A Dual Approach to Enhancing Dexterity and Sensory Feedback in Prosthetic Hands

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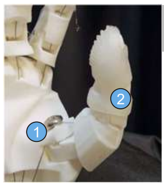
Introduction

The human hand is highly versatile: it senses, grips, and manipulates with power and precision

Understanding the complexity of biological hands can advance prosthetic form and function

Research aims to draw prosthetic hands closer to how real hands move and feel

Original Tendon-Actuated Prosthetic Hand (TAPH) Thumb



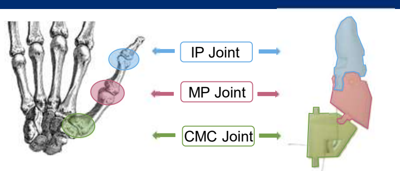
- Passively mechanically actuated
- Only two joints, limiting degrees of freedom
- No sensory feedback

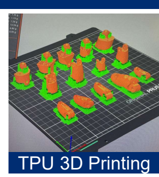
Objectives

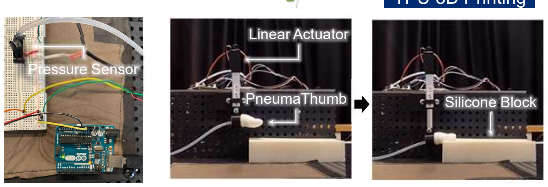
- Tendon-Actuated Thumb Design → Automated thumb control with increased DOFs
- Pressure-sensing Pneumatic Fingers → Tactile feedback such as object stiffness identification

We hypothesized that expanding thumb dexterity and incorporating pressure sensing would enable stable interactions and capture information about object size, shape, and stiffness.

Methodology



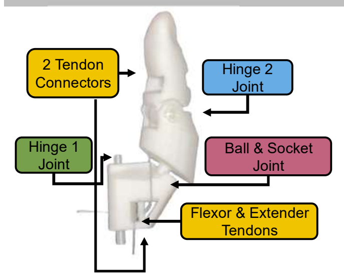


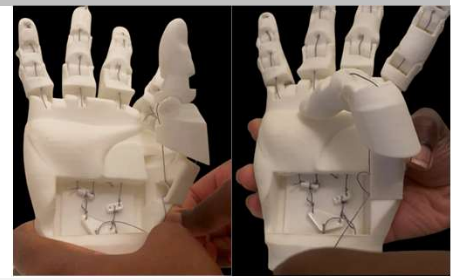


Pneumafingers were connected to high-resolution pressure sensors to detect tip deformation. Silicone blocks of varying Shore hardness (ECO30, ECO35, DS20) were compressed using a linear actuator.

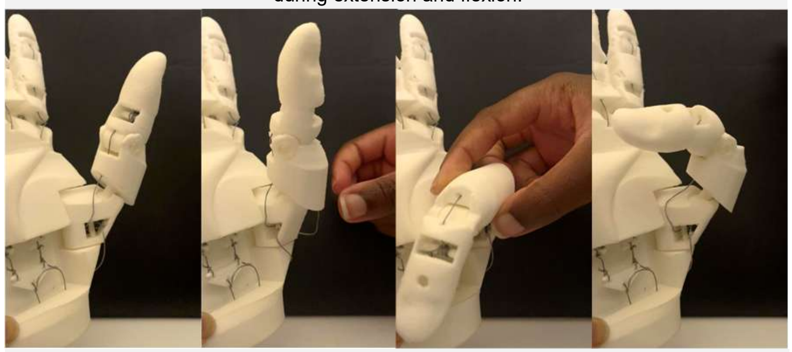
Design

Redesigned Tendon-Actuated Prosthetic Hand (TAPH) Thumb



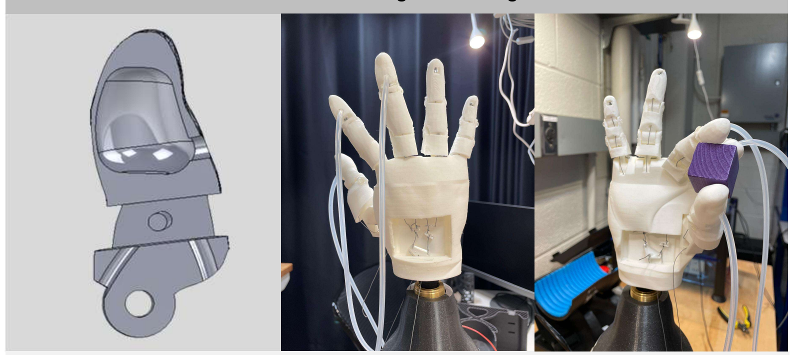


Sequential joint actuation demonstrates improved dexterity and anatomical range during extension and flexion.



Biologically inspired joints were integrated in the thumb to achieve coordinated motion across multiple degrees of freedom.

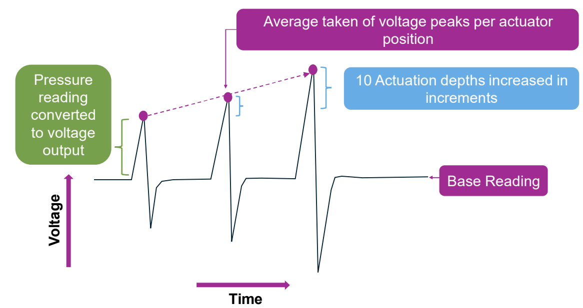
Pressure-Sensing Pneumafingers



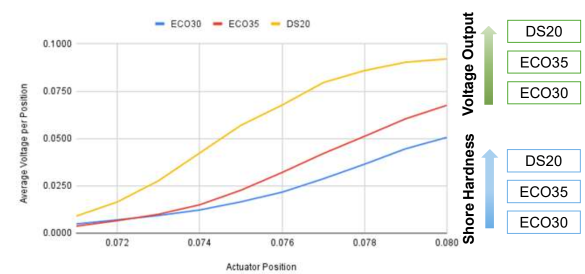
Hollow TPU fingertips coupled with pressure sensors capture deformation

Results

Example of Pressure Readings



Sensor Voltage vs. Linear Actuator Position



Results show that pressure increased with both actuator displacement and block stiffness, with stiffer materials producing greater displacement. These findings support the feasibility of using Pneumafingers to detect object stiffness, and potentially object size, based on pressure readings on all fingertips

Challenges	Future Work
Ball-sockets cause fingers to be **too pliable**	Configure a method for fingers and thumb to be **more stable**
↓ Tendon actuation supplies **insufficient force**	**Expand characterization** to the entire hand
↓ **No pressure reading** can be detected	**Extend the cavity-based pressure-sensing** design to each finger joint

Acknowledgement

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