Offer #2024-08267

Post-Doctoral Research Visit F/M Learning Variational Mathematical Morphological Operators for Computer Vision

Contract type : Fixed-term contract

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 Saclay-Île-de-France Research Centre was established in 2008. It has developed as part of the Saclay site in partnership with **Paris-Saclay University** and with the **Institut Polytechnique de Paris** .

The centre has 39 project teams , 27 of which operate jointly with Paris-Saclay University and the Institut Polytechnique de Paris; Its activities occupy over 600 people, scientists and research and innovation support staff, including 44 different nationalities.

Context

Assignment

Project Summary The aim of this project is to bridge the gap between classical mathematical morphology and state of the art deep learning techniques for computer vision. Mathematical morphology is a widely used tool in image processing and computer vision because of its usefulness in manipulating geometric structures within an image or graph. However, its use in modern deep learning pipelines remains limited. While some work has been done in this direction, for instance with so-called MorphoLayers [5], we propose a different approach based on a variational formulation of morphological operators given in [4].

Using this alternative formulation we will be able to differentiate mathematical morphological operators and learn their parameters using automatic differentiation and first-order optimization methods. This will enable learning variational mathematical morphological operators in a data-driven manner, e.g., through backpropagation, and also allow the use of variational mathematical morphological operators as implicit layers [1,3] in a neural network. Neural networks for image segmentation and classification will be explored as primary applications in this direction.

Main activities

Objectives Propose and analyze learnable mathematical morphological operators using implicit differentiation techniques that are compatible with autodifferentiation combined with variational mathematical morphology.

Context The techniques outlined in the project topic are frequently used in medical image analysis, which constitutes a large part of the activity of the host laboratory (Inria OPIS team).

Methods The project topic builds on the expertise of the supervisory team in high-dimensional optimization methods, deep learning, and mathematical morphology. It is an extension of some of the work recently carried out in this team [4,2].

Expected Results New neural network architectures based on learnable variational mathematical morphological operators, software implementations in PyTorch/JAX.

Bibliography

[1] Shaojie Bai, J Zico Kolter, and Vladlen Koltun. Deep equilibrium models. Advances in neural information processing systems, 32, 2019.
[2] Jérôme Bolte, Tam Le, Edouard Pauwels, and Tony Silveti-Falls. Nonsmooth implicit differentiation for machine-learning and optimization. Advances in neural information processing systems, 34:13537–13549, 2021.
[3] Fangda Gu, Heng Chang, Wenwu Zhu, Somayeh Sojoudi, and Laurent El Ghaoui. Implicit graph neural

networks. Advances in Neural Information Processing Systems, 33:11984–11995, 2020.
[4] Laurent Najman, Jean-Christophe Pesquet, and Hugues Talbot. When convex analysis meets mathematical morphology on graphs. In Mathematical Morphology and Its Applications to Signal and Image Processing: 12th International Symposium, ISMM 2015, Reykjavik, Iceland, May 27-29, 2015. Proceedings 12, pages 473–484. Springer, 2015.
[5] Santiago Velasco-Forero, Samy Blusseau, and Mateus Sangalli. Mathematical morphology meets deep learning. In 13th European Congress for Stereology and Image Analysis (ECSIA), 2024

Skills

The desired candidate should have experience with image processing, in particular image segmentation and classification, and first-order optimization methods. Experience and familiarity with vectorized Python programming, in particular with the common deep learning libraries (PyTorch, JAX, or TensorFlow), will be necessary. Fluency in English is also required.

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 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

2788 € gross/month

General Information

- **Theme/Domain :** Optimization, machine learning and statistical methods
  Data production, processing, analysis (BAP E)
- **Town/city :** Gif-sur-Yvette
- **Inria Center :** Centre Inria de Saclay
- **Starting date :** 2025-02-01
- **Duration of contract :** 12 months
- **Deadline to apply :** 2024-12-31

Contacts

- **Inria Team :** OPIS
- **Recruiter :**
  Silveti-falls Antonio / antonio.silveti-falls@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.