Offer #2024-07786

PhD Position F/M Forming carbon fiber fabrics by visual servoing

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Other valued qualifications : Research Master2

Fonction : PhD Position

About the research centre or Inria department

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.

Context

As part of the PERFORM program, IRT Jules Verne and the Rainbow team of the Inria centre at Rennes University are offering a PhD thesis entitled “Forming carbon fiber fabrics using visual servoing”.

Thesis location: The thesis work will take place in Rennes, within the Rainbow team of the Inria centre at Rennes University.

Supervisors: Alexandre Krupa (Inria, Rainbow team), Benyamine Allouche (IRT Jules Verne, ROC team)

Contract:

- The selected candidate will be employed by IRT Jules Verne (3-year fixed-term contract).
- The remuneration proposed by the IRT for the 3-year thesis is as follows:
  - 1st and 2nd year: €31,125 per year, i.e. €2,593.75 per month
  - 3rd year: €32,816 per year, i.e. €2,734.66 per month
  - the PhD student will also receive lunch vouchers worth 9.8€ / day worked, of which 5.88€ will be paid by the IRT.

Assignment

Context:

The manipulation of rigid objects by robotic devices has been studied for many decades and is currently commonly performed in robotic tasks where the environment is controlled, such as in an automated production line. Conversely, few research works have focused on the manipulation of deformable objects made of soft material. Providing robots with the capability to interact with deformable objects is therefore an important challenge for robotics to enable robots to precisely manipulate compliant objects. To meet this challenge, the IRT Jules Verne, in association with the Rainbow team from the INRIA center at the University of Rennes, has launched a thesis entitled **“Forming carbon fiber fabrics using visual servoing”** as part of the PERFORM program.

The application context of this thesis specifically targets manufacturing robotics. The targeted application is the automatic positioning of a carbon fiber fabric in a concave-shaped mold to facilitate the manufacturing process of composite material parts. This step of the process, which involves positioning the fiber fabric in the mold, is currently done manually. It requires shaping the fabric with an optimal orientation of its fibers to ensure that the manufactured part obtains very good mechanical properties, including high resistance to stress in desired directions.

Description:

The main objective of this PhD thesis is to develop a robotic control approach to manipulate a flexible planar object (a carbon fiber fabric) to apply a desired shape curvature to it. The general idea is to use visual feedback provided by a camera to estimate and track in real-time the deformations of the object of interest and to develop a visual servoing control approach to control multiple robotic manipulators to autonomously apply a desired deformation to the object. This active deformation control would enable the implementation of new robotic applications such as automatic forming of a fiber fabric, which is particularly targeted in this thesis.

To control the deformation of a soft object, it is necessary to understand how the movements of the robotic manipulators translate into deformation of the manipulated object. This relationship can be estimated from previous visual observations using data-driven approaches [1-2] or expressed by a physical model of the object such as the finite element model (FEM) [3] or the mass-spring model (MSM) [4-5].

In order to link the movements of the robotic manipulators to the deformations of the object of interest, we aim in this thesis work to develop a new visual servoing control strategy based on an approximate interaction model, thus overcoming the need for complex modeling of the object and pre-identification of its rheological parameters.

Another aspect of the thesis work will involve the development of an image processing method to track in real-time the deformation of the fiber fabric from the data stream provided by one or more RGB-D camera(s).

The proposed methods will be developed, tested, and validated on an experimental setup consisting of one or more RGB-D camera(s), multiple 6-degrees-of-freedom robotic arms, multiple carbon fiber fabric samples, and a mold.

References:

[1] D. Navarro-Alarcon, Y. Liu, J.G. Romero, and P. Li. On the visual deformation servoing of compliant objects: Uncalibrated control methods and experiments. The International Journal of Robotics Research, 33(11):1462– 1480, September 2014.

[2] R. Lageau, A. Krupa, M. Marchal. Automatic Shape Control of Deformable Wires based on Model-Free Visual Servoing. IEEE Robotics and Automation Letters (also presented at IROS'20), 5(4):5252-5259, October 2020.

[3] F. Ficuciello, A. Migliozzi, E. Coevoet, A. Petit and C. Duriez, "FEM-Based Deformation Control for Dexterous Manipulation of 3D Soft Objects," In IEEE/RSJ Int. Conf.on Intelligent Robots and Systems, IROS'18, Pages 4007-4013, Madrid, Spain.

[4] F. Makiyeh, F. Chaumette, M. Marchal, A. Krupa. Shape Servoing of a Soft Object Using Fourier Series and a Physics-based Model. In IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, IROS'23, Pages 6356-6363, Detroit, USA, October 2023.

[5] F. Makiyeh, M. Marchal, F. Chaumette, A. Krupa. Indirect Positioning of a 3D Point on a Soft Object Using RGB-D Visual Servoing and a Mass-Spring Model. In Int.Conf. on Control, Automation, Robotics and Vision, ICARCV'22, Singapore, December 2022.

Main activities

- Produce a state-of-the-art report on the manipulation of deformable objects.
- Implement a strategy for interaction and manipulation of deformable objects (design of the effector / definition of the perception system).
- Model object deformation as a function of grasping point displacements.
- Develop a visual deformation tracking algorithm based on RGB-D camera data.
- Develop a visual servo-control method based on model 3) to apply a desired deformation to the object.
- Define an experimental protocol, acquire data and reconstruct/model deformable objects using meshes.
- Validate results on a use case defined by IRT Jules Verne.
- Follow the capitalization process of the IRT Jules Verne ROC team.
- Present work progress at the annual PERFORM seminar organized by IRT Jules Verne.
- Write scientific articles and thesis manuscript.
- Thesis defense.

Skills

Skills required:

Knowledge:

- In-depth knowledge in control theory, robotics and computer vision.
- Solid experience in C++, Python and ROS.
- Experience in visual servoing and 3D visual perception with RGB-D camera would be appreciated.
- Proficiency in one of the CAD tools.
- English level B2 spoken and written.

Know-how:

- Rigorous analysis.
- Ability to synthesize.
- Good scientific writing and communication skills.

Personal skills:

- The person recruited must be dynamic, curious, open-minded, autonomous, have initiative and be a team player.

- A keen interest in robotic experimentation.

Benefits package

- 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

Remuneration

Salaire mensuel brut de 2 100 € les deux premières années et 2 190 € la troisième

General Information

- **Theme/Domain :** Robotics and Smart environments
- **Town/city :** Rennes
- **Inria Center :** Centre Inria de l'Université de Rennes
- **Starting date :** 2024-10-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2024-07-31

Contacts

- **Inria Team :** RAINBOW
- **PhD Supervisor :**
  Krupa Alexandre / alexandre.krupa@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

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

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.