Transforming How We Physically Integrate Exoskeletons With The Human Body To Augment Movement

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Exoskeletons can Restore Mobility and Enhance Human Capabilities...

Indego exoskeleton enables paralyzed individuals to walk [Hartigan 2015]
Soft exosuit reduces the metabolic cost of walking with a load by 7% [Panizzolo 2016]
Ankle exoskeleton reduces the metabolic cost and muscle use, and increases total ankle power [Koller 2015]
Unpowered ankle exoskeleton reduces the metabolic cost of walking by 7% [Collins 2015]

...But Current Physical Interfaces Limit Exoskeleton Performance Benefits

Exoskeleton Force Transmission Issue
- Axial limb loading → skin-tissue stretch, migration of interface [Asbeck 2013]
- Orthogonal limb loading → soft tissue compression [Pons 2010]

Exoskeleton Power Transmission Issue
- As much as 50% of power may be lost during transmission to the body [Cherry 2015] due to deformation of soft tissue and interface materials, and to relative motion of interface with respect to the body.

Advanced Interfaces could Resolve Force and Power Transmission Issues

Approach: Isolate and Quantify Human-Exoskeleton Interface Dynamics (Axial Limb Loading)

Results: Innovative Exo-Interfaces can Increase Axial Load-Bearing Capabilities

Tablet

Motion Capture

Motion Capture

Apply Axial Force to Interface

Measure the Displacement of the Interface Relative to the Body

New Exo-Interface

Prosthetic Liner + Semi-Rigid Plastic Shell

Foam Padding + Semi-Rigid Plastic Shell

Estimate of Soft Tissue Stretch (Interface Performance Limit)

Conventional Interface

Interface slipped off subject’s leg

Future: Extend Methods to Study Exoskeletons with Orthogonal Limb Loading Attachments

Actuate Individual Joints

Measure Joint Torques

Track Exoskeleton Relative to Subject via Motion Capture

Novel Interfaces could Overcome Current Limitations, Enhancing Exoskeleton Benefits by Improving Force and Power Transfer to the User