

PhD **Leo DAVY**

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Education

PhD in Signal and Image Processing — *Lab. Physique, Lyon*
Ecole Normale Supérieure (ENS) — *2022 - 2025*

- Advisors: Patrice Abry & Nelly Pustelnik
- Title: Segmentation of anisotropic and scale-free textures: Complex multiband wavelets, variational and bilevel optimisation, informed neural networks. [PDF]
- Reviewers: Stéphane Mallat & Samuel Vaiter; Examiners: Hermine Biermé (Chair) & Agnès Desolneux

MSc. (M2) Advanced Mathematics, Statistics & Probability track — *Lyon*
Ecole Normale Supérieure — *2021 - 2022*

- Internship on *Segmentation of anisotropic scale-free textures with proximal algorithms*, supervised by P. ABRY & N. PUSTELNIK

MSc. (M1) Fundamental Mathematics — *Montpellier, France*
Faculté des Sciences — *2020 - 2021*

- Project on *Sparse reconstruction of signals: frames, atomic decompositions and compressed sensing*, supervised by Prof. J-F. CROUZET at Inst. Math. Alexander Grothendieck

University Qualification (DU) in Digital Rights — *Perpignan, France*
Université Perpignan Via Domitia — *2020*

MSc. (M1) in Electrical Engineering and Robotics (EEA) — *Montpellier, France*
Faculté des Sciences — *2019-not fin.*

BsC. (Licence) Mathematics, advanced track (Parcours Spécial) — *Toulouse, France*
Université Toulouse 3 Paul Sabatier — *2016 - 2019*

Other Experiences

2025 **Beg-Rohu Summer School on *Learning with Physics, Machines and Minds*, Brittany, France**, Lectures by Y. Le Cun, M. Mézard, S. Mallat, J-R. King, J. Kempe, E. Agliari & A. Murugan

2024 **DeepInverse Hackaton at Centre International de Recherche en Mathématiques (CIRM), Marseille, France**, Invited at coding hackaton, worked on integration of diffusion and sampling methods

2024 **Visiting researcher, New-York University, Tandon School, Brooklyn, NY, USA**, Combining Gaussian Mixture Models and Dual-Tree transforms for image segmentation - Supervised by Prof. I. SELESNICK

2023 **Coordinator of volunteers at the *European Signal Processing Conference*, Lyon, 2023**,

2019 **Research Internship, Bristol University, School of Mathematics, Bristol, England**, Erdös-Rényi random graphs and branching processes Supervised by Prof. J. NAJNUDEL

Research interests and expertise

Imaging In my curriculum I have been primarily interested in the numerical analysis of images through mathematical frameworks. I have extensively worked with multi-scale methods, such as *wavelets*, in a variety of contexts ranging from *sparse representations*, *fractal analysis* or *image segmentation*.

Modeling and inverse problems I have a strong interest in combining *stochastic* and *physical* modeling for *applications* using *variational* and *energy-based* problems. My PhD was focused on textures in images and a multiscale analysis led to an *inverse problem* capturing critical features of images related to *roughness* and *anisotropy*.

Learning and optimization I have a strong interest in learning methods that leverage available data to improve model-based systems. I worked with *unrolled neural networks* designed from *convex optimization algorithms* for various applications and learning tasks (hyperparameter tuning, unsupervised learning, bilevel optimization, PnP). I proposed ReTune, a learning algorithm that enables designing and training efficient, interpretable neural networks grounded in *energy-based* modeling.

Software and implementation I have strong programming skills in Python, with advanced expertise in *PyTorch*, including custom autograd implementations, efficient operations on high-dimensional tensors, and end-to-end training pipelines. I have authored open-source libraries for wavelet transforms and texture segmentation, and contributed to DeepInverse, a Python package for imaging inverse problems that is part of the official PyTorch ecosystem. My implementations span the full research cycle, from dataset creation and benchmarking to proof-of-concept architectures.

Publications

Journal Articles

Davy, L., Pustelnik, N., & Abry, P. (2026) *Regularized local multiband complex wavelet analysis for piecewise homogeneous anisotropic self-similar textures*. *SIAM Journal on Imaging Sciences*. [PDF]

Hu, Z., D'Inverno, G. A., **Davy, L.**, Unser, M., Rozza, G., Dong, J. (2026) *Revisiting Deep Information Propagation: Fractal Frontier and Finite-size Effects*. *Neural Networks*. [PDF]

Tachella, J., Terris, M., Hurault, S., Wang, A., Chen, D., … & **Davy, L.** (2025). *DeepInverse: A Python package for solving imaging inverse problems with deep learning*. *Journal of Open Source Software*. [PDF]

Book Chapter

Davy, L., Briceño-Arias, L., & Pustelnik, N. (2026) *Restarted contractive operators to learn at equilibrium*. Chapter in *Handbook of Numerical Analysis, Vol. 26: Machine Learning Solutions for Inverse Problems* (eds. A. Hauptmann, B. Jin, C.-B. Schönlieb). [PDF]

Conference Proceedings (international)

Davy, L., Pustelnik, N., & Abry, P. (2024). *Restart strategies enabling automatic differentiation for hyperparameter tuning in inverse problems*. *European Signal Processing Conference (EUSIPCO)*, Lyon, France. [PDF]

Davy, L., Pustelnik, N., & Abry, P. (2023). *Combining Dual-Tree Wavelet Analysis and Proximal Optimization for Anisotropic Scale-Free Texture Segmentation*. *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, Rhodes Island, Greece, pp. 1–5. [PDF]

Conference Proceedings (national)

Abbas, K., **Davy, L.**, Abry, P., & Roux, S. (2025). *Modèles de diffusion pour la synthèse de textures anisotropes.GRETSI 2025*, Strasbourg, France. [PDF]

Davy, L., Pustelnik, N., & Abry, P. (2023). *Sélection d'hyperparamètres non supervisée par différentiation automatique, application à la segmentation de textures*. *GRETSI 2023*, Grenoble, France. [PDF]

Presentations

Invited Talks & Seminars

March 2025. *Restart Strategies for Learning Hyperparameters of Proximal Neural Networks via Automatic Differentiation*. Invited talk: GDR IASIS day "Bilevel optimization and hyperparameter learning", Lyon, France.

Oct. 2024. *Segmentation of anisotropic textures*. Invited talk: ANR Textures meeting, Vannes, France.

Jul. 2024. *Texture segmentation with wavelets and unrolled proximal networks*. Seminar: NYU Tandon School of Engineering, New York, USA.

Jun. 2023. *Segmentation of anisotropic scale-free textures based on dual-tree wavelet analysis and proximal optimization*. Seminar: Laboratoire Jean Kuntzmann, Grenoble, France.

Contributed Conference Presentations (no proceedings)

Jun. 2026. SIAM OP Conference on Optimization — *Edinburgh, UK.*
Restarted Contractive Operators to Learn at Equilibrium — Invited Talk

Jul. 2025. EurOpt : European Conference on advances in continuous optimization — *Southampton, UK.*
Learning Proximal Neural Networks at Equilibrium Without Jacobian — Invited Talk

May. 2024. SIAM IS Conference on Imaging Science — *Atlanta, GA, USA.*
Proximal Unfolded Neural Networks for Anisotropic Scalefree Texture Segmentation — Invited Talk

Teaching Experience

2025 **Introduction to signal and image processing** Teaching Assistant (16 hrs) *EPITA Eng. School, Lyon*

2024 **Cryptography** Teaching Assistant (16 hrs) *EPITA Eng. School, Lyon*

2024 **Mathematics of Signal Processing** Teaching Assistant (16 hrs) *EPITA Eng. School, Lyon*

Outreach & Professional Development

Service and Outreach

2023 **European Signal Processing Conference** Coordinator of student volunteers for the conference *Lyon*

Open-Source libraries contributions

Deep Inverse A Python library for imaging with deep learning, part of the official PyTorch ecosystem, *contributor*

Undecimated DTCWT Undecimated extension of the dual-tree complex wavelet transform, *author*

LIR3A Python library for segmentation of textures with jointly rough and anisotropic features *author*

SiSyPhe Lab A signal and image processing for physics developed within ENS Lyon, *contributor*

Peer Review

IEEE Transactions of Image Processing;

IPOL Image Processing On Line