

# LORENZO SANI

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## Summary

I am a Ph.D. student in Computer Science at the University of Cambridge. Prof. Nicholas D. Lane, the head of the CaMLSys lab at the Computer Laboratory, supervises me. My research interests include **distributed and federated learning** on data centers and edge devices. Currently, I am focusing on optimizing the efficiency of **large-scale federated learning** settings. My latest works investigate machine learning and system optimizations for **federated pre-training of large language models**, e.g., the **Photon** system and the **DEPT** method.

## Education

### University of Cambridge

*PhD in Computer Science*

*Machine learning and system optimizations for federated pre-training of large language models.*

*Supervised by Prof. Nicholas D. Lane*

**September 2022 – Ongoing**

*Cambridge, United Kingdom*

### Università di Bologna

*Master of Science in Applied Physics*

*Thesis titled "Unsupervised Clustering of MDS data using federated learning".*

*Supervised by Prof. Enrico Giampieri and Prof. Gastone Castellani*

**December 2019 – March 2022**

*Bologna, Italy*

### Università di Bologna

*Bachelor of Science in Physics*

*Thesis titled "Correzioni relativistiche negli atomi idrogenoidi e struttura fine".*

*Supervised by Prof. Roberto Zucchini*

**September 2016 – December 2019**

*Bologna, Italy*

## Selected Papers

### Photon: Federated LLM Pre-Training

Lorenzo Sani, Alex Iacob, Zeyu Cao, Royson Lee, Bill Marino, Yan Gao, Wanru Zhao, Dongqi Cai, Zexi Li, Xinchu Qiu, Nicholas D. Lane

*This work presents the first complete system for federated end-to-end LLM training, leveraging cross-silo FL for global-scale training with minimal communication overheads.*

**Accepetd MLSys'25**

### DEPT: Decoupled Embeddings for Pre-training Language Models

Alex Iacob\*, Lorenzo Sani\*, Meghdad Kurmanji, William F. Shen, Xinchu Qiu, Dongqi Cai, Yan Gao, Nicholas D. Lane

*DEPT decouples embeddings from the transformer body while simultaneously training the latter on multiple data sources without requiring a shared vocabulary.*

**Accepetd (Oral) ICLR'25**

### SparsityFed: Sparse Adaptive Federated Learning

Adriano Guastella\*, Lorenzo Sani\*, Alex Iacob, Alessio Mora, Paolo Bellavista, Nicholas D. Lane

*SparsityFed is a practical federated sparse training method that critically addresses problems such as consensus over sparse masks among clients and robustness to nonIID data.*

**Accepetd ICLR'25**

### Flower: A Friendly Federated Learning Research Framework

Daniel J. Beutel, Taner Topal, Akhil Mathur, Xinchu Qiu, Javier Fernandez-Marques, Yan Gao, Lorenzo Sani, Kwing Hei Li, Titouan Parcollet, Pedro Porto Buarque

Gusmão, Nicholas D. Lane.

*Flower is the most popular and friendly federated learning framework. It has more than 1000 citations.*

**arXiv**

## Projects

### SPRIN-D Composite Learning Challenge | Python, PyTorch, Ray, gRPC, Flower

**February 2025**

- The focus of [this ongoing challenge](#) is on developing solutions that enable efficient model training on heterogeneous Hardware, from high-performance GPUs to CPUs of different types and manufacturers. Solutions must also be resilient, dynamically adapting to computing resource fluctuations and device outages. The teams will deliver a functional core for this framework as open source, which will serve as the foundation for further development, including commercial services and proprietary product features.

### FlowerLLM/Photon | Python, PyTorch, Ray, gRPC, Flower, SLURM

**May 2023**

- Flower, in partnership with the [CaMLSys lab](#) at the University of Cambridge, has trained a 1.3 billion parameter LLM for the first time using a novel formulation of federated learning methods. The first announcement can be found in [this blog post](#), while the research papers above summarize the most interesting results.

### Flower Framework | Python, PyTorch, Ray, JAX, TensorFlow, gRPC, Flower, SLURM

**May 2021**

- [Flower](#) is a friendly federated AI framework. It proposes a unified approach to federated learning, analytics, and evaluation. I joined this project as an advisor and researcher in 2021. I contributed by advising the main developer about the new features that researchers and practitioners would have liked Flower to have.

## Teaching Experience

### L361 - Federated Learning Theory and Practice.

**January 2023 – March 2025**

*Teaching Assistant*

*Cambridge, UK*

- Course ran for **three academic years** during Lent Term (from January to March): 2023, 2024, 2025
- First-ever university-level academic course in Federated Learning.**
- We expanded students' machine learning expertise by examining the manifestation of concepts in decentralized settings, encompassing theoretical aspects like decentralized optimization and practical considerations like networking efficiency.
- Course on Federated Learning technologies taught by Prof. Nicholas D. Lane to PatII, PartIII, and MPhil students at the Department of Computer Science and Technology of the University of Cambridge.

### L46 - Principles of Machine Learning Systems.

**October 2023 – December 2023**

*Teaching Assistant*

*Cambridge, UK*

- We covered the principles and methodologies of scalable and efficient machine learning systems, covering algorithms and system techniques for training models across diverse computing environments.
- Course on Federated Learning technologies taught by Prof. Nicholas D. Lane to PartIII and MPhil students at the Department of Computer Science and Technology of the University of Cambridge.

## Other Papers

### The Future of Large Language Model Pre-training is Federated **FM@FL NeurIPS '24 Workshop (Oral)**

**Lorenzo Sani**, Alex Iacob, Zeyu Cao, Bill Marino, Yan Gao, Tomas Paulik, Wanru Zhao, William F. Shen, Preslav Aleksandrov, Xinchu Qiu, Nicholas D. Lane

*Initial technical report on my work related to federated pre-training of large language models.*

### Worldwide Federated Training of Language Models

**FM@FL NeurIPS '24 Workshop (Oral)**

Alex Iacob, **Lorenzo Sani**, Bill Marino, Preslav Aleksandrov, William F. Shen, Nicholas D. Lane

*We propose a Worldwide Federated Language Model Training (WorldLM) system based on federations of federations, where each federation has the autonomy to account for factors such as its industry, operating jurisdiction, or competitive environment. **Outstanding Paper Award.***

### LUNAR: LLM Unlearning via Neural Activation Redirection

[arXiv](#)

William F. Shen, Xinchu Qiu, Meghdad Kurmanji, Alex Iacob, **Lorenzo Sani**, Yihong Chen, Nicola Cancedda, Nicholas D. Lane

*In this paper, we propose LUNAR, a novel unlearning methodology grounded in the Linear Representation Hypothesis. LUNAR operates by redirecting the representations of unlearned data to regions that trigger the model's inherent ability to express its inability to answer.*

### Fedanchor: Enhancing federated semi-supervised learning

[arXiv](#)

#### with label contrastive loss for unlabeled clients

Xinchu Qiu, Yan Gao, **Lorenzo Sani**, Heng Pan, Wanru Zhao, Pedro Porto Buarque Gusmão, Mina Alibeigi, Alex Iacob, Nicholas D. Lane

*We propose FedAnchor, an innovative Federated Semi-Supervised Learning method that introduces a unique double-head structure, called anchor head, paired with the classification head trained exclusively on labeled anchor data on the server.*

### Sheaf hypernetworks for personalized federated learning

[arXiv](#)

Bao Nguyen, **Lorenzo Sani**, Xinchu Qiu, Pietro Liò, Nicholas D. Lane

*We propose a novel class of HNs, sheaf hypernetworks (SHNs), which combine cellular sheaf theory with HNs to improve parameter sharing for PFL.*

### Pollen: High-throughput simulation of federated learning

[arXiv](#)

#### via resource-aware client placement

**Lorenzo Sani**\*, Pedro Porto Buarque Gusmão\*, Alex Iacob\*, Zhao Wanru, Xinchu Qiu, Yan Gao, Javier Fernandez-Marques, and Nicholas D. Lane

*This work proposes Pollen, a novel resource-aware system for speeding up federated learning simulations in highly heterogeneous resource environments.*

### D6.2 - Preliminary conclusions about Federated Learning applied to clinical data

[Zenodo](#)

Álvarez Federico, Zazo Santiago, Parras Juan, Almodóvar Alejandro, Alonso Patricia, Giampieri Enrico, Castellani Gastone, **Sani Lorenzo**, Rollo Cesare, Sanavia Tiziana, Krogh Anders, Prada-Luengo Iñigo, Kanterakis Alexandros, Sfakianakis Stelios, Cremonesi Francesco

*This report comprises the first contributions from different partners of the GenoMed4All H2020 Project on Federated Learning (FL).*

## Work Experience

### Flower Labs

**May 2024 – September 2024**

*Research Intern*

*Cambridge, UK*

- During the internship at [Flower Labs](#), I have developed methods and tools for efficient federated pre-training of language models. I extended the Flower Framework to allow complete compatibility with the Photon system and contributed to designing the open-source framework's components.

### Oppent

**March 2020 – June 2020**

*Software Specialist*

*Milan, Italy*

- During my part-time contract with [Oppent](#), I developed software for allowing the control and monitoring of the traffic control system managing a fleet of automated vehicles.

## Technical Skills

**Languages/ML Frameworks:** Python, Java, C++, HTML/CSS, JavaScript, PyTorch, TensorFlow, Jax

**Developer Tools:** VS Code, Cursor, Android Studio, Various Cloud Computing Infrastructures (e.g., Lambda Labs, Fluidstack, Runpod)

**Technologies/Frameworks:** Linux, Jenkins, GitHub, Slurm

## Leadership / Extracurricular

### U.S. Santos 1948 a.s.d.

**2021 - Ongoing**

*Council Member*

*Reggio Emilia, Italy*

- I am currently serving as a Council Member for my hometown's local non-professional football club.
- I mostly focus on digital processes and the club's administration.
- U.S. Santos 1948 a.s.d. counts more than 500 associates, more than 50 coaches, and tens of team managers.
- This activity is carried on as unpaid volunteering.

### U.S. Santos 1948 a.s.d.

**2011 - 2022**

*Football Coach*

*Reggio Emilia, Italy*

- I served as a football coach for up to three teams per season for about 11 years.
- I had the privilege to coach from kids to adults, achieving the most important results in the history of the football club by winning as a deputy coach the playoff tournament of the non-professional league we were competing in.