UNIVERSITÄT HEIDELBERG
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User-wearable actuated orthosis – Walking Assistance

Technology Offer

Ref. No.: 1002-22

Category

Actuated orthosis

Keywords

Exosuit, Orthosis, Soft Robotic Suit

Development stage

Working prototype

Seeking

Licensing

IP status

Application Pending

Background

This technology originates from the area of user-wearable orthoses, specifically focusing on powered, user-wearable devices designed to assist with motion. It represents a fully portable, robotic suit that aids users during walking by enhancing their mobility.

In the context of assistive wearable devices, key requirements include being lightweight, portable, and adaptable to the wearer's natural walking pattern. The presented technology successfully integrates these features, enabling a wider range of applications. For example, it can assist individuals recovering from injury or managing conditions that affect mobility. Additionally, the technology has potential use in supporting workers in physically demanding environments or enhancing performance during leisure activities.

By combining portability with adaptability, this wearable robotic suit offers significant benefits across various domains.

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Technology

The primary innovation of this technology lies in its **use of a soft, tendon-driven underactuated architecture combined with real-time gait-phase estimation**, enabling adaptive assistance to lower-limb movement with minimal hardware. This system extracts gait progression from inertial sensing and autonomously synchronizes assistance with the user's natural motion. This approach substantially reduces mechanical complexity and weight while maintaining the ability to finely modulate assistance throughout the gait cycle.

The wearable technology consists of a lightweight textile-based suit incorporating adjustable garment components, artificial tendons routed through Bowden cables, and a compact actuation and power module. Operating in parallel with the user's lower-limb joints, the system delivers assistive forces that support leg movement without restricting natural kinematics. Integrated sensors and an onboard controller compute gait phase from joint kinematics, enabling responsive, bilateral fully actuated (or underactuated) lower-limb assistance. This efficient design ensures scalable, comfortable, and dynamic assistance suitable for real-world walking.

Benefits

- The lightweight tendon-driven architecture and centralized mass distribution minimize added weight, bulk, and metabolic impact during walking.
- Increased comfort and wearability
- Real-time gait-phase estimation enables smooth, adaptive assistance that automatically synchronizes with the user's walking pattern across speeds.
- Can be easily adapted to different body shapes and sizes – modular and adjustable components

Applications

- medical device (e.g. rehabilitation)
- support in a working environment (e.g. logistics, mechanics, construction workers)
- leisure activities

Publications

- **E. Tricomi,** G. Piccolo*, F. Russo*, X. Zhang, F. Missiroli, S. Ferrari, L. Gionfrida, F. Ficuciello, M. Xiloyannis and L. Masia, "*Leveraging geometric modeling-based computer vision for context aware control in a hip exosuit*", ***IEEE Transactions on Robotics*** (2025)
- E. Tricomi, Missiroli F.*, Xiloyannis M.*, Lotti N., Zhang X., Stefanakis M., Theisen M., Bauer J., Becker C., and Masia L. "Soft robotic shorts improve outdoor walking efficiency in older adults", Nature Machine Intelligence (2024)
- E. Tricomi, M. Mossini, F. Missiroli, N. Lotti, X. Zhang, M. Xiloyannis, L. Roveda, and L. Masia, "Environment-based Assistance Modulation for a Hip Exosuit via Computer Vision" IEEE Robotics and Automation Letters (2023)
- E. Tricomi*, X. Zhang*, F. Missiroli, N. Lotti, C. Bokranz, D. Nicklas, and L.Masia, "Enhancing Gait Assistance Control Robustness of a Hip Exosuit by means of Machine Learning", *IEEE Robotics and Automation Letters* (2022)
- Tricomi, Enrica, et al. "Underactuated Soft Hip Exosuit Based on Adaptive Oscillators to Assist Human Locomotion." IEEE Robotics and Automation Letters (2021).

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