Offre n°2025-09131

PhD Position F/M Hardware Acceleration for Unmanned Aerial Vehicle Control Algorithms

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 Rennes - Bretagne Atlantique Centre is one of Inria's eight centres and has more than thirty research teams. The Inria Center 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

Disclaimer

A PhD is not a continuation of coursework or a natural next step after a Master's degree. **A PhD is** a long-term, research-focused **commitment** that requires deep **curiosity**, **self-motivation**, **resilience**, and a certain degree of **autonomy**.

By research, we mean **creating new knowledge**, not just applying existing theories. Your task is to discover, design, or prove something that no one has done before—work that will become what future students study.

If you are mainly looking for structured classes, predefined assignments, or a repeat of your Master's experience, you will likely find this path **unfulfilling**. We welcome applications from candidates who are **excited by uncertainty**, driven to ask **original questions**, and eager to shape the frontier of their field.

Context & background:

Robots are physical agents that interact with their physical environment. Accordingly, their sensorimotor capabilities are essential and largely determine the activities that robots can perform. In recent years, great progress has been made in

sensory capabilities thanks to significant advances in machine learning and dedicated hardware. In contrast, much less progress has been made in motor skills. Examples of promising approaches in the current scientific literature are Model Predictive Control (MPC) [1] and Model Predictive Path Integral (MPPI) control [2], where control actions are optimized over a finite time horizon, considering the time evolution of robot dynamics to optimize a given cost or reward function that describes the robot motion. Such algorithms are particularly suited for **optimizing control trajectories and planning horizons in real time** due to their ability to handle dynamic environments.

From a control perspective, **planning a horizon that is as long as possible** to manage complex trajectories while considering the environment is essential. Additionally, maintaining **a high control frequency** is crucial to meet the **real-time** demands imposed by real-world physics and, if necessary, to adjust the sequence of movements. In the **resource-constrained context of small-scale UAVs**, such control algorithms are crucial as they enable **optimal trajectory generation and real-time decision-making** in complex, dynamic, and uncertain environments. However, particularly for **battery-powered UAVs**, achieving a high control frequency while planning for a long horizon is difficult due to limited computational power and energy constraints [3], and conventional GPU acceleration often requires excessive energy consumption.

In recent years, **hardware acceleration** [4] has become increasingly popular, using **dedicated platforms** such as **FPGAs** (Field Programmable Gate Arrays) and **ASICs** (Application-specific Integrated Circuits)**,** increasing energy efficiency by **orders of magnitude** [5]. However, **dedicated hardware acceleration for small-scale UAV control has not been proposed**.

The PhD is in collaboration between the computer architecture team (TARAN) and the robotics team (RAINBOW) at Inria Centre at Rennes University.

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[1] E. F. Camacho and C. Bordons, Model Predictive control. in Advanced Textbooks in Control and Signal Processing. London: Springer, 2007. doi: 10.1007/978-0-85729-398-5.
[2] G. Williams, P. Drews, B. Goldfain, J. M. Rehg, and E. A. Theodorou, “Aggressive driving with model predictive path integral control,” in 2016 IEEE International Conference on Robotics and Automation (ICRA), May 2016, pp. 1433–1440. doi: 10.1109/ICRA.2016.7487277.
[3] K. Nguyen, S. Schoedel, A. Alavilli, B. Plancher, and Z. Manchester, “TinyMPC: Model-Predictive Control on Resource-Constrained Microcontrollers,” in 2024 IEEE International Conference on Robotics and Automation (ICRA), May 2024, pp. 1–7. doi: 10.1109/ICRA57147.2024.10610987.
[4] W. J. Dally, Y. Turakhia, and S. Han, “Domain-specific hardware accelerators,” Commun ACM, vol. 63, no. 7, pp. 48–57, Jun. 2020, doi: 10.1145/3361682
[5] J. L. Hennessy and D. A. Patterson, “A new golden age for computer architecture,” Commun ACM, vol. 62, no. 2, pp. 48–60, Jan. 2019, doi:

10.1145/3282307.

Mission confiée

This Ph.D. thesis aims to use **algorithm-specific custom hardware acceleration** to implement **efficient real-time control for UAVs** with **long prediction horizons** and **high control frequencies**. The structure of the control algorithms is complex and sensitive to numerical errors or reduced arithmetic precision. Thus, applying a **hardware-algorithm Co-design** approach is necessary, i.e., adapting **the control algorithms to the hardware** and **designing the hardware to suit the control algorithms optimally.**

Principales activités

After a detailed study of UAV state-of-the-art control algorithms, the student will identify HW acceleration opportunities, such as **parallelization**, **pipelining**, and **data specialization**. The student will apply **co-design** approaches to realize efficient accelerators, utilizing the control algorithms' properties to improve the hardware while adjusting the algorithms to the hardware's characteristics. **Simulations** will be carried out to validate the proposed approaches and prepare the final **integration in the UAV platform**, which is already available to the RAINBOW team.

Compétences

Required technical skills:

- Good knowledge of **computer architectures** and **embedded systems**
- **HW design**: VHDL/Verilog basics, HW synthesis flow
- **Programming** knowledge (C/C++, python)
- Experience in **HW/SW co-design** and **robotics** is a plus

Candidates must have a Master's degree (or equivalent) in **Computer Engineering or related areas relevant to the PhD topic**

Languages: proficiency in written English and fluency in spoken English are required.

Relational skills: the candidate will work in a research team, where regular meetings will be set up. The candidate has to be able to present the progress of their work in a clear and detailed manner.

Other values appreciated are open-mindedness, strong integration skills, and team spirit.

Most importantly, we seek highly motivated candidates.

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 2200 euros

Informations générales

- **Thème/Domaine :** Architecture, langages et compilation
- **Ville :** Rennes
- **Centre Inria :** Centre Inria de l'Université de Rennes
- **Date de prise de fonction souhaitée :** 2025-10-01
- **Durée de contrat :** 3 ans
- **Date limite pour postuler :** 2025-09-15

Contacts

- **Équipe Inria :** TARAN
- **Directeur de thèse :**
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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'e?orce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

L'essentiel pour réussir

Candidates with knowledge and experience in at least one of the following areas are **highly valued**: **Hardware Design, Hardware/Software co-design,** and **Robotics fundamentals.**

We seek **highly motivated and passionate** candidates. **Autonomy** is a highly appreciated quality.

Essential qualities to fulfill a PhD thesis are feeling at ease in an environment of scientific dynamics and wanting to **learn**, **listen**, **share**, and **work in the unknown**. There is no clear and definite answer, and often no clear-cut notion of “right” or “wrong” until the scientific community has weighed in. Expect long, probing discussions with your advisor, lab-mates, conference audiences, reviewers, and peers who may challenge or disagree with you. Debate is part of the process.

Candidates must have a Master’s degree (or equivalent) in **Computer Engineering or related areas relevant to the PhD topic**

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

For more information, please contact marcello.traiola@inria.fr

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.