PhD thesis
Learning Continuous Representations for Inverse Problems

Supervision:

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Context and objectives

How can neural networks learn the structure of images, even when most of the information is missing? This is the central question of this PhD project. In tomographic imaging, the goal is to reconstruct a three-dimensional object from observations acquired along a limited number of directions. Such problems are inherently ill-posed, yet recent advances in machine learning have shown that it is possible to recover high-quality reconstructions even under severe degradation.

This PhD is positioned at the intersection of machine learning, applied mathematics, and scientific imaging, with applications ranging from structural biology to medical imaging. The project focuses on a new class of models, known as coordinate-based neural representations (CBNRs) [1, 2], which represent images and volumes as continuous functions rather than discrete grids. Coordinate-based neural representations have recently emerged as powerful tools in computer vision and graphics, and are now being explored for solving inverse problems in imaging. Their ability to represent signals continuously provides new opportunities for reconstruction, especially in settings where data is incomplete or highly noisy

Despite their empirical success, a fundamental question remains open: why do these models perform so well in ill-posed regimes? This PhD project aims to address this question by developing a deeper understanding of CBNRs in the context of inverse problems, with a particular focus on high-noise settings and incomplete measurements, as encountered in applications such as cryo-electron tomography and medical imaging.

The objective of this PhD is to understand, design, and push the limits of these representations in some of the most challenging inverse problems.

From theory to real-world impact

While the project is primarily methodological, it is strongly motivated by practical applications, which the candidate may explore depending on their interests. In structural biology, cryo-electron tomography enables the visualization of molecular structures within cells at high resolution, providing insights into the organization and function of cellular machinery. CBNRs have already demonstrated their potential in this context [3, 4].

In medical imaging, improving reconstruction quality while reducing radiation dose is a key objective, with direct implications for diagnosis and treatment planning. Here again, CBNRs offer promising perspectives [5].

The project also offers opportunities to interact with experimental environments, including visits to hospital imaging facilities or access to electron microscopy platforms, providing a unique link between theory, algorithms, and real data acquisition [6].

Scientific approach and expected skills

This PhD project aims to establish the foundations for the use of CBNRs in imaging inverse problems. You will investigate how these representations behave when data is extremely noisy, measurements are incomplete or corrupted, and the problem is fundamentally ill-posed. The work will combine theoretical analysis, numerical experiments, and algorithm design, with the goal of understanding what these models learn and how they can be improved.

A background in applied mathematics, machine learning, or signal processing is expected. Familiarity with concepts such as Fourier analysis, linear algebra, and optimization will be helpful, although not all of these are required. The mathematical tools involved remain relatively accessible yet original, and the project emphasizes understanding rather than technical complexity.

An important part of the work will involve implementing and testing the proposed models. Experience with programming and scientific computing is therefore important. Knowledge of modern deep learning frameworks such as PyTorch, as well as familiarity with GPU computing, will be beneficial.

We are looking for a motivated and curious candidate with a strong interest in interdisciplinary research at the interface between theory and applications, and a desire to develop a deep understanding of modern machine learning methods.

Why apply?

This PhD offers the opportunity to work on fundamental questions with real-world impact, to connect theory with experimental science, and to grow in a supportive and ambitious research environment. It provides a strong foundation for pursuing a career in academic or industrial research.

Research environment

You will join a dynamic and collaborative research group at CREATIS (Lyon), where several PhD students and postdoctoral researchers work on closely related topics. This environment provides interactions between machine learning, imaging, and applied mathematics.

You will also have opportunities to supervise master's interns, contribute to open-source scientific software, and participate in collaborative research projects at both national and international levels. The project is supported by funded research programs, ensuring regular participation in major international conferences, as well as opportunities for research stays in France or abroad and interactions with leading international researchers.

How to apply? Please send a curriculum and your academic records to

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This position will remain open until a suitable candidate is found.

References

[1] Ben Mildenhall, Pratul P Srinivasan, Matthew Tancik, Jonathan T Barron, Ravi Ramamoorthi, and Ren Ng. Nerf: Representing scenes as neural radiance fields for view synthesis. *Communications of the ACM*, 65(1):99–106, 2021.

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[5] AmirEhsan Khorashadizadeh, Valentin Debarnot, Tianlin Liu, and Ivan Dokmanić. Glimpse: Generalized local imaging with mlps. *arXiv preprint arXiv:2401.00816*, 2024.

[6] Vinith Kishore, Valentin Debarnot, Ricardo D Righetto, Benjamin D Engel, and Ivan Dokmanić. Icecream: High-fidelity equivariant cryo-electron tomography. *Acta Crystallographica Section D*, pages 2026–03, 2026.