Report - APL405

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Nomenclature

$\boldsymbol{\sigma}$	Stress tensor
A	Area of cross-section (m^2)
E	Young's modulus (MPa)

Contents

1 Introduction

Soft robotics is the study of designing, controlling, and fabricating robots made of soft materials rather than hard links. Unlike rigid metal, ceramic, and hard plastic robots, soft robots' compliance may increase their safety while operating near humans.

Soft robotics, a new technology that has arisen in recent years, has added flexibility and adaptability to rigid robots that were previously unavailable. In soft robotics, three-dimensional (3D) printing has evolved into four-dimensional (4D) printing, with the fourth dimension referring to the printed mechanism's time-dependent reaction to varied stimuli such as heat, electricity, magnetism, and pneumatic pressure.

You should add the citations as described here [**?**]. You can refer to this document for more latex symbols[1].

1.1 Actuators

1.1.1 Soft Pneumatic Actuators (SPA)

In this study, 4D-printed soft pneumatic actuators (SPA) are used which are invented by Harvard's Whitesides Research Group. They are composed of finger-like structures with bellows that inflate when compressed, allowing them to extend and bend.

Inside an elastomer, they are made up of a number of channels and chambers. When pressured, these channels expand, causing motion. Modifying the shape of the embedded chambers and the material qualities of their walls changes the nature of the motion.

When a PneuNets actuator is pressured, the most compliant (least stiff) areas expand first. If the PneuNet is made of a single, homogeneous elastomer, for example, the thinnest structures will experience maximum expansion. Designers may pre-program the actuator's behavior by choosing wall thicknesses that will provide the required motion. These actuators are less expensive, lighter, easier to make, adaptive, flexible, and deformable than stiff alternatives.

[1] https://wch.github.io/latexsheet/

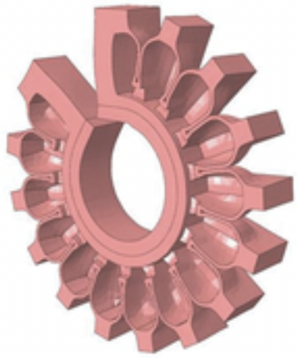

Figure 1: Soft Pneumatic Actuators (SPA).

Furthermore, the softness and flexibility of the material reduce the effect on human skin and other delicate items and surfaces. In a closed-loop system, these sorts of soft robot actuators were used to construct a soft surgical manipulator.

This technology's promise also rests in its application to the rehabilitation of a wrist and finger exoskeleton that aids joint mobility. Because of its capacity to make soft robots and actuators with intricate inner structures, 3D/4D printing is being researched. Ninjaflex material was chosen because it can be 3D printed without air bubbles and has hyperelastic qualities that give flexibility and sensitivity to applied stress.

Figure 2: SPA cross section.

2 Problem statement

One of the key issues in 4D printing soft robots and actuators is modeling and predicting their motion, which is complicated by the material's nonlinearity. In many cases, a linear analytical model fails to effectively predict the actuation behavior of 4D printed actuators, but numerical simulations using nonlinear material principles enhance accuracy. Using machine learning (ML) algorithms based on numerical findings, on the other hand, might assist reduce time and effort throughout the design process.

3 Methodology

Explain the solution procedure.

4 Results and discussion

5 Conclusion

References