Offre n°2024-07552

PhD Position F/M [DOCT2024-ACENTAURI] Efficient polynomial systems solvers for large scale robotic problems

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 Université Côte d'Azur includes 37 research teams and 8 support services. The centre's staff (about 500 people) is made up of scientists of different nationalities, engineers, technicians and administrative staff. The teams are mainly located on the university campuses of Sophia Antipolis and Nice as well as Montpellier, in close collaboration with research and higher education laboratories and establishments (Université Côte d’Azur, CNRS, INRAE, INSERM ...), but also with the regiona economic players.

With a presence in the fields of computational neuroscience and biology, data science and modeling, software engineering and certification, as well as collaborative robotics, the Inria Centre at Université Côte d'Azur is a major player in terms of scientific excellence through its results and collaborations at both European and international levels.

Contexte et atouts du poste

ACENTAURI is a robotic team that studies and develop intelligent, autonomous and mobile robots that can help humans in their day-to-day lives at home, at work or during their displacements. The team focuses on perception, decision and control problems for multi-robot collaboration by proposing an original hybrid model-driven / data driven approach to artificial intelligence and by proposing efficient algorithms for real-time solution of large scale problems. The team focuses on robotic applications in smart territories, smart cities and smart factories. In these applications several collaborating robots will help humans by using multi-sensor information eventually coming from infrastructure. The team demonstrates the effectiveness of the proposed approaches on real robotic systems like cars AGVs and UAVs together with industrial partners. Innovation and the transfer of the research work towards industrial partners are a concern of ACENTAURI.

Mission confiée

Many perception and control problems in robotics are solved as the optimization of a non-linear cost function [14]. In general a "closed form" solution (a solution that can be expressed analytically in terms of a finite number of certain simple operations) for such problems does not exists and we need to use iterative method like Gradient Descent, Newton or Gauss-Newton [6] or more efficient second order methods [13]. These methods needs an initial starting point to compute a solution and may fall in a local minimum. Unfortunately, such knowledge of a good starting point close to the global minimum is usually unavailable a priori. To solve this problem numerical continuation methods [1] has become one of the standard techniques to find the global minimum. It has been successfully used for finding the solution of a system of polynomial equations [4].

In this PhD we will focus on the optimization of polynomial cost functions since the number of equilibrium points (global minimum, local minima, saddle points) can be deterministically numbered. Indeed, when the cost function is a polynomial function the optimal solution can be obtained by solving a polynomial system of equations [5]. For such problems, we can find a "closed form" using only standard linear algebra operations: matrix decomposition (LU, QR, SVD, ...), eigenvalues and eigenvector computations, etc. Many of the state-of-the-art specific polynomial
systems solvers are based on Grobner bases and the action-matrix method [5]. There are now powerful
tools available for the automatic generation of efficient Gröbner basis solvers for [8, 9, 11]. Such methods
work extremely well for problems of reasonably low degree, involving a few variables. Currently, the limiting factor in
using these methods for larger and more demanding problems are numerical difficulties. When considering larger
problems numerical stability is still an issue [3]. Another approach to polynomial system solution based on
generalization of the homogeneous resultant introduced by Macaulay [12] to multivariate homogeneous polynomials.
Resultant based approaches [2, 16] can be divided into u-resultant where an additional equation is added to the
system of h-resultant where one of the unknown is hidied in the coefficients. In both cases the solution is found by
computing the eigenvalues (u-resultant) or the generalized eigenvalues (h-resultant) of matrices which size (and
computation time) depends on the number of unknowns and the degree of the polynomials. For sparse polynomial
systems it is possible to obtain more compact resultants using Sparse Resultants [7, 17]. Further improvements in
efficiency can be obtained considering symmetries in the polynomials [10].

The main objective of this PhD is to study and design efficient solvers for large scale polynomial system of
equations that have the property of being computed in real-time (typically few milliseconds) while providing sufficiently
accurate solution closed to the global minimum that may be refined by non-linear iterative methods. Indeed,

extremely precise (but costly to compute) solution are often not needed in real-time applications and somehow unnecessary
since the cost functions we need to optimize are generated with imperfect models. Therefore, another
objective of this PhD is to study the best compromise between accuracy and efficiency. An approximate
solution not “too far” from the true one but computed in real-time is preferable to a precise solution computed
too late. It would be interesting to find a way to have a parameter in the algorithm regulating this trade-off. Finding the solver
which yields that smallest template or the best numeric result is a difficult problem. Some heuristic that usually
works well in practice have been proposed in [9]. A complete study and analysis of computational
requirements of different algorithms will be carried out building new benchmarks. We will consider estimation and
control problems using data acquired by vision and lidar sensors [15]. The algorithms will be implemented in C/C++ for
real-time experiments with data acquired by the ACENTAURI robots.

References

multivariate polynomial equations. In Proc. of The IEEE International Conference on Numerical
Association for Computing Machinery.
Computer Vision, 2016.
Conference on Computer Vision and Pattern Recognition, 2018.
Principales activités

The work will be decomposed with incremental steps as follows:

- Bibliography on polynomial systems solvers
- Implementation of the more efficient state of the art algorithms
- Design of new efficient algorithms and implementation
- Comparison with the state of the art techniques
- Experimental results on real data
- Writing of reports and conference papers
- Improvement on the algorithms
- Development of a C/C++ library for real-time applications
- Real-time experimental results on real data and new benchmarks
- Writing Phd Thesis and journal papers

Examples of activities:

- Analyse the requirements of {partners, clients, users}
- Propose **** solutions for ****
- Develop programs/applications/interfaces of ****,****
- Design experimental platforms ****
- Write documentation
- Write reports
- Write ****
- Test, change up until validation
- Distribute the *** * to **** via ****
- Provide user training for the service’s main clients
- Lead a user community
- Present the works’ progress to partners, ****to an audience of financiers ****
- Other ****

Compétences

The candidate is expected to have a Master in Applied Mathematics, as well as solid skills in software development (LINUX, Git, MATLAB, MAPLE, C/C++). A good level of written/spoken English is also important.

Avantages

- 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

Rémunération

Duration: 36 months
Location: Sophia Antipolis, France
Gross Salary per month: 2100€ brut per month (year 1 & 2) and 2190€ brut per month (year 3)
Informations générales

- Thème/Domaine : Robotique et environnements intelligents
- Calcul Scientifique (BAP E)
- Ville : Sophia Antipolis
- Centre Inria : Centre Inria d'Université Côte d'Azur
- Date de prise de fonction souhaitée : 2024-11-01
- Durée de contrat : 3 ans
- Date limite pour postuler : 2024-04-28

Contacts

- Équipe Inria : ACENTAURI
- Directeur de thèse : Malis Ezio / Ezio.Malis@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

He/she must be highly motivated for multidisciplinary studies and all aspects of research ranging from fundamental theory to applications.

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

Before applying, it is strongly recommended that you contact the Scientific manager beforehand.

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.