ISTITUTO ITALIANO DI TECNOLOGIA

THESIS PROPOSAL AT REHAB TECHNOLOGIES IIT-INAIL LAB

Development of multi-body multi-physics model of 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. Motivated by this, researchers have been developing a vast range of robotics exoskeletons for spinal cord injury patients. 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 reference approach for controlling lower-limb exoskeletons in case of SCI patients consists of imposing predefined gait trajectories which are generally inspired from a healthy person and replicated by the exoskeleton.

The development of walking strategies for a lower-limb exoskeleton is a process that requires accurate benchmarking and testing before being tested on a real person. In this direction the definition of models to simulate the all the dynamics of the system is a mandatory requirement.

Given this context, the goal of this thesis is the development of a Simulink model of the actuated joints of the TWIN exoskeleton to be used as a tool to assess and compare different walking patterns. The candidate should develop the electromechanical model of the four motors of the TWIN exoskeleton and be able to simulate their dynamics considering the dynamic model of the whole device structure.

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Proposed work plans

Development of multi-body multi-physics model of the lower limb exoskeleton TWIN.
Goal: The developed simulative model of the robot should be capable of providing information about the mechanical and electrical behavior of the actual device in terms of drained current by the motors, generated trajectories and torques at the actuated joints, and in general give information about the performances without directly testing the actual exoskeleton.

1. *Phase 1.*
   The candidate will perform an initial literature review of existing lower-limb exoskeletons, while also acquiring the know-how about the lower-limb exoskeleton TWIN.
2. *Phase 2.*
   The thesis will focus on the development of a virtual simulative model of TWIN. The model will be implemented in the Simscape/Simulink environment and should include:
   a. The robotic structure of the exoskeleton including the masses, inertias and kinematic connections of all the subsystems of the device;
   b. An equivalent electro-mechanical model of the actuators of each actuated joint of the robot
   The model will be developed using a modular-iterative approach consisting of modelling the different subsystems of the robot, with a particular focus on the actuating units and the exoskeleton structure, and validating each sub-system by means of experimental tests performed on the actual device.
3. *Phase 3.*
   Once each sub-model has been correctly implemented and validated, the candidate will proceed on assembling the complete exoskeleton model and perform a set of experimental tests to compare the model performances with the actual robot ones.
4. *Phase 4 (Optional):*
   An additional value on the thesis would be given if the model will be capable also of performing predictive analysis of the robot behavior while performing unknown or untested tasks.

Required skills

The student should have a solid academic background in robotics and/or mechatronics. Proved experience of MATLAB and Simulink in academic projects is mandatory.
A good mastery of the English language is required.

Working location

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

Max number of students: 1

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REFERENCES

[1] C. Vassallo, S. De Giuseppe, C. Piezzo, 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)