



Maurice Weiler

Deep Learning Researcher

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Personal Profile

I received my PhD from the University of Amsterdam, supervised by Max Welling. Prior to my doctorate, I obtained a Master's degree in computational and theoretical physics from Heidelberg University.

A primary focus of my research is on the representation theory of *equivariant convolutional neural networks* (CNNs), that is, networks that are guaranteed to commute with geometric transformations. I developed a *gauge theory* of coordinate independent CNNs on Riemannian manifolds, which constitutes a paradigm shift from global symmetries to local gauge transformations. Our insights led to the PyTorch extension *escnn* and are published as a *monograph*.

Besides my core research topics, I am more broadly interested in generative models, graph neural networks, non-Euclidean embedding methods, PDE-inspired deep models, and deep learning for the physical sciences. In my freetime I enjoy climbing, hiking, MTBing, cooking, playing strategic games and DJing.

Education

PhD, Machine Learning - University of Amsterdam 2018 - 2024

- Research on equivariant and geometric deep learning
- Supervisor: Prof. Max Welling
- Thesis: *Equivariant and Coordinate Independent Convolutional Networks*
- *Cum Laude* doctorate (highest Latin honors awarded for Dutch doctorates, equivalent to *Summa Cum Laude* elsewhere)

M.Sc. Physics - Heidelberg University 2015 - 2017

- Specialization in computational and theoretical physics
- Thesis: *Learning Steerable Filters for Rotation Equivariant CNNs*
- GPA: 4.00 / 4.00 (converted via *modified Bavarian formula*)

B.Sc. Physics - Technical University of Darmstadt 2012 - 2015

- Thesis: *On the Existence of Inhomogeneous Phases in the Nambu-Jona-Lasinio Model*
- GPA: 3.62 / 4.00 (converted via *modified Bavarian formula*)

Professional Experience

Amazon Development Center Germany GmbH May - Sep. 2021

- Applied Science Internship
- Research on causality for object detection
- Supervisor: Dr. Francesco Locatello

Awards & Scholarships

- *Cum Laude* doctorate (Highest Latin honors for Dutch doctorates, equivalent to *Summa Cum Laude* elsewhere)
- Deutschlandstipendium (Scholarship of the German federal ministry of education and research for talented students)
- DPG-Buchpreis (Award of the German physical society for highest mark in the year)

Teaching and Supervision

Master's thesis, honors project and internship supervision:

- Erik Jenner Jan. 2021 - Apr. 2022
Steerable Partial Differential Operators for Equivariant Neural Networks
Internship at QUVA Lab, University of Amsterdam
- Leon Lang Oct. 2019 - Jul. 2020
A Wigner-Eckart Theorem for Steerable Kernels of General Compact Groups
M.Sc. Artificial Intelligence, University of Amsterdam
- Andrii Skliar Dec. 2018 - Aug. 2019
Hyperbolic Convolutional Neural Networks
M.Sc. Artificial Intelligence, University of Amsterdam
- Gabriele Cesa Feb. 2018 - Sep. 2020
E(2)-equivariant Steerable CNNs
Honors project & M.Sc. Artificial Intelligence, University of Amsterdam

Teaching experience:

- Geometric Deep Learning summer school Jul. 2022
D'Annunzio University of ChietiPescara
- Machine Learning 1 autumn 2018, autumn 2019
University of Amsterdam
- Deep Learning autumn 2018, spring 2019, autumn 2019, autumn 2020
University of Amsterdam
- Physics 1 winter 2015
University of Heidelberg
- Private tutoring in Mathematics and Physics since 2014

Invited Talks and Lectures

- *Equivariant Convolutional Networks & Steerable Kernels* Mar. 24th 2023
Interplay between AI and mathematical modelling in the post-structural genomics era
Centre International de Rencontres Mathématiques (CIRM), France
- *Equivariant and Coordinate Independent Convolutional Networks* Jan. 10th 2023
PIER Helmholtz Graduate School Data Science Lecture
DESY & Hamburg University, Germany
- *Equivariant and Coordinate Independent Convolutional Networks* Aug. 3rd 2022
Hammers & Nails 2022 – Machine Learning Meets Astro & Particle Physics
Weizmann Institute of Science, Israel
- Geometric Deep Learning lectures (4×1.5h):
 - *Groups, Representations & Equivariant maps* Jul. 25th, 2022
 - *Manifolds & Fiber bundles* Jul. 25th, 2022
 - *Group Equivariant Convolutional Networks on Euclidean spaces* Jul. 26th, 2022
 - *Equivariant & Coordinate Independent CNNs on Riemannian manifolds* Jul. 27th, 2022First Italian School in Geometric Deep Learning
D'Annunzio University of ChietiPescara

- *Equivariant and Coordinate Independent Convolutional Networks* Jul. 12th, 2022
Swiss Equivariant Learning Workshop
EPFL (Lausanne)
- *Equivariant and Coordinate Independent Convolutional Networks* Jul. 8th, 2022
Toth Seminar
Inria Grenoble
- *Equivariant and Coordinate Independent Convolutional Networks* Jun. 17th, 2022
DeepMind/ELLIS CSML Seminar
University College London (UCL)
- *Equivariant and Coordinate Independent Convolutional Networks* Jun. 16th, 2022
Cambridge Image Analysis group Seminar
University of Cambridge
- *Equivariant and Coordinate Independent Convolutional Networks* Jun. 15th, 2022
OxCSML Seminar
University of Oxford
- *Equivariant and Coordinate Independent Convolutional Networks* Apr. 7th, 2022
DIEP seminar
Dutch Institute for Emergent Phenomena (DIEP)
- *Gauge Equivariant Convolutional Networks* Nov. 26th, 2019
Bayes Forum
Max-Planck-Institute for Physics, LMU
- *Gauge Equivariant Convolutional Networks* Nov. 20th, 2019
Giersch International Symposium - AI for Science
Frankfurt Institute for Advanced Studies (FIAS)
- *Gauge Equivariant Convolutional Networks* Mar. 29th, 2019
Deep Learning Theory Kickoff Meeting
Max Planck Institute for Mathematics in the Sciences
- *3D Steerable CNNs* Nov. 20th, 2018
Deep Learning & AI Meetup
Qualcomm AI Research Netherlands
- *Learning Steerable Filters for Rotation Equivariant CNNs* Sep. 13th, 2018
System and Machine Learning group Seminar
NEC Laboratories Europe
- *Learning Steerable Filters for Rotation Equivariant CNNs* May 30th, 2017
AMLab Seminar
University of Amsterdam

Conferences and Courses

- Interplay between AI and mathematical modelling in the post-structural genomics era, Mar. 2023
Centre International de Rencontres Mathématiques (CIRM), France
- Hammers & Nails 2022 – Machine Learning Meets Astro & Particle Physics, Aug. 2022
Weizmann Institute of Science, Israel
- First Italian School in Geometric Deep Learning, ChietiPescara Jul. 2022
- Swiss Equivariant Learning Workshop, EPFL (Lausanne) Jul. 2022
- ICLR 2022, Virtual Conference Apr. 2022
- ICLR 2021, Virtual Conference May 2021
- NeurIPS 2020, Virtual Conference Dec. 2020
- ELLIS Workshop on Geometric and Relational Deep Learning, Amsterdam Apr. 2020
- NeurIPS 2019, Vancouver Dec. 2019

- AI for Science (FIAS), Frankfurt Nov. 2019
- Mathematics of Deep Learning (4TU AMI), Delft Nov. 2019
- ICML 2019, Long Beach Jun. 2019
- Deep Learning Theory Kickoff meeting (MPI MIS), Leipzig Mar. 2019
- NeurIPS 2018, Montreal Dec. 2018
- Deep Learning and Reinforcement Learning Summer School (CIFAR), Toronto Jul. 2018
- CVPR 2018, Salt Lake City Jun. 2018
- Deep generative models in NLP Workshop, Amsterdam Mar. 2018
- 1st European Machine Vision Forum, Heidelberg Sep. 2016
- 36th Heidelberg Physics Graduate Days, Heidelberg Apr. 2016
- 35th Heidelberg Physics Graduate Days, Heidelberg Oct. 2015

Publications

🔗 see also: <https://scholar.google.com/citations?hl=en&user=uQePx6EAAAAJ>

* equal contribution

- **Clifford-Steerable Convolutional Neural Networks**
Maksim Zhdanov, David Ruhe*, Maurice Weiler*, Ana Lucic, Johannes Brandstetter, Patrick Forré
arXiv preprint (2024)
- **Equivariant and Coordinate Independent Convolutional Networks - A Gauge Field Theory of Neural Networks**
Maurice Weiler, Patrick Forré, Erik Verlinde, Max Welling
Monograph (under review at academic publisher) (2023)
PhD thesis, University of Amsterdam (pre-release, defense pending) (2023)
- **Artificial Intelligence for Science in Quantum, Atomistic, and Continuum Systems**
Shuiwang Ji et al. (see publication for full author list)
arXiv preprint (2023)
- **Steerable Partial Differential Operators for Equivariant Neural Networks**
Erik Jenner, Maurice Weiler
ICLR (2022)
- **A Program to Build E(N)-Equivariant Steerable CNNs**
Gabriele Cesa, Leon Lang, Maurice Weiler
ICLR (2022)
- **Coordinate Independent Convolutional Networks - Isometry and Gauge Equivariant Convolutions on Riemannian Manifolds**
Maurice Weiler, Patrick Forré, Erik Verlinde, Max Welling
arXiv preprint (2021)
- **A Wigner-Eckart Theorem for Group Equivariant Convolution Kernels**
Leon Lang, Maurice Weiler
ICLR (2021)
- **Gauge Equivariant Mesh CNNs - Anisotropic convolutions on geometric graphs**
Pim de Haan*, Maurice Weiler*, Taco S. Cohen, Max Welling
ICLR (2021)
- **General E(2)-Equivariant Steerable CNNs**
Maurice Weiler*, Gabriele Cesa*
NeurIPS (2019)
- **A General Theory of Equivariant CNNs on Homogeneous Spaces**
Taco S. Cohen, Mario Geiger, Maurice Weiler
NeurIPS (2019)

- **Gauge Equivariant Convolutional Networks and the Icosahedral CNN**
Taco S. Cohen*, Maurice Weiler*, Berkay Kicanaoglu*, Max Welling
ICML (2019)
- **Covariance in Physics and Convolutional Neural Networks**
Miranda C. N. Cheng, Vassilis Anagiannis, Maurice Weiler, Pim de Haan, Taco S. Cohen, Max Welling
ICML workshop on Theoretical Physics for Deep Learning (2019)
- **Hyperbolic Convolutional Neural Networks**
Andrii Skliar, Maurice Weiler
M.Sc. thesis of Andrii, supervised by me, University of Amsterdam (2019)
- **3D Steerable CNNs: Learning Rotationally Equivariant Features in Volumetric Data**
Maurice Weiler*, Mario Geiger*, Max Welling, Wouter Boomsma, Taco S. Cohen
NeurIPS (2018)
- **Explorations in Homeomorphic Variational Auto-Encoding**
Luca Falorsi*, Pim de Haan*, Tim Davidson*, Nicola De Cao, Maurice Weiler, Patrick Forré, Taco S. Cohen
ICML workshop on Theoretical Foundations and Applications of Deep Generative Model (2018)
- **Intertwiners between Induced Representations
(with Applications to the Theory of Equivariant Neural Networks)**
Taco S. Cohen, Mario Geiger, Maurice Weiler
arXiv preprint (2018)
- **Learning Steerable Filters for Rotation Equivariant CNNs**
Maurice Weiler, Fred A. Hamprecht, Martin Storath
CVPR (2018)
- **Learning Steerable Filters for Rotation Equivariant Convolutional Neural Networks**
Maurice Weiler
M.Sc. thesis, Heidelberg University (2017)
- **On the Existence of Inhomogeneous Phases in the Nambu-Jona-Lasinio Model**
Maurice Weiler
B.Sc. thesis, Technical University of Darmstadt (2015)

Further Research Projects

- SU(2)-invariant Neural Wavefunctions for the Quantum Heisenberg Model Sep. 2021 - Apr. 2022
Supervisor: Roberto Bondesan, Max Welling, Qualcomm AI Research Netherlands
- Implementation of an Ensemble Kalman Filter for a Data Assimilation Framework Sep. 2015
Supervisor: Prof. Kurt Roth, Institute of Environmental Physics, University of Heidelberg
- Implementation and quantitative evaluation of a Runge-Kutta-Cash-Karp solver for ODEs Aug. 2015
Supervisor: Prof. Kurt Roth, Institute of Environmental Physics, University of Heidelberg