Offer #2025-08613

PhD Position F/M Identification robotique des paramètres musculaires du membre supérieur chez l'humain

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

Level of experience : From 3 to 5 years

About the research centre or Inria department

Inria is a national research institute dedicated to digital sciences that promotes scientific excellence and transfer. Inria employs 2,400 collaborators organised in research project teams, usually in collaboration with its academic partners.
This agility allows its scientists, from the best universities in the world, to meet the challenges of computer science and mathematics, either through multidisciplinarity or with industrial partners.
A precursor to the creation of Deep Tech companies, Inria has also supported the creation of more than 150 start-ups from its research teams. Inria effectively faces the challenges of the digital transformation of science, society and the economy

Context

The researcher will be part of the CAMIN team at INRIA.

The position will be funded by INRIA under the ANR B-IRD project.

The aim of this project is to develop new methods for upper-limb muscle parameters identification, using robotics platforms. The ambition is to tackle this still open issue using an innovative experimental setup and dedicated estimation and control algorithms developed in a unified framework.

The development of accurate and personalized musculoskeletal (MSK) models is essential for changing paradigms of rehabilitation and interactions involving assistive devices. Body segment inertial parameters and joint centers of rotation are important parameters, the identification of which has been vastly studied. One of the main remaining challenges is to identify the muscular part of these models parameters [1, 2].

In this project, we want to address muscle parameters identification thanks to a unique setup combining the computation of precise parameter-exciting trajectories [3, 4] and the use of robots as position and force sensors, in contact with the patient's body. Their precise kinematics and embedded force sensors make them perfect experimental platforms to quantify body motions and adapt the model's parameters based on their measurements.

We plan to develop a formulation that will combine, in a single real-time optimization problem, the estimation of the user-specific MSK parameters and the computation of the future exciting movements of the upper limb, in order to guarantee a good observability of the parameters of interest. Implemented as a combination of a sliding windowestimator [5] and a nonlinear model predictive control algorithm [6], the relevance of this approach lies in the exploitation of the fact that the same dynamical system is controlled and estimated at the same time [7]. This unified formulation will ensure the sensitivity of the variables to be estimated with respect to the control variables.

Once the MSK model has been personalized and calibrated to the subject, it can be used in conjunction with a robotic device such as an exoskeleton to assist upper limb motion [8, 9] or a cobot to provide physical therapy [10].

[1] G. Valente, L. Pitto, D. Testi, A. Seth, S. L. Delp, R. Stagni, M. Viceconti, and F. Taddei, "Are subject-specific musculoskeletal models robust to the uncertainties in parameter identification?" PLoS One , vol. 9, no. 11, p. e112625, 2014.

[2] Ackland, D. C., Lin, Y. C., & Pandy, M. G. (2012). Sensitivity of model predictions of muscle function to changes in moment arms and muscle–tendon properties: a Monte-Carlo analysis. *Journal of biomechanics*, *45*(8), 1463-1471.

[3] J. Jovic, F. Philipp, A. Escande, K. Ayusawa, E. Yoshida, A. Kheddar, and G. Venture, "Identification of dynamics of humanoids: Systematic exciting motion generation," in 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) .IEEE, 2015, pp. 2173–2179

[4] A. D. Wilson, J. A. Schultz, and T. D. Murphey, "Trajectory optimization for well-conditioned parameter estimation," IEEE Transactions on Automation Science and Engineering , vol. 12, no. 1, pp. 28–36, 2014

[5] Ceglia, A., Bailly, F., & Begon, M. (2023). Moving horizon estimation of human kinematics and muscle forces. *IEEE Robotics and Automation Letters*.

[6] M. Neunert, C. De Crousaz, F. Furrer, M. Kamel, F. Farshidian, R. Siegwart, and J. Buchli, "Fast nonlinear model predictive control for unified trajectory optimization and tracking," in 2016 IEEE international conference on robotics and automation (ICRA) . IEEE, 2016, pp. 1398–1404.

[7] M. Mukadam, J. Dong, F. Dellaert, and B. Boots, "Steap: simultaneous trajectory estimation and planning," Autonomous Robots , vol. 43, pp. 415–434, 2019

[8] Escarabajal, R. J., París, E., Petri?, T., Valera, Á., Mata, V., & Babi?, J. (2023, December). Assistive Upper-Limb Control using a Novel Measure of Human Muscular Manipulability based on Force Envelopes. In *2023 IEEE International Conference on Robotics and Biomimetics (ROBIO)* (pp. 1-8). IEEE.

[9] Quesada, L., Verdel, D., Bruneau, O., Berret, B., Amorim, M. A., & Vignais, N. (2024). EMG-to-torque models for exoskeleton assistance: a framework for the evaluation of in situ calibration. *bioRxiv*, 2024-01.

[10] Prendergast, J. M., Balvert, S., Driessen, T., Seth, A., & Peternel, L. (2021). Biomechanics aware collaborative robot system for delivery of safe physical therapy in shoulder rehabilitation. *IEEE Robotics and Automation Letters*, *6*(4), 7177-7184.

Assignment

Collaboration :

The recruited person will be in connection with other INRIA teams for the robotics experiment.

He/She will closely collaborate with a postdoc researcher already working on these topics in the team.

Main activities

Main activities:

- Literature review on the calibration of muscle models
- Formalization of a theoretical framework unifying muscle parameter estimation and robot control
- Analysis of the combined human-robot workspace (force polytope + model validity), singularities and model validity
- Communication of excitatory trajectories to the participant (work on visualising instructions)
- Participation in experimentation on valid subjects

- Dissemination of results (publications and scientific communications)

Benefits package

- Subsidized meals
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (few days per week) and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Contribution to mutual insurance (subject to conditions)

Remuneration

Gross Salary:

1st year : 2200 € per month

2nd and 3rd year : 2300 €per month

General Information

- **Theme/Domain :** Modeling and Control for Life Sciences
  Biologie et santé, Sciences de la vie et de la terre (BAP A)
- **Town/city :** Montpellier
- **Inria Center :** Centre Inria d'Université Côte d'Azur
- **Starting date :** 2024-10-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2025-07-31

Contacts

- **Inria Team :** CAMIN
- **PhD Supervisor :**
  Bailly François / francois.bailly@inria.fr

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

Warning : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

Instruction to apply

Defence Security :
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.