Inducing limb posture and manipulating muscle forces in robotic and cadaveric specimens

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Intro

This research allows us to mathematically look at the responses that a robotic or cadaver finger will experience when exposed to different forces while in different postures. Having this data can tell us about how a finger should respond to different forces given its posture which is an important step toward truly understanding how tendons drive a finger's position and direction. It could become possible to analyze the data in real time to compare how well a model is mimicking true limb control.

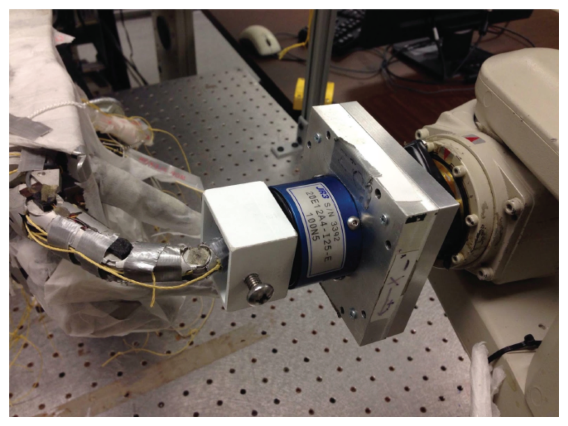
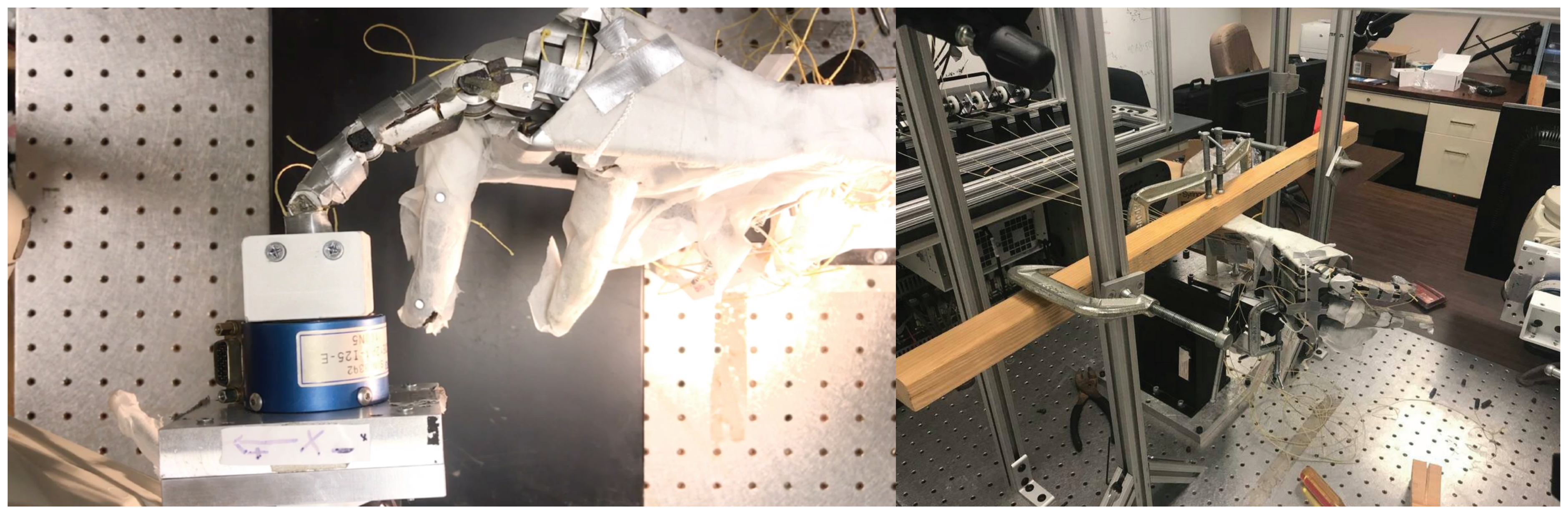


Figure 1: Finger setup (without finger clamp) with Finger-JR3 Mount, and JR3-Adept Mount.



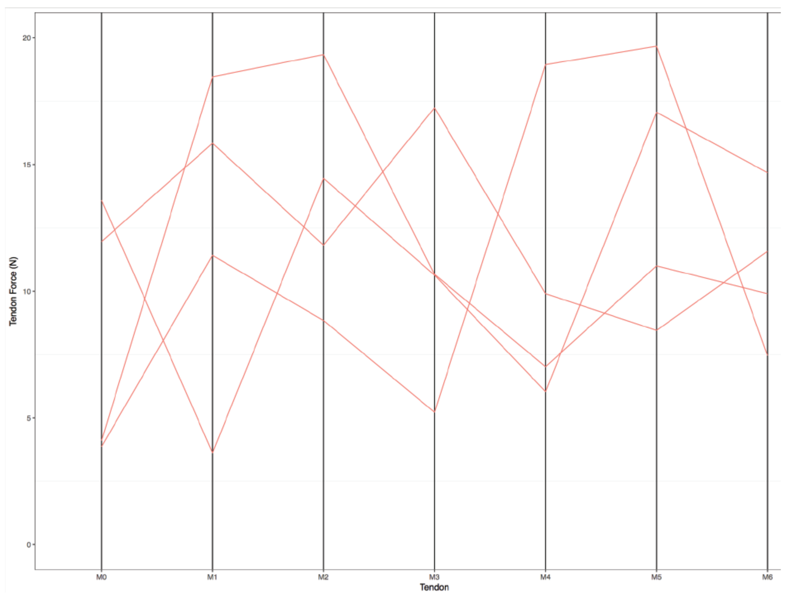
Left: Top view of full setup including improved finger clamp screw setup (not visible).
Right: Brace setup to prevent any movement at the wrist or hand.

Experiment/Method

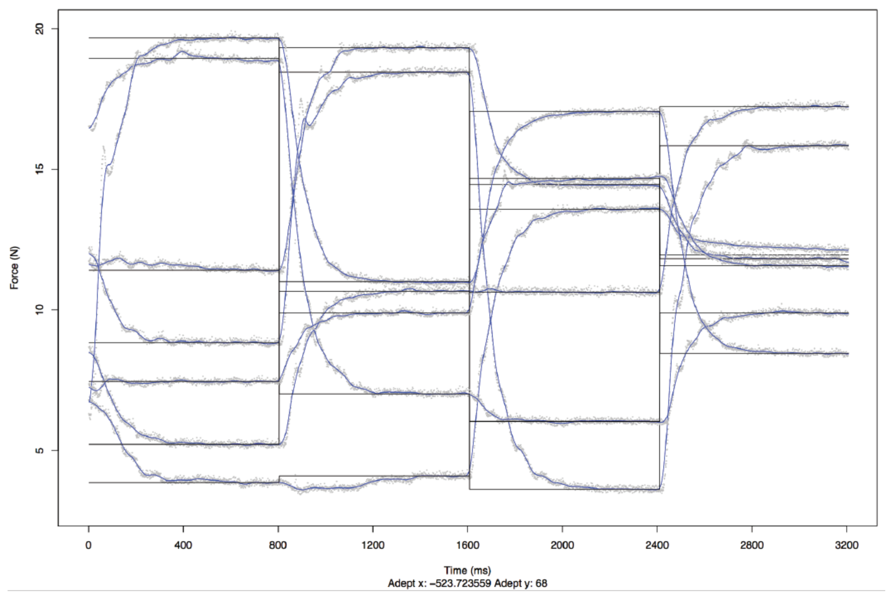
We wind up tension on cables that are tied directy to cadaveric tendons. The cable bends around the pulley where we measure cable force.

7 motors wind up 7 tendons, producing 3D robotic fingertip force. With 100 positions and 100 forces per posture, we recorded the tensions applied (x), and record the fingertip forces (b).

Results



(a)



(b)

(a) The randomized forces on each of the 7 tendons
(b) Each time the randomized force was changed during a single posture, it took some time for the tendons to reach the desired force.

Discussion

Initially, the finger (in regards to the tip, or endpoint) was postured along an arc with randomized forces applied to it. It was found that this method for postures was difficult to run tests with as the finger tip does not naturally move in a small arc without significantly rotating the last joint. The problem with this is that the JR3 to finger mount could not hold the finger over long experimental tests due to the variety of orientations that the fingertip was postured to. Because of this, it was decided that the endpoint postures should be mapped along two perpendicular lines on the same plane as the finger. This reduced the variance in the orientations of the fingertip allowing the mount to reliably hold the finger to the JR3 for very long tests (> 24 hours). With this new posture arrangement, longer tests were run to get larger sets of data while still enabling us to discover how a finger reacts to tendon driven forces.

Future Work

If an optimized mount can be designed which will not interfere with the postures or forces, but will allow the fingertip to be oriented in any way, the mapping of the postures can become more complex. Being able to change the postures to follow different lines or shapes will greatly extend what the data can show about a finger's reaction to tendon driven forces.

In addition to the mount, our experiment could be extended by doing tests on a human cadaver finger, which we have not done yet. This aspect of the experiment is very important because it will allow us to look at the difference between our robotic tendon driven model and an actual human finger. Additionally it will allow us to gain valuable information about how a human cadaver finger will truly respond for different postures.

Additional References available upon request:

1. Valero-Cuevas, FJ, Fundamentals of Neuromechanics, Springer-Verlag London, 2016.
2. Valero-Cuevas, F, Cohn, B, Yngvason, H, & Lawrence, E, J Biomech, 48(11), 2887-2896, 2015.
3. Inouye J, Kutch J, Valero-Cuevas FJ "Optimizing the topology of tendon-driven fingers: Rationale, predictions and im-

For questions or to request project updates:

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