Personal Profile

I am a final-year PhD student at the University of Amsterdam, supervised by Max Welling. Prior to my doctoral studies, 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 - 2023
- Research on equivariant and geometric deep learning
- Supervisor: Prof. Max Welling
- Thesis: Equivariant and Coordinate Independent Convolutional Networks (defense pending)

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 2021 - May - Sep. 2021
- Applied Science Internship
- Research on causality for object detection
- Supervisor: Dr. Francesco Locatello
Awards & Scholarships

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

Teaching experience:

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

Invited Talks and Lectures

- Equivariant Convolutional Networks & Steerable Kernels  
  Interplay between AI and mathematical modelling in the post-structural genomics era  
  Centre International de Rencontres Mathématiques (CIRM), France  
  Mar. 24th, 2023
- Equivariant and Coordinate Independent Convolutional Networks  
  PIER Helmholtz Graduate School Data Science Lecture  
  DESY & Hamburg University, Germany  
  Jan. 10th, 2023
- Equivariant and Coordinate Independent Convolutional Networks  
  Hammers & Nails 2022 – Machine Learning Meets Astro & Particle Physics  
  Weizmann Institute of Science, Israel  
  Aug. 3rd, 2022
- Geometric Deep Learning lectures (4 × 1.5h):  
  Groups, Representations & Equivariant maps  
  Manifolds & Fiber bundles  
  Group Equivariant Convolutional Networks on Euclidean spaces  
  Equivariant & Coordinate Independent CNNs on Riemannian manifolds  
  First Italian School in Geometric Deep Learning  
  D’Annunzio University of Chieti-Pescara  
  Jul. 25th, 2022
- Equivariant and Coordinate Independent Convolutional Networks  
  Swiss Equivariant Learning Workshop  
  EPFL (Lausanne)  
  Jul. 12th, 2022
- **Equivariant and Coordinate Independent Convolutional Networks** ..........................  Jul. 8th, 2022
  Thoth 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 Plank 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

• 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