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HERON Robotics Excellence

POWERS: Developing Attentive Soft Wearable Robotic Exosuits for Upper Body

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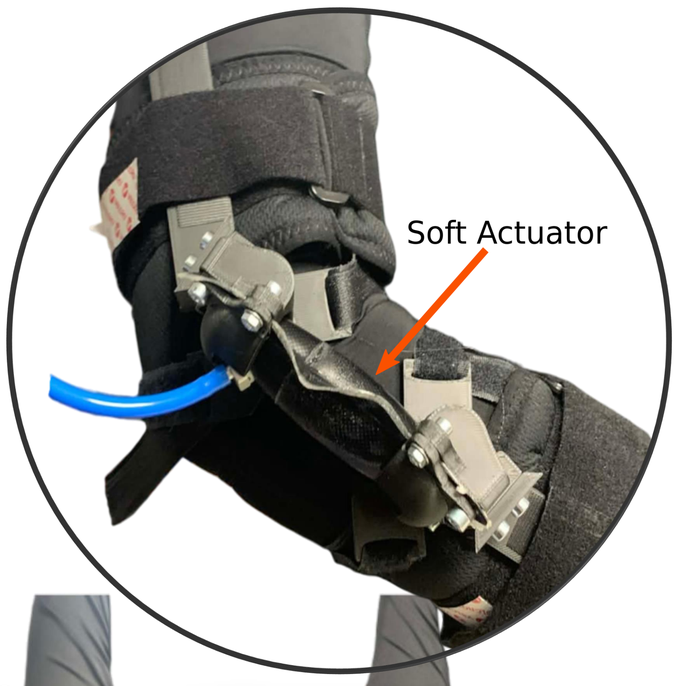
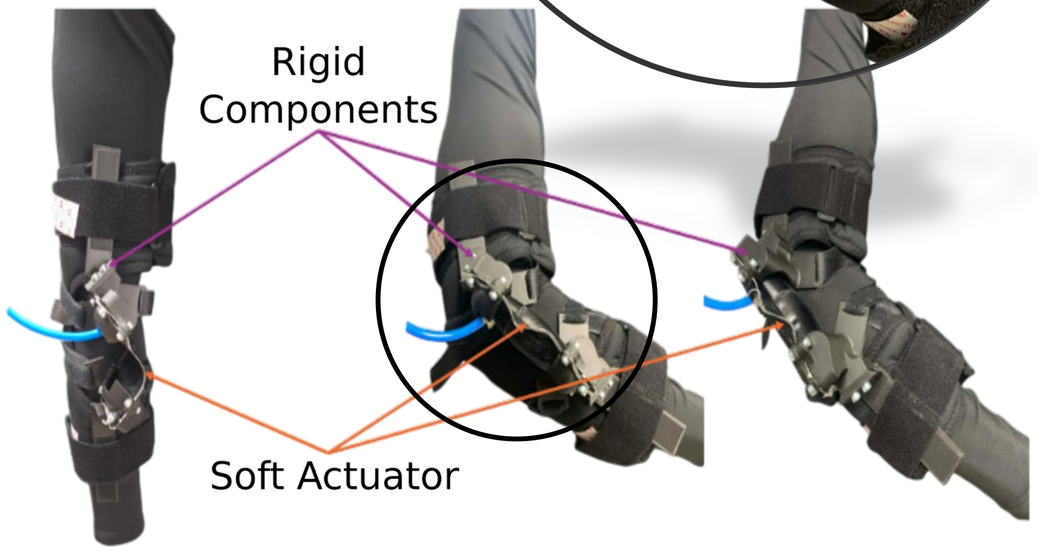
Scope of research

POWERS focuses on developing a soft pneumatic exosuit for strenuous upper-limb tasks. Its hybrid design will pair soft fabric actuators with lightweight rigid components to deliver the assistive torque needed while minimizing the required air volume.

Achieving fully untethered operation remains challenging:
- ► Pneumatic actuators need a portable air supply
- ► High-force tasks usually demand bulky reservoirs or high-power pumps
- ► Increase in energy consumption and limit in portability



POWERS Prototypes



Hybrid Soft-Rigid Design

POWERS aims to pair soft fabric-based actuators with lightweight rigid elements:
- ► Soft fabric actuators inflate to drive elbow flexion/extension and shoulder ab/adduction
- ► Encasing each chamber in an inextensible fabric pouch enables high-pressure operation and large torque output from a compact, fully collapsible design
- ► Lightweight rigid components maintain joint alignment and efficiently transfer loads to the body

Together, these components deliver high assistive torques in a compact form factor, while minimizing air volume requirements, enabling a lightweight untethered system

Distributed Sensing

A network of garment-embedded sensors:

- ► Soft fabric sensors measure joint angle and strain without stiffening the suit
- ► Surface EMGs detect muscle activationas an early indicator of user intent.
- ► IMUs track limb orientation and motion
- ► Pressure sensors monitor actuator inflation for closed-loop control
- ► Machine learning and sensor-fusion algorithms combine these signals to estimate movement intent and amplify the wearer's natural motion

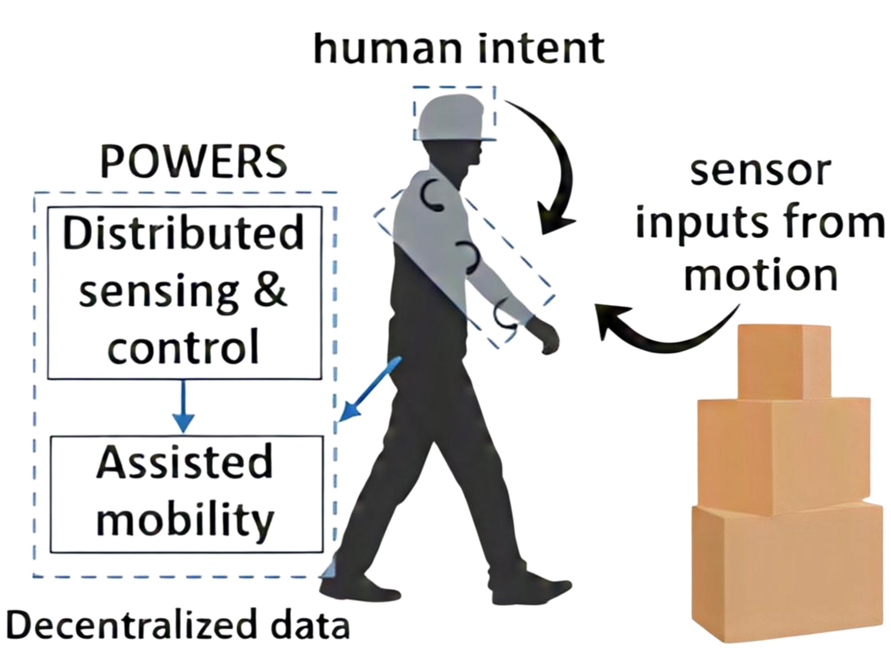
Actuation Requirements

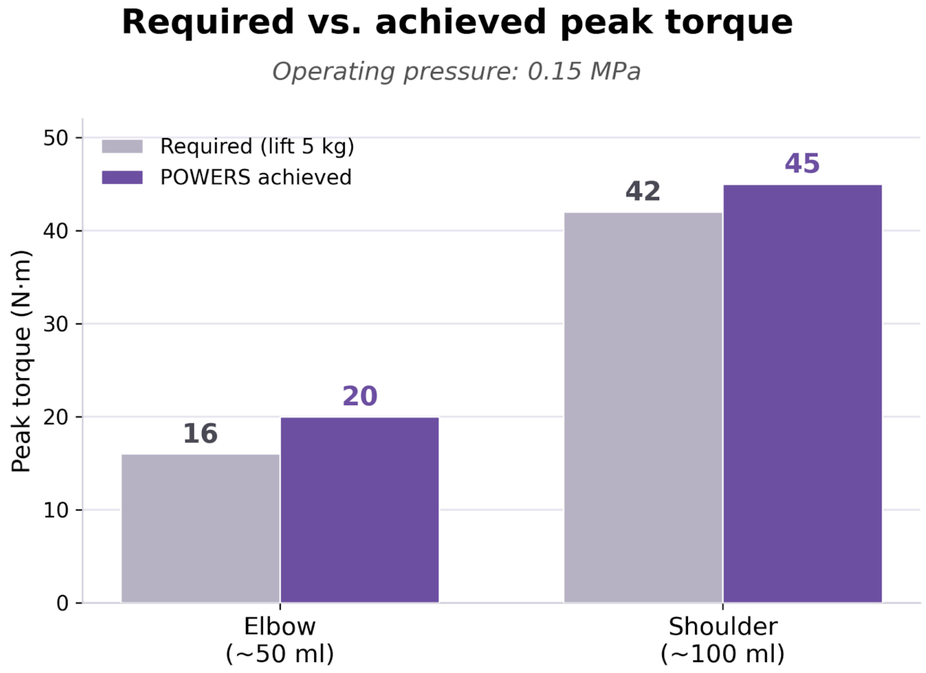
Derived from **biomechanical** analysis:
- ► Peak torque required for **unladen** motion:
  Elbow: **~3 Nm**
  Shoulder: **~11 Nm**
- ► Peak torque required while lifting a **5 kg load**:
  Elbow: **~16 Nm**
  Shoulder: **~42 Nm**

The proposed soft actuators air volumes:
  Elbow: **~50 ml**
  Shoulder: **~100 ml**
- ► Generate up to **20 Nm** for the elbow and **45 Nm** for the shoulder at **0.15 MPa**

Conclusions

- ► Preliminary prototypes demonstrate the effectiveness of hybrid soft-rigid actuation for a wearable exosuit
- ► Generate sufficient assistive torques while minimizing the required air volume
- ► Achieve high power-to-weight and power-to-volume ratios.





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