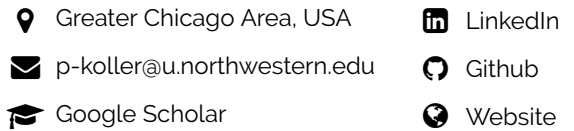


# PATRICK KOLLER

PhD Candidate



## OVERVIEW

PhD candidate working on scientific machine learning, focusing on physics-informed neural networks and neural operators for accelerating large-scale physical simulations. Backed by over 10 years of hands-on industry experience in algorithm and software development, machine learning, and project management. I am driven to bridge the gap between cutting-edge research and real-world applications.

## EDUCATION

- 09/2024 - Today **PhD Candidate in Electrical and Computer Engineering** **Northwestern University**
- PhD student in Prof. Dr. Katsaggelos's Image and Video Processing Lab (IVPL). GPA: 3.9/4.0
  - Conducting research in scientific machine learning, focusing on physics-informed neural networks (PINNs) and neural operators (PINOs) for accelerating large-scale physical simulations in astrophysics.
  - Developing machine learning methods for solving differential equations and modeling complex physical systems, with an emphasis on generalization, scalability, and physical consistency.
  - Research supported by the NSF-Simons AI Institute for the Sky (SkAI), leveraging large-scale HPC systems (e.g., *Delta*, *DeltaAI*, and *Northwestern's Quest HPC cluster*) for simulation and model development.
  - Previous work on explainable AI and robustness in deep learning, including methods for analyzing bias and improving model interpretability.
- 02/2020 - 02/2023 **Master of Science in Data Science** **Eastern Switzerland University of Applied Sciences**
- Part-time studies alongside working as an engineer at Stettbacher Signal Processing AG. Grade: 5.52/6
  - Master Thesis: Development of a novel explainable AI method called "Caption-based explainable AI" at the Image and Video Processing Lab at Northwestern University under the supervision of Prof. Dr. Katsaggelos, Prof. Dr. Guido Schuster and my mentor Amil Dravid. Grade: 6/6
  - Development of a quantitative trading engine using a combination of fixed horizon and triple barrier labels, gaussian processes to accelerate the hyperparameter tuning and a novel trading strategy. Grade: 5.5/6
  - Development of an "AI in injection molding" anomaly detection model, which is able to classify the quality of produced goods using the cavity pressure curve. We optimized a wide range of machine learning models like linear regression, autoencoder, variational-autoencoder, convolutional-autoencoder, gated-recurrent-unit-autoencoder, elliptic envelope, isolation forest, local outlier factor, and one-class support vector machines on a NVIDIA DGX-2. An autoencoder based model delivered the best performance considering the restricted resources of the embedded system. The success of this thesis led to the implementation in a product called ComoNeo by Kistler AG. Grade: 5.5/6
- 05/2014 **Vocational Trainer for Automation Engineers** **Berufsbildner AG**
- 09/2012 - 09/2016 **Bachelor of Science in Electrical Engineering** **Zurich University of Applied Sciences**
- Part-time studies alongside working as an automation engineer at Comsys Bärtsch AG.
  - Bachelor thesis: Development of electronics, optics, mechanics, and software for a medical device to detect brucellosis. A lock-in algorithm allows to detect a signal hidden in the noise. Grade: 5.5/6
  - Development of a force control system in a stranding machine to prevent a corkscrew effect during custom cable production. The project has been rewarded with a 1'500.00 CHF price by the company Huber+Suhner AG. Grade: 5.5/6
- 08/2007 - 08/2011 **Apprenticeship as an Automation Engineer** **Comsys Bärtsch AG**

## PUBLICATIONS

- 04/2026 **Physics-Informed Neural Operators for Stellar Structure Modeling in Equilibrium** **Machine Learning: Science and Technology (under review)**  
S. Lopez-Tapia, M. Ballester, S. Gossage, P. M. Srivastava, U. Demir, **P. Koller**, C. Wuersch, S. Chakraborty, V. Kalogera, A. K. Katsaggelos
- 04/2026 **Learning the Stellar Structure Equations via Self-Supervised Physics-Informed Neural Networks** **Scientific Reports (under review)**  
M. Ballester, S. Lopez-Tapia, S. Gossage, **P. Koller**, P. M. Srivastava, U. Demir, Y. Jo, A. P. Marquez, C. Wuersch, S. Chakraborty, V. Kalogera, A. K. Katsaggelos
- 03/2026 **Irregularly Sampled Time Series Interpolation for Binary Evolution Simulations Using Dynamic Time Warping** **The Astrophysical Journal (under review)**  
U. Demir, P. M. Srivastava, A. K. Katsaggelos, V. Kalogera, S. Lopez-Tapia, M. Ballester, S. Lalvani, **P. Koller**, J. J. Andrews, S. Gossage, M. M. Briel, E. Teng

09/2025	<b>Caption-Driven Explainability: Probing CNNs for Bias via CLIP (Workshop)</b> P. Koller, A. Dravid, G. M. Schuster, A. K. Katsaggelos	IEEE ICIP
09/2025	<b>Size-Informed Representations for Unsupervised Image Clustering (Workshop)</b> P. R. M. Srivastava, C. Apostolidis, S. Pailwan, P. Koller, L. Stefanopoulos	IEEE ICIP

## AWARDS & HONORS

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11/2025	<b>Travel Grant</b> Awarded a departmental travel grant to present the paper "Caption-Driven Explainability: Probing CNNs for Bias via CLIP" at IEEE International Conference on Image Processing (ICIP) 2025 Conference in Anchorage, Alaska.	Northwestern University
10/2025	<b>Hackathon Project: Deep Neural Operators for Detailed Binary Evolution Simulation</b> Developed a neural-operator-based approach for accelerating large-scale astrophysical simulations during the NCSA and NVIDIA hackathon, in collaboration with the POSYDON project and within the NSF-Simons AI Institute for the Sky (SkAI). The project was subsequently selected for presentation at the Open Accelerated Computing Summit 2025.	NVIDIA, NCSA
09/2025	<b>Medicus Scholarship</b> Awarded in recognition of academic excellence and cross-disciplinary research contributions as a Swiss doctoral student pursuing graduate studies in the United States. (USD 10,000)	Swiss Benevolent Society of New York
09/2024 - 08/2025	<b>Walter P. Murphy Fellowship</b> Endowed fellowship supporting outstanding PhD students during their first year of graduate study. (USD 45,000)	Northwestern University
07/2018	<b>Red Dot Award-Winning Ophthalmic Surgery Device</b> Contributed to the engineering team at Stettbacher Signal Processing AG. Improved eye-tracking algorithms for robust off-center gaze detection and restored reliable Bluetooth file transfer functionality.	Red Dot GmbH & Co. KG
01/2016	<b>Recognition Award for Bachelor Project</b> Awarded for outstanding performance on a bachelor project conducted at Huber+Suhner AG. Developed a force-control system for a stranding machine to prevent corkscrew effects in custom cable production. (CHF 1,500)	Huber+Suhner AG

## EXPERIENCE

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07/2023 - 08/2024	<b>Data Scientist / Management Team Member</b> <ul style="list-style-type: none"> <li>Member of the management team, contributing to technical strategy and product decisions in industrial sensing and smart factory initiatives.</li> <li>Developed and deployed a machine learning model to estimate vehicle velocity for passive (undetectable) speed camera systems using difference brightness sensors under real-world constraints.</li> <li>Led the transfer of an explainable AI model for injection molding from research to production, resulting in integration into the ComoNeo system.</li> <li>Designed and deployed ML models for manufacturing process monitoring, reducing scrap rates and helping prevent costly production failures in support of Kistler AG's vision of a smart factory.</li> </ul>	Kistler AG
03/2023 - 06/2023	<b>Traveller</b> Explored destinations across America, Canada, Colombia, Portugal, and Switzerland.	All over the world
06/2017 - 02/2023	<b>Engineer / Project Leader</b> <ul style="list-style-type: none"> <li>Developed a computer vision system (transfer learning with YOLOv5) with augmented visual overlays to detect and localize waste containers, enabling automated control of a robotic arm for bin emptying on waste disposal trucks developed by Villiger AG.</li> <li>Designed and implemented signal processing systems, including one of the most precise acoustic impedance measurement devices in the world used by EMPA.</li> <li>Contributed to the software stack (Linux, Bluetooth, eye tracking) of a Red Dot Award-winning ophthalmic device, improving eye-tracking robustness and system reliability.</li> <li>Led the development of a ruggedized tablet, coordinating international teams across time zones. Contributed to electronics, custom Linux system, and software. The device featured the brightest display available in a tablet at the time.</li> </ul>	Stettbacher Signal Processing AG

- 01/2020 - 02/2020 **Soldier (World Economic Forum Deployment)** **Swiss Armed Forces**
- Selected among Swiss Armed Forces personnel for deployment at the World Economic Forum Annual Meeting 2020 in Davos.
  - Supported security and operational coordination for a high-profile international summit involving heads of state and global executives.
  - Operated in a fast-paced, multinational environment requiring discipline, reliability, and situational awareness.
- 10/2016 - 05/2017 **Development Engineer / Project Leader** **Optotune AG**
- Selected to work in the CEO Office (3-person team), contributing to strategic and operational initiatives and supporting executive decision-making in a 60-person deep-tech company.
  - Led a multidisciplinary team of 10 engineers, including PhD-level specialists across electronics, mechanics, chemistry, and photonics, to develop a robotic system for automated production of liquid tunable lenses in precision optical systems with micro-/nano-scale surface and coating requirements, contributing to deployment in commercial smartphone products (Xiaomi Fold 1 and 2).
  - Designed and optimized control systems, increasing production yield by 20%, including work in clean-room environments.
- 08/2016 - 09/2016 **Traveller** **Eastern Europe**
- Explored multiple countries across Eastern Europe, including Slovenia, Croatia, Serbia, Hungary, Czech Republic, and Austria.
- 08/2011 - 04/2016 **Automation Engineer / Project Leader** **Comsys Bärtsch AG**
- Developed software with PID controllers for home automation and smart home systems and trained apprentices.

## SKILLS

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Core Expertise	Explainable AI (XAI), Physics-Informed Neural Networks (PINNs), Neural Operators (PINOs), Scientific Machine Learning, Robustness & Domain Generalization, Signal Processing, Algorithm Development, Optimization
Robotics & Systems	Robotics, Embedded Systems, Real-Time Systems, Edge AI, Sensor Data Processing, Hardware-Software Co-Design, Control Systems
Programming	Python (PyTorch, TensorFlow, Scikit-learn), C/C++, MATLAB, R
Tools	Git, Linux, Conda, Jupyter, Docker
Languages	Swiss German (Native), German (Fluent), English (Fluent), French (Basic)

## PRESENTATIONS

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- 12/2025 PhD qualification exam presentation on "Review of Physics-Informed Machine Learning (PIML)" at Northwestern University, evaluated by Prof. Aggelos K. Katsaggelos, Prof. Ermin Wei, and Prof. Ying Wu.
- 09/2025 Presented the paper "Caption-Driven Explainability: Probing CNNs for Bias via CLIP" at the IEEE International Conference on Image Processing Workshops (ICIPW) in Anchorage, Alaska (session honoring Prof. Aggelos K. Katsaggelos).
- 06/2025 Guest lecture on industry experience in the *Computational Optics* course at Northwestern University, instructed by Prof. Emma Alexander.
- 03/2025 Literature survey on "Robustness in Computer Vision" in the *Advanced Computer Vision* course at Northwestern University, taught by Prof. Ying Wu.
- 12/2024 Delivered a lecture on "Unlocking Explainable AI: A Beginner's Guide" in the *Machine Learning* course at Northwestern University, taught by Prof. Aggelos K. Katsaggelos and instructed by Santiago Tapia.
- 12/2024 Presented "Caption-based Explainable AI" in the *PhD Life Skills Building* course at Northwestern University, instructed by Prof. Nivedita Aurora.
- 11/2024 Presented and discussed "Learning Transferable Visual Models from Natural Language Supervision" (Radford et al.) in the *Generative Deep Models* course at Northwestern University, taught by Prof. Bryan Pardo.
- 11/2023 Presented the "AI in injection molding" project to the Plastics business unit at Kistler AG; the work was later integrated into the ComoNeo system.
- 07/2023 Delivered a talk on interpretable machine learning at Kistler's Innovation Lab, introducing methods such as permutation importance, LIME, partial dependence plots, and Shapley values (materials available on GitHub).

- 02/2023 Presented the novel explainable AI method "Caption-based Explainable AI" at Northwestern University (in person) and the Eastern Switzerland University of Applied Sciences (online).
- 08/2022 Presented a quantitative trading engine leveraging Gaussian processes for hyperparameter optimization at the Eastern Switzerland University of Applied Sciences.
- 02/2022 Presented an "AI in injection molding" anomaly detection system for product quality classification using cavity pressure curves at the Eastern Switzerland University of Applied Sciences.
- 07/2016 Presented the development of a medical device for brucellosis detection using lock-in signal processing at the Zurich University of Applied Sciences.
- 01/2016 Presented a force-control system for stranding machines to prevent corkscrew effects in cable production at the Zurich University of Applied Sciences.

## SERVICE, TEACHING, AND OUTREACH

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- 04/2026 **Peer Reviewer** **NPJ Heritage Science (Springer Nature)**  
Reviewed interdisciplinary research at the intersection of machine learning and digital art history (digital humanities), focusing on experimental design, model interpretability, and methodological rigor.
- 04/2026 - 09/2026 **Local Organizing Committee Member** **Open SkAI Conference 2026**  
Invited to rejoin the local organizing committee in recognition of contributions to the inaugural conference. Supporting the planning, coordination, and execution of the 2026 edition, with continued focus on fostering collaboration between machine learning and astrophysics communities.
- 01/2026 - 03/2026 **Teaching Assistant** **Northwestern University**  
Supported instruction for a graduate-level course in scientific machine learning. Led office hours, assisted with assignments and projects, and mentored 60+ students on topics such as differential equations, optimization, physics-informed neural networks, and neural operators.
- 04/2025 - 09/2025 **Local Organizing Committee Member** **Open SkAI Conference 2025**  
Served on the local organizing committee and created the "AI + Astrophysics Glossary," a collaborative reference bridging technical vocabulary across machine learning and astrophysics. Supported the planning, logistics, and communication for the first Open SkAI Conference.
- 06/2025 - 08/2025 **Research mentor** **Harvard Undergraduate OpenBio Laboratory**  
Selected as a mentor for the highly competitive Student Research Institute (over 2,000 applicants; 70 admitted; 3.88% acceptance rate), supporting students from underserved backgrounds with little prior research experience. Mentored Shaurya Jeevagan on a full physics-informed neural network (PINN) project involving advection–diffusion modeling, Fourier feature construction, boundary-condition handling, PDE-residual sampling, and neural-network training with data–physics hybrid loss functions.
- 09/2023 - 06/2024 **Master thesis mentor** **Kistler AG**  
Mentoring Ken Geeler over the course of his master thesis classifying the correct air pressure in tires using a machine learning model and Kistler AG's Weight In Motion sensor.
- 11/2019 - 04/2021 **Volunteer coach** **Powercoders**  
Coaching refugee Sharif Shayan during his internship at UBS (largest Swiss bank), which led to a permanent position at Brack.ch (Swiss e-commerce company).
- 03/2013 - 01/2016 **Math tutor** **Freelancer**  
Math tutoring for Robin Kreis, Nicolas Kleinert, Roman Kümpel and Sandro Rovetto.