LISN
LABORATOIRE INTERDISCIPLINAIRE DES SCIENCES DU NUMÉRIQUE

anr agence nationale de la recherche

12 (+6) months Postdoctoral Position in Computational Fluid Mechanics and Machine Learning

Synergies in Turbulent Natural Convection: Bridging Convolutional Neural Networks, Physics-Informed Machine Learning, and High-Performance Computing for improved modeling

Keywords
super-resolution analysis, turbulent flows, physics-inspired machine learning, natural convection

Context
The mechanical engineering department of the LISN lab invites applications for a one-year postdoctorate position to conduct cutting-edge research at the intersection of turbulent natural convection, convolutional neural networks (CNN), physics-informed machine learning, and high-performance computing (HPC). The successful candidate will work on advancing the field of super-resolution analysis for turbulent fluid flows using innovative approaches based on numerical and experimental ombroscopy techniques.

Research Focus
The research will build upon recent surveys on machine-learning-based super-resolution reconstruction of turbulent flows. The candidate will explore and develop methods to enhance the resolution of turbulent flows through the application of CNN-based techniques, physics-informed loss functions with access to direct numerical simulations databases produced with high-performance computing technologies on national supercomputers. The goal is to reconstruct instantaneous vortical flows and temperature fields with high fidelity, even in scenarios with limited/partial training data and noisy inputs.

Key Responsibilities
1. Implement and refine machine-learning models, particularly CNN-based methods, for super-resolution reconstruction of turbulent flows.
2. Investigate the use of physics-informed loss functions and neural network structures to improve the accuracy and robustness of super-resolution models.
3. Collaborate with the lab team to integrate multi-scale filters, unsupervised techniques, and spectral properties into the super-resolution models.
4. Assess the robustness and sensitivity of models against noisy inputs, especially in the context of experimental measurements.
5. Contribute to the development of super-resolution models in wavespace for incorporating specific spectral properties.

Qualifications
- Ph.D. in Computational Fluid Mechanics, Aerospace Engineering, Applied mathematics, Computer Science or a related field.
- Strong background in machine learning, particularly convolutional neural networks.
- Experience in physics-informed machine learning and high-performance computing.
- Proven track record of publications in relevant peer-reviewed journals.
- Very good programming skills (e.g., Python, TensorFlow, PyTorch).

Supervision and research team
The Postdoc will work in collaboration with Didier Lucor and Anne Sergent from LISN, and Julien Salort and Francesca Chillà from the Physics Lab of ENS Lyon (https://www.ens-lyon.fr/PHYSIQUE). Thus, the research team is composed by physicist, fluid mechanics and artificial intelligence researchers from different laboratories, leading to a multidisciplinary project funded by ANR.

Application Process
Interested candidates should submit the following documents to didier.lucor@lisn.fr and anne.sergent@lisn.fr :

1. Curriculum Vitae (CV) including a list of publications.
2. Cover letter detailing the candidate's research experience and interest in the position.
3. Contact information for three references.

Funding
This project is funded by the ANR research project THERMAL.
The post-doctoral position is a one-year full-time appointment starting during 2024. Gross salary will depend on the experience of the candidate, up to approx. 40,000 €/year (net salary: up to approx. 32,000 €/year). The candidate will also benefit from French social insurance.

Within the framework of the ANR project THERMAL the postdoc will have funding for participation in conferences, publication fees and visits to Lyon lab. Moreover, the postdoc will have access to compute servers from University Paris-Saclay and GENCI national supercomputers.

Deadline for Applications: first semester 2024

LISN lab (CNRS & Université Paris Saclay):
The mechanical engineering department develops broad-spectrum research activities mainly in fluid mechanics and computer science. Over the last decade, expertise has developed at the interface of computational fluid mechanics, HPC and physics-informed machine learning, uncertainty quantification and data assimilation techniques.

The Postdoc is expected to start in 2024 (preferably during the first semester)

References

Shengze Cai, Zhicheng Wang, Sifan Wang, Paris Perdikaris, George Em Karniadakis, "Physics-Informed Neural Networks for Heat Transfer Problems", J. Heat Transfer, 143(6): 060801, 2021

D. Lucor, A. Agrawal and A. Sergent, "Simple computational strategies for more effective physics-informed neural networks modeling of turbulent natural convection", J Comp. Phys., 456, 111022, 2022
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