Mahdi Mohammadigohari

Free University of Bozen–Bolzano, Italy
mahdi.mohammadigohari@unibz.it | mahdi.mohammadigohari@gmail.com
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Research Summary

I develop theoretical foundations for deep learning from a function-space and statistical perspective. My work focuses on understanding generalization in deep models beyond parameter-based analyses, using kernel methods, operator-theoretic techniques, and hierarchical constructions of hypothesis spaces. A central theme of my research is to characterize how compositional depth influences regularity and statistical complexity. I develop frameworks that yield dimension-free and depth-uniform generalization guarantees, providing a principled explanation for how deep architectures can remain both expressive and statistically stable. More broadly, my goal is to connect functional analysis and statistical learning theory with modern deep learning, and to build mathematically grounded models for complex learning systems.

Research Interests

Statistical Learning Theory; Deep Learning Theory; High-Dimensional Statistics; Kernel Methods; Functional Analysis; Operator Theory; Generalization and Optimization in Deep Learning.

Education

- **Ph.D. in Computer Science**, Free University of Bozen–Bolzano, Italy Nov 2022 – Apr 2026 (expected)
  Thesis: *Mathematics of Deep Learning: Generalization in Single-Task and Multi-Task Architectures via Operator-Theoretic and Kernel-Based Methods*
  Advisor: Prof. Giuseppe Di Fatta
- **M.S. in Data Analytics**, Rochester Institute of Technology (RIT Dubai) Sep 2020 – May 2022
  GPA: 3.7/4. Completed all coursework and thesis requirements. Graduation could not be formally finalized due to a visa interruption (documentation available upon request).
  Thesis: *Energy Consumption Forecasting Using Machine Learning* (online link)
  Advisor: Prof. Sanjay Modak
- **Ph.D. in Mathematics (Functional Analysis)**, Islamic Azad University of Mashhad, Iran Sep 2014 – Mar 2018
  Thesis: *Operator Inequalities and Operators Preserving Orthogonality*, GPA: 18.7/20
- **M.S. in Pure Mathematics**, Islamic Azad University of Mashhad, Iran Sep 2003 – Feb 2006
- **B.S. in Applied Mathematics**, Islamic Azad University of Mashhad, Iran Sep 1999 – Sep 2003

Research Experience

- **Doctoral Researcher in Machine Learning Theory**, Free University of Bozen–Bolzano 2022 – Present
  - *Brownian Kernel Ladders (BKL):* Introduced a hierarchical function-space framework based on integral RKHS constructions driven by Brownian kernels. Developed an intrinsic complexity functional independent of parameterization and established depth-uniform, dimension-free Gaussian complexity and excess-risk bounds of order $\mathcal{O}(n^{-1/2})$. This shows that increasing depth does not necessarily increase statistical complexity.
  - *Operator-Theoretic Generalization for Multi-Task Deep Learning:* Developed a Koopman operator-based framework for analyzing generalization in deep multi-output models. Introduced Brownian integral RKHSs as an alternative to Sobolev spaces, yielding improved spectral scaling and a unified treatment of injective and non-injective architectures.

Applied Data Science Experience

- **Time Series Modeling and Forecasting:** Developed machine learning models for energy consumption forecasting using real-world data, including statistical and learning-based approaches for temporal prediction.

Teaching Experience

- **Faculty Member / Instructor**, Islamic Azad University (Iran) 2006 – 2020
  Courses: Linear Algebra, Real Analysis, Probability Theory, Statistical Inference, Differential Equations, Numerical Analysis.

Research Grants & Funded Projects

- **Post-Lauream Research Grant**, Free University of Bozen–Bolzano, Italy Dec 2025 – Present
  Project: *AI Engineering Suite to Support Agile and Efficient Software Engineering (AI4SWEng)*
  Principal Investigator: Prof. Giuseppe Di Fatta
  Funding: University Research Grant (CUP: I53C250000000006)
  Role: Doctoral researcher contributing to theoretical aspects of machine learning and generalization in AI-driven systems.
- **Learning Fair Latent Representations with Multi-Task Deep Learning** Nov 2025 – Dec 2025
  Short-term funded research project under the MTDL Start-Up Fund
  Focus: Fairness-aware multi-task deep learning and theoretical generalization guarantees for representation learning.

Selected Publications

Machine Learning Theory

- M. Mohammadigohari, G. Di Fatta, Z. Szabó, G. Nicosia, P. M. Pardalos. *Brownian Kernel Ladders*. Manuscript in preparation.
- M. Mohammadigohari, T. Borsani, G. Di Fatta, G. Nicosia. *Fair Latent Representation Learning by Multi-Task Deep Learning*. Manuscript under review.
- M. Mohammadigohari, T. Borsani, G. Di Fatta. *Tight Generalization Bounds for Multi-Task Deep Learning*. Manuscript under review.
- M. Mohammadigohari et al. *On the Koopman-Based Generalization Bounds for Multi-Task Deep Learning*. LNCS, 2025. https://arxiv.org/abs/2512.19199
- M. Mohammadigohari et al. *Operator-Based Generalization Bound for Deep Learning*. LNCS, 2025. https://arxiv.org/abs/2512.19184

Mathematics / Functional Analysis

- M. Mohammadigohari, M. Amyari. *Operator-Valued Parallelism and Norm-Parallelism in Matrices. Indian Journal of Pure and Applied Mathematics*, 51(4):1305–1316, 2020.
- M. Mohammadigohari, M. Amyari. *Parallelism in Hilbert $K(\mathcal{H})$-Modules. Tbilisi Mathematical Journal*, 12(2):67–75, 2019.
- M. Mohammadigohari, M. Amyari. *Refinements of the Heinz Inequalities for Operators and Matrices. Mathematica Slovaca*, 68(6):1431–1438, 2018.

Technical Skills

- Mathematics: Functional Analysis, Operator Theory
- Machine Learning: Statistical Learning Theory, Kernel Methods, Deep Learning
- Programming: Python, R, MATLAB
- Tools: LaTeX, Git, TensorFlow, scikit-learn
- Languages: English (Proficient), Persian (Native)

References

- **Prof. Panos M. Pardalos** — University of Florida pardalos@ise.ufl.edu
- **Prof. Zoltán Szabó** — LSE z.szabo@lse.ac.uk
- **Prof. Giuseppe Di Fatta** — Free University of Bozen–Bolzano Giuseppe.DiFatta@unibz.it