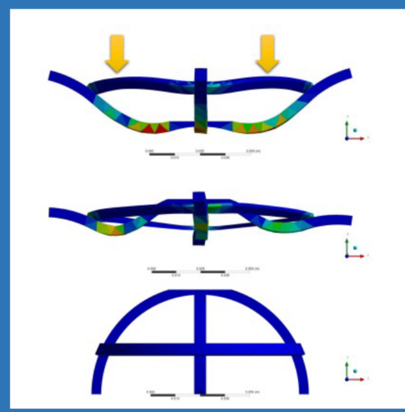

Figure 4: Passive fast acting gripper that uses elastic potential energy to close. The needs to be opened manually to reuse.

Conclusion

In conclusion, this paper has presented the design and simulation of a low-cost compliant soft linear mechanism for use in soft robotic applications. The mechanism is made of TPU and utilizes flexures to create a compliant joint. The mechanism has the potential to be used in a variety of soft robotic applications, such as soft grippers, soft actuators, and soft robots that can crawl, swim, or fly through complex environments.

Further work

The future work of this research includes the fabrication and testing of the mechanism, which has already been designed. The mechanism will be tested in a variety of applications to evaluate its performance, this includes force output testing, further testing for the best position for the compliant arms to output the largest amount of force.

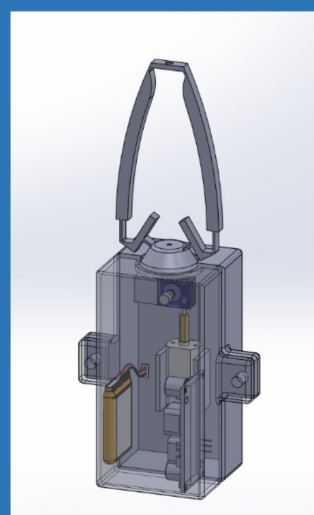

Figure 5:Testing setup for the compliant manipulator

References

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