Hermes: An Ultra-Lightweight and Versatile Soft Exoskeleton for Mobility Augmentation in Communities

**Epidemiology of Knee Pain and Mobility Impairments**

Patient Populations with Knee Pain and Mobility Impairment in U.S.

- **Osteoarthritis** affects over 30 million U.S. adults.
- About 13% of women and 10% of men aged 60 years and older have symptomatic knee osteoarthritis.
- The cost of knee replacements per year > $40 billion.

**Unmet Clinical Needs**

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**Concept Generation**

- Deliver comfortable and unobtrusive assistance with textile and cable based soft exoskeleton.
- Knee extension assistance (blue) to unload the knee joint, increase weight bearing ability and reduce pain.
- Knee flexion assistance (red) to increase ground clearance.

Working with elderly adults, geriatric rehabilitation expert Prof. Mooyeon Oh-Park (MD) and rehabilitation expert Mar Cortes.

**Objectives**

- Independent and quick donning/doffing
- Ultra-Lightweight
- Comfortable
- Under garment
- Soft

**Advantage of Our Soft Exoskeleton**

- Unrestricted kinematics
- Passive assistance
- Adjustable assistance
- Imposed kinematics
- Soft Knee Exoskeleton Assistant

**Soft Exoskeleton Design**

- Our custom-designed motor has the highest continuous torque density in the similar motor radius, which brings lightweight design potential to our soft exoskeleton.

**Performance augmentation**

- Ultra-lightweight
- High torque density actuator
- Bionic Controls
- Bio-inspired cable transmission
- Textile suit
- Independent and quick donning/doffing

**Features of Hermes Exoskeleton (First Generation)**

- Total weight: 1.8 kg
- Output peak torque: 20 Nm
- Range of Motion: 127 degree
- Output peak speed: 52.3 rad/s

**Experiment Results**

- Experiments demonstrate that the exoskeleton is:
  - Conformal and unobtrusive
  - Imposes minimal kinematic constraints to the users
  - Versatile: assists walking, sit to stand, stair climbing, and standing

- Experiments Result of Our Rigid Exoskeleton

  - Foot angular velocity-based gait detection result shows the exoskeleton has good torque tracking performance. The red shaded area illustrates the torque tracking performance in 30 strides during the subject walking.