Controlling Palm-Object Interactions via Friction for Enhanced In-Hand Manipulation

Clark B. Teeple, Buse Aktaş, Michelle C. Yuen, Grace R. Kim, Robert D. Howe, and Robert J. Wood

Introduction

In-hand manipulation is a critical skill for real-world robots, but most hand designs focus on developing highly-dexterous fingers. We achieve higher whole-hand dexterity without changing finger complexity by adding controlled friction forces between objects and the palm with 1 DOF.

Our active palm designs enhance in-hand manipulation capabilities and improve grasp stability.

Two Palm Designs

Variable-friction palm
A soft high-friction membrane is stretched underneath a rigid, low-friction, porous surface.

At rest, the low friction shell touches the object. Under pneumatic actuation, the soft membrane is pushed through holes in the shell, increasing the coefficient of friction of the palm's surface.

Variable-preload palm
A cylinder of compliant, open-cell foam is housed inside a thermoplastic elastomer pouch.

Initially, the pouch is compressed slightly by a slight negative air pressure. During a grasp, the fingers hold the object in place against the palm while the palm is inflated or deflated to modulate the normal force between the palm and object.

Discussion & Conclusions

An active palm that controls contact constraints can enhance the in-hand manipulation capabilities of soft robotic hands with limited finger dexterity.

Controlling the frictional characteristics of the palm allows for control of grasp stability, but the upper bound is limited.

The palm's compliance, plasticity, and conformability can play a large role in the success of in-hand manipulation tasks (future work will explore these).

Results (In-Hand Manipulation)

Active control of the palm's friction forces enables access to different sets of motion primitives by sliding and pivoting objects.

Results (Grasping)

“Initial grasp stability” is related to friction forces applied by the palm on the object.

For the variable-friction palm, the high-friction state has 2x higher grasp stability. For the variable-preload palm, the grasp stability increases as a function of the preload, with an external preload on the object resulting in a 2.5x increase.

Combinations of sliding and pivoting motions enable the hand to perform arbitrary pose shifts on objects without increased finger dexterity.