Towards Tenodesis-Modulated Control of an Assistive Hand Exoskeleton for SCI

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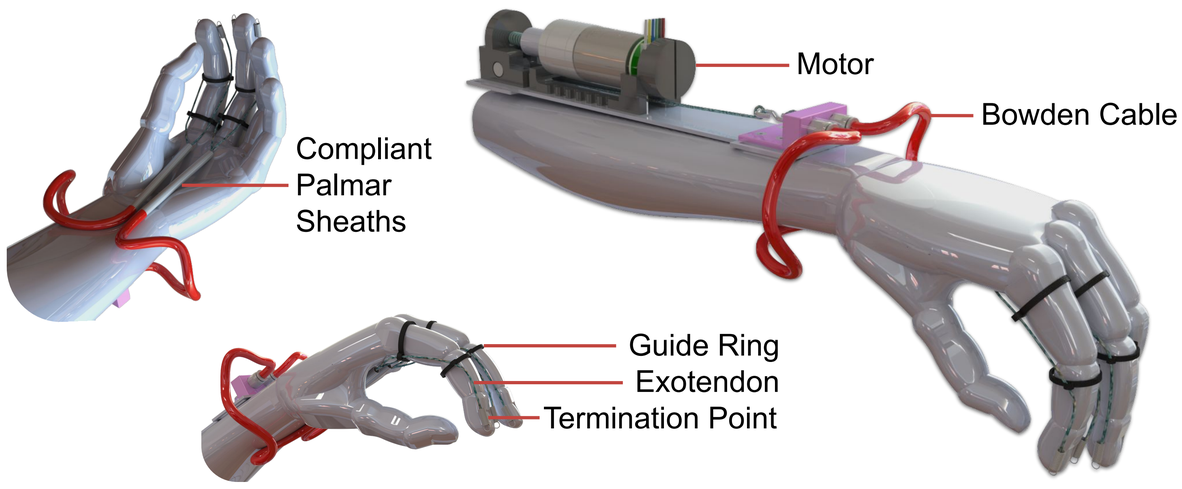
Motivation

- There are 18,000 cases of **Spinal Cord Injuries** (SCI) per year in the US [1].
  - Often results in loss of hand function (grasping), limiting independence.
- For C6 injury individuals, **tenodesis** is commonly leveraged for grasping, but it generates small forces.
- Robotic assistive devices present great potential in aiding hand functions [2]-[4]; however, research into integrating tenodesis-based user control remains limited.

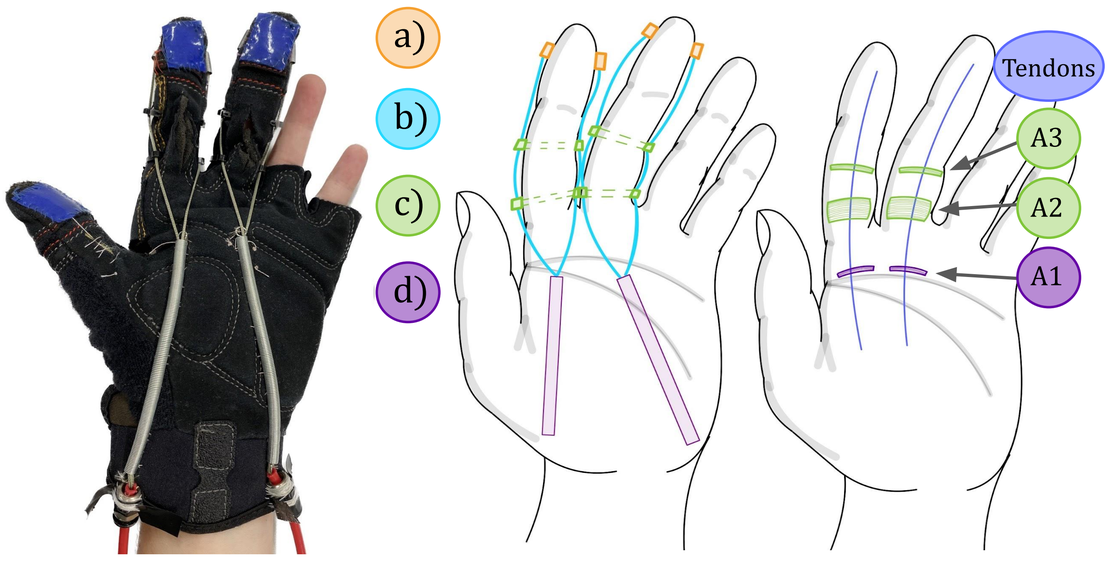
Device Design

- We present the MyHand-SCI, a wearable, tendon driven robotic device that provides active grasping assistance.
- Our device keeps the wrist unencumbered, which makes it capable of integrating tenodesis-based user control.
  - Bowden cables bypass wrist to preserve free mobility.
  - Underactuated → Lightweight (295 g).



Bioinspired Tendon Routing

- Exotendon routing mimics hand anatomy to encourage natural grasping:

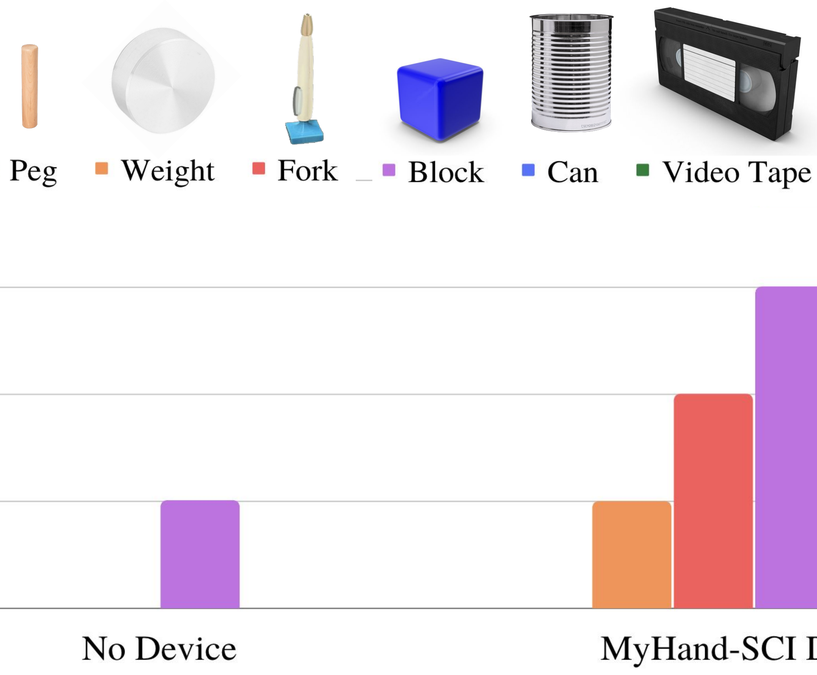


Left: Palmar side of device.
Middle: Device diagram showing a) Termination point, b) Exotendons, c) Guide rings, d) Bowden cables.
Right: Simplified diagram with labeled anatomical tendon pulleys.

SCI-User Case Study

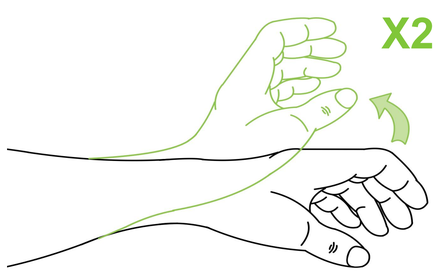
- A participant with C6 tetraplegia tested our device:
  - Performed Grasp and Release Test (GRT).
  - Device operated by a occupational therapist using buttons to modulate grasping force responding to verbal cues from participant.
- Considerable GRT score improvement:
  - **Scored 11 using device compared to 1 without it.**
- Participant responded well: found the device comfortable and helpful.

Grasp Release Test Results



Future Extensions

- Current design provides a testing ground to explore tenodesis as a user control method.
  - Opens the door to innovative features to improve user experience:



X2 → Lock Closed/Open Grasping.
  - E.x. Double wrist extension to activate & deactivate grasping.
    - Reduce user exertion and fatigue.

References & Acknowledgments

[1] National Spinal Cord Injury Statistical Center, Traumatic Spinal Cord Injury Facts and Figures at a Glance. Birmingham, AL: University of Alabama at Birmingham, 2023.

[2] E. Y. Chang, R. Mardini, A. I. W. McPherson, Y. Gloumakov and H. S. Stuart, "Tenodesis Grasp Emulator: Kinematic Assessment of Wrist-Driven Orthotic Control," 2022 International Conference on Robotics and Automation (ICRA), Philadelphia, PA, USA, 2022, pp. 5679-5685.

[3] C.G. Rose and M.K. O'Malley, "Hybrid Rigid-Soft Hand Exoskeleton to Assist Functional Dexterity," IEEE Robot. Autom. Letters, vol. 4, no. 1, pp. 73–80, 2019.

[4] H. In, B.B. Kang, M. Sin, and K. Cho, "Exo-Glove: A Wearable Robot for the Hand with a Soft Tendon Routing System," IEEE Robot. Autom. Mag., vol. 22, no. 1, pp. 97–105, 2015.

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