Robust Estimation and Control for Robotic Rehabilitation

PhD offer in the Laboratory of Automatic Control, Mechanics, Industrial and Human Computer Science (LAMIH) — UMR CNRS 8201 and Research Center for Supervision, Safety and Automatic Control

Universities	Université Polytechnique Hauts-de-France (UPHF) and Universitat Politècnica de Catalunya (UPC)
PhD candidate in	Automatic control
Duration	3 years
Starting date	September 2024
Location	Valenciennes, France (18 months) and Barcelona, Spain (18 months)

Research context

According to a report published by the World Health Organization [2], there are an estimated 1.3 billion people who experience significant disability. This represents 16% of the world's population, or 1 in 6 of us. Rehabilitation aims to mitigate the impact of a health condition on a person's daily life by optimizing their functioning and minimizing the effects of disability. It broadens the scope of health care beyond prevention and cure, ensuring that individuals with health conditions can maintain maximum independence and actively participate in education, work, and meaningful life roles. Robotic rehabilitation presents promising benefits such as repetitive, consistently performed training over extended periods, quantitative performance analysis, reduced labor intensity, cost-effectiveness, and enhanced rehabilitation efficiency [1].

The selection of a rehabilitation robot depends on factors such as patient needs, rehabilitation type, and available resources. Cable-driven systems, in comparison to exoskeletons or rigid robotic arms, offer versatility, adaptability, and reduced weight. These systems allow variable resistance through cable tension adjustment, resulting in smoother, more natural movements during exercises [3]. Additionally, cable-driven systems can incorporate safety features like force sensors, ensuring rehabilitation exercises are conducted safely, and preventing injuries during therapy. Figure 1 depicts the main idea of this project. Based on that, this thesis will focus mainly

- How to understand human capacities. Many patient-specific parameters can affect the outcome of the treatment, which needs to be taken into consideration. The identification and estimation of variables belong to learning capabilities and will be one of the crucial points of the methodology development. Developing a tool that learns the relationships between assistance or rehabilitation methods (such as when, how much, etc.) and individual patient characteristics (including inter and intra-individual differences, age, pathology, etc.) is highly useful in enhancing the effectiveness of treatment strategies.

- To combine a biomechanical model with advanced control theory methods to control the lower limb rehabilitation device and estimation of parameters with limited measurement sensors.
- To control the device since passive to active resistance still brings open problems in control theory (switching control, shared command, robustness, fault detection). This is particularly crucial in a partially unknown environment with partially unmeasured variables.

As we delve into these aspects, the thesis aims to contribute to the field of rehabilitation robotics, ensuring not only effective rehabilitation but also the safety and well-being of individuals undergoing therapy. Real tests and empirical validation will play a key role in validating the proposed methodologies.

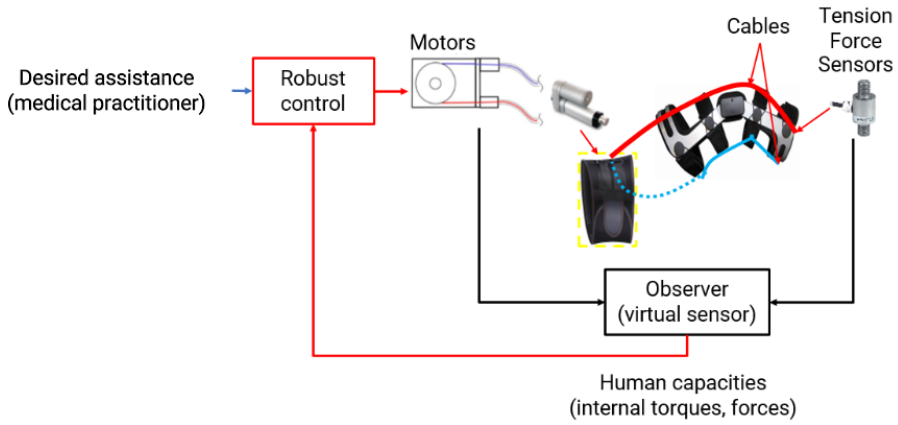

Figure 1: Cable drive orthosis scheme.

Main requirements

- Master degree or equivalent in Automatic Control, Electrical engineering, Mechanics, or Mechatronics
- Excellent background in control techniques
- Good programming skills (Matlab)
- Professional English (French and Spanish are not necessary)

How to apply

- Send your CV with 2 academic referees, a cover letter (explaining why you are interested in this offer and how you can contribute to this project), and your transcript of records for the last 3 years.
- Contacts: Márcia L. C. Peixoto (marcialuciana.dacostapeixoto@uphf.fr), Thierry-Marie Guerra (guerra@uphf.fr), and Vicenç Puig (vicenc.puig@upc.edu)

References

[1] Iñaki Díaz, Jorge Juan Gil, Emilio Sánchez, et al. Lower-limb robotic rehabilitation: literature review and challenges. *Journal of Robotics*, 2011, 2011.

[2] World HealthOrganization. Disability and health, 2023. {https://www.who.int/news-room/fact-sheets/detail/disability-and-health} [Accessed: 2023-01-31].

[3] Hao Xiong and Xiumin Diao. A review of cable-driven rehabilitation devices. *Disability and Rehabilitation: Assistive Technology*, 15(8):885–897, 2020.