Rigid robotic transformations can approximate the kinematics of soft fingers with 'bones'

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INTRODUCTION

- The ability to model and control **soft bio-inspired robotic hands** would enable a new class of manipulation applications because softness, by passively conforming, decreases the precision required for control[1].

Goal

To test how well **traditional rigid robotic transformations** can approximate the **kinematics of a semi-soft robotic finger** (i.e., rigid 'phalanges' embedded in soft material), we made one **tendon-driven, semi-soft finger** which was compared against a ground-truth, **rigid 3-link planar hinged finger**.

MATERIALS AND METHODS

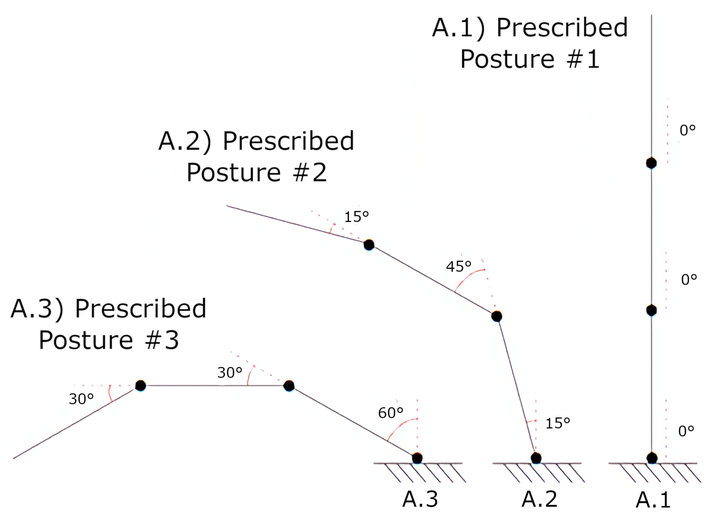
- The **tendon-driven, semi-soft finger** was constructed with a **length of 13 cm** and **three 4 cm phalanges** (plus a *'metacarpal'* for mounting) with **0.15 cm of silicone** between serving as the *'joints'*
- **Tendons** were routed per the **N+1 design**[3] where **N is 3 degrees of freedom**, in which tendons **cross**, and therefore **affect multiple joints**.
- **Motors pulled on tendons** with **seven activation sets** to drive the finger to **different flexion-extension positions**.
- The resulting **finger endpoints**. were measured **at each position** using the **DeepLabCut motion tracking software** [2].
- To test the validity of the **linear rigid robotic transformations** for our **semi-soft finger**, we calculated a **linear regression** relating **endpoint locations** to the **seven tendon excursion sets**.

RESULTS

The **proportion of variance** explained by the regression for the **semi-soft finger** was **69%** ($R^2 = 0.688$), compared to **100%** for the **rigid-finger**. The **average discrepancy** between the predicted and observed **finger endpoints** for **the 7 positions** was **2.1 (± 1.9) mm** for the **semi-soft finger** and **0 (± 0) mm** for the **rigid finger**.

	Only Posture 1	Only Posture 2	Only Posture 3
R^2 Value	0.3676	0.3346	0.0144

R^2 using Ref Pos. to calculate Monte Carlo Δ	R^2 using Monte Carlo data & Reference Pos. data
0.3098	0.6759



DISCUSSION

Our results indicate that while kinematic prediction of fingertip endpoints for the semi-soft finger did not follow the linear rigid robotic transformations as closely as that of the rigid finger, they were approximated well with about 69% of the variance explained. These results are encouraging as they show that there may be a way to combine the ability of semi-soft fingers to passively conform to objects grasped with the numerous effective control methods developed for hinged rigid kinematics chains.

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