Type d'offre : Corporate offer

Post date : 29.09.26

LEMTA/INRS/ASNR

PhD Position ASNR - Field Reconstruction and Source Identification in Pollutant Flows in Ventilated Environments Using Physics-Informed Deep Learning

Informations générales

Contract type : Fixed-term contract

Contract length : 36 months

Education level : Master/Engineer Degree

Contact :

Yoann CHENY

Starting date : Thu 01/10/2026 - 12:00

LEMTA/INRS/ASNR :

Research Environment and Partners

The PhD project is part of a collaboration between three partners with complementary areas of expertise:

- LEMTA **(UMR 7563 CNRS – Université de Lorraine):** academic supervision, expertise in physics-informed learning and computational fluid mechanics ;
- INRS **(French National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases):** expertise in industrial ventilation, production of CFD data, and experimental data in occupational environments ;
- ASNR **(French Authority for Nuclear Safety and Radiation Protection):** experimental facilities, aerosol physics, and radiation protection issues.

This PhD project offers the opportunity to work at the interface between fluid mechanics, applied mathematics, and deep learning, with direct applications to occupational exposure assessment, ventilation optimization, and radiation protection.

Keywords: *inverse problems, data assimilation, field reconstruction, source identification, advection-diffusion equation, Physics-Informed Neural Networks, neural operators, deep learning, fluid mechanics, ventilation.*

Détail de l'offre (poste, mission, profil) :

In occupational environments, workers may be exposed to gaseous or particulate pollutants generated by industrial processes. These chemical, biological, or radiological emissions may occur under both normal and accidental conditions. Ambient measurements used to monitor pollutant dispersion within a room are generally limited to a small number of point sensors, which are insufficient to accurately characterize the spatial distribution of concentrations.

Pollutant dispersion in ventilated air is governed by the advection-diffusion equation:

$$\partial c/\partial t + (\mathbf{u} \cdot \nabla)\, c = \nabla \cdot (D\, \nabla c) + S(x, t; \theta),$$

where c is the pollutant concentration, u is the air velocity field, D is the effective diffusivity, and S is the source term parameterized by θ (position, shape, emission intensity). Under real-world conditions, the field $c(x, t)$ and parameters θ are unknown: only discrete, noisy, and sparse sensor signals are available.

The PhD project addresses two distinct yet complementary problems:

1. **Field reconstruction:** estimating $c(x, t)$ over the entire domain from available measurements, using the PDE as a physical constraint;
2. **Source identification:** estimating θ from sensor signals, with a real-time requirement to enable a rapid operational response.

Scientific Approach

Field Reconstruction: PINNs as Variational Regularization

Physics-Informed Neural Networks (PINNs) formulate the reconstruction problem as the minimization of a functional combining a sensor data-fitting term with a residual of the advection-diffusion equation, thereby using physics as a regularization constraint. The sensitivity to sensor placement and weighting hyperparameters will be rigorously analyzed.

A 2D prototype developed during a preparatory Master's internship has validated the approach for a stationary Gaussian leak scenario. The PhD project will extend this framework to the 3D unsteady case in a ventilated room and to the coupled inverse source problem.

Real-Time Source Identification and Reconstruction: Surrogate–Inversion Pipeline

To meet real-time operational requirements, the PhD project will develop a two-stage pipeline:

1. Fast surrogate model. A neural operator (Fourier Neural Operator or DeepONet) will be trained to approximate the solution operator $\theta \to c(\cdot\,; \theta)$. This surrogate model will make it possible to evaluate the concentration field for a very large number of source configurations at negligible computational cost.

2. Data generation and inversion learning. The surrogate model will be used to generate a large synthetic dataset of pairs consisting of source configurations and sensor signals. An inversion network will then learn the direct mapping:

sensor signals → θ,

trained offline and deployable in real time in the event of an incident.

This part represents the most exploratory component of the PhD project; its development will depend on the results obtained for field reconstruction using PINNs.

Data

CFD simulations used as training and reference data will be produced by INRS. Experimental data acquired by ASNR in an instrumented ventilated enclosure will be used for final validation. An interest in techniques for developing numerical and experimental databases is expected.

Objectives

- Reconstruct a 3D concentration field from sparse measurements while enforcing the PDE constraint; quantify the influence of the number and placement of sensors on reconstruction quality;
- Formulate and solve the inverse source identification problem coupled with field reconstruction;
- Develop the surrogate–inversion pipeline for real-time source identification;
- Validate the overall approach using real experimental data (INRS/ASNR ventilated enclosure).

Candidate Profile

Education: Research Master's degree or engineering degree in applied mathematics or in mechanics/physics with a strong numerical component, and a solid background in:

- partial differential equations and numerical analysis;
- optimization and/or inverse methods;
- fluid mechanics or spectral methods (a strong asset).

Required skills: scientific programming in Python (NumPy, PyTorch), experience with deep learning, and the ability to work at the interface between mathematics, physics, and numerical computing.

Additional assets: knowledge of data assimilation methods, experience with neural operators or model reduction methods, and experimental data processing.

URL de l'offre :

https://www.dataia.eu/sites/default/files/2026-09/offre_these_INRS_LEMTA_ASNR.pdf

Lien vers l'offre sur le site dataia.eu : https://da-cor-dev.peppercube.org/node/1606