Offre n°2024-07304

Post-Doctoral Research Visit F/M Estimation of joint and muscular effort-generating capacities for people with neurodegenerative pathologies to assist the upper limb in everyday movements

Type de contrat : Fixed-term contract

Niveau de diplôme exigé : PhD or equivalent

Fonction : Post-Doctoral Research Visit

Niveau d'expérience souhaité : From 3 to 5 years

A propos du centre ou de la direction fonctionnelle

The Inria Centre at Rennes University is one of Inria's nine centres and has more than thirty research teams. The Inria Centre is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative PMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute, etc.Le centre Inria Rennes - Bretagne Atlantique est un des huit centres d'Inria et compte plus d'une trentaine d'équipes de recherche. Le centre Inria est un acteur majeur et reconnu dans le domaine des sciences numériques. Il est au cœur d'un riche écosystème de R&D et d'innovation : PME fortement innovantes, grands groupes industriels, pôles de compétitivité, acteurs de la recherche et de l'enseignement supérieur, laboratoires d'excellence, institut de recherche technologique

Contexte et atouts du poste

The employment context of this position is the Inria MusMaps exploratory action.

MusMapS exploits effort maps of pathological subjects to personalize the assistance of an upper limb exoskeleton by shared control. Musculoskeletal coupling - shared control for neuromuscular (myopahties) or neurodegenerative (multiple sclerosis, post-stroke, etc.) pathologies is a research challenge with high applicative potential for these patients.

This exploratory project is being carried out jointly by the Inria MimeTIC and Rainbow teams, in collaboration with the Pôle Saint Hélier and the Innovations Handicap Autonomie et Accessibilité (IH2A) chair at INSA Rennes.

Shared control has now become a benchmark in the development of assistance systems (cobots, exoskeletons) designed to partially or fully replace or assist a user's activity. Shared control refers to a collaborative and cooperative approach in which man and machine contribute to the control of a system. This enables a balance to be struck between human intuition and machine precision. In particular, robotics for the disabled has long been concerned with these issues, which require both a good interpretation of the user's intentions and the generation of a control adapted to the needs of the identified task and the user. In this project, we will be focusing on upper limb assistance systems. Many shared control strategies are based on admittance control [4]. Common applications in the context of disability are assistance with everyday tasks, such as grasping an object, opening a door, drinking... Patients suffering from neuromuscular pathologies (myopathies) or neurodegenerative diseases (Parkinson's, multiple sclerosis, age-related muscle weakness, etc.) experience a reduction in their capacity for generations of effort, but also potentially in their motor control. This individual variability means that the assistance system needs to be customized according to the level of impairment, through several operating "modes".

For the upper limb, the simplest assistance modes simply compensate for gravity by estimating the actions of gravity on the assisted limb (and therefore by estimating its joint configuration) [5]. More complex controls take into account the residual effort-generating capacities of subjects, directly adapting the level of assistance according to the task to be assisted and this estimated muscular capacity [9]. This approach is very promising, as it enables the development of personalized effort control, and allows the assistance system to be seen as a real extension of the subject's limb. However, this approach is uncommon in the literature due to the complexity of the problem posed. In particular, the use of an estimator of muscular effort generation capacities for pathological subjects has not yet been realized. It's this kind of original approach that we're considering in MusMapS.

From a methodological point of view, our first aim is to map muscular capacities by indirect measurement (mapping) of joint capacities in pathological subjects. Direct (in vivo) measurement of muscular effort-generating capacity is impossible, so methods based on isokinetic ergometer measurements have been developed. These machines, commonly used in rehabilitation, map joint effort capacity as a function of the position and speed of movement of the targeted joint. As muscles are viscoelastic actuators, and their action on the joint varies according to joint configuration, it is necessary to traverse these two dimensions for each joint. These capacities can then be exploited as they stand to represent subjects' effort generation at joint level, but also as input data to customize the muscular capacities of a musculoskeletal model [1, 3, 8]. This type of approach has never been applied to neuromuscular (myopathies) or neurodegenerative (Parkinson's, multiple sclerosis, age-related muscle weakness, etc.) pathological populations, due to the difficulty of mobilizing the subjects' upper limbs. This is one of the two major objectives of this exploratory project. Secondly, we want to use supervised learning to train a state estimator of the model representing the subject during the task. This type of approach has been proposed using surface electromyography [10], but we propose to exploit only the sensors present on the exoskeleton for this estimator (effort and IMU sensors, motor encoders), to minimize the time needed to set up, equip and adjust the exoskeleton.

[1] Brian A Garner et Marcus G Pandy. "Estimation of musculotendon properties in the human upper limb". In : Annals of biomedical engineering 31 (2003), p. 207-220.
[2] Diane Haering et al. "Using Torque-Angle and Torque–Velocity Models to Characterize Elbow Mechanical Function : Modeling and Applied Aspects". In : Journal of Biomechanical Engineering 141.8 (2019), p. 084501.
[3] Frederik Heinen et al. "Muscle–tendon unit scaling methods of Hilltype musculoskeletal models : An overview". In : Proceedings of the Institution of Mechanical Engineers, Part H : Journal of Engineering in Medicine 230.10 (2016), p. 976-984.
[4] Arvid QL Keemink, Herman van der Kooij et Arno HA Stienen. "Admittance control for physical human–robot interaction". In : The International Journal of Robotics Research 37.11 (2018), p. 1421-1444.
[5] Maxime Manzano et al. "Model-based upper-limb gravity compensation strategies for active dynamic arm supports". In : 2023 International Conference on Rehabilitation Robotics (ICORR). IEEE. 2023, p. 1-6.
[6] Antoine Muller et al. "CusToM : a Matlab toolbox for musculoskeletal simulation". In : Journal of Open Source Software 4.33 (2019), p. 1-3.
[7] Antoine Muller et al. "Non-invasive techniques for musculoskeletal model calibration". In : Congrès Français de Mécanique. 2017.
[8] Pierre Puchaud et al. "Knee torque generation capacities modelled with physiological torque-angle-velocity relationships". In : Computer Methods in Biomechanics and Biomedical Engineering 22.sup1 (2019), S286-S288.
[9] Lowell Rose, Michael CF Bazzocchi et Goldie Nejat. "A modelfree deep reinforcement learning approach for control of exoskeleton gait patterns". In : Robotica 40.7 (2022), p. 2189-2214.
[10] Benjamin Treussart et al. "Controlling an upper-limb exoskeleton by EMG signal while carrying unknown load". In : 2020 IEEE International Conference on Robotics and Automation (ICRA). IEEE. 2020, p. 9107-9113.

Mission confiée

Missions :
As part of this project, the postdoctoral fellow recruited will be tasked with conceptualizing and implementing muscle mapping in patients suffering from neurodegenerative pathologies (post-stroke, multiple sclerosis...).More specifically:
- Passage of a pathological cohort on an isokinetic ergometer:to easily carry out this experiment, we plan to propose a personal protection committee with the Pôle Saint Hélier (PSH) in Rennes, which is equipped with this type of machine and can integrate this type of measurement into clinical routine (i.e. into the systematic examination of its patients).The Pôle Saint Hélier is a rehabilitation and adaptation center in Rennes with which we have been collaborating for over 10 years on disability issues.In this exploratory approach we will include all possible pathologies, depending on patients' willingness to be included in the protocol.If we also have access to medical imaging data (EOS X-rays, MRIs), we will also use them for the for step 2 (see below).
- Joint and muscle mapping: To represent the subjects' effort-generating capacities, we want to exploit the joint mapping (torque-angle-velocity relationship) obtained from the measurement in step 1 [2], but also exploit these data to customize the parameters of a musculoskeletal model that will enable us to map effort-generating capacities more accurately and increase the data available [7, 8]. This work will be based on our library [6]. At this stage, we have no certainty as to the generalizability of the modeling and mapping results, and one of the challenges will eventually be to classify the cohort according to external factors and clinical elements.
The person recruited will be responsible for liaising and organizing manipulations with the Pôle Saint-Hélier, monitoring cohort inclusions and data processing. The person recruited will also be responsible for supervising trainees throughout the contract on the development of musculoskeletal calibration and elements of muscle mapping.

Principales activités

Main activities (5 maximum) :
- organize experiments
- monitor a cohort
- analyze data
- link data with clinical analyses
- format data for shared control of robotic system

Complementary activities (maximum 3):
- present results to patients and practitioners
- promote research through scientific articles

- collaborate with the exoskeleton development team

Avantages

- Subsidized meals
- Partial reimbursement of public transport costs
- Possibility of teleworking (90 days per year) and flexible organization of working hours
- Partial payment of insurance costs

Rémunération

Monthly gross salary amounting to 2788 euros.

Informations générales

- **Thème/Domaine :** Modeling and Control for Life Sciences
  Biologie et santé, Sciences de la vie et de la terre (BAP A)
- **Ville :** Rennes
- **Centre Inria :** Centre Inria de l'Université de Rennes
- **Date de prise de fonction souhaitée :** 2024-05-01
- **Durée de contrat :** 1 year, 6 months
- **Date limite pour postuler :** 2024-04-30

Contacts

- **Équipe Inria :** MIMETIC
- **Recruteur :**
  Pontonnier Charles / Charles.Pontonnier@irisa.fr

A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L'institut s'efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

L'essentiel pour réussir

The profile sought is as follows:

Trained biomechanist (thesis in biomechanics)
Clinical knowledge of target pathologies
Proven numerical skills (non-exhaustive list: optimization methods, musculoskeletal modeling, learning, etc.)
Ability to organize large-scale experiments with patients
Ability to communicate with multiple interlocutors (clinicians, roboticists, etc.)
Scientific English

Attention: Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

Consignes pour postuler

Please submit online : your resume, cover letter and letters of recommendation eventually

Sécurité défense :
Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

Politique de recrutement :
Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.