Curriculum Vitae of Alessandro Lonardi

Alessandro Lonardi (he/him) | Network Scientist | alessandro.lonardi.vr@gmail.com | aleable.github.io

Research positions

Sony AI, Barcelona, ES
Jul, 2024 - Dec, 2024   **Research Intern**
Focus: Research on Knowledge Graphs (KG) for scientific hypothesis generation. I am developing a novel post-hoc explainability method for KG completion, working on integrating generative graph models in the context of KG, and assembling fit-for-purpose software tools for scientists.

Max Planck Institute for Intelligent Systems (MPI-IS), Tübingen, DE
Jan, 2024 - Aug, 2024   **Guest Researcher**
Sep, 2020 - Dec, 2023   **PhD Student**
Mar, 2020 - Aug, 2020   **Research Intern**
Focus: I developed physical models for designing and routing in transportation networks inspired by Optimal Transport (OT) theory. Our approaches simulate complex interactions of multiple agents in networks, including the Paris Métro, Copenhagen streets, and European highways. We studied how network design impacts the sustainability of roads and the safety of bicycle transport.

Education

Sep, 2020 - Apr, 2024
PhD in Computer Science at MPI-IS, Tübingen, DE (magna cum laude)
Thesis: Designing Networks with Adaptation Rules and Optimal Transport
Supervisor: Prof. Caterina De Bacco
Program: International Max Planck Research School for Intelligent Systems (IMPRS-IS)

Oct, 2018 - Jul, 2020
Master's Degree in Mathematical Engineering at the University of Padova, IT (cum laude)
Thesis: Developing new methods for routing and optimal transport on networks
Supervisors: Prof. Mario Putti, Prof. Caterina De Bacco
Program: Mathematical Modelling for Engineering and Science

Oct, 2015 - Sep, 2018
Bachelor's Degree in Physics at the University of Padova, IT

Additional work experience

Oct, 2022 - Apr, 2023
Head, co-founder at Commute (startup), DE
Advancement: Our startup was providing data-driven solutions to policymakers to build transportation infrastructures for liveable cities. It was admitted to the initial phase of the MAX!mize incubator of the Max Planck Society, supported by Max Planck Innovation GmbH.

Research interests, outputs, and impact

Mathematical Optimization, Optimal Transport, and Complex Networks

(1) Developed OT-based optimization models and efficient algorithms for routing in transportation networks [JP1-4, JP6, PP1] and supervised image classification [JP5].
(2) Designed a multicommodity model to account for passenger interactions in transportation systems [JP1], analyzed the impact of network designs on the robustness and emissions of the Paris Métro

and the Bordeaux road network [JP2-3]. Evaluated the quality of service of Copenhagen's bicycle lanes [PP1].
(3) Investigated the effects of non-stationary passenger loads in OT-based models for transportation networks [JP5].
(4) Integrated OT into bilevel optimization to study the impact of tolls on road networks [JP6].
Impact: Our works pioneered the integration of OT into network design tasks. They enable the modeling of real-world transportation systems that we evaluate in terms of their quality of service and sustainability. By leveraging OT insights, we coded our models into scalable and robust software.

Probabilistic Models, Community Detection, and Statistical Inference [JP7]

(1) Developed a belief-propagation algorithm for hypergraph inference and community detection, and a standalone method for hypergraph sampling.
(2) Derived theoretical detectability limits of hypergraphs, advancing seminal results on networks.
(3) Implemented an efficient code that effectively handles hypergraphs using dynamic programming.
Impact: Our model generalized detectability limits of complex networks to hypergraphs. We made belief propagation efficient via dynamic programming and designed a fast generative hypergraph model. We validated and tested our model on synthetic and real data.

Open Sourcing, Coding Practices, Societal Impact

I am an advocate for open-source science and codes. Open-source, fully-documented, and reproducible software accompanies all the projects I contributed to. I also work to make all my scientific outputs accessible.

Selected talks and seminars

Bilevel optimization for flow control in optimal transport networks
[Invited] Research Seminar on Mathematical Optimization (Saarland University, DE, 2024) | Slides
[Contributed] Netsci 2023 (Vienna, AT, 2023) | Abstract | Slides

Infrastructure adaptation and emergence of loops in network routing with time-dependent loads
[Contributed] Netsci 2023 Satellite, Networks & cities (Vienna, AT, 2023) | Abstract | Slides

Teaching experience and mentoring

Oct, 2021 - Feb, 2022 | Apr, 2021 - Jul, 2021
Teaching assistant of Advanced Probabilistic Machine Learning and Applications, University of Tübingen, DE
Role: I taught Master's students in hands-on practice sessions and reviewed theoretical lectures for 2 semesters (approx. 40 students in total). Topics: Introduction to Probabilistic Machine Learning, Mean Field Theory, TAP approximation, Bethe Approximation, Belief Propagation, Variational Inference.

Jul, 2022
Volunteer for TReND in Africa Python Workshop 2022, online
Role: I was a lecturer in a Python workshop organized to introduce African scientists to Python programming through experienced-based learning.

Peer-review service

Venue (# reviews) Physical Review E (2), Scientific Reports (1), Journal of The Royal Society Interface (1), Journal of Physics Communications (3), Physica Scripta (2), SysDo Conference 2024 (1)

IT skills and languages

Advanced level (> 6 years) Python (libraries for machine learning, scientific computing, data science, data visualization), Linux: Debian, macOS, LaTeX, code parallelization on cluster computing infrastructures, git, developer productivity tools
Intermediate-beginner level C++, Mathematica, MATLAB, HTML, CSS, Linux: Arch
Languages English (full proficiency), Italian (native), German (independent user), Spanish (basic)

Extracurricular activities

University orientation for high schoolers: Career paths in AI, Verona, IT
Role: I organized and held 2 presentations and Q&A sessions in my former high school to engage and discuss with senior students on AI's impact on scientific careers (approx. 30 students in total).
Volunteer for Pint of Science Italia, Padua, IT
Role: I volunteered for the promotion, organization, and moderation of 3 scientific outreach events in the context of the Italian division of Pint of Science.

Journal papers [JP] and preprints [PP]

Asterisks denote equal contribution.

[PP1]   Cohesive urban bicycle infrastructure design through optimal transport routing in multilayer networks
Alessandro Lonardi, Michael Szell, Caterina De Bacco
Under review in Journal of The Royal Society Interface | arXiv | GitHub

[JP7]   Message-Passing on Hypergraphs: Detectability, Phase Transitions, and Higher-Order Information
Nicolò Ruggeri*, Alessandro Lonardi*, Caterina De Bacco
Journal of Statistical Physics: Theory and Experiment (4), 043403 (2024) | arXiv | GitHub

[JP6]   Bilevel Optimization for Traffic Mitigation in Optimal Transport Networks
Alessandro Lonardi, Caterina De Bacco
Physical Review Letters 131, 267401 (2023) | arXiv | GitHub

[JP5]   Immiscible Color Flows in Optimal Transport Networks for Image Classification
Alessandro Lonardi*, Diego Baptista*, Caterina De Bacco
Frontiers in Physics 11:1089114 (2023) | arXiv | GitHub | Poster

[JP4]   Infrastructure adaptation and emergence of loops in network routing with time-dependent loads
Alessandro Lonardi, Enrico Facca, Mario Putti, Caterina De Bacco
Physical Review E 107, 024302 (2023) | arXiv | GitHub

[JP3]   Multicommodity routing optimization for engineering networks
Alessandro Lonardi, Mario Putti, Caterina De Bacco
Scientific Reports 12, 7474 (2022) | arXiv | GitHub

[JP2]   Optimal Transport in Multilayer Networks for Traffic Flow Optimization
Abdullahi Adinoyi Ibrahim, Alessandro Lonardi, Caterina De Bacco
Algorithms, 14(7), 189 (2021) | arXiv | GitHub

[JP1]   Designing optimal networks for multicommodity transport problem
Alessandro Lonardi, Enrico Facca, Mario Putti, Caterina De Bacco
Physical Review Research 3, 043010 (2021) | arXiv | GitHub