



**Offer #2024-07535**

## **PhD Position F/M Deformable object manipulation by "photometric shape servoing"**

**Contract type** : Fixed-term contract

**Level of qualifications required** : Graduate degree or equivalent

**Fonction** : PhD Position

### **About the research centre or Inria department**

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 PME's, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute, etc.

### **Context**

**Conditions:**

- The PhD student will be hosted in the IRISA/Inria Rainbow group <https://team.inria.fr/rainbow/> at Rennes.
- 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.

**Supervisors:** Alexandre Krupa, Eric Marchand

### **Assignment**

**Context:**

A major challenge in robotics is the interaction with deformable objects. Indeed, nowadays most of the robot control frameworks are built for rigid objects observed in the scene. Therefore, in order to extend the manipulation capabilities of robots, the main objective of this thesis is to investigate a new robotic control approach for manipulating soft objects to apply a desired deformation. The general idea is to use visual feedback to estimate and track in real time the deformations of the object of interest, and to develop a visual servo-control approach to control one or more robotic manipulators in order to apply a desired deformation to the object.

Automatically controlling the deformation of soft object would enable numerous robotic applications such as gripping a deformable object with a robotic hand, assembling flexible elements, accurately manipulating elastic materials or food products.

Recently, a number of studies have proposed solutions for applying controlled deformations to soft objects by robots, leading to the emergence of a new field of robotics research that is called "Shape servoing".

Controlling the deformation of soft materials requires the knowledge of how displacements of the robotic manipulator are translated into material deformation. This relationship can be either estimated from past visual observation with data-driven approaches [1] or expressed by a physics-model of the object such as finite element [2] or mass-spring models [3-4].

**Objectives:**

The various existing approaches need to extract visual geometric features to represent the object current deformations. For example they use 3D points of the objects surface provided by an RGB-D camera. Therefore, one of their limitations is the requirement of a real-time process that extracts and tracks these geometric features. This process usually involves a segmentation process which is only optimized and efficient for a specific type of object.

To avoid the need for extracting geometric features, we will propose in this thesis to consider directly the photometric information as well as the depth information provided by the RGB-D camera as the visual features to be regulated by the control law. This was already done for positioning a camera with respect to a rigid object by the "direct visual servoing" concept introduced in [5-6]. However, at our best knowledge photometric features were never considered for shape visual servoing.

## References:

- [1] R. Lagneau, A. Krupa, M. Marchal. Automatic Shape Control of Deformable Wires based on Model-Free Visual Servoing. IEEE Robotics and Automation, 5(4):5252-5259, October 2020.
- [2] F. Ficuciello, A. Miglinozzi, 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, October 2018.
- [3] 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.
- [4] 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.
- [5] C. Collewet, E. Marchand, F. Chaumette. Visual servoing set free from image processing. In IEEE Int. Conf. on Robotics and Automation, ICRA'08, Pages 81-86, Pasadena, California, Mai 2008.
- [6] C. Collewet, E. Marchand. Photometric visual servoing. IEEE Trans. on Robotics, 27(4):828-834, August 2011.
- [7] E. Marchand. Direct visual servoing in the frequency domain. IEEE Robotics and Automation Letters, 5(2):620-627, April 2020.
- [8] E. Marchand. Subspace-based Visual Servoing. IEEE Robotics and Automation Letters, 4(3):2699-2706, July 2019.

## Main activities

### Envisaged activities:

This thesis will therefore focus on the elaboration of a new shape servoing framework that we call "photometric shape servoing". One of the scientific contributions will concern the modelling of the interaction that provides the variation of the observed photometric information with respect to the motion of the robot acting on the soft object. This interaction model will then be considered in the design of a robot controller that will allow the autonomous shaping of a soft object by several robotic arms. A reduction of the dimensionality of the photometric shape features will be also considered thanks to projection approaches [7-8].

The methods studied will be developed, tested and validated on an experimental bench consisting of deformable objects, depth cameras, 2 robotic arms with 6 degrees of freedom, each equipped with a force sensor and a robotic griper/hand.

## 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

Monthly gross salary amounting to 2100 euros for the first and second years and 2190 euros for the third year.

## 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** : 2024-05-31

## Contacts

- **Inria Team** : [RAINBOW](#)
- **PhD Supervisor** :  
Krupa Alexandre / [alexandre.krupa@inria.fr](mailto: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.

## The keys to success

### Qualification requirements:

The candidate must have an excellent track of records and a Master Degree (or equivalent) in robotics and computer vision.

The candidate must have the following qualifications:

- Strong background in robotics
- Experience with computer vision, physical robots, or 3D simulation
- Excellent programming skills in C++
- Strong proficiency in both written and spoken English
- Ability to perform experimental validations
- Ability to work independently as well as collaboratively

**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.