HUBERT LETERME

PhD Student in Applied Mathematics and Computer Science

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EDUCATION

PhD in Applied Mathematics and Computer Science
Université Grenoble Alpes, Laboratoire Jean Kuntzmann

📅 October 2019 – Ongoing   📍 Grenoble, France

- **Supervisors**: Valérie Perrier (Professor, Grenoble INP Ensimag), Karteek Alahari (Researcher, Inria).
- **Topic**: Construction of Wavelet-based Neural Networks for Image Classification.
- **Scholarship**: LabEx PERSYVAL-Lab (ANR-11-LABX-0025-01), funded by the French program Investissement d'avenir.
- **Description**: See "Research activities".

MSc in Industrial and Applied Mathematics (MSIAM)
Université Grenoble Alpes, Grenoble INP Ensimag

📅 September 2018 – July 2019   📍 Grenoble, France

Resumption of studies after a few years of professional experience.

- **First semester**: Fundamentals of Data Science. Courses in machine learning and deep learning, Bayesian inference, signal and image processing (wavelets), model reduction, model selection, data assimilation, high performance computing.
- **Second semester**: Research internship at Laboratoire Jean Kuntzmann, Grenoble. See "Experiences" for more details.

Graduate Engineering School
École Centrale Paris (now CentraleSupélec – Université Paris-Saclay)

📅 September 2009 – December 2012   📍 Paris, France

The diploma received from French institutes of technology is equivalent to a master's degree.

- **Main subject area**: Industrial Engineering and Operations Research.
- **Other topics**: Seminars about Operational Management.

Exchange Semester (Erasmus Program)
KTH Royal Institute of Technology

📅 January 2010 – June 2010   📍 Stockholm, Sweden

- **Main subject area**: School of Industrial Engineering and Management.

EXPERIENCES

PhD Student
Université Grenoble Alpes, Laboratoire Jean Kuntzmann

📅 October 2019 – Ongoing   📍 Grenoble, France

See "Education" and "Research activities" for more details.
This PhD project follows the master's thesis defended in June 2019—see below, "Research Intern".

Teaching Assistant
Grenoble INP Ensimag – Université Grenoble Alpes

📅 Academic years 2019-2020 and 2020-2021   📍 Grenoble, France

- **Description:** See "Teaching activities".

Research Intern
Université Grenoble Alpes, Laboratoire Jean Kuntzmann

📅 February – July 2019   📍 Grenoble, France

Preparation of a master's thesis, defended in June 2019.

- **Supervisors**: Valérie Perrier, Karteek Alahari.
- **Topic**: Wavelet-Nets: Construction of Wavelet-Type Neural Networks and Application to Image Classification.

Passenger Flow Analyst
AREP – SNCF Group

📅 September 2016 – September 2018   📍 Paris, France

Studies of pedestrian flows in train stations and other public spaces.

Data Analyst
Air Liquide

📅 October 2015 – February 2016   📍 Paris, France

Marketing-oriented data analyses in a project for the development of a new type of connected gas cylinder.

Supply Chain Analyst and Coordinator
Air Liquide Nordics

📅 June 2013 – July 2015   📍 Malmö, Sweden

Operational management of gas cylinder storage and distribution within the Nordic countries.

TRAINING PROGRAMS

Ethics in Research and Scientific Integrity
Inria

📅 25th March 2022   📍 Grenoble, France

Since 2016, every PhD student in France is required to follow a program raising awareness about ethics in research and scientific integrity. The need is especially strong in the very fast growing fields of applied mathematics and computer science, where researchers are subject to severe competition and publishing pressure.
Training volume: 7h.

PAISS – Artificial Intelligence Summer School
PRAIRIE and MIAI Research Institutes in Artificial Intelligence

📅 5th – 9th July 2021   📍 Virtual conference

Third edition of the summer school, which comprises lectures conducted by renowned experts in different areas of artificial intelligence. Topics include computer vision, machine learning, natural language processing, robotics, healthcare. Attended as participant and presenter—poster presentation on my own research.
Training volume: 17h.

Research School on Mathematics, Signal Processing and Learning
CIRM Centre International de Rencontres Mathématiques

📅 25th – 29th January 2021   📍 Marseille, France

Courses on machine learning, signal processing, optimization, deep learning and reinforcement learning.
Training volume: 30h.

MOOC on Replicability

Inria Learning Lab

📅 May 2020 – March 2021 📍 Online

Methodological principles for transparent science.
Training volume: 24h.

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Reading Group on Graph Wavelets

Laboratoire Jean Kuntzmann

📅 April – July 2020 📍 Virtual conference

Basics of graph signal processing; paper presentations on graph wavelets and deep learning.
Attended as participant and presenter—oral presentation on graph CNNs [DBV16].
Training volume: 8h approximately.

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Course on Category Learning and Object Recognition

Université Grenoble Alpes, Grenoble INP Ensimag

📅 October 2019 – January 2020 📍 Grenoble, France

Course taken as part of MSIAM master's program.
Training volume: 18h.

WORKSHOPS, SEMINARS, CONFERENCES

CollaboTICS

Université Grenoble Alpes, Ruhr-Universität Bochum, University of Tsukuba

📅 15th – 16th December 2021 📍 Virtual conference

- **Content**: Third edition of the International Collaborative Workshop of RUB-UGA-UT – Recent Trends in Computer Science and Artificial Intelligence. The workshop consists of sessions of oral and poster presentations.
- **Contribution**: Oral presentation: "Sparsifying Convolutional Layers with Dual-Tree Wavelet Packets".

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ORASIS – French-speaking Workshop for Young Researchers in Computer Vision

IRIT – Research Institute in Computer Science, INP Toulouse

📅 13th – 17th September 2021 📍 Lake Saint-Ferreol, Toulouse area, France

- **Content**: Series of talks conducted by field experts. Short oral presentations or posters made by the participants. Topics include deep learning, image processing, remote sensing, medical imaging, and robotics.
- **Contribution**: Accepted paper: "Modélisation Parcimonieuse de CNNs avec des Paquets d'Ondelettes Dual-Tree". Oral presentation on the topic—video available online at `https://orasis2021.sciencesconf.org/resource/page/id/18`.

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Other Events Attended as Participant

19th – 24th Jun. 2022	CVPR 2022, New Orleans, Louisiana, USA.
19th & 20th May 2022	Kymatio Workshop 2022, Nantes, France.
12th May 2022	Signal Processing Methods for Machine Listening, CNRS, Paris, France.
7th Apr. 2021	Explainability and Interpretability of AI Methods for Computer Vision, CNRS, virtual.
11th – 13th Jan. 2021	Mathematics and Image Analysis (MIA'21), virtual.
4th & 5th Apr. 2019	StatLearn'19, Grenoble, France.

RESPONSIBILITIES

2021 – Ongoing	Elected co-representative of PhD students on the laboratory council.
2020 – Ongoing	Co-organizer of a recurring PhD student seminar at LJK.
Jan. 2020	Co-organizer of the doctoral school's annual PhD Student Day.

RESEARCH ACTIVITIES

Description of my PhD Project

Topic   Construction and Study of Wavelet-based Neural Networks for Image Classification.

Background   Deep convolutional neural networks (CNNs) [LeC+89] have dramatically improved the state-of-the-art in many domains such as speech recognition, visual object recognition or object detection [LBH15]. However, they are very resource-intensive, and a mathematical understanding of their behavior remains a challenging issue. On the other hand, signal processing techniques such as wavelet and multi-resolution analysis have proved to be very efficient in feature extraction, signal compression and denoising [Vet01]. The two fields, albeit both based on convolution filters, differ on an important point. In wavelet theory, filters are specifically designed to meet restrictive conditions, whereas CNNs use freely-trained filters without any prior assumption on their behavior. Nevertheless, they tend to learn parameters which are similar to oriented Gabor filters in the first layer [Yos+14].
In order to overcome the lack of understanding about CNNs, attempts to combine the two approaches have been made, such as wavelet scattering networks [BM13; OM15; SK17; Zar+20; ZL20]. Their goal is to build CNN-like classifiers which are composed of well-defined mathematical operators, and perform a theoretical study of their properties.

Goals   In a similar spirit, my work is focused on combining the two above fields by building "mathematical twins" of popular CNN architectures. Such models involve the dual-tree complex wavelet packet transform [BS08], i.e., a complex, redundant and oriented version of the discrete wavelet packet transform. The objective is twofold. First, we want to establish some mathematical properties of CNNs for image classification such as oriented feature extraction and stability with respect to image transformations. Then, we seek to enhance classification performance using theoretical arguments.
Research on wavelet scattering networks is driven by the purpose of building ad-hoc CNN-like feature extractors, structured into well defined mathematical operators specifically designed to meet a certain number of desired properties. By contrast, my work seeks evidence that such properties are, to some extent, satisfied in *existing* CNN architectures, with no need to alter their behavior or introduce new features.

Implementation   Python, using PyTorch and Scikit-learn libraries.

Publications, Preprints, Reports

PhD Student

📅 October 2019 – Ongoing

- Hubert Leterme, Kévin Polisano, Valérie Perrier, and Karteek Alahari. "Modélisation Parcimonieuse de CNNs Avec Des Paquets d'Ondelettes Dual-Tree". In: *ORASIS*. Saint Ferréol, France, 09/2021

- Hubert Leterme, Kévin Polisano, Valérie Perrier, and Karteek Alahari. "Sparsifying Convolutional Layers with Dual-Tree Wavelet Packets". Preprint. 02/2021.

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MSc Program MSIAM

📅 September 2018 – July 2019

- Hubert Leterme. "Wavelet-Inspired Neural Networks and Application to Image Classification". MA thesis. 06/2019.

- Sebastian Agerhäll, Anatole Gallouët, Guillaume Lacharme, Hubert Leterme, and Federico Rubes. *The Wavelet Scattering Network for Image Classification*. Project Report. 02/2019. Based on [BM13].

- Sebastian Agerhäll and Hubert Leterme. *Data Challenge on DNA Sequence Classification*. Project Report. 02/2019.

- Albin Soutif, Hubert Leterme, Shalu Dwivedi, Suman Chakraborty, and Guillaume Lacharme. *Audio-Visual Multi-Speaker Tracking*. Project Report. 02/2019. Based on [Ban+19].

- Artyom Burda, Hubert Leterme, and Federico Rubes. *Reduced Order Data Assimilation*. Bibliographic Review. 01/2019.

- Sélim Chraibi, Raphaël Lambert, Hubert Leterme, and Maxence Ménager. *Research-Oriented Practical Works on Probabilistic Graphical Models, Independent Mixture Models and Hidden Markov Models*. Project Report. 02/2019.

- Hubert Leterme. *Complexity Analysis of the Lasso Regularization Path*. Paper Summary. 12/2018. Based on [MY12].

Oral Communications and Poster Presentations

PhD Student

📅 October 2019 – Ongoing

- Hubert Leterme. *How Shift Invariant Are Feature Extractors in CNNs?* Talk given at Rutgers Business School. New Brunswick, New Jersey, USA, 06/2022

- Hubert Leterme. *Sparsifying Convolutional Layers with Dual-Tree Wavelet Packets*. Laboratoire Jean Kuntzmann – EDP Team Meeting. Grenoble, France, 01/2022

- Hubert Leterme. *Sparsifying Convolutional Layers with Dual-Tree Wavelet Packets*. Poster. MSTIC-MIAI-PERSYVAL Scientific Days. Grenoble, France, 04/2022

- Hubert Leterme. *Sparsifying Convolutional Layers with Dual-Tree Wavelet Packets*. International Collaborative Workshop of RUB-UGA-UT. Virtual conference, 11/2021

- Hubert Leterme. *Sparsifying Convolutional Layers with Dual-Tree Wavelet Packets*. Inria – Thoth Team Seminar. Villard-de-Lans, France, 10/2021

- Hubert Leterme. *Modélisation Parcimonieuse de CNNs Avec Des Paquets d'Ondelettes Dual-Tree*. Paper Presentation. ORASIS. Saint Ferréol, France, 09/2021

- Hubert Leterme. *Sparsifying Convolutional Layers with Dual-Tree Wavelet Packets*. Poster. PAISS PRAIRIE/MIAI Artificial Intelligence Summer School. Virtual conference, 07/2021

- Hubert Leterme. *Dual-Tree Wavelet Packet CNNs for Image Classification*. Paper Presentation. Inria Thoth Reading Group. Virtual conference, 11/2020.

- Hubert Leterme. *Convolutional Neural Networks on Graphs with Fast Localized Spectral Filtering*. Paper Presentation. Graph Wavelet Reading Group. Virtual conference, 07/2020. Based on [DBV16].

MSc Program MSIAM

📅 September 2018 – July 2019

- Hubert Leterme. *Wavelet-Inspired Neural Networks and Application to Image Classification*. Master's Thesis Defense. Grenoble INP Ensimag, 06/2019.

- Sebastian Agerhäll, Anatole Gallouët, Guillaume Lacharme, Hubert Leterme, and Federico Rubes. *The Wavelet Scattering Network for Image Classification*. Project Defense. Grenoble INP Ensimag, 02/2019.

- Albin Soutif, Hubert Leterme, Shalu Dwivedi, Suman Chakraborty, and Guillaume Lacharme. *Audio-Visual Multi-Speaker Tracking*. Project Defense. Grenoble INP Ensimag, 02/2019.

- Daria Bystrova, Hubert Leterme, and Vadim Sushko. *Gaussian Process Forecast with Multidimensional Distributional Entries*. Paper Presentation. Grenoble INP Ensimag, 01/2019. Based on [Bac+20].

- Artyom Burda, Hubert Leterme, and Federico Rubes. *Reduced Order Data Assimilation*. Project Defense. Grenoble INP Ensimag, 01/2019.

References

[Bac+20]   François Bachoc, Alexandra Suvorikova, David Ginsbourger, Jean-Michel Loubes, and Vladimir Spokoiny. "Gaussian Processes with Multidimensional Distribution Inputs via Optimal Transport and Hilbertian Embedding". In: *Electronic Journal of Statistics* 14.2 (2020).

[Ban+19]   Yutong Ban, Xavier Alameda-Pineda, Laurent Girin, and Radu Horaud. "Variational Bayesian Inference for Audio-Visual Tracking of Multiple Speakers". In: *IEEE Transactions on Pattern Analysis and Machine Intelligence* (2019).

[BM13]   Joan Bruna and Stéphane Mallat. "Invariant Scattering Convolution Networks". In: *IEEE Transactions on Pattern Analysis and Machine Intelligence* 35.8 (05/2013).

[BS08]   Ilker Bayram and Ivan W. Selesnick. "On the Dual-Tree Complex Wavelet Packet and M-Band Transforms". In: *IEEE Transactions on Signal Processing* 56.6 (06/2008).

[DBV16]   Michaël Defferrard, Xavier Bresson, and Pierre Vandergheynst. "Convolutional Neural Networks on Graphs with Fast Localized Spectral Filtering". In: *Advances in Neural Information Processing Systems 29*. 2016.

[LBH15]   Yann LeCun, Yoshua Bengio, and Geoffrey Hinton. "Deep Learning". In: *Nature* 521.7553 (2015).

[LeC+89]   Yann LeCun, B. Boser, J. S. Denker, D. Henderson, R. E. Howard, W. Hubbard, and L. D. Jackel. "Backpropagation Applied to Handwritten Zip Code Recognition". In: *Neural Computation* (1989).

[MY12]   Julien Mairal and Bin Yu. "Complexity Analysis of the Lasso Regularization Path". In: *International Conference on Machine Learning*. 05/2012.

[OM15]   Edouard Oyallon and Stephane Mallat. "Deep Roto-Translation Scattering for Object Classification". In: *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. 2015.

[SK17]   Amarjot Singh and Nick Kingsbury. "Dual-Tree Wavelet Scattering Network with Parametric Log Transformation for Object Classification". In: *ICASSP, IEEE International Conference on Acoustics, Speech and Signal Processing - Proceedings*. 2017.

[Vet01]   Martin Vetterli. "Wavelets, Approximation, and Compression". In: *IEEE Signal Processing Magazine* 18.5 (09/2001).

[Yos+14] Jason Yosinski, Jeff Clune, Yoshua Bengio, and Hod Lipson. "How Transferable Are Features in Deep Neural Networks?" In: *Advances in Neural Information Processing Systems*. 2014.

[Zar+20] John Zarka, Louis Thiry, Tomás Angles, and Stéphane Mallat. "Deep Network Classification by Scattering and Homotopy Dictionary Learning". In: *International Conference on Learning Representations*. 2020.

[ZL20] Dongmian Zou and Gilad Lerman. "Graph Convolutional Neural Networks via Scattering". In: *Applied and Computational Harmonic Analysis* 49.3 (11/2020).

TEACHING ACTIVITIES

Mathematical Analysis for Engineers

Grenoble INP Ensimag – Université Grenoble Alpes
First year of graduate engineering school

📅 2019-2022 (3 academic years), 1st semester   📍 Grenoble, France

Teaching volume: 30.5 hours per academic year.

- Tutorial classes (18.5 hours): basics of integration, Fourier transform, normed vector spaces.
- Practical work with Jupyter Notebook (two groups, 6 hours per group): floating-point arithmetic, computation of integrals, Fourier series and Gibbs phenomenon, Gerschgörin theorem.

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Image Processing

Grenoble INP Ensimag – Université Grenoble Alpes
Second year of graduate engineering school

📅 2019-2022 (3 academic years), 2nd semester   📍 Grenoble, France

Practical works, implementation in C.
Teaching volume: 12 hours per academic year.

- Implementation of spectral and spatial filtering for image denoising, complexity of the two approaches.
- Edge detection using first and second order differential operators.
- Nonlinear denoising: noise estimation, median filter, adaptive filters.