Giuseppe Alessio D'Inverno

Curriculum Vitae

August 9, 2025

Personal data

Birth Date: December 27, 1993
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Academic appointments

Current position

02/2024– **Postdoctoral Researcher**, *MathLab Group, Mathematics Area, SISSA, International School for Advanced Studies*, Trieste, Italy

Education

29/04/2024 **PhD in Information Engineering & Science (XXXVI cycle)**, *Department of Information Engineering and Mathematics, University of Siena*, Italy, Evaluation: "Excellent" cum laude
Thesis: "*Theoretical properties of Graph Neural Networks*", advisors: Maria Lucia Sampoli, Franco Scarselli, Monica Bianchini,

17/04/2020 **MS in Applied Mathematics**, *University of Siena*, Italy, 110/110 cum laude
Thesis: "*Towards the determination of threshold in neural networks*", advisor: Luca Chiantini

22/02/2018 **BS in Mathematics**, *University of Siena*, Italy, 110/110 cum laude
Thesis: "*Studio della decomposizione ai valori singolari applicata alla ricostruzione di modelli 3D (A study on singular value decomposition and its application on 3D Models Reconstruction)*", advisor: Maria Lucia Sampoli

26/11/2015 **BA in Violin**, *Conservatorio "R. Franci"*, Italy, 106/110
Thesis: "*La seconda sonata per violino BWV 1003 di J. S. Bach: Isotropia polifonica e sintassi tonale. (J.S.Bach Second Violin Sonata BWV 1003: Polyphonical isotropy and tonal syntax)*", advisor: Antonio Anichini

04/07/2012 **Upper secondary school diploma**, *Liceo Scientifico "P. Aldi" of Grosseto*, Italy, 100/100 cum laude

Grants and Fellowships

01/02/2024- **Postdoc Fellowship (CUP G93C22000610007)**, *SISSA, Trieste*, Italy

18-22/10/2023 **Grant "Organizzazione Convegni Scuole e Workshop" (CUP E53C22001930001), Gruppo Nazionale Calcolo Scientifico, INdAM (contribution for Third Young Applied Mathematicians Conference, September 18-22, 2023, Siena)**, *Italy*

28/02–04/03/2022 **Travel Grant, "Lectures on Mathematics of Deep Learning"** , *Isaac Newton Institute for Mathematical Sciences,*, Cambridge, United Kingdom

11/2020–10/2023 **Ph.D. Full Scholarship in Information Engineering & Science (XXXVI cycle),"Theoretical foundations of Graph Neural Networks"**, *Department of Information Engineering and Mathematics, University of Siena*, Italy

Research interests

Mathematical Foundations of Deep Learning - Graph Representation Learning - Numerical modeling for PDEs - Physics Informed Neural Networks - Neural Operators

Publications

Peer–reviewed Journals

1. L. Desiderio, **G. A. D'Inverno**, M. L. Sampoli, A. Sestini (2025). "Hierarchical matrices for 3D Helmholtz problems in the multi-patch IgA-BEM setting", *Engineering with Computers*, https://doi.org/10.1007/s00366-025-02144-w

2. **G. A. D'Inverno**, S. Moradizadeh, S. Salavatidezfouli, P. C. Africa, G. Rozza (2025). "Mesh-Informed Reduced Order Models for Aneurysm Rupture Risk Prediction", *Journal of Computational and Applied Mathematics*, 470, 116727, https://doi.org/10.1016/j.cam.2025.116727

3. **G. A. D'Inverno**, M. Bianchini, F. Scarselli (2024). "VC dimension of Graph Neural Networks with Pfaffian activation functions", *Neural Networks*, 182, 106924, https://doi.org/10.1016/j.neunet.2024.106924

4. **G. A. D'Inverno**, S. Brugiapaglia, M. Ravanelli (2024). "Generalization Limits of Graph Neural Networks in Identity Effects Learning" , *Neural Networks, Special Issue: Graph Representation Learning*, 181, 106793, https://doi.org/10.1016/j.neunet.2024.106793

5. **G. A. D'Inverno**, J. Dong, (2024). "Comparison of Reservoir Computing topologies using the Recurrent Kernel approach", *Neurocomputing*, 611, 128679, https://doi.org/10.1016/j.neucom.2024.128679

6. **G. A. D'Inverno**, M. Bianchini, M. L. Sampoli, F. Scarselli (2024)."On the approximation capability of GNNs in node classification/regression tasks", *Soft Computing*, 28, 8527–8547, https://doi.org/10.1007/s00500-024-09676-1

7. M. S. Bucarelli, **G. A. D'Inverno**, M. Bianchini, F. Scarselli, F. Silvestri (2024). "A topological description of loss surfaces based on Betti Numbers", *Neural Networks*, 178, 106465, https://doi.org/10.1016/j.neunet.2024.106465

8. S. Beddar-Wiesing, **G. A. D'Inverno**, C. Graziani, V. Lachi, A. Moallemy-Oureh, F. Scarselli, J. M. Thomas (2024). "Weisfeiler–Lehman goes dynamic: An analysis of the expressive power of graph neural networks for attributed and dynamic graphs", *Neural Networks*, 173, 106213, `https://doi.org/10.1016/j.neunet.2024.106213`

9. A. Falini, **G. A. D'Inverno**, M. L. Sampoli, F. Mazzia (2022). "Splines Parameterization of Planar Domains by Physics-Informed Neural Networks", *Mathematics*, 11(10), 2406, `https://doi.org/10.3390/math11102406`

10. **G. A. D'Inverno**, S. Brunetti, M. L. Sampoli, D. F. Muresanu, A. Rufa, M. Bianchini (2021). "Visual Sequential Search Test Analysis: An Algorithmic Approach", *Mathematics*, 9(22), 2952, `https://doi.org/10.3390/math9222952`

Conference Papers

1. C. Fontana, **G. A. D'Inverno**, N. Cappetti (2024). Diagnostic Enface Imaging of Retinal Vascularization: Topological Reconstruction and Intersection Identification. In: Carfagni, M., Furferi, R., Di Stefano, P., Governi, L., Gherardini, F. (eds) Design Tools and Methods in Industrial Engineering III. ADM 2023. Lecture Notes in Mechanical Engineering. Springer, Cham. `https://doi.org/10.1007/978-3-031-58094-9_5`

Submitted

1. B. T. Corradini, B. Cullen, C. Gallegati, S. Marziali, **G. A. D'Inverno**, M. Bianchini, F. Scarselli. "Training Dynamics of GANs Through the Lens of Persistent Homology" (2025). *Under review*.

2. **G. A. D'Inverno**, Z. Hu, L. Davy, M. Unser, G. Rozza, J. Dong. "Revisiting Deep Information Propagation: Fractal Frontier and Finite-size Effects" (2025). *Under review*. arXiv:2508.03222,

3. A. Poggi, **G. A. D'Inverno**, H. Brismar, O. Öktem, M. Barreau, K. Morozovska. "Data-driven multi-agent modelling of calcium interactions in cell culture: PINN vs Regularized Least-squares" (2025). arXiv:2505.20327, *Under review*.

4. **G. A. D'Inverno**, K. Ajavon, S. Brugiapaglia. "Surrogate models for diffusion on graphs via sparse polynomials" (2025). arXiv:2502.06595.

5. L. Chiantini, **G. A. D'Inverno**, S. Marziali. "Product Of Tensors and Description of Networks" (2025). arXiv:2402.06768, *Under review*.

Teaching and supervision

Teaching: Doctoral level

21/06/2025 **Invited Lecture "Graph Neural Networks: Theory and applications"**, *Summer school on Physics-Informed Neural Networks and their applications*, Stockholm (SE)

Teaching: Bachelor and master level

10/2024–12/2024 **Teaching Assistant for the course "Advanced Programming" (Fall 2024)**, *Università degli Studi di Trieste & SISSA*, Trieste (TS)

09/2023–12/2023 **Lecturer for the course "Discrete Mathematics & Theory 2" (Fall 2023)**, *CET Academic Programs for Virginia University*, Siena, Italy

03/2021–07/2022 **Teaching Assistant for the Mathematical Analysis 2 undergraduate course (Spring 2021, 2022)**, *Department of Information Engineering and Mathematics, University of Siena*, Siena, Italy

10/2021–02/2022 **Teaching Assistant for the Numerical Calculus undergraduate course (Fall 2021, 2022)**, *Department of Information Engineering and Mathematics, University of Siena*, Siena, Italy

10/2020–02/2022 **Teaching Assistant for the Linear Algebra undergraduate course (Fall 2020, 2021, 2022)**, *Department of Information Engineering and Mathematics, University of Siena*, Siena, Italy

16/04/2019 **Invited lesson for the course of "Numerical Analysis" for the Master in Applied Mathematics**, *University of Siena*, Siena,Italy

Supervision: Bachelor and Master level

2024 **Co-supervision for Master's degree thesis in Mathematics**, *"Surrogate Models for diffusion on graphs: a high-dimensional polynomial approach", Candidate: Kylian Ajavon*, Department of Mathematics and Statistics, Concordia University, Montréal (CA)

2022 **Co-supervision for Master's degree thesis in Applied Mathematics**, *"One Dimensional Model of Navier-Stokes Equations for the Arterial Blood Flow", Candidate: Hasel Cicek Konan*, Department of Information Engineering and Mathematics, University of Siena

2020 **Co-supervision for Master's degree thesis in Applied Mathematics**, *"Different classes of tensors for modeling rater agreement data", Candidate: Federica Cenni*, Department of Information Engineering and Mathematics, University of Siena

2023 **Co-supervision for Bachelor's degree thesis in Mathematics**, *"Studio di formule di quadratura per l'approssimazione numerica di integrali singolari ed ipersingolari", Candidate: Sofia Corsi*, Department of Information Engineering and Mathematics, University of Siena

2023 **Co-supervision for Bachelor's degree thesis in Mathematics**, *"Analisi di sopravvivenza su dati clinici tramite il metodo di Kaplan-Meier", Candidate: Daniela Bagno*, Department of Information Engineering and Mathematics, University of Siena

Research Stays

02/2025–06/2025 **Visiting researcher**, *Concordia University & Montréal Institute for Learning Algorithms (MILA), Montréal*, Canada, hosts Prof. Simone Brugiapaglia & Prof. Mirco Ravanelli

02/2023–05/2023 **Visiting scholar**, *Montréal Institute for Learning Algorithms (MILA) & Université de Montréal , Montréal*, Canada, hosts Prof. Mirco Ravanelli & Prof. Simone Brugiapaglia

05/2022–09/2022 **Visiting scholar**, *Biomedical Imaging Group, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne*, Switzerland, host Prof. Michael Unser

Conferences, workshops and seminars

Invited talks

10/03/2025 **Invited Talk "Theoretical Properties of Graph Neural Networks"**, *CRM Applied Math Seminars*, Montréal (CA)

20/06/2024 **Contributed talk "Mesh-Informed reduced order models for aneurysm rupture risk prediction"**, *Scientific Machine Learning: Emerging Topics*, Trieste, Italy

06/06/2024 **Invited talk at minisymposium "DeepONet for inverse operator approximation in matrix-free contexts"**, *ECCOMAS 2024 Conference*, Lisbon, Portugal

29/02/2024 **Invited talk at minisymposium "VC dimension of Graph Neural Networks with Pfaffian Activation Functions"**, *SIAM UQ24 Conference*, Trieste, Italy

22/02/2024 **Contributed talk "Physics Informed Graph Neural Networks for Optimal Power Flow"**, *Workshop "PINN-PAD"*, Padova, Italy

19/01/2024 **Contributed talk "VC dimension of Graph Neural Networks with Pfaffian Activation Functions"**, *Workshop "Mathematics for Artificial Intelligence and Machine Learning"*, Milano, Italy

08/09/2023 **Contributed talk "Distress prediction based on Pennes' Bioheat Equation: a Physics Informed Neural Network approach"**, *Bioinformatiha 10*, Siena, Italy

30/09/2023 **Invited talk at minisymposium "Bounds and limitations on generalization capabilities of Graph Neural Networks"**, *SIMAI23 Conference*, Matera, Italy

29/09/2023 **Invited talk at minisymposium "An H-matrix based acceleration of Iga-BEM for 3D Helmholtz problems"**, *SIMAI23 Conference*, Matera, Italy

26/11/2022 **Contributed talk "Splines parameterization of planar domains by Physics Informed Neural Networks"**, *Workshop "Matematica per l'Intelligenza Artificiale ed il Machine Learning – Giovani Ricercatori"*, Torino (TO)

29/09/2022 **Contributed talk "Hierarchical matrices techniques for Helmholtz problem in IgaBEM setting"**, *GIMC-SIMAI Young 2022*, Pavia (PV)

22/09/2022 **Contributed talk "Hierarchical matrices techniques for Helmholtz problem in IgaBEM setting"**, *SMART 2022*, Rimini(RI)

19/09/2022 **Contributed talk "Hierarchical matrices techniques for Helmholtz problem in IgaBEM setting"**, *2nd Young Applied Mathematicians Conference (YAMC)*, Arenzano(GE)

29/10/2021 **Contributed talk "The expressive power of Graph Neural Networks – A unifying point of view"**, *20th International Conference of the Italian Association for Artificial Intelligence*, online

22/07/2021 **Contributed talk "The expressive power of Graph Neural Networks – A unifying point of view"**, *ACDL 2021*, Certosa di Pontignano (SI)

Organizer

15-29/06/2025 **Organizing committee for the 'Summer school on Physics-Informed Neural Networks and their applications'**, *Royal Institute of Technology (KTH)*, Stockholm (SW), with K. Morozovska, F. Bragone, N. Tonicello, Z. Dimitrov, O. Bourchas, A. Panagiotopoulos, E. Monti, D. Coscia

07/06/2025 **Session "Mathematics of Machine Learning", CMS Summer Meeting**, *Université Laval*, Quebec City (CA), with B. Adcock, S. Brugiapaglia

4-6/12/2024 **Organizing Committee for the 'Learning on Graph Conference 2024 - Italy Meetup'**, *University of Siena*, Italy, with P. Bongini, F. Costanti, B. Cullen, C. Gallegati, C. Graziani, V. Lachi, S. Marziali, N. Pancino, F. Pichi

16–20/09/2024 **Scientific and Organizing Committee for the 'Fourth Young Applied Mathematicians Conference'**, *University of Rome "La Sapienza"*, Italy, with G. Auricchio, C. Carrara, C. Graziani, A. Kushova, G. Loli, S. Marziali, A. Marchetti, M. Menci, E. Onofri

9-13/09/2024 **Program Committee for the "21st International Workshop on Mining and Learning with Graphs"**, *ECML PKDD 2024*, Vilnius, Lithuania

24-28/06/2024 **Organizing Committee for the Summer School "Artificial Intelligence for Biomedical Applications"**, *Monasterino della Conoscenza, Siena*, Italy, with P. Bongini, C. Graziani, V. Lachi, N. Pancino

13-14/05/2024 **Minisymposium "Deep Learning Methods for Numerical Linear Algebra", SIAM LA24 Conference**, *Sorbonne Université*, Paris (FR), with C. Millevoi

18–22/09/2023 **Scientific and Organizing Committee for the 'Third Young Applied Mathematicians Conference'**, *University of Siena*, Italy, with G. Auricchio, C. Graziani, V. Lachi, F. Locatelli, G. Loli, L. Zambon

Communication

28/10/2024 **Communication talk "Reti Neurali per grafi: dalle molecole ai social network"**, *AI2S*, Trieste, Italy

Journal and Proceeding activities

Guest Editor

07/2025– **Special issue "Advances in Physics-Informed Machine Learning – Selected Papers from the PhD Summer School on Physics-Informed Neural Networks and Applications 2025"**, *Springer Journal "Advances in Continuous and Discrete Models"*, with M. Barreau, K. Morozovska and K. Shukla

Referee work: journals

IEEE Transaction on Neural Network and Learning Systems, Nature Communications, Neural Networks, Neurocomputing, Applied Numerical Mathematics, Soft Computing, Opuscula Mathematica,

International Journal of Knowledge–Based and Intelligent Engineering Systems

Referee work: proceedings

International Conference for Learning Representations (ICLR), European Conference of Machine Learning (ECML)

Research projects

2025 **INdAM-GNCS Project 2025: "Modelli di ordine ridotto per problemi complessi di fluidodinamica computazionale" (Coordinator: Dott. Niccolò Tonicello, Duration 12 Months**, *Gruppo Nazionale di Calcolo Scientifico, INdAM*, Italy

2022 **INdAM-GNCS Project 2022: "Verso nuove frontiere dell'analisi isogeometrica" (Coordinator: Prof. Francesca Pelosi, Duration 12 Months)**, *Gruppo Nazionale di Calcolo Scientifico, INdAM*, Italy

Educational activities

18–30/07/2023 **Summer School on Physics Informed Neural Networks and Applications**, *KTH*, Stockholm, Sweden

29/06–01/07/2022 **Summer Research Institute 2022 - Learning: Optimization and Stochastics**, *EPFL*, Lausanne, Switzerland

28/02–04/03/2022 **Lectures on Mathematics of Deep Learning**, *Isaac Newton Institute for Mathematical Sciences*, Cambridge, United Kingdom

26–30/07/2021 **DeepLearn 2021**, Las Palmas di Gran Canaria, Spain

19–23/07/2021 **Advanced Course on Data science & Machine Learning (ACDL) 2021**, Certosa di Pontignano (SI), Italy

21–25/06/2021 **Regularization Methods for Machine Learning (RegML) 2021**, *MaIGA, University of Genova*, online

Further information

Scientific Associations

- *Società Italiana di Matematica Applicata e Industriale* (SIMAI), Young Member (2022-)
- *"AI&ML&MATH Group", Unione Matematica Italiana* (UMI) (2021-)
- *Gruppo Nazionale di Calcolo Scientifico (GNCS), Istituto Nazionale di Alta Matematica* (INdAM), Young Member (2020-)

Professional Experience

01/09/2021 – **Maths & Physics Teacher**, *Liceo Statale "A. Rosmini"*, Grosseto, Italy

07/01–06/02/2020 **Violin Teacher**, *Istituto di Istruzione Superiore Polo "Luciano Bianciardi"*, Grosseto, Italy

11/2019–06/2020 **Violin Teacher**, *Fondazione Grosseto Cultura*, Grosseto, Italy

2021 – 2023 **Second Section violin player**, *Ensemble Symphony Orchestra*, Massa, Italy

2020 – 2023 **First Section violin player**, *Orchestra AMAT*, Firenze, Italy

2018 – 2023 **First Section violin player**, *Filharmonie Orchestra*, Campi Bisenzio (FI), Italy

2016 – 2023 **External adjoint violin player**, *Conservatorio "R. Franci"*, Siena, Italy

2012 – 2023 **First Section violin player**, Orchestra Filarmonica di Lucca, Lucca, Italy

2010 – 2023 **First Section violin player**, *Orchestra Città di Grosseto*, Grosseto, Italy

Professional activities and projects

10/2024 **AI Forum Hackathon – Mentorship**, Tavagnacco (UD)

10/2021 **Hackaton 4 Rare Diseases – Winner (Team "Power rAIngers")** , Firenze, Italy

2016 – 2023 **"Pint of Science", Local Team Collaborator(2016–2019, Siena; 2024, Trieste), Local Team Leader (2020-2023, Siena)**

2011 – 2014 **Youth National Lead Collaborator Società "Dante Alighieri"**, Roma, Italy

2009-2011 **Olimpiadi della Matematica, National Round, Group Cathegory (2009-2011), Individual Cathegory (2011)** , Cesenatico (RI), Italy

Computer skills and competencies

- R, HTML, Javascript, C : basic knowledge
- C++, Python, Matlab: proficient knowledge
- Java: Experis Back-End developer course (06-07/2020)
- ECDL certification

Language competences

Italian (Mother tongue), English (Proficient: C1 Cambridge Certificate, Grade: 198/210), French (Diplôme DELF B1, Grade: 83.5/100)

References

Prof. Dr. **Maria Lucia Sampoli**
Associate Professor in Numerical Analysis
Department of Information Engineering and Mathematics, University of Siena
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Prof. Dr. **Simone Brugiapaglia**
Associate Professor in Numerical Analysis
Interim Director of the Applied Math Laboratory of the Centre de Recherches Mathématiques
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Prof. Dr. **Gianluigi Rozza**
Full Professor in Numerical Analysis
Head of SISSA Mathematics Area, SISSA mathLab coordinator

PI of European Research Council project AROMA-CFD
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