Dual-Mode Soft Gripper With Tunable Stiffness Achieving Large-Scale Robust Grasping Tasks

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Soft pneumatic grippers, structures created from silicone rubber and powered by air pressure, can grasp and transfer items with remarkable stability and precision. Their light weight, flexibility, and deformability allowed them many applications—in automated labs such as Carnegie Mellon University's Cloud Lab, medical assistance, underwater missions, etc. However, traditional soft grippers face serious difficulties with gripping objects of different volumes and weights. This study aims to improve soft grippers' weight capacity and ability to grab large objects by achieving tunable stiffness and dual-mode grasping. To produce two gripping modes, a unique sandwich structure comprising two pneumatic fingers and a variable stiffness unit between was employed. To tune the stiffness, this study introduced a novel layer-jamming technique executed by pumping negative pressure into the variable stiffness unit, increasing friction between the jamming substances and stiffening the finger. A Polyvinylidene fluoride (PVDF) sensor was installed to measure whether the stiffness was altered. Then, the process of gripping was automated through the introduction of a camera and recognition algorithms capable of computing the size and depth of the detected object. Based on the object's size and depth, the gripper's controlling program can determine what mode of gripping will be used, completing a fully automated gripping process. The prototype built in this study reflected a significant advancement from traditional soft grippers. The variable stiffness unit can boost the soft gripper's weight capacity by 45%, and the addition of two automatic gripping modes allowed soft grippers to grip large objects efficiently.

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