Robust Control and Estimation for Cable-Driven Rehabilitation Robots

PhD offer in the e-Controls/UFAM Research Group and Laboratory of Automatic Control, Mechanics, Industrial and Human Computer Science (LAMIH UMR CNRS 8201)

Universities	Universidade Federal do Amazonas (UFAM) and Université Polytechnique Hauts-de-France (UPHF)
PhD candidate in	Automatic Control and Electrical Engineering
Duration	3-4 years
Starting date	September 2026 or March 2027
Location	Manaus, Brazil (18-30 months) and Valenciennes, France (18 months)
Closing date:	July 31, 2026

Remark: although flexible, the doctorate scheduling must begin and end in Brazil.

Research context

The emergence of Industry 5.0 has promoted a shift from fully automated systems toward human-centered cyber-physical systems, where humans and intelligent machines collaborate to achieve common objectives. In this context, cyber-physical-human systems have attracted significant attention due to their ability to integrate human decision-making, physical processes, and computational intelligence into a unified framework. Such systems are characterized by complex interactions between humans and autonomous agents, requiring robust control, estimation, and decision-making strategies to ensure safety, robustness, and efficiency.

The challenges associated with human-machine interaction in Industry 5.0 are not limited to manufacturing environments. Similar issues arise in robotic rehabilitation, where robotic devices must interact safely and effectively with patients exhibiting highly variable and uncertain behaviors. In these systems, human actions, intentions, fatigue, and physiological conditions introduce unknown inputs and time-varying dynamics that complicate both control and estimation.

Among the different rehabilitation technologies, cable-driven robotic systems have gained increasing attention due to their lightweight structure, flexibility, and inherent safety characteristics. Unlike rigid exoskeletons or conventional robotic manipulators, cable-driven systems can provide compliant assistance while reducing the mechanical burden on the user. However, these advantages come at the cost of significant control challenges arising from cable elasticity, nonlinear dynamics, actuation constraints, external disturbances, and the presence of unmeasurable human-generated forces and torques.

To address these challenges, robust control and estimation methodologies are required to ensure safe and effective operation under uncertain conditions. In particular, the development of unknown input observers, disturbance estimation techniques, and adaptive control strategies can enable the real-time estimation of human contributions and external perturbations using only measurable system outputs. By incorporating such estimates into the control loop, it becomes possible to improve trajectory tracking performance, enhance patient safety, and adapt the level of robotic assistance according to the user's condition. Therefore, the development of robust control and estimation strategies for cable-driven robotic systems represents a promising research direction at the intersection of cyber-physical-human systems, human-machine interaction, and intelligent robotics.

The main objective of this PhD is to develop robust control and estimation methodologies for cable-driven robotic systems interacting with humans, with a particular focus on rehabilitation applications. The proposed framework aims to ensure safe, adaptive, and reliable operation in the presence of uncertainties, unmeasured human inputs, and varying patient conditions.

To achieve this goal, the following specific objectives are defined:

1. **Modeling of the human-robot system considering inherent uncertainties, disturbances, and nonlinearities and incorporating biomechanical characteristics, and inter- and intra-subject variability**
2. **Design observer-based approaches for estimating unmeasurable states, external disturbances, and human-generated joint torques**
3. **Develop robust and safe control strategies capable of guaranteeing trajectory tracking and stability despite uncertainties and integrating estimated human contributions into the control loop**
4. **Validate the proposed estimation and control methodologies using the cable-driven knee rehabilitation platform**

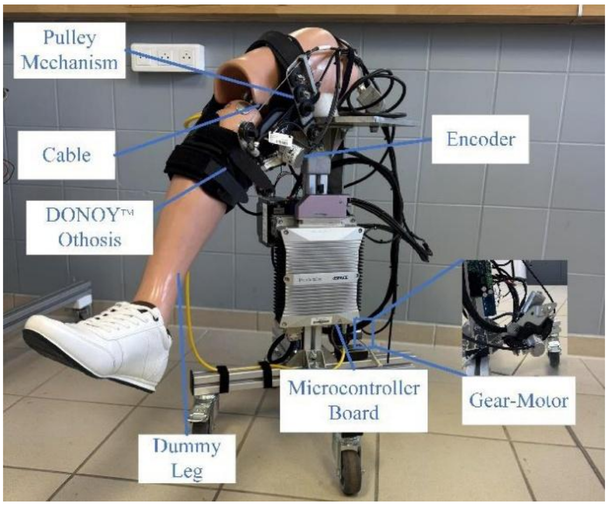

Figure 1. Experimental testbed in LAMIH/UPHF for cable-driven knee control

Main requirements

We are seeking a highly motivated and skilled candidate with:

- A Master's degree (or equivalent) in Automatic Control, Robotics, Mechatronics, or Electrical Engineering.
- A strong background in control theory, particularly nonlinear control, observer design and LPV systems.

- Excellent programming skills (e.g., MATLAB/Simulink, Python).
- A strong interest in human-robot interaction.
- Good communication skills and the ability to work in a collaborative, multidisciplinary team.
- Proficiency in English. Knowledge of French or Portuguese is not mandatory.

Supervisors

- Iury Bessa – Associate Professor (iurybessa@ufam.edu.br)
- Márcia L. C. Peixoto – Junior Professor (marcialuciana.dacostapeixoto@uphf.fr)
- Thierry-Marie Guerra – Full Professor (guerra@uphf.fr)

How to apply

Send the following documents to Iury Bessa (iurybessa@ufam.edu.br), Márcia Luciana da Costa Peixoto (marcialuciana.dacostapeixoto@uphf.fr), and Thierry-Marie Guerra (guerra@uphf.fr):

- Your CV with two academic referees;
- Recommendation letters are also welcome;
- A cover letter explaining why you are interested in this offer and how you can contribute to this project;
- Transcript of records.

References

[1] World Health Organization. Disability and health, 2023. https://www.who.int/news-room/fact-sheets/detail/disability-and-health

[2] I. Díaz, J. J. Gil, E. Sánchez, et al. Lower-limb robotic rehabilitation: literature. review and challenges. *Journal of Robotics*, 2011.

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

[4] N. U. O. Gutierrez, M. L. C. Peixoto, T. -M. Guerra, A. Dequidt, V. Puig, and S. Paganelli. Cable-Driven Knee Rehabilitation Orthosis: Design, Control, and Experimental Validation, *7th IFAC Conference on Intelligent Control and Automation Sciences*, Padova, Italy, 2025, pp. 335-340. https://doi.org/10.1016/j.ifacol.2025.12.057

[5] N. U. O. Gutierrez, T. M. Guerra, M. L. C. Peixoto, P. S. P. Pessim, A. Dequidt, S. Delprat, V. Puig, and S. Paganelli. Reference-Model-Based Control including Human Torque Estimation for Cable-Driven Rehabilitation System. *IFAC Journal of Systems and Control*. (35):100403, 2026. https://doi.org/10.1016/j.ifacsc.2026.100403