Francesco Di Giovanni

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Research interests

I have a PhD in Riemannian geometry, with a thesis on Ricci flow. Currently, I am interested in Geometric Deep Learning, with emphasis on understanding the mathematical mechanisms underpinning current paradigms, and building towards novel frameworks to meet the challenges of Life Sciences. In the last two years, I have mainly worked on Graph Neural Networks, one of the most prominent instance of Geometric Deep Learning, spearheading research in oversquashing, a phenomenon arising when the graph topology hinders message exchange, and pioneering graph rewiring, a paradigm shift where the graph connectivity itself is elevated to design factor for more powerful models.

Current Position

Nov. 2023 -Department of Computer Science, University of OxfordPresentSenior Research AssociateSupervisor: Michael Bronstein

Previous Positions

Jan. 2023 – Nov. Department of Computer Science & Technology, University of Cambridge 2023 Research Associate Supervisor: Pietro Liò

Sep. 2021 – **Twitter Cortex (London)** Dec. 2022 *Machine Learning Researcher*

Education

- 2017 2021Department of Mathematics, University College London
PhD, with thesis on Ricci flow (Riemannian Geometry)
Supervisor: Jason Lotay
- 2016 2017 **Mathematical Institute, University of Oxford** *MSc in Mathematical and Theoretical Physics* Distinction
- 2013 2016 **Department of Physics, University of Pavia** Bachelor in Physics 110/110 cum laude

Honors and scholarships

- 2023 Best Reviewer at LOG conference
- 2023 Oral award at New Frontiers in Graph Learning workshop at NeuriPS23
- 2022 Outstanding Paper Honorable Mention at ICLR22 (top 10 out of 3300 submissions)
- 2017–2021 UCL 4-year Ph.D. Teaching Assistantship
 - 2020 Archibald Richardson Scholarship, UCL
 - 2018 Mayer de Rothschild Scholarship, UCL
- 2013–2016 National Scholarship Universitaly for outstanding undergraduate students from lowincome families

Publications and Preprints (in chronological order)

- 2023 Locality-Aware Sequential Graph-Rewiring in GNN F. Barbero, A. Velingker, A. Saberi, M. Bronstein, F. Di G. *arXiv preprint arXiv:2310.01668*
- 2023 **Can strong structural encoding reduce the importance of Message Passing?** F. Eijkelboom, E. Bekkers, M. Bronstein, F. Di G. *Topological, Algebraic and Geometric Learning Workshops at ICML23*
- How does oversquashing affect the power of GNNs?
 F. Di G.*, T. K. Rusch*, M. Bronstein, A. Deac, M. Lackenby, S. Mishra, P. Veličković arXiv preprint arXiv:2306.03589; a version of the work received an oral award at the New Frontiers in Graph Learning workshop at NeuriPS23
- 2023 Edge Directionality Improves Learning on Heterophilic Graphs E. Rossi, B. Charpentier, F. Di G., F. Frasca, S. Günnemann, M. Bronstein Second Edition of LOG conference
- 2023 On oversquashing in Message Passing Neural Networks: The Impact of Width, Depth, and Topology
 F. Di G., L. Giusti, F. Barbero, G. Luise, P. Liò, M. Bronstein *ICML23*
- 2023 DRew: Dynamically Rewired Message Passing with Delay B. Gutteridge, X. Dong, M. Bronstein, F. Di G. *ICML23*
- 2023 Understanding convolution on graphs via energies
 F. Di G.*, J. Rowbottom*, B. Chamberlain, T. Markovich, M. Bronstein Transactions Machine Learning Research
- 2022 Neural Sheaf Diffusion: A Topological Perspective on Heterophily and Oversmoothing in GNNs
 C. Bodnar, F. Di G., B. Chamberlain, P. Liò, M. Bronstein NeurIPS22

2022	Heterogeneous manifolds for curvature-aware graph embedding F. Di G.*, G. Luise*, M. Bronstein GTLR Workshop at ICLR22
2022	Understanding oversquashing and bottlenecks on graphs via curvature J. Topping*, F. Di G.*, B. Chamberlain, X. Dong, M. Bronstein <i>ICLR22, Outstanding Paper Honorable Mention (top 10/3300)</i>
2022	Beltrami flow and Neural Diffusion on graphs B. Chamberlain, J. Rowbottom, D. Eynard, F. Di G., X. Dong, M. Bronstein <i>NeurIPS22</i>
2021	Convergence of Ricci flow solutions to Taub-NUT F. Di G. <i>Communications in Partial Differential Equations</i> https://doi.org/10.1080/03605302.2021.1883651
2021	Rotationally symmetric Ricci flow on \mathbb{R}^{n+1} F. Di G. Advances in Mathematics https://doi.org/10.1016/j.aim.2021.107621
2020	Ricci flow of warped Berger metrics on \mathbb{R}^4 F. Di G. <i>Calculus of Variations and Partial Differential Equations</i> https://doi.org/10.1007/s00526-020-01823-4
	Teaching and Service
2023	Guest Lecture at the L45 course in Graph Representation Learning, University of Cambridge
2023	Reviewer for LOG conference
2023	Reviewer for NeurIPS
2023	Reviewer for ICML
2022	Guest Lecture at the African Masters of Machine Intelligence
2022	Teacher at the First Italian School in Geometric Deep Learning
2022	Mentor for the London Geometry & Machine Learning Summer School
2022	Co-supervision of 2 research interns at Twitter Duties involved research project managements, weekly meetings, and reviews of progress
2022	Reviewer for NeurIPS
2022	Reviewer for ICLR
2017–2021	Teaching Assistant at the Department of Mathematics, UCL Courses included Linear Algebra, Analysis I, II, Logic, Complex Analysis, Group Theory

Selected Invited Talks

2023 Can GNNs mix variables? Mathematics of Geometric Deep Learning Workshop, ICIAM

2023	On oversquashing and expressivity: can GNNs mix variables? From theory to physics-inspired solutions <i>CECAM-Psi-k Conference on 'Bridging length scales with machine learning: from wave-functions to thermodynamics', Berlin</i>
2023	On oversquashing and expressivity: can GNNs mix variables? From theoretical un- derstanding to practical solutions <i>Topological Data Analysis seminar, Mathematical Institute, University of Oxford</i>
2023	Oversquashing and over-smoothing through the lenses of curvature and multi- particle dynamics <i>Complex Network Analysis (CNA) at NCSR</i>
2023	Oversquashing in GNNs: from theoretical understanding to graph-rewiring solutions LOG^2 Seminar, Mathematical Institute, University of Oxford
2022	Should we focus on the architecture or the computational graph? Local Meetup for LOG conference, University of Cambridge, 2022,
2022	GNNs and graph representation learning through the lens of curvature Neurips 2022 Workshop: New Frontiers on Graph Learning
2022	Panelist for the worskhop on Graph Rewiring and fairness Learning on Graphs Conference
2022	Oversquashing in GNNs: from theoretical understanding to graph-rewiring solutions <i>MML seminar at UCLA</i>
2022	Oversquashing in GNNs: from theoretical understanding to graph-rewiring solutions <i>Stanford GNN Reading Group</i>
2022	Oversquashing and over-smoothing through the lenses of curvature and multi- particle dynamics <i>Hammers & Nails Workshop, Weizmann Institute</i>
2022	Panelist at the GT-RL Workshop ICLR
2022	GNNs and graph representation learning through the lens of curvature Dagstuhl Seminar 22132 "Graph Embeddings: Theory meets Practice",
	Technical skills

Programming Python, PyTorch, Git