CURRICULUM VITAE

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(a) Research interests

I am a Research Associate in Pietro Lio's group at the University of Cambridge. I am interested in understanding and developing deep learning frameworks by relying on differential geometry, partial differential equations and physics – special emphasis on Graph Neural Networks (GNNs). A common thread to my research consists in analysing and 'controlling' the evolution of the computational graph. Namely, I am currently

- Studying theoretical and practical advantages of 'rewiring' the graph in GNNs. The goal here consists in proving rigorously how all major shortcomings of existing frameworks precisely arise due to the computational graph being equal to the input one at each step (layer) of the architecture. This in turn would allow to develop GNNs that can deal with long-range dependencies. From a dual perspective, the same ideas can be used to improve the 'sparsification' of Transformers.
- Building an energy functional approach akin to classical (quantum) physics for GNNs so that the layer operations can be formally derived as gradient flow (Euler-Lagrange) equations. This is important for learning unknown symmetries and invariant quantities which can ultimately justify our prediction.
- Investigating the notion of 'time' in a GNN to understand over-smoothing/over-squashing and prove why graph-structured data can be better processed by a GNN rather than a Transformer.
- Extending ideas from control differential equations to deep learning frameworks.

(b) Publications and preprints

I have published in top-tier pure mathematics journals and in top ML conferences – with a paper (joint first authors contribution, where I formalised all main ideas and proved all theoretical results) that received *outstanding paper honorable mention* at ICLR22.

1. F. Di Giovanni, et al. *On Over-Squashing in Message Passing Neural Networks: The Impact of Width, Depth, and Topology*, arXiv preprint arXiv:2302.02941, 2023
2. F. Di Giovanni*, J. Rowbottom*, et al. *Graph neural networks as gradient flows: understanding graph convolutions via energy*, arXiv preprint arXiv:2206.10991, 2022
3. F. Di Giovanni*, G. Luise*, et al., *Heterogeneous manifolds for curvature-aware graph embedding*, arXiv preprint arXiv:2202.01185, 2022.
4. C. Bodnar, F. Di Giovanni, et al., *Neural Sheaf Diffusion: A Topological Perspective on Heterophily and Oversmoothing in GNNs*, Advances in Neural Information Processing Systems 36, 2022.
5. J. Topping*, F. Di Giovanni* et al., *Understanding over-squashing and bottlenecks on graphs via curvature*, **Outstanding Paper Honorable Mention** (top 10/3300) at ICLR22, 2022.
6. F. Di Giovanni, *Convergence of Ricci flow solutions to Taub-NUT*, Communications in Partial Differential Equations, 2021.

https://doi.org/10.1080/03605302.2021.1883651.

7. B.P.Chamberlain*, J. Rowbottom*, D. Eynard, F. Di Giovanni, et al., *Beltrami Flow and Neural Diffusion on Graphs*, Advances in Neural Information Processing Systems 35, 2021.
8. F. Di Giovanni, *Rotationally symmetric Ricci flow on* $\mathbb{R}^{n+1}$, Advances in Mathematics, 381, 2021. https://doi.org/10.1016/j.aim.2021.107621
9. F. Di Giovanni, *Ricci flow of warped Berger metrics on* $\mathbb{R}^4$, Calculus of Variations and Partial Differential Equations, 59, 162, 2020. https://doi.org/10.1007/s00526-020-01823-4

(c) Education

University College London	Mathematics	Ph.D., 2017-2021
University of Oxford	Math. and Theor. Physics	M.Sc. *Distinction*, 2016-2017
Università degli Studi di Pavia	Physics	B.Sc. *magna cum laude*, 2013-2016

(d) Experience

- Supervision of 3 research interns at Twitter, co-supervision of 2 PhD students at University of Oxford and supervision of 2 Master students.
- Mentor for the London School of Geometry and Machine Learning (2022).
- Reviewer for NeurIPS 2022.
- Teaching Assistant at Department of Mathematics, UCL, 2017-2021.
  Courses: Analysis 1, Analysis 2, Algebra 1, Algebra 2, Algebra 3, Complex Analysis, Logic.
- Academic Tutor at Department of Engineering, University of Pavia, 2015-2016.

(e) Invited Talks

- Invited panelist at LoG tutorial on Graph-rewiring and Fairness, December 2022
- Keynote speaker at Neurips 2022 Workshop: New Frontiers on Graph Learning, December 2022
- LoGaG reading group, August 2022
- MML seminar at UCLA, August 2022
- Stanford GNN Reading Group, August 2022
- Hammers&Nails Workshop at Weizmann Institute, 2022, August 2022
- First Italian School in Geometric Deep Learning, Pescara, July 2022.
- Guest Lecture at African Masters of Machine Intelligence, June 2022.
- Graph Learning panelist at GT-RL Workshop, ICLR 2022, May 2022.
- AI + Math colloquia, April 2022.

- Dagstuhl Seminar 22132 "Graph Embeddings: Theory meets Practice", March 2022.
- LoGaG reading group, November 2021.

(f) Scholarships and Awards

- UCL 4-year Ph.D. Teaching Assistantship, 2017-2021.
- Archibald Richardson Scholarship, UCL, 2020.
- Mayer de Rothschild Scholarship, UCL, 2018.
- National Scholarship Universitaly for outstanding undergraduate students, 2013-2016.