

Research question

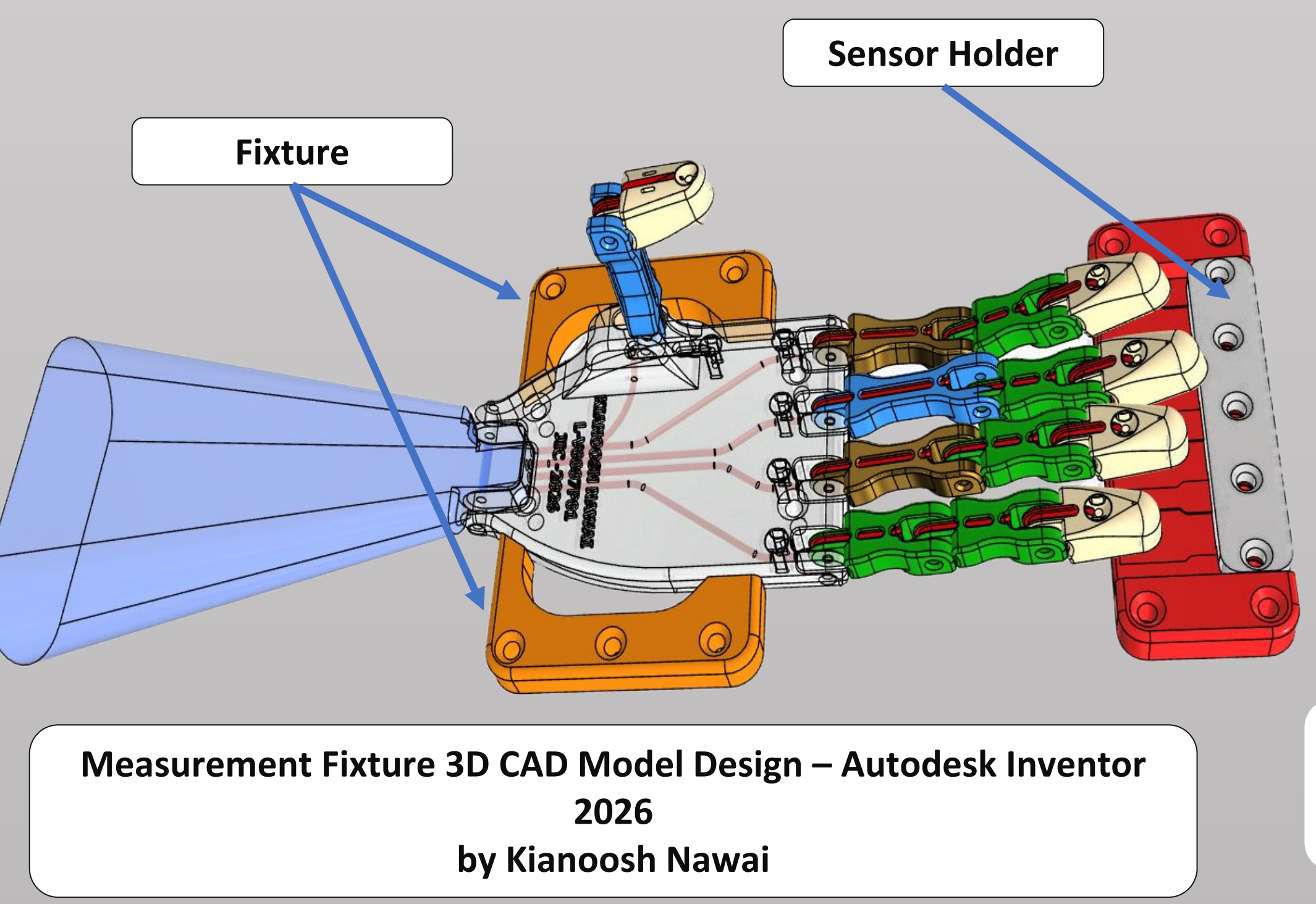
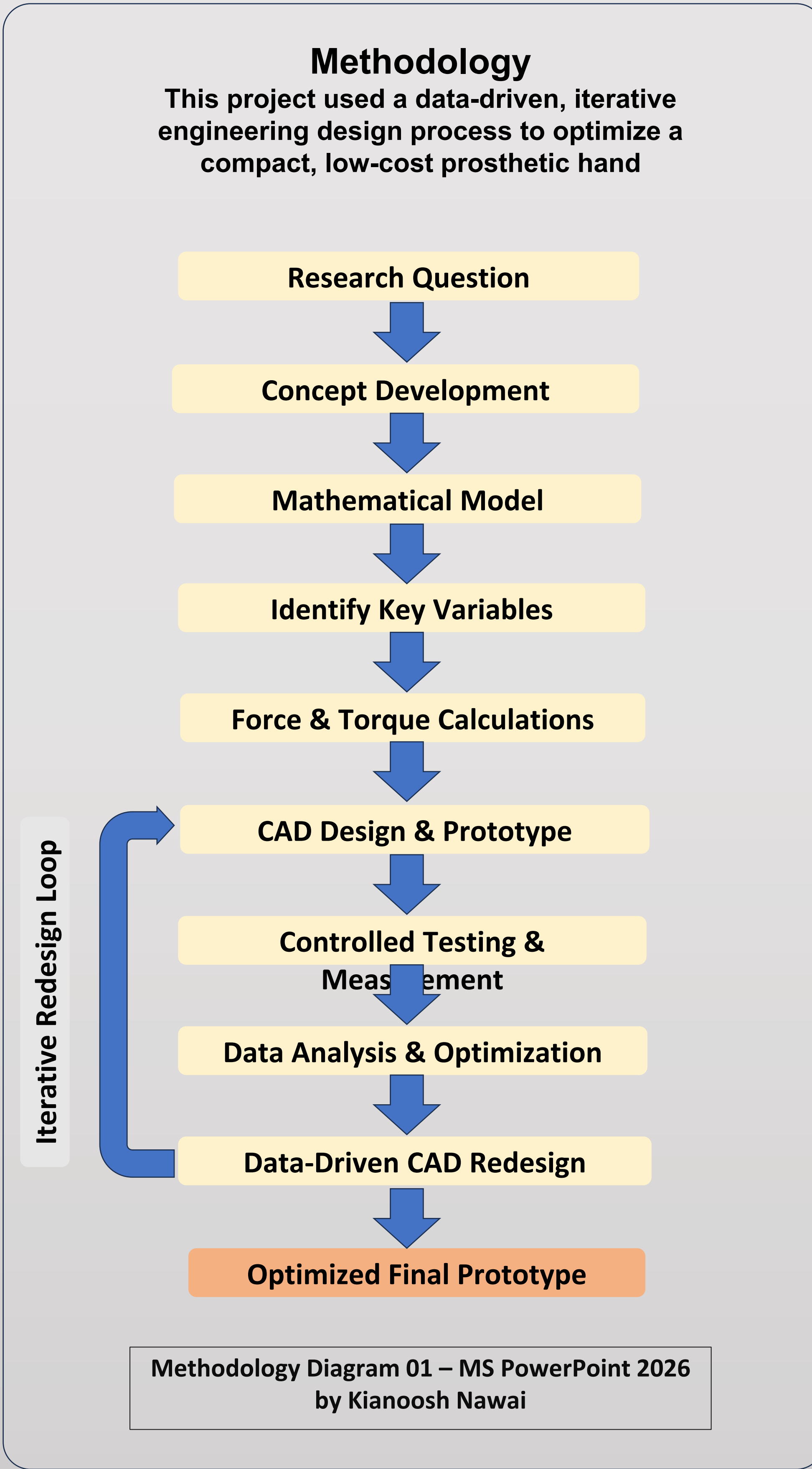
How can iterative biomechanical design optimization using force gauge and pressure sensor data improve the efficiency, compactness, and functional grip performance of a low cost and functional prosthetic hand?

Design Objective & Optimization Criteria

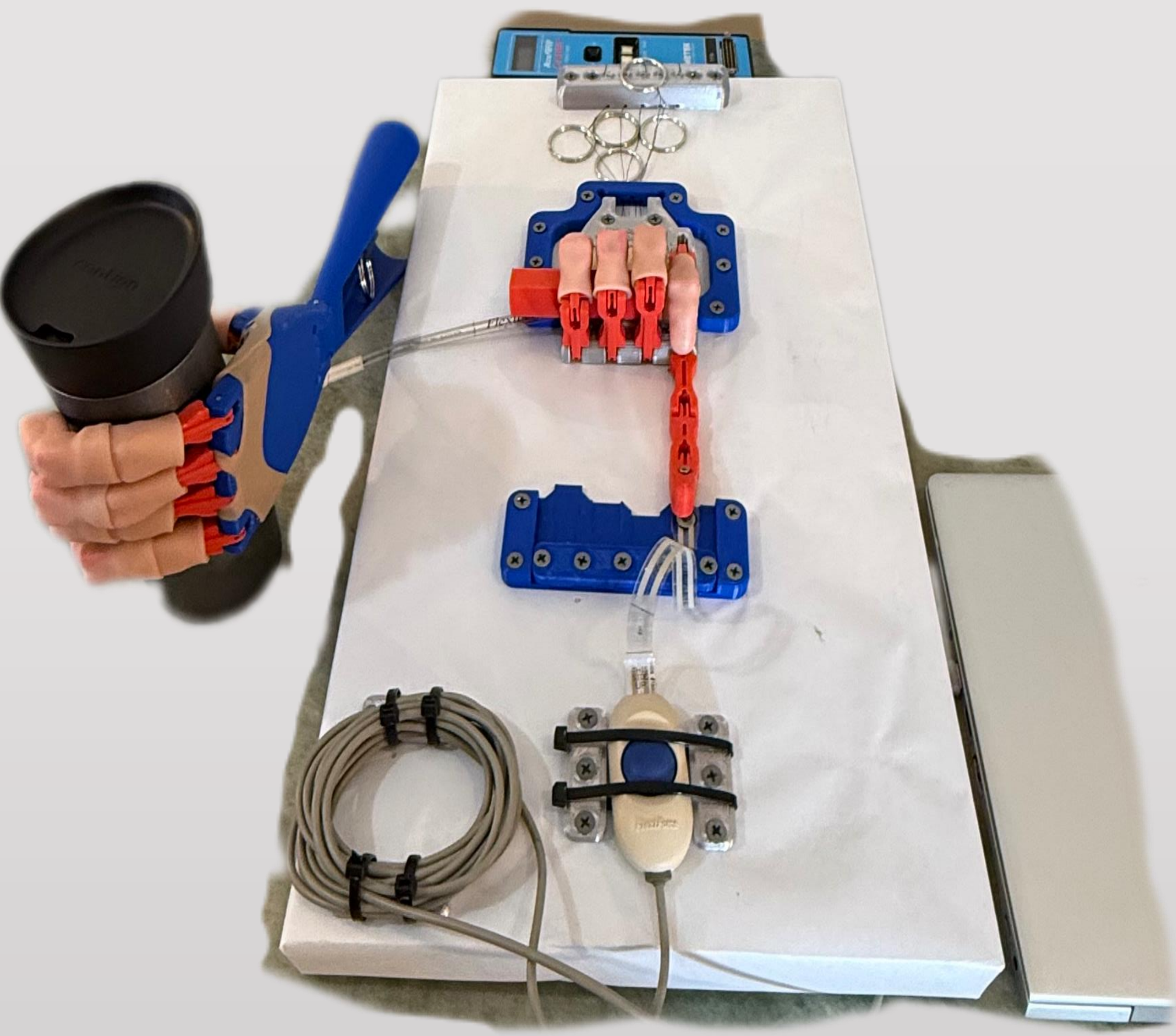
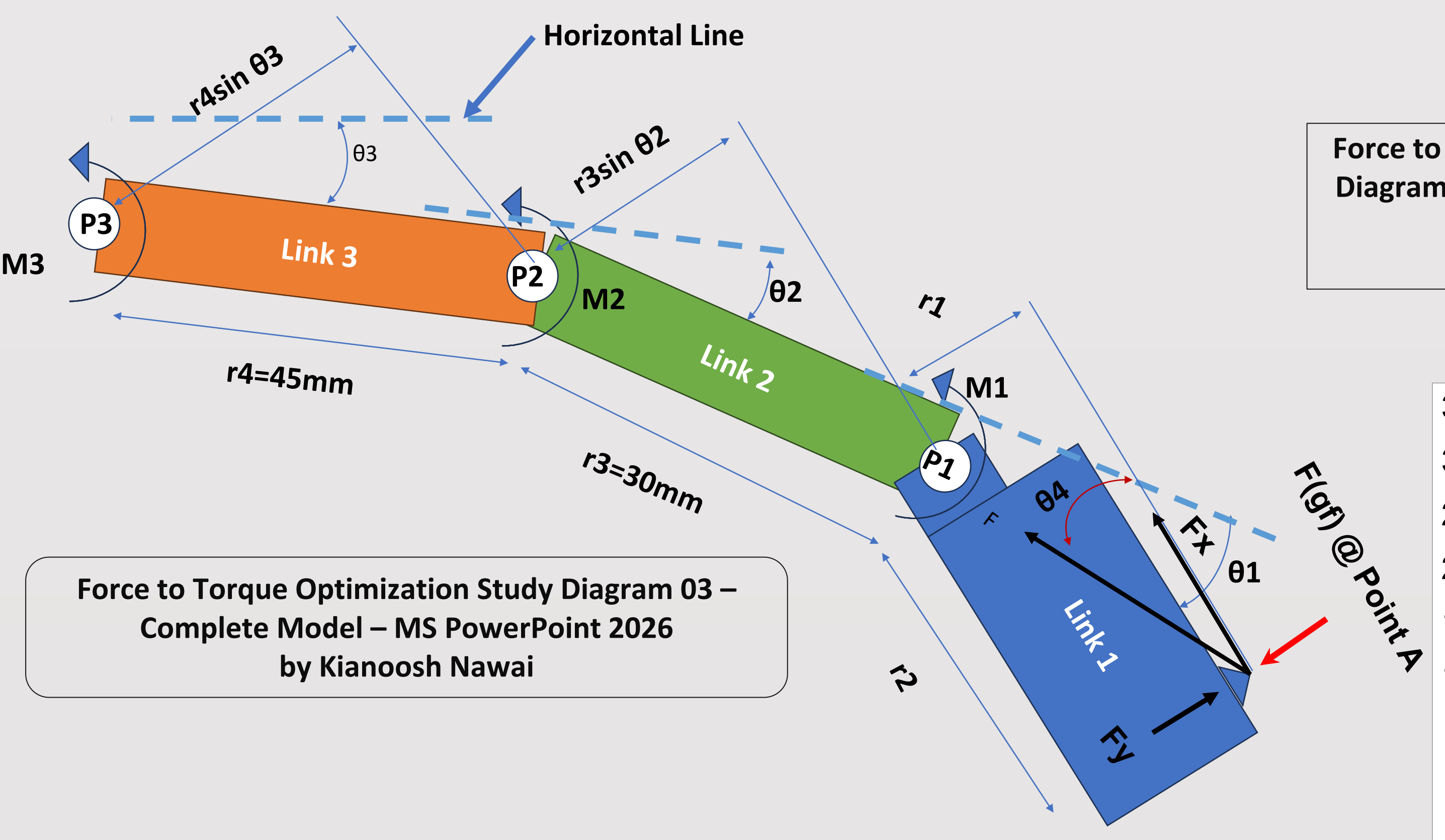
Optimize finger geometry, cable routing, and TPU tension to increase useful output force while reducing required pulling force and maintaining compact, repeatable motion.

Success Criteria

Lower input force • Higher useful output force • Stable grip • Compact, reliable design



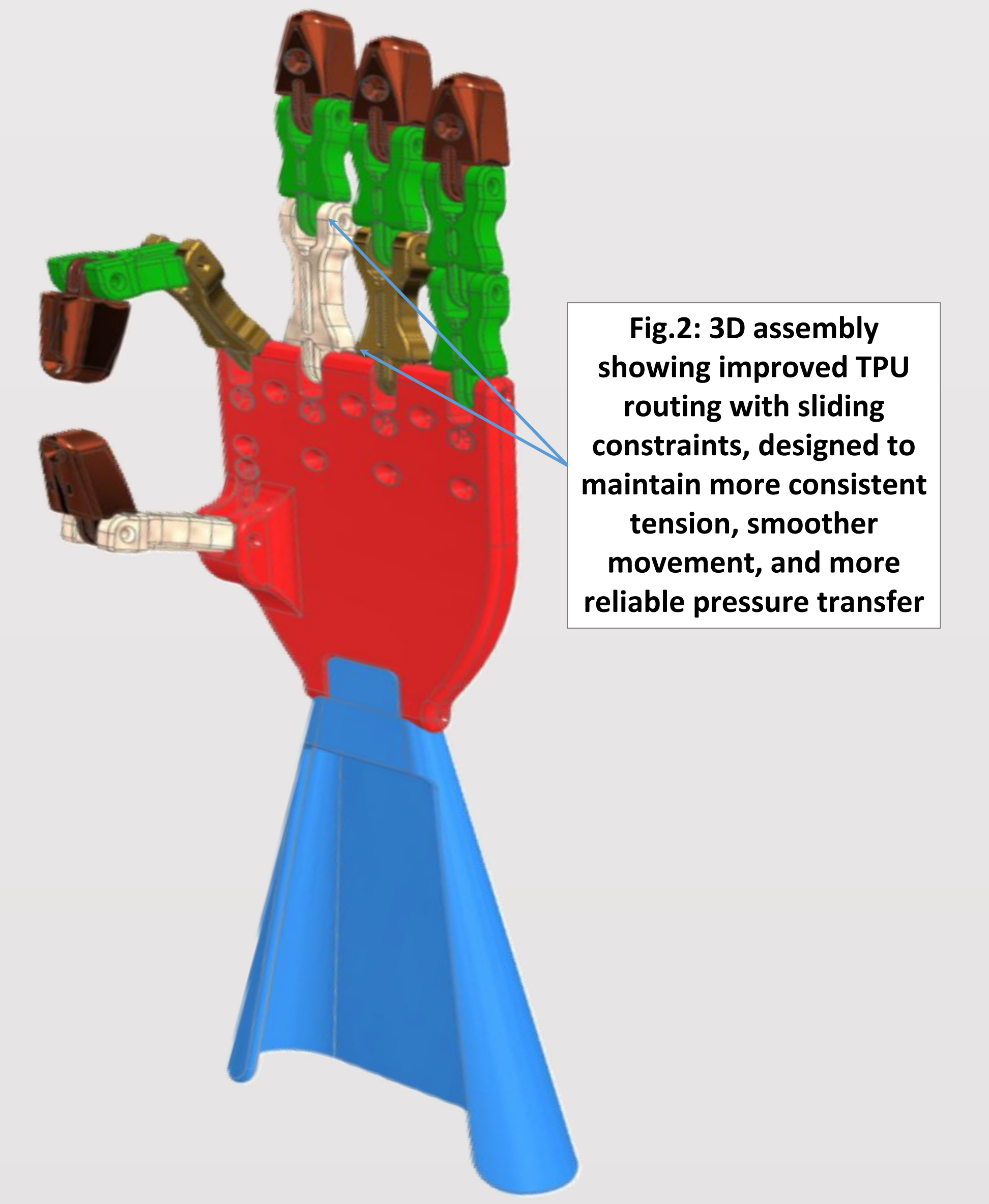
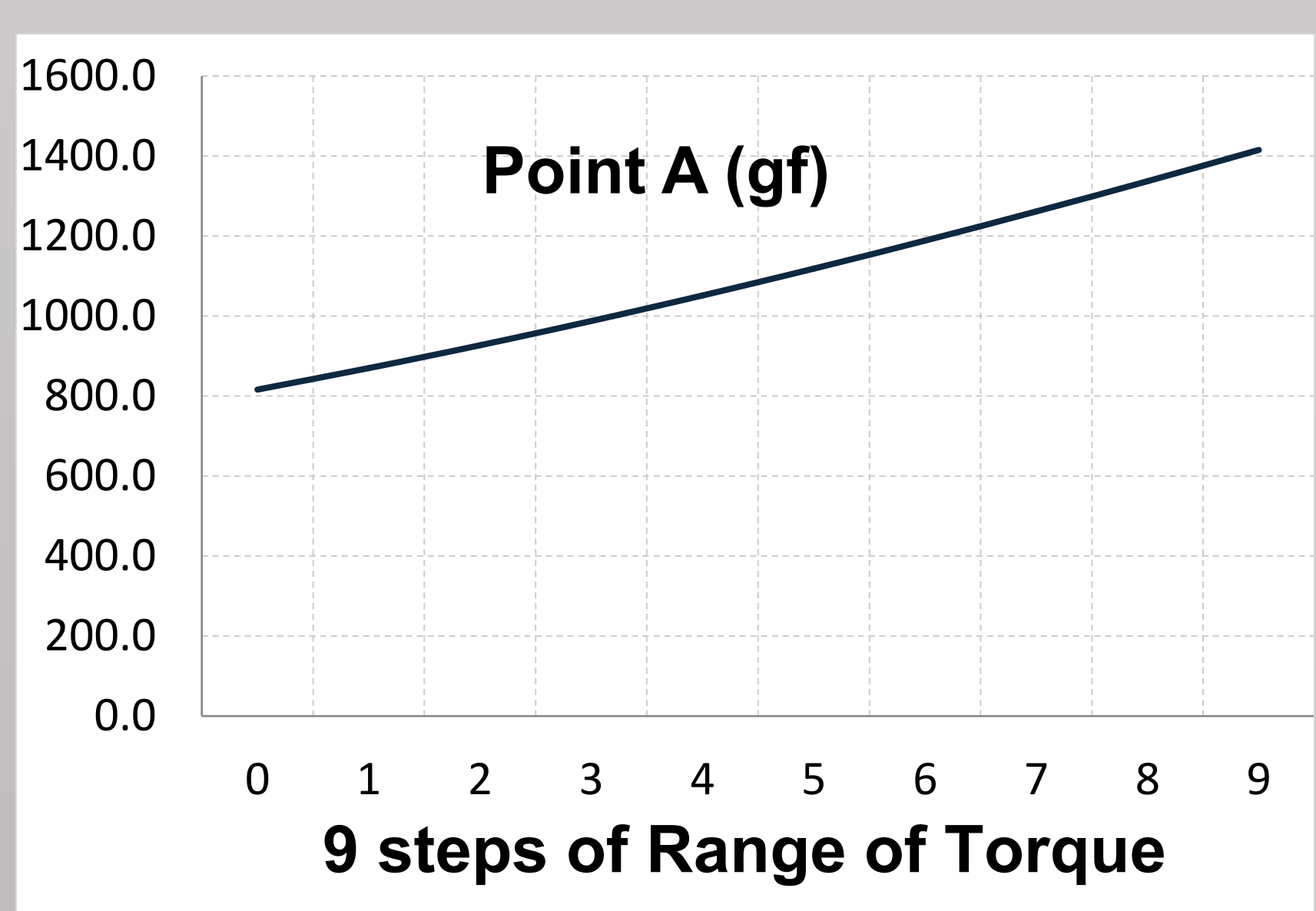
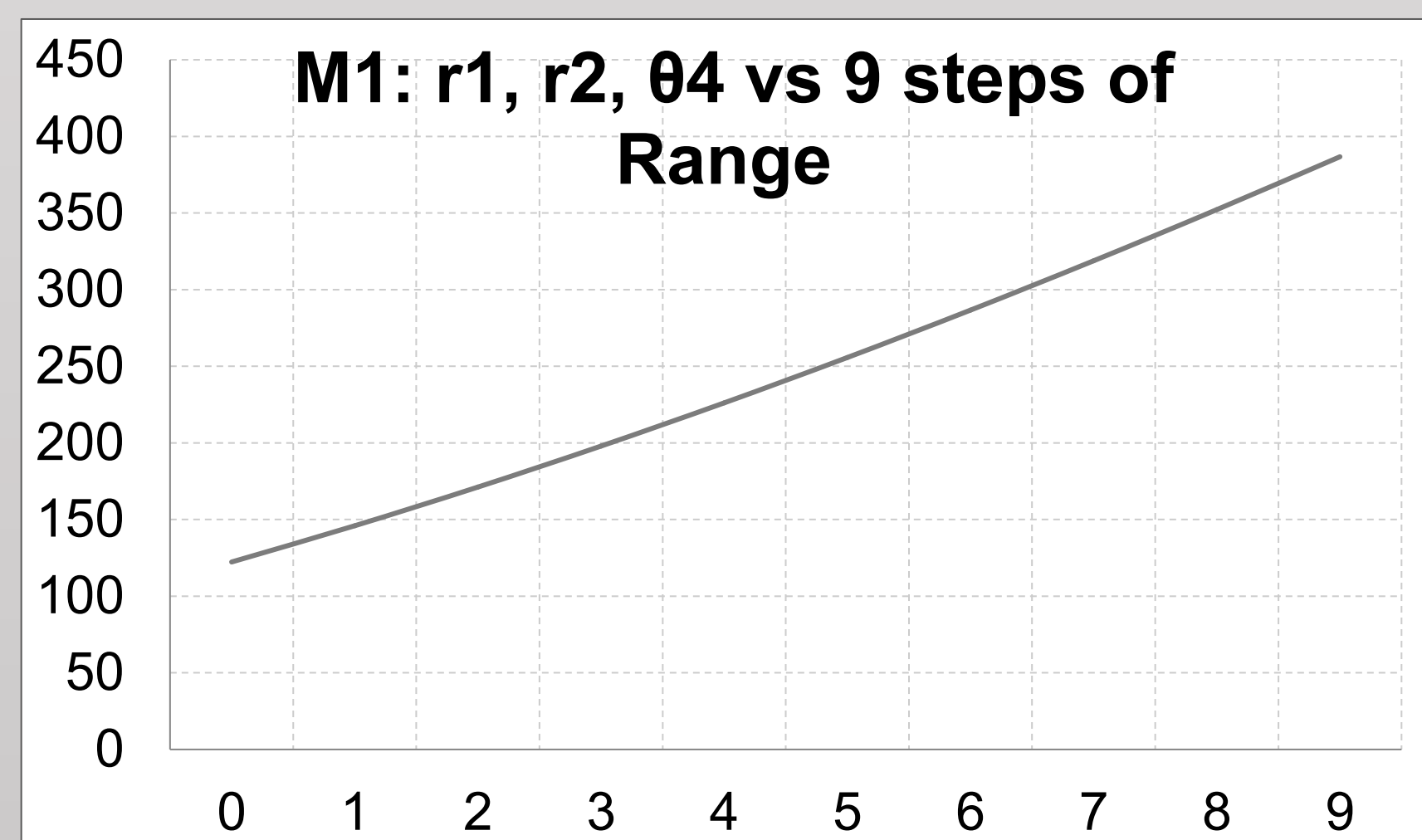
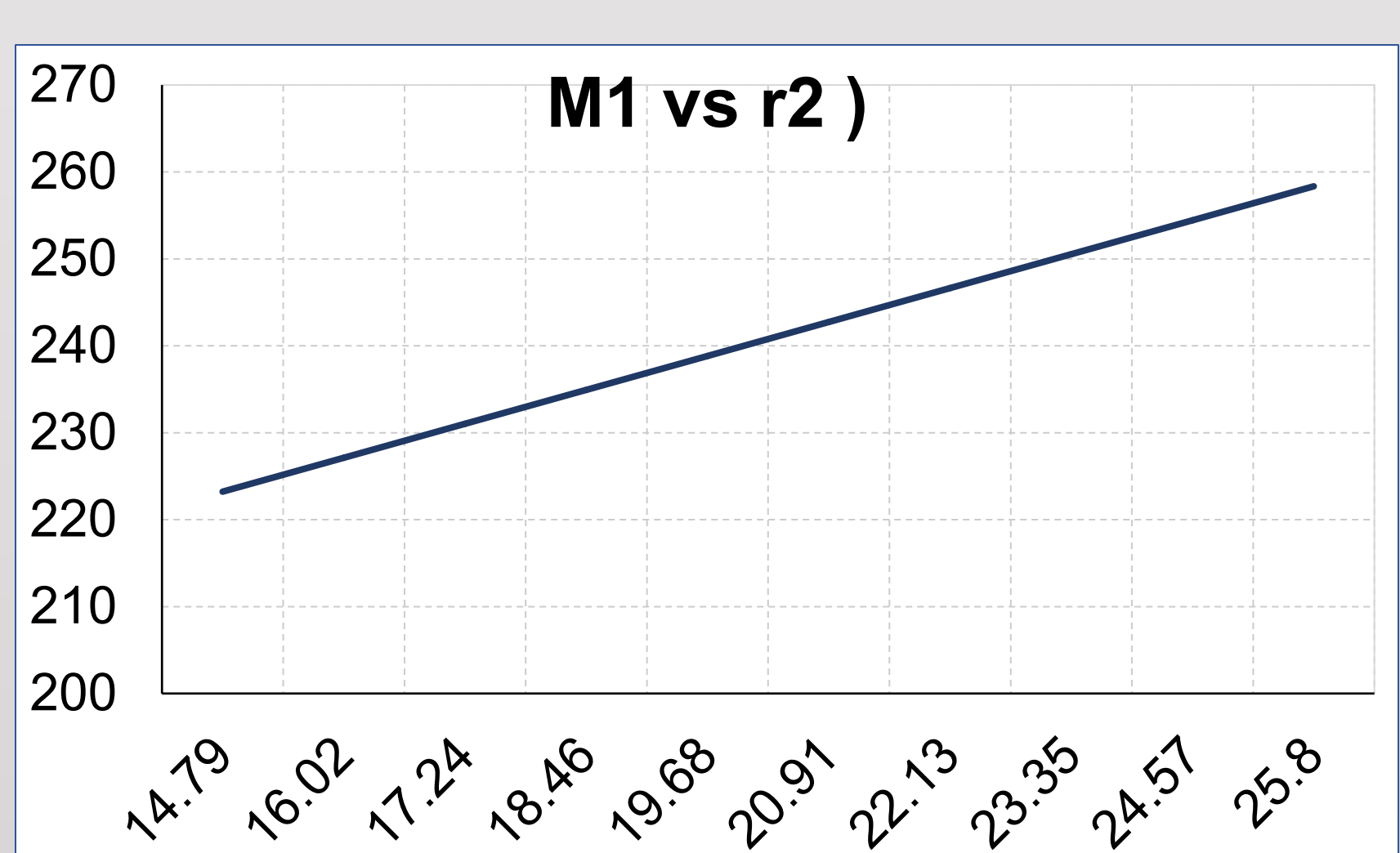
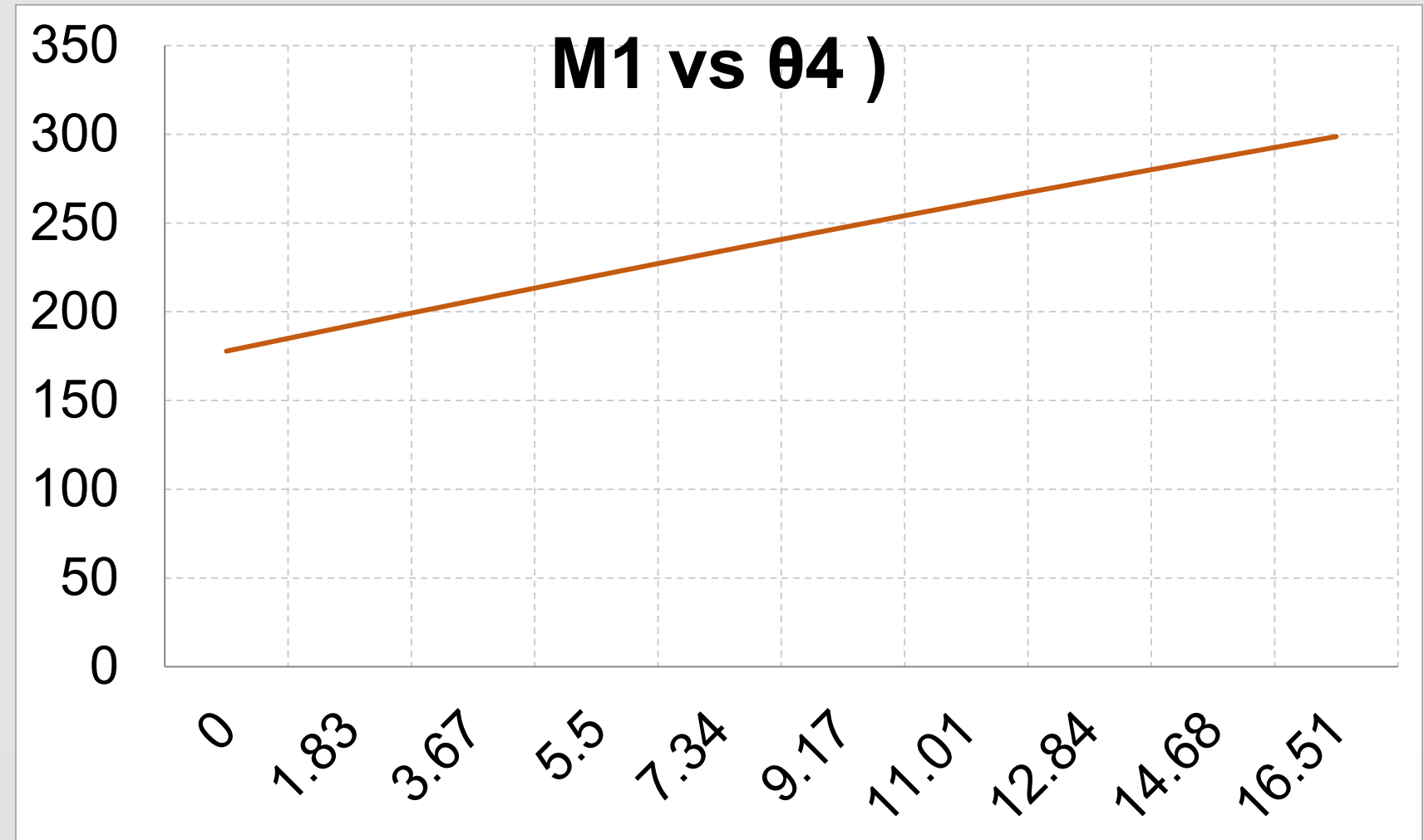
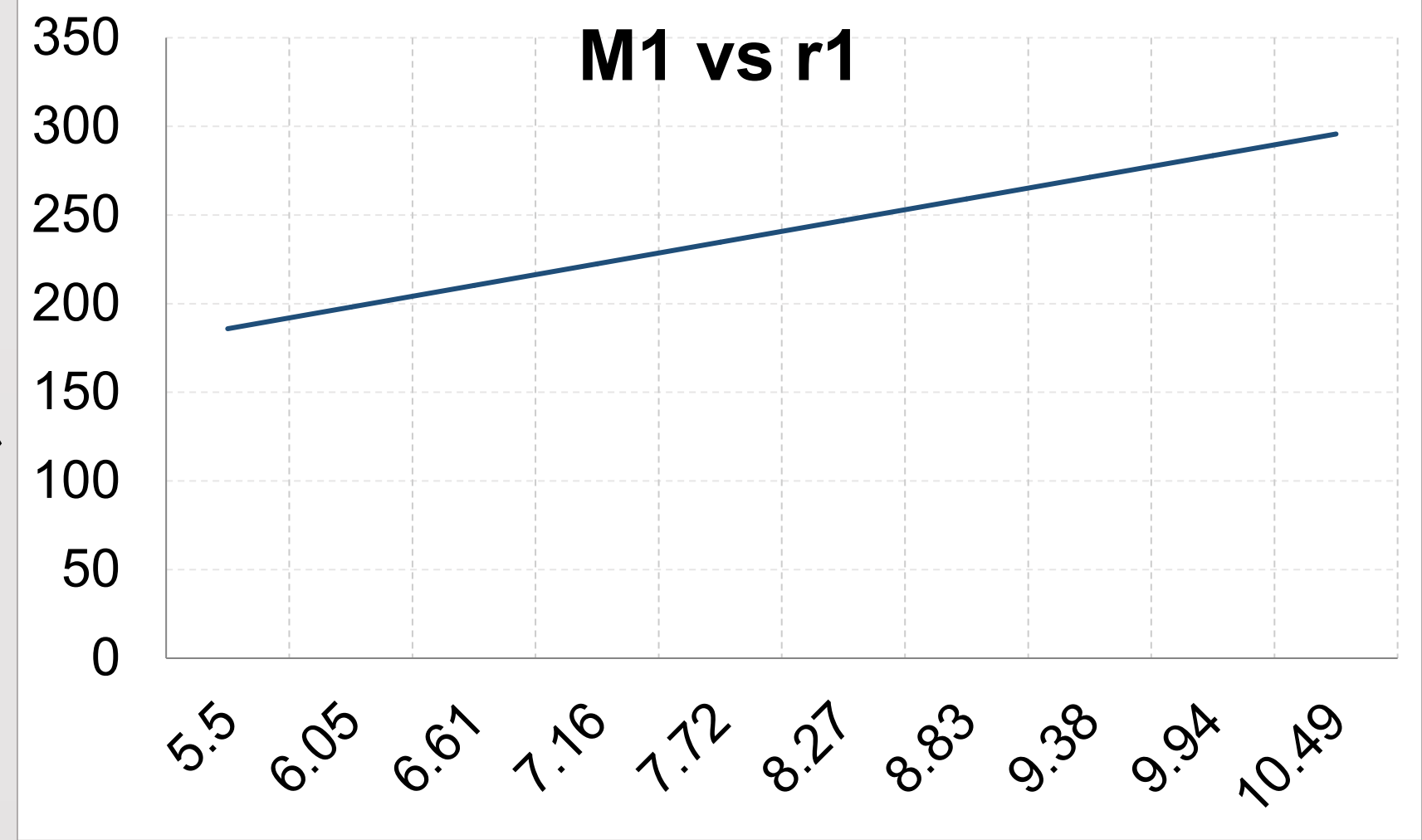
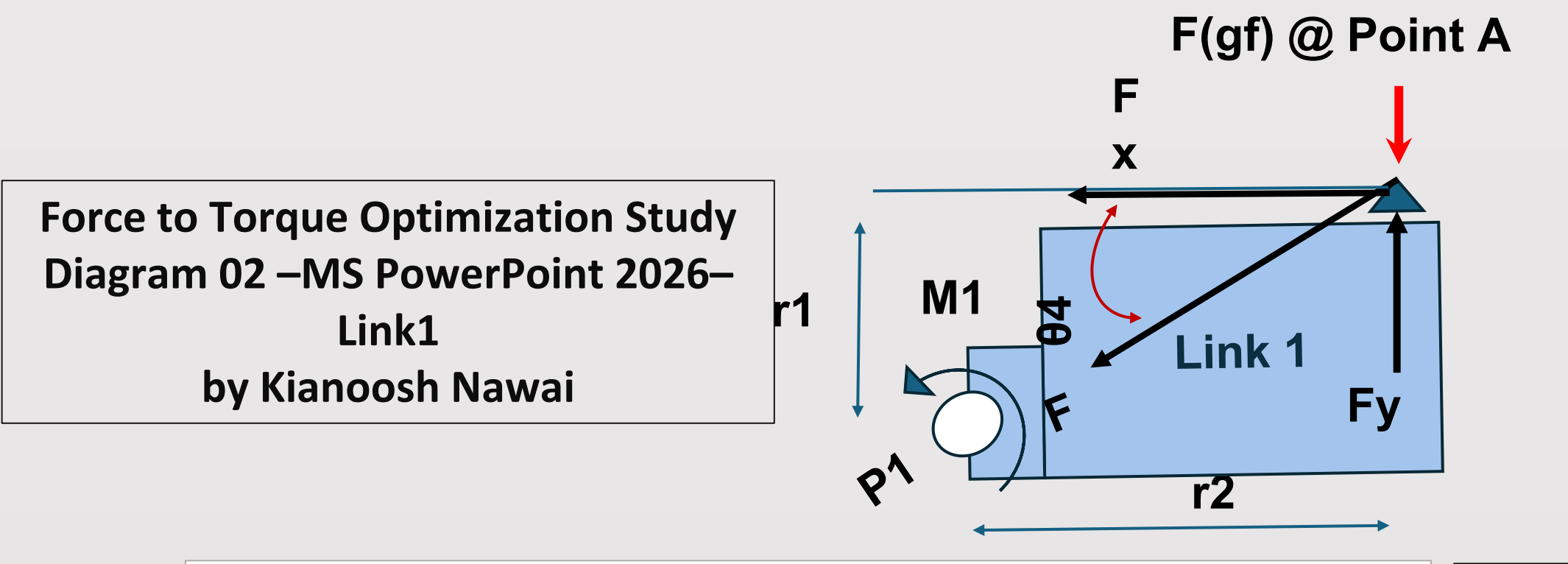
Design, Optimization and Evaluation of a Low-Cost, Compact Bionic Hand for Functional Restoration and Accessibility



Prosthetic Hand 3D Print Prototype – 16 Fl-Oz Water Bottle–Grip test by Kianoosh Nawai

Step	Point A (N)	Point A (gf)	Improve ment
0	8.005	816.2	0.0%
1	8.531	869.9	6.6%
2	9.091	927.0	13.6%
3	9.685	987.6	21.0%
4	10.312	1051.5	28.8%
5	10.970	1118.6	37.0%
6	11.657	1188.6	45.6%
7	12.372	1261.6	54.6%
8	13.114	1337.2	63.8%
9	13.880	1415.4	73.4%

Fig.1: Measurements setup Photo by Kianoosh



Prosthetic Hand 3D CAD Model Design – Main Assembly Autodesk Inventor 2026 by Kianoosh Nawai

Estimate of the total cost of one prototype: \$ 119.95

Design Validation

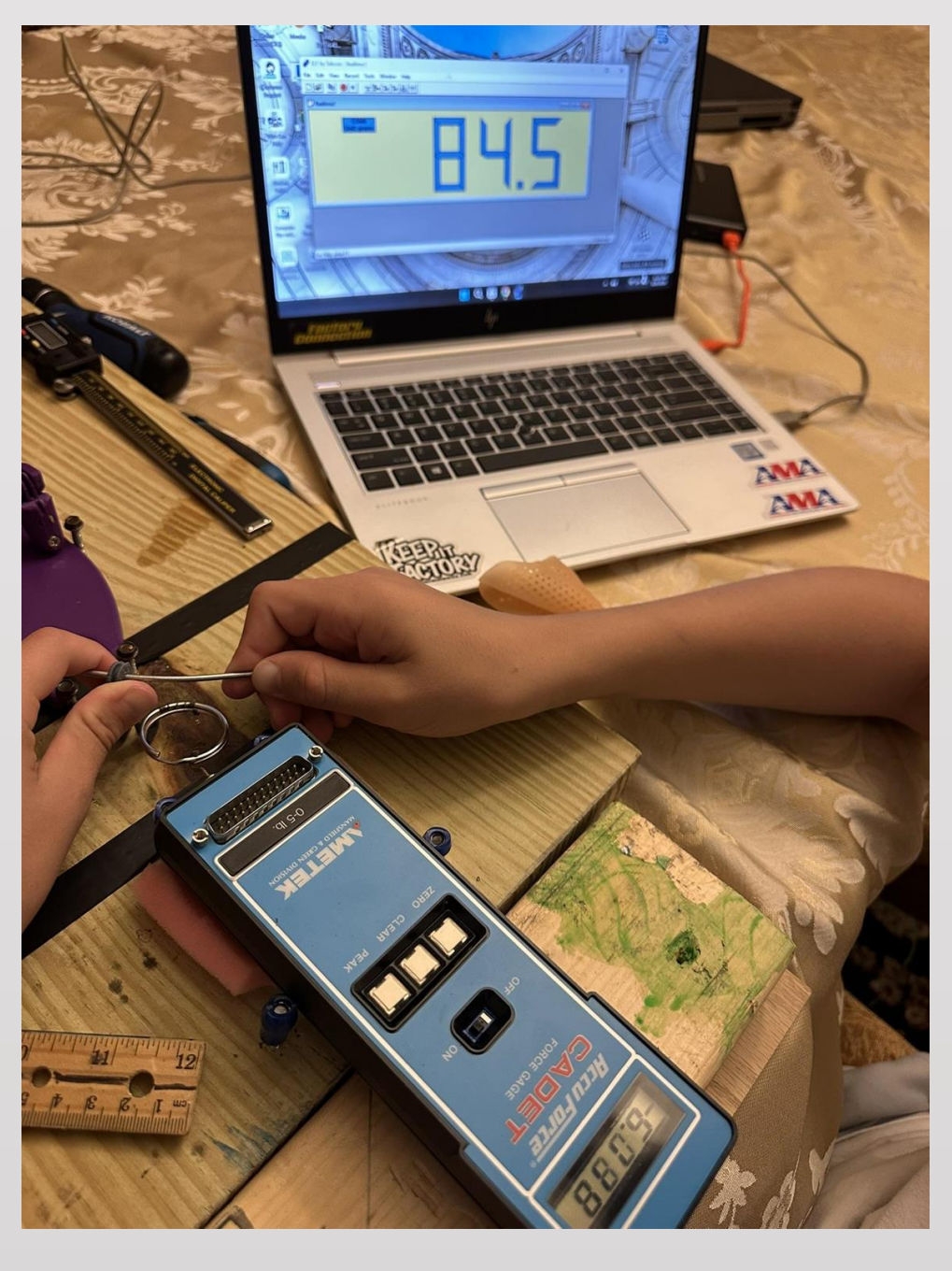


Fig.3: Force Measurement at Point A Photo by Kianoosh Nawai



Fig.4: Force Measurement at Point A Photo by Kianoosh Nawai

Conclusion

My mathematical optimization showed how strongly finger geometry affected performance. By isolating r_1 , r_2 , and θ_4 , I could identify how each variable changed the calculated force at Point A, with θ_4 producing the greatest improvement within the ranges I studied. When the variables were optimized together, the model predicted that the force at Point A could increase from about 816.2 gF to 1,415.4 gF, an improvement of approximately 73.4%.

The mathematical model helped me isolate variables, identify which changes had the greatest effect, and use data to guide my CAD design. Instead of changing many features at once, I tested variables individually and used the results in an iterative process of designing, testing, analyzing, and redesigning.

This showed me that relatively small changes in geometry can produce significant mechanical improvements. Better mechanical efficiency could reduce the force required from a future actuator, potentially allowing it to be smaller, use less power, and experience less mechanical stress while still producing functional grip.

Limitations: no human use research only.

2026 - Project made by Kianoosh Nawai