Offer #2023-05741

Post-Doctoral Research Visit F/M Post-Doctorant - Multi-robot formation control for collaborative SLAM

Renewable contract : Yes

Level of qualifications required : PhD or equivalent

Fonction : Post-Doctoral Research Visit

Level of experience : Recently graduated

About the research centre or Inria department

The Inria Université Côte d'Azur center counts 36 research teams as well as 7 support departments. The center's staff (about 500 people including 320 Inria employees) is made up of scientists of different nationalities (250 foreigners of 50 nationalities), engineers, technicians and administrative staff. 1/3 of the staff are civil servants, the others are contractual agents. The majority of the center's research teams are located in Sophia Antipolis and Nice in the Alpes-Maritimes. Four teams are based in Montpellier and two teams are hosted in Bologna in Italy and Athens. The Center is a founding member of Université Côte d'Azur and partner of the I-site MUSE supported by the University of Montpellier.

Context

Environment:

This Post-doc subject is proposed in the context of the ROAD-AI Challenge involving the Cerema and the Inria Team ACENTAURI.

ACENTAURI is a robotic team located in Sophia Antipolis that studies and develop intelligent, autonomous and mobile robots that collaborate between them to achieve challenging tasks in dynamic environments. The team tackle perception, decision and control problems for multi-robot collaboration by proposing an original hybrid model-driven/data driven approach to artificial intelligence and by studying efficient algorithms. The team focus on robotic applications like environment monitoring and transportation of people and goods. In these applications, several robots will share multi-sensor information eventually coming from infrastructure. The effectiveness of the proposed approaches are demonstrated on real robotic systems like cars AGVs and UAVs together with industrial partners.

Non Destructive Evaluation of Structures and Materials (ENDSUM), directed by Cyrille FAUCHARD, has for main objective to contribute to the development of tools and methods of characterization and diagnosis with great efficiency, less invasive than the current tools and not altering the environments auscultated to meet the challenges of Asset Management of Infrastructures (IPM). The research carried out is aimed first of all at the physical and geometric characterization of environments using a multi-parameter, multi-scale and multi-physical approach linking the quantities measured to indicators useful for the diagnosis and monitoring over time of the environments observed. ENDSUM also aims at the development of analytical and numerical modeling, inversion and data processing and analysis methods (signals, images) allowing access to the desired physical and geometric properties. Finally, ENDSUM aims to develop innovative prototype software and hardware as well as tools for training, research and expertise.

Context:

The infrastructures (road network, bridges, buildings, ...) are among the most important elements of the public heritage. Operators are responsible for maintaining, operating, developing, replacing and preserving this heritage while ensuring careful management of budgetary and human resources. Today, these infrastructures are put to the test by climate change (increase in the frequency of extreme phenomena which in particular favor floods and land movements). Users are also extremely attentive to questions of safety and comfort related to the use of infrastructure but also to environmental issues relating to their construction and maintenance.

The ROAD-AI Challenge objective is to design a multi-robot system comprising ground vehicles and aerial drones collaborating in the collection of data on structures with on-board sensors. Aerial drones seem to be a very promising solution for data acquisition because they can have points of view not obscured by obstacles and access structures more easily. On the other side, the ground vehicle seems better appropriated to supervise the mission of data acquisition for environment exploration and mapping.

Assignment

In this Postdoc, we want to study active strategies of data acquisition involving a master robot (the ground vehicle) and two slave robots (aerial robots) in order to optimize in terms of accuracy and stability the mapping of the environment. Each robot will be equipped with its own large field vision with a time stamping. We assume also that synchronized velocity control inputs can be sent to the ground and aerial robots. The master robot centralizes the information and manages the multi-robots formation. One robot of the formation, so-called the leader (not necessary the master) is manually driven by a human operator who ensures the completness of the exploration of the scene.

The first scientific problem we want to deal with in this Postdoc will be to guarantee a stable structure of the robot formation in the reference frame of the master robot. The choice of an optimal structure of the formation will be directed by the task objectives (i.e., exploration context, optimization of the map acquisition...). Recent works on Cooperative Multi-Robots Systems [1],[2],[3],[4],[5],[6] will be used to organize and to manage the formation taking into account the navigability constraints. Considering that each robot can be observed by at least one of the other, we intend to realize and to control the formation by means of sensor-based control and visual servoing techniques [7], [8].

The second scientific concern will be to investigate how we can use the constraints induced by the formation to stabilize the ill-posed problem of SLAM (Simultaneous Localization and Mapping). SLAM is a key problem in mobile robotic which consists of exploiting the observation of the environment for conjointly estimating the robot's trajectory and building a map of the environment [9],[10], [11]. Basically, the robot's trajectory is built thanks to an odometry method integrating an estimate of the displacement. As result, we observe a drift in the trajectory leading to a distorted map. A classical solution to minimize this drift and to correct the distortion is the use of closed loop methods based on the re-observation of landmarks and a backpropagation of the drift along the trajectory [12],[13]. To be efficient a sufficient large number of landmarks dispatched all along the trajectory have to be re-observed. Considering the constraints introduced by the structure of formation described above, it seems possible to formulate a SLAM problem for collaborative robots as a global optimization problem involving the trajectories of the different robots AND the constraints due to the structure of the formation. In such a case, we expect to largely simplify or, maybe to eliminate, the problem of drift and the need of closed loop methods.

The system will be evaluated on Inria robots on a structure known to the Cerema services, for which the civil engineering service will be requested. For the experimental evaluation, the candidate will work in close collaboration with a PhD student and an R&D engineer who will be in charge of the implementation of the multi-robot system.

Reference:

[1] D. Koung, O. Kermorgant,I. Fantoni, L. Belouer. « Cooperative Multi-Robot Object Transportation System Based on Hierarchical Quadratic Programming", June 2021.IEEE Robotics and Automation Letters PP(99):1-1.

[2] G. Arechavaleta, A. Morales-Díaz, H. M. Pérez-Villeda, and M. Castelán "Hierarchical Task-Based Control of Multirobot Systems With Terminal Attractors", Control Systems Technology, IEEE Transactions on 25(1):1-8, April 2016.

[3] Two-layers Workspace: A New Approach to Cooperative Object Transportation with Obstacle Avoidance for Multi-Robot System. January 2022, IEEE Access PP(99):1-1.

[4] L. Zhang, Y. Sun, A. Barth and O. Ma. "Decentralized Control of Multi-Robot System in Cooperative Object Transportation Using Deep Reinforcement Learning", January 2020.

[5] G. Lozenguez, L. Adouane, A. Beynier, Abdel-Illah Mouaddib, P. Martinet. Punctual versus continuous auction coordination for multi-robot and multi-task topological navigation, Autonomous Robot (2016) 40:599–613.

[6] D. Koung, I. Fantoni, O. Kermorgant and L. Belouaer. Consensus-based formation control and obstacle avoidance for nonholonomic multi-robot system, International Conference on Control, Automation, Robotics and Vision (ICARCV) December 13-15, 2020. Shenzhen, China.

[7] S. A. Hutchinson, G. D. Hager, and P. I. Corke. A tutorial on visual servo control. IEEE Trans. Robot. Automat., 12(5):651--670, Oct. 1996.

[8] E. Malis and P. Rives. "Robustness of image-based visual servoing with respect to depth distribution errors". In IEEE International Conference on Robotics and Automation, September 2003.

[9] R. Mur-Artal and J. D. Tardós, "ORB-SLAM2: An Open-Source SLAM System for Monocular, Stereo, and RGB-D Cameras," in *IEEE Transactions on Robotics*, vol. 33, no. 5, pp. 1255-1262, Oct. 2017.

[10] Georg Klein and David Murray, "Parallel Tracking and Mapping for Small AR Workspaces"
In Proc. International Symposium on Mixed and Augmented Reality (ISMAR'07, Nara).

[11] M. Meilland, A. Comport, and P. Rives. "Dense omnidirectional rgb-d mapping of large-scale outdoor environments for real-time localization and autonomous navigation". Journal of Field Robotics, 32(4):474–503, 2015.

[12] Kin Leong Ho, P. Newman. "Loop closure detection in SLAM by combining visual and spatial appearance", Robotics and Autonomous Systems 54 (2006).

[13] A. Chapoulie, P. Rives, D. Filliat. "A spherical representation for efficient visual loop closing."
International Conference on Computer Vision Workshops (ICCV Workshops) , 2011.

Main activities

The work will be broken down into stages as follows:

- Bibliography on Visual Servoing, mission planning for collaborative robots, SLAM techniques, nonlinear optimization
- Implementation of the most efficient state-of-the-art techniques
- Study and implementation of a robot's formation specification and control using visual servoing
- Study and implementation of a collaborative SLAM scheme
- Comparison with state-of-the-art localization techniques
- Validation with remotely operated robots (not autonomous)
- Writing articles for international conferences and journals, writing project reports

Skills

The candidate should preferably have a PhD in Robotics, solid foundations in software development (C / C ++, Python, LINUX, ROS, Git, OpenCV). He / she should also be endowed with a strong passion for multidisciplinary studies and all aspects of research ranging from fundamental work to experimental work. Finally, a good level in read / written / spoken English is also important.

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- 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 (after 6 months of employment) 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
- Social security coverage

Remuneration

Gross Salary: 2746 € per month

General Information

- **Theme/Domain :** Robotics and Smart environments
  Scientific computing (BAP E)
- **Town/city :** Sophia Antipolis
- **Inria Center :** Centre Inria d'Université Côte d'Azur
- **Starting date :** 2023-04-01
- **Duration of contract :** 1 year, 6 months
- **Deadline to apply :** 2023-07-31

Contacts

- **Inria Team :** ACENTAURI
- **Recruiter :**
  Malis Ezio / Ezio.Malis@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.