

Manuel Caipo

Machine Learning Engineer | Mechanical Engineer

15.02.97, Peru | Schubartstraße 62 | 89134 Blaustein, Germany

manuelcaipoc@outlook.com | +49 176 32618095

[GitHub](#) | [in LinkedIn](#) | [Website](#) | [Arb.-Erlaubnis DE – Vollzeit \[ID\]](#)

German: C1 [[Certificate](#)] English: C1 Spanish: Native



Mechanical Engineer and Machine Learning researcher working at the intersection of artificial intelligence and engineering systems. My work focuses on physics-aware machine learning for complex cyber-physical systems, combining industrial domain knowledge with data-driven models to develop interpretable and reliable AI methods. In industrial settings, I have developed scalable machine learning pipelines for high-frequency sensor data, addressing anomaly detection, degradation modeling, and remaining useful life prediction for large-scale hydraulic systems. These experiences motivated my interest in understanding how complex engineered systems can be represented computationally so that learning algorithms can exploit their physical structure and design constraints. My research interests focus on structured and topology-aware machine learning approaches that integrate system architecture, physical constraints, and engineering design knowledge into learning algorithms. More broadly, I am interested in developing machine learning methods that combine physics-based and data-driven models to enable robust AI systems capable of reasoning about and improving complex engineered systems.

PROFESSIONAL EXPERIENCE

11.2024 – 03.2026

Bosch Rexroth, Ulm, Germany

DC-SSD3 – Master's Thesis

- Master's thesis focusing on the development of an ML/AI-based condition monitoring module for *CytroConnect*, combining physical models, hydraulic domain knowledge, and data compliant with the *Fluid 4.0* standard.

DC-SSD3 – Data Scientist Working Student

- Built scalable ETL pipelines for high-frequency industrial time-series data (SQL/NoSQL) and integrated message brokers (Solace/MQTT).
- Developed and deployed ML/DL-based predictive models for anomaly detection and RUL prediction in hydraulic systems.
- Applied explainable AI methods to increase transparency, robustness, and acceptance of data-driven models.

04.2021 – 07.2023

Freeport-McMoRan Cerro Verde, Phoenix, U.S.A.

Data Analytics – Junior Data Scientist 2

- Developed, scaled, and globally deployed ML/DL models (LSTM, CNN, XGBoost) in Azure ML for anomaly detection and wear prediction, including implementation of explainability methods (SHAP, PDP) and continuous retraining processes for transparent and adaptive model usage.
- Introduced RUL models for proactive maintenance planning; +1.5% asset availability (≈\$10M/year savings). Awarded with Innova 2022, Showroom Award, and President's Award.

Data Analytics – Junior Data Scientist 1

- Implemented ML models in Azure ML Jobs for daily wear prediction of critical assets (FLSmidth primary crushers, Weir Minerals cyclone pumps) and optimized SQL Stored Procedures for accelerated data preparation for ML training and analytics.
- Conducted historical analyses to derive condition-based maintenance strategies in SAP, focusing on transforming static intervals into data- and condition-based decisions.

Maintenance Reliability – Junior Data Analyst 1

- Transformed maintenance strategies through advanced time-series analyses (AR/MA/ARIMA) for wear and failure prediction, optimized SQL queries for rapid data processing, and automated KPI reporting using Dagster, developing interactive Power BI dashboards for efficient monitoring and decision support of machine conditions.

Maintenance Reliability – Trainee Data Analyst

- Long-term analyses of asset performance (primary crushers, conveyor belts, cyclone pumps, ball mills, secondary crushers, HPGR) by linking pattern anomalies, RCA results, and operational variables for condition-based failure classification.

08.2020 – 03.2021

IMCO Servicios S.A.C, Arequipa, Peru

Engineering and Development – Junior Engineer

- Performed static and dynamic structural analyses with topology optimization in a BIM-oriented methodology, including architectural modeling (Tekla), FEM-based structural design (SAP2000, IdeaStatica, Inventor, Ansys Structural), and final plan review in AutoCAD 3D.

01.2020 – 06.2020

Freeport-McMoRan Cerro Verde, Arequipa, Peru

Maintenance Reliability – Intern

- Used multiphysics CFD simulations (Ansys Fluent, Autodesk CFD) to predict wear mechanisms, evaluate protective coatings, and for simulation-supported optimization of maintenance strategies and service life predictions.



TECHNICAL SKILLS

Programming & Scientific Computing: Python (NumPy, Pandas, SciPy, scikit-learn, PyTorch), SQL, C/C++, MATLAB; object-oriented design and numerical modeling

Machine Learning & AI Systems: End-to-end ML system design for predictive maintenance and RUL modeling; LSTM (Attention), CNN, XGBoost, Random Forest; time-series forecasting, anomaly detection; Explainable AI (SHAP, PDP)

Data Engineering & ETL: PostgreSQL, Snowflake, InfluxDB (SQL & NoSQL); Dagster, Apache Airflow; database schema design, batch and streaming pipelines

Cloud & Scalable ML Deployment: Azure ML (pipelines, model registry, deployment, automated retraining), Databricks; Kafka, MQTT; scalable cloud-based ML services

MLOps & DevOps: Git, Docker, CI/CD; experiment tracking, reproducible environments, containerized inference services

Industrial & Physical Systems: OPC UA integration, Siemens TIA Portal (PLC), Bosch Rexroth CtrlX Core; FEM (Ansys), CFD; physics-informed modeling for cyber-physical systems

PUBLICATIONS

02.2026 **Explainable Edge-AI Framework for Fault Diagnosis and Remaining Useful Life Prediction in Hydraulic Systems.** Submitted to *Discover Mechanical Engineering* (Springer Nature). Currently under peer review. [Z]

Note: [Z] Preprint

EDUCATION

10.2025 – Today [i] **Advanced Graduate Coursework – Computational Science and Engineering** —
Focus: Numerical Optimization, High-Performance Computing, Theoretical Computer Science.
Ulm University, Ulm, Germany

09.2024 – 03.2026 [i] **Master of Science – Advanced Precision Engineering** 1,8
Furtwangen University of Applied Sciences, Villingen-Schwenningen, Germany
[ii] Thesis: Fluid 4.0-compliant framework for digital representation and graph-based neural modeling.

06.2021 – 02.2022 [i] **Postgraduate Diploma – Machine Learning & Deep Learning** [Top 5%]
Universidad Católica San Pablo, Arequipa, Peru 19.6/20.0

03.2015 – 12.2019 [i] **Bachelor – Mechanical Engineering** [Top 1%]
National University of San Agustín, Arequipa, Peru 15.2/20.0
[ii] *Recognition by the Government*
[iii] *Award for the highest academic performance.*
[iv] Thesis: Design of a 350 TPH copper concentrate conveyor belt with automatic hydraulic tensioning system and loading hopper
Notes: [i] View diploma/program status.

AWARDS & HONORS

2019 **Top Graduate (Top 1%)** – Mechanical Engineering, National University of San Agustín, Peru. [Z]

2021 **Outstanding Bachelor's Thesis Award** – Engineering Sciences. [Z]

Innova 2022 – Triple Award Winner (1st Place Digital Transformation, Showroom & President's Award)

2022 – Freeport-McMoRan. *Machine & Deep Learning Life Data Analysis* with measurable impact (+1.5% asset availability, ≈>\$10M USD/year). [Z]

Note: [Z] Certificate / Letter

REFERENCES

2026 **Dr. Jörn Kretschmer, M.Sc.**, Hochschule Furtwangen University. Supervisor of my Master's thesis — Joern.Kretschmer@hs-furtwangen.de.

2025 **Prof. Dr.-Ing. G. Ketterer**, Hochschule Furtwangen University, Dean of Studies M.Sc. *Advanced Precision Engineering*. Recommendation for PhD studies — gunter.ketterer@hs-furtwangen.de. [Z]

2023 **Travis Gaddie**, Freeport-McMoRan, Data Scientist III, Metals Optimization. Reference for career development and advanced studies — tgaddie@fmi.com. [Z]

2021 **Dr. L. Rodríguez B.**, National University of San Agustín (UNSA), Director of Mechanical Engineering & Bachelor's thesis supervisor. Recommendation for Master's studies — lrodriguez4@unsa.edu.pe. [Z]

Note: [Z] Reference letter

SCHOLARSHIPS & GRANTS

2017 **President of the Republic Scholarship – Peru.** Full scholarship awarded for academic excellence (Top 1%).

2019 **Research Grant – SERESSA 2019, Spain.** 15th International School on Radiation Effects.

ADDITIONAL COURSES

2024 German Courses B2, C1 (Ulm vhs & Berlitz) [Z]	2020 Structural & Multiphysics Analysis with FEM (ESSS) [Z]
2022 Leadership and Soft Skills (UCSP) [Z]	2019 Industrial Plant Systems (TECSUP) [Z]
2021 Hydraulic Systems (Bosch Rexroth) [Z]	2019 Autodesk Nastran – FEM & CFD (Autodesk) [Z]
2019 Pipeline Calculation (EADIC) [Z]	2019 Autodesk Inventor – CAD (Autodesk) [Z]
	2018 Process Improvement (Proavance) [Z]

