A Comprehensive Computational Framework to Evaluate Grasp Quality of Tendon-Driven Hands with Arbitrary Topology

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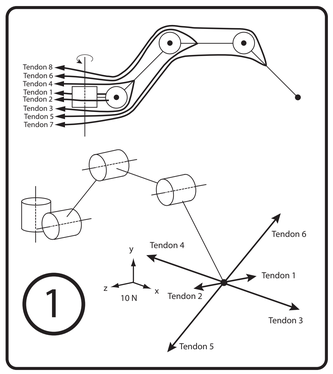
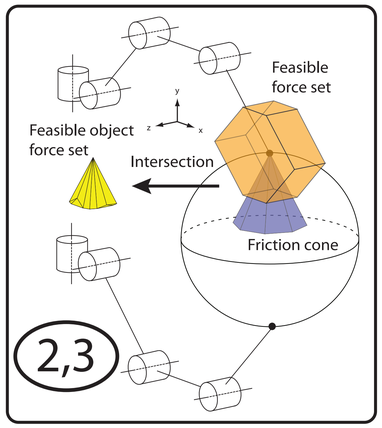
Introduction

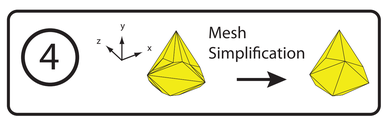
- Biologically-inspired tendon-driven robotic hands have many advantages over torque-driven hands [1,2].
- Previous work has been unable to fully characterize the grasp capabilities of these hands [3,4].
- We have developed a novel comprehensive computational framework for evaluating grasp capabilities of these hands.
- ***This breakthrough now enables the systematic design, evaluation, and optimization of complex tendon-driven systems.***

Methods

1. Find fingertip wrench basis vectors
2. Build fingertip feasible force set
3. Find feasible object force set
4. Simplify feasible object force set (optional)
5. Translate contact forces to object wrenches
6. Find feasible grasp wrench set
7. Compute grasp quality metrics
8. Visualization (optional)

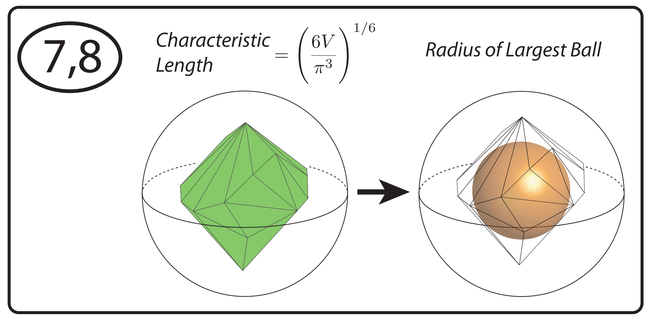






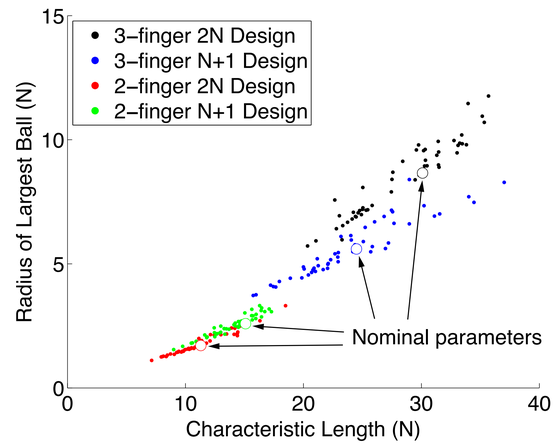
$$5 \quad \mathbf{w}_{i,j} = \begin{bmatrix} \mathbf{f}_{i,j} \\ \lambda(\mathbf{d}_i \times \mathbf{f}_{i,j}) \end{bmatrix}$$

$$6 \quad FGWS = ConvexHull(\bigoplus_{i=1}^{n} \{w_{i,1}, ..., w_{i,m}\})$$

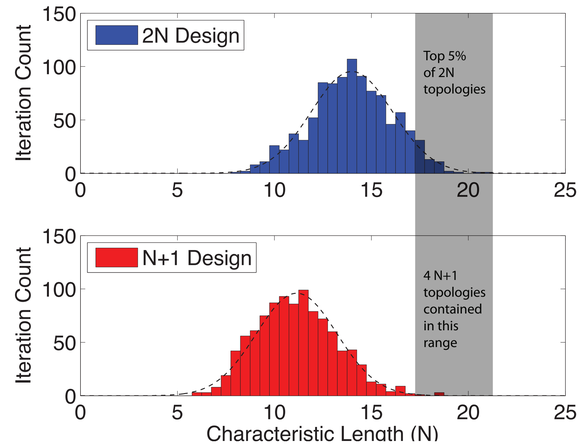


Results

Nominal and Monte Carlo results (parameters perturbed ±20%)



Characteristic Length for 2-finger grasp



Conclusions and future work

- We successfully developed and implemented this methodology for use in analyzing the grasp capabilities of tendon-driven hands.
- Monte Carlo results show that:
  - topology greatly affects grasp quality.
  - grasp quality can be vastly affected by making modest changes in parameters.
  - simpler topologies can be designed to outperform more complex ones.
- ***Future work will use this methodology to design dexterous, tendon-driven hands with higher grasp capabilities than are currently available, and simpler hands with specific capabilities.***

References

1. Pons JL et al. *Robotica* 54, 674, 1999. **2.** Tsai LW. *J of Mech Design* 117, 80, 1995. **3.** Fu JL et al. *IEEE/RSJ IROS*, 1068-1075, 2006. **4.** Miller et. al, *IEEE Robotics Automation Mag.*, 11, 110-122, 2004.

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