Offre n°2024-07468

PhD Position F/M Sensors-based Distributed Control of Multi-Drone Systems for Agile Cooperative Aerial Manipulation

Le descriptif de l'offre ci-dessous est en Anglais

Type de contrat : CDD

Niveau de diplôme exigé : Bac + 5 ou équivalent

Fonction : Doctorant

A propos du centre ou de la direction fonctionnelle

The Inria Centre at Rennes University is one of Inria's eight 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.

Contexte et atouts du poste

Conditions:

- The work will be carried in English in the Rainbow team at the Inria Rennes Bretagne Atlantique research center.
- The Ph.D. position is full-time for 3 years (standard duration in France). The position will be paid according to the French salary regulations for PhD students.
- We do high quality and impactful research in robotics, publishing on the major journals and conferences.
- We often collaborate with other top researchers in europe and worldwide.
- You will have access to a well established laboratory including:
- two flying arenas equipped with motion tracking system, several quadrotors, and a few fully-actuated manipulators,
- one robotic manipulation lab equipped with several robotic arms, like the Franka Emika Panda.
- You will be part of an international and friendly team. We organize several events, from after works, to multi-day lab retreat.
- Regular visits and talks by internationally known researchers from top research labs.

Supervisors : M. Tognon, P. Robuffo Giordano

Mission confiée

Short Abstract: This research focuses on coordinating multi-aerial robots for manipulating cable-suspended loads in industrial settings. By leveraging sensor data and distributed coordination, we aim to enhance system autonomy and efficiency. Experimental validation using a cable-driven platform will demonstrate the effectiveness of our approach, with potential applications in construction and inspection industries.

Description:

Over the past decade, there has been a surge in the exploration of aerial robots able to perform challenging physical interaction tasks. However, the inherent limitations in the payload capacity of individual drones have prompted researchers to explore the potential of **collaborative efforts among teams of aerial robots** [8]. This collaborative approach is envisioned to revolutionize various application domains, including construction, inspection, maintenance, and beyond. One of the preferred solutions to enable the aerial manipulation/transportation of objects is using cables or tethers to suspend leads to the robots (see the figure). This solution is lightweight and decouples the attitude dynamics of the aerial robots to the one of the load, which in turns increases the stability of the system.

Full pose manipulation of a cable-suspended load using multiple UAVs is a promising technique for a huge variety of future industrial applications. However, the physical interactions between UAVs, load and cables render collaborative manipulation a challenging task from both a planning and control perspective. Existing solutions have focused on one hand, on quasi-static regimes that limit the dynamic

behavior and capabilities of the system [3]. On the other hand, most solutions are centralized [1,6] or consider access to system-wide information (poses, forces, etc.) [1], which reduces the autonomy and robustness of the system and limits the applicability of these solutions to relevant real-world scenarios.

Research Objectives: The primary objective of this Ph.D. thesis is to explore **sensor-based and distributed coordination strategies for multi-aerial robot systems with cable-suspended loads**, facilitating collaborative object manipulation and transportation through local interactions. Distributed solutions pose particular challenges, especially when addressing communication constraints among the robots. The objective is then to consider hierarchical strategies where robots communicate at a low frequency and coordinate at a higher/planning level, subsequently executing the plan through local implicit communication based on sensor-based feedback such as vision and/or force sensing.

Related references:

1.
    1. S. Sun and A. Franchi, "Nonlinear MPC for Full-Pose Manipulation of a Cable-Suspended Load using Multiple UAVs," 2023 International Conference on Unmanned Aircraft Systems (ICUAS), Warsaw, Poland, 2023, pp. 969-975.
    2. Sanalitro, D. (2022). Aerial Cooperative Manipulation: full pose manipulation in air and in interaction with the environment (Doctoral dissertation, INSA de Toulouse).
    3. D. Sanalitro, H. Savino, M. Tognon, J. Cortés, and A. Franchi "Full-pose manipulation control of a cable-suspended load with multiple UAVs under uncertainties". IEEE Robotics and Automation Letters, 2020,5(2), 2185-2191.
    4. C. Gabellieri, M. Tognon, D. Sanalitro and A. Franchi, "Force-Based Pose Regulation of a Cable-Suspended Load Using UAVs with Force Bias," 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Detroit, MI, USA, 2023, pp. 6920-6926.
    5. N. de Carli, P. Salaris, P. Robuffo Giordano. Multi-Robot Active Sensing for Bearing Formations. MSR 2023 - IEEE International Symposium on Multi-Robot & Multi-Agent Systems, Dec 2023, Boston (MA), United States. pp.1-7.
    6. L. Guanrui, and G. Loianno. "Nonlinear Model Predictive Control for Cooperative Transportation and Manipulation of Cable Suspended Payloads with Multiple Quadrotors." arXiv preprint arXiv:2303.06165 (2023).
    7. A. Ollero, M. Tognon, A. Suarez, D. J. Lee, and A. Franchi. `` Past, present, and future of aerial robotic manipulators." IEEE Trans. on Robotics, 2021.
    8. S., Ola, and M. Schwager. "Distributed Model Predictive Control via Separable Optimization in Multi-Agent Networks." IEEE Transactions on Automatic Control (2023).
    9. L. Peric, Brunner, M., Bodie, K., M. Tognon, and Siegwart, R., "Direct Force and Pose NMPC with Multiple Interaction Modes for Aerial Push-and-Slide Operations", in 2021 IEEE Int. Conf. on Robotics and Automation, Xi'an, China, 2021

Principales activités

Envisaged Activities:

Envisioned solutions will build upon existing centralized or kinematic results [2,3] and communication-less regulation approaches [4] to propose a fully **sensor-based**, **dynamics-based**, and **distributed** framework for *collaborative agile manipulation of cable-suspended loads*. For the control side, a starting point are the existing centralized approaches based on Model Predictive Control (MPC) for single- [9] and multi-aerial robots [1,6]. Our team has undertaken preliminary work exploring the extension of [1] through a distributed MPC solution based on [9], initially at a kinematic level. Should this endeavor yield promising results, a potential trajectory involves advancing the algorithm to operate at a dynamic level. For the sensing side, the starting point will be the works on sensor-based collaborative global state estimation for multi-robot systems such as [5].

Experimental validation: The devised coordination strategies for the manipulation and transportation of cable-suspended loads will undergo thorough validation and testing using the cable-driven platform, shown in the figure, already present at Rainbow.

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 2082 euros for the first and second years and 2190 euros for the third year

Informations générales

- **Thème/Domaine :** Robotique et environnements intelligents
- **Ville :** Rennes
- **Centre Inria :** Centre Inria de l'Université de Rennes
- **Date de prise de fonction souhaitée :** 2024-01-01
- **Durée de contrat :** 3 ans

- **Date limite pour postuler :** 2024-06-15

Contacts

- **Équipe Inria :** RAINBOW
- **Directeur de thèse :**
  Tognon Marco / marco.tognon@inria.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

Requirements:

- M.Sc. degree in mechatronics, robotics, engineering, computer science (or related fields)
- Excellent written and spoken English skills
- Good experience in C/C++ , ROS, Matlab/Simulink, CAD
- Good experience with numerical trajectory optimization tools for robotics (e.g., use of CaSaDi, Acado, Autodiff, Crocoddyl, etc.)
- Scientific curiosity, large autonomy and ability to work independently
- Experience with visual sensors and visual perception for robotics is a plus
- Experience with robotic systems and/or aerial robots is a plus

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.