THESIS PROPOSAL
AT REHAB TECHNOLOGIES IIT-INAIL LAB

Development of a human-like walking pattern for the TWIN lower-limb exoskeleton

OVERVIEW

The Laboratory

Rehab Technologies Lab (http://rehab.iit.it/) is an innovation lab jointly created by IIT and INAIL (National Institute for Insurance against Accidents at Work) to develop new high tech robotic rehabilitation devices of high social impact and market potential. The solutions developed so far include: the CE marked poly-articulated hand prosthesis (Hannes), the upper-limb (Float) and the lower-limb (TWIN) exoskeletons, both developed in compliance with the IEC 60601-1 standard for medical devices, and a number of prototypes of lower-limbs robotic prosthesis.

Motivations and general objectives

Spinal cord injury is a critical condition which often leads to permanent disability, permanent use of wheelchair and several secondary clinical complications. In most cases, repetitive and task-oriented movements of the impaired limbs can prevent complications such as muscle atrophy and osteoporosis. In this scenario, lower-limb exoskeletons can be a valid tool for rehabilitation: they can intensify the training, allowing the patient to autonomously walk over ground, for longer duration and reproduce rhythmically correct movement patterns. The current leading products are ReWalk, Ekso and Indego.

Traditional designs of lower-limb exoskeleton use two degrees of freedom in each leg to obtain the flexion-extension of the knee and hip joints, which are generally actuated by electric motors. The possibility of parametrizing walking trajectories plays a key role in the context of rehabilitation. Therefore, we developed methods to generate customizable gait patterns, based on a basis function interpolation method [1-2].

Based on such an expertise, the aim of this thesis is to enhance the walking capabilities of the TWIN lower limb exoskeleton by developing a novel walking strategy inspired to human locomotion. The goal of this work is to define a gait pattern able to satisfy the following criteria (*S.F.P.*):

- *Safe*: the gait pattern should be feasible, stable, and reliable
- *Fast*: up to now, the TWIN exoskeleton can reach a maximum gait speed of 1 km/h. To overcome such a limit, different control strategies can be considered based on the study of human walking.
- *Physiological*: the developed gait pattern should closely mirror the natural human gait.

Proposed work plan

1) *State-of-the-art analysis of lower-limb exoskeletons walking patterns and paradigms*. As a preliminary activity for the development that will follow, a study of recent devices and the pertinent walking strategies is required.
2) *Setup of the development environment and interaction with the device*. The candidate will work in close contact with our team of roboticists and software engineers, and instructed about the correct

usage of prototype devices, in terms of safety, usability and development in order to allow her/him to operate them autonomously.

3) *Design and control of a novel human-like walking trajectory for the TWIN exoskeleton*. The activity foresees the design and the implementation of novel gait patterns for the TWIN lower-limb exoskeleton, able to match the *S.F.P* walking criteria mentioned above. The trajectory planning will be developed in MATLAB and integrated and validated in C++. The triggering strategy, used by the pilot to start each step, will be analyzed and adapted to the continuous walking paradigm.

Required skills

The student should have a solid academic background in robotics and object-oriented programming. Proved experience of MATLAB and C++ programming in academic projects is mandatory. Knowledge of Linux and Git is considered beneficial.
A good mastery of the English language is required.

Working location

Department of Rehab Technologies, IIT (Morego, Genoa, Italy)

Max number of students: 1

REFERENCES

[1] C. Vassallo, S. De Giuseppe, C. Piazzo, S. Maludrottu, G. Cerruti et al., “Gait patterns generation based on basis functions interpolation for the TWIN lower-limb exoskeleton,” in 2020 IEEE International Conference on Robotics and Automation (ICRA), 2020, pp. 1778–1784.

[2] G. Zinni, C. Vassallo, C. Piezzo, S. Scarpetta, S. Maludrottu, M. Laffranchi, L. De Michieli, “A feasibility study of trajectories based on basis functions interpolation for real-world challenges with the TWIN lower-limb exoskeleton,” *submitted* in 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)