

Ali Momeni

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Summary

Expert in: Analog AI, Learning algorithms, large foundation models, On-device training, analog AI accelerators, neuromorphic computing, physics-informed machine learning.

Co-Leading: several projects including:

- **GradPI:** Locality-aware surrogate models (GradPI loss function) for black-box online optimization and training.
- **GraCo:** A Graph composer for integrated circuits.
- **ForwardFormer:** Local, "Forward-only", training of Transformer models without backward passes.
- **PhyLL:** Physical Local Learning of deep Physical Neural Networks (PNNs) without backpropagation (BP).
- **Analog neuroacoustic computing:** Neuromorphic computing directly with sound waves for speech recognition tasks.
- **Time-varying optical neural networks:** The first Time-varying optical neural networks (ONNs).

Ph.D. Degree at: Electrical Engineering department of EPFL

Education

Ecole Polytechnique Federale de Lausanne (EPFL)

Lausanne, Switzerland

Ph.D. in Electrical Engineering

Oct 2020 - Current

- **Specialization:** Learning algorithms, large foundation models, In-hardware training, Physics-aware Machine Learning, Analog AI accelerators, Neuromorphic Computing, Deep Learning, Optimization

Iran University of Science and Technology (IUST)

Tehran, Iran

M.Sc in Electrical and Computer Engineering, GPA: 4/4 (Ranked 1st)

Sep 2016 - Sep 2019

- **Specialization:** Neuromorphic and Analog Optical Computing Systems, Optimization, Optics.

Shiraz University of Technology (SUTech)

Shiraz, Iran

B.Sc. in Electrical and Computer Engineering, GPA: 4/4 (Ranked 1st)

Sep 2012 - Sep 2016

- Analysis of biological signals (EEG and ECG) using deep-learning and statistical approaches

Work Experience

Sony AI AICD - Sony AI

Zurich, Switzerland

Research Intern

July 2024 - Present

- Contributed to three machine learning projects related to **AI for Chip Design**, including:
- **GradPI:** Developed locality-aware surrogate models trained using the GradPI loss function (based on the Gradient Theorem) for black-box optimization and training analog neural networks.
- **GraCo:** Designed a novel method for synthesizing integrated circuits using **reinforcement learning (RL)**. GraCo incrementally constructs a graph, which is subsequently converted into a netlist and simulated with SPICE (arXiv paper).
- **Schemato:** Developed a **large language model (LLM)** for netlist-to-schematic conversion (arXiv paper).
- **Skills:** Reinforcement learning, optimization, Python (PyTorch), Git, and cloud services.

EPFL LWE - EPFL

Lausanne, Switzerland

Research Scientist

Oct 2020 - Current

- I am in **Wave-based information processing** group of LWE at EPFL, supervised by Prof. Romain Fleury
- Worked on **several Analog Computing and AI/ML and big data projects**, including:
- **ForwardFormer:** Training **Transformer models** with Forward-Forward algorithm in order to reduce memory usage. Demonstrated exceptional performance across various **NLP** and **vision** tasks.
- **PhyLL:** Collaborated with **Microsoft** in UK and **CNRS** in France to develop a novel method, Model-free Forward-Forward algorithm, for training deep physical neural networks (PNNs) without backpropagation (BP) (published in **Science**).
- **Time-varying ONNs:** Proposed a unique time-varying entanglement in **optical neural networks** to enable a power-efficient wave-based platform for analog extreme deep learning, published in **Nature Com.** This research has been recognized as one of **the top 50 latest published Nature papers in Applied Physics and Mathematics**.
- **Skills:** Solving optimization problems, Python with PyTorch, Tensorflow, NumPy, Matplotlib, Pandas, Scikit-learn.

EPFL LTS2 - EPFL

Lausanne, Switzerland

Research Scientist

Nov 2021 - Feb 2023

- I worked as an ML researcher at EPFL's **Signal Processing Laboratory LTS2**, under the supervision of Hervé Lissek, and collaborated with cross-functional teams.
- I proposed a novel concept of **neuromorphic computing** directly with sound waves based on nonlinear multiple scattering for **speech recognition** tasks. In this project, we implemented a physics-inspired version of **recurrent neural networks** and **reservoir computing** for speech and vowel recognition directly in its native domain, leveraging nonlinear sound scattering in a real-world environment without pre-processing and conversion (see the **arXiv** paper).
- **Skills:** PyTorch, NumPy, Pandas, Scikit-learn, Simulink, Matlab

- I was in **optical computing** group of Applied Electromagnetic Laboratory (AEML) at IUST, supervised by Ali Abdolali.
- Worked on several **neuromorphic** and **optical computing** projects in collaboration with **Stanford University**, **EPFL**, and **Aalto University**.
- Developing state-of-the-art optical analog computing with flat optics and metasurface. **Results published in Nanophotonics, Carbon, IEEE Transaction on antennas and propagation, and PRApplied journals.**
- **Skills:** Matlab, Python, NumPy, C++, Comsol, CST Studio.

Achievements

- 2023 **Award**, Research Highlights In **Science** Journals, highlighted paper in **Machine Learning**
- 2022 **Award**, Featured paper as an Editor's highlight, **the top 50 latest published Nature papers** in Applied Physics and Mathematics
- 2020 **Fellowships Award**, Ph.D. program fellowship by Purdue and UofT
- 2019 **Fellowships Award**, M.Sc. entrance examination waived as an award for being among the Top-10
- 2018 **Award**, Student Award from Iran's National Elites Foundation
- 2016 **Best Paper Award**, 1st International Conference on New Research Achievements in Electrical and Computer Engineering, Tehran, Iran
- 2010 **Rank 1st**, Ranked 1st in "SAMPAD Inventions" National competition

Selected Publications

* PLEASE VISIT MY *Google Scholar* FOR AN UPDATED VERSION OF THE PUBLICATIONS AS WELL AS CONFERENCE PROCEEDINGS.

Schemato-An LLM for Netlist-to-Schematic Conversion

Ryoga Matsuo, et al.

arXiv preprint arXiv:2411.13899 (2024). 2024

Backpropagation-free Training of Analog AI Accelerators

Ali Momeni, et al.

2024 Eighteenth International Congress on Artificial Materials for Novel Wave Phenomena (Metamaterials), 2024

Training of physical neural networks

Ali Momeni, et al.

Nature (2024). Under review, 2024

GraCo-A Graph Composer for Integrated Circuits

Stefan Uhlich, et al.

arXiv preprint arXiv:2411.13890 (2024). 2024

Backpropagation-free training of deep physical neural networks

Ali Momeni, Babak Rahmani, Matthieu Malléjac, Philipp Del Hougne, Romain Fleury

Science (2023) eadi8474. American Association for the Advancement of Science, 2023

PhyFF: Physical forward forward algorithm for in-hardware training and inference

Ali Momeni, Babak Rahmani, Matthieu Malléjac, Philipp Del Hougne, Romain Fleury

NeurIPS 2023 Workshop Machine Learning with new Compute Paradigms (2023). 2023

Electromagnetic wave-based extreme deep learning with nonlinear time-Floquet entanglement

Ali Momeni, Romain Fleury

Nature Communications 13.1 (2022) p. 2651. Nature Publishing Group UK London, 2022

Physics-inspired Neuroacoustic Computing Based on Tunable Nonlinear Multiple-scattering

Ali Momeni, Xinxin Guo, Herve Lissek, Romain Fleury

arXiv preprint arXiv:2304.08380 (2022). 2022

Switchable and simultaneous spatiotemporal analog computing with computational graphene-based multilayers

Ali Momeni, Kasma Rouhi, Romain Fleury

Carbon 186 (2022) pp. 599–611. Elsevier, 2022

Parallel wave-based analog computing using metagratings

Hamid Rajabalipanah, Ali Momeni, Mahdi Rahmanzadeh, Ali Abdolali, Romain Fleury

Nanophotonics 11.8 (2022) pp. 1561–1571. De Gruyter, 2022

Parallel analog computing based on a 2×2 multiple-input multiple-output metasurface processor with asymmetric response

Amirhossein Babaee, Ali Momeni, Ali Abdolali, Romain Fleury

Physical Review Applied 15.4 (2021) p. 044015. APS, 2021

Reciprocal metasurfaces for on-axis reflective optical computing

Ali Momeni, Hamid Rajabalipanah, Mahdi Rahmanzadeh, Ali Abdolali, Karim Achouri, Viktor S Asadchy, Romain Fleury

IEEE Transactions on Antennas and Propagation 69.11 (2021) pp. 7709–7719. IEEE, 2021

Generalized optical signal processing based on multioperator metasurfaces synthesized by susceptibility tensors

Ali Momeni, Hamid Rajabalipanah, Ali Abdolali, Karim Achouri

Physical Review Applied 11.6 (2019) p. 064042. APS, 2019

Skills

Programming	Python (NumPy, Pandas, Scikit-learn, Spacy), MATLAB, PyTorch, Tensorflow, Cloud Computing (CUDA), SQL, C/C++
Applications	Docker, Git/Github, Huggingface, Matlab, CST Studio, COMSOL, Lumerical, Latex
Soft Skills	Teamwork, Communication, Agile, Time Management, Problem-solving, Collaborate with cross-functional teams

Invited Talks & Conferences

DAC, San Francisco, 2025	upcoming event: GraCo–A Graph Composer for Integrated Circuits
DAC, San Francisco, 2025	upcoming event: Schemato–An LLM for Netlist-to-Schematic Conversion
Metamaterials, Greece, 2024	Backpropagation-free Training of Analog AI Accelerators
USRI, Spain, 2024	Training of Analog AI accelerators
SPIE, California, 2024	Training of Deep Optical Neural Networks with forward only passes
NeurIPS, New Orleans, 2023	PhyFF: Physical forward algorithm for in-hardware training and inference
PIERS, Prague, 2023	Waves for AI: from ELM and RC to deep neural networks
EcoCloud, Lausanne, 2022	Deep physical Neural Networks

References

Prof. Romain Fleury	Assistant Professor, Department of Electrical Engineering, EPFL, Lausanne, Switzerland romain.fleury@epfl.ch
Prof. Peter L. McMahon	Assistant Professor, Cornell University, USA. peter.mcmahon@alumni.stanford.edu
Prof. Azalia Mirhoseini	Assistant Professor, Assistant Professor of Computer Science, Stanford - Google DeepMind, USA. azalia@stanford.edu
Prof. Viktor Asadchy	Assistant Professor, Department of Electronics and Nanoengineering, Aalto University, Finland viktar.asadchy@aalto.fi
Dr. Stefan Uhlich	Senior Principal Engineer, Sony AI stefan.uhlich@sony.com