



# Giuseppe Alessio D'Inverno

## Curriculum Vitae

September 20, 2024

### Personal data

Birth Date: December 27, 1993

Gender: M

Nationality: Italian

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34136, Italy

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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

## 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*
- 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. **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>
2. 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*, 106465, <https://doi.org/10.1016/j.neunet.2024.106465>
3. S. Beddar-Wiesing, **G. A. D’Inverno**, C. Graziani, V. Lachi, A. Moallem-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*, 106213, <https://doi.org/10.1016/j.neunet.2024.106213>
4. 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>
5. **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](https://doi.org/10.1007/978-3-031-58094-9_5)

### Submitted

1. **G. A. D’Inverno**, J. Dong. “Extension of Recurrent Kernels to different Reservoir Computing topologies” (2024). arXiv:2401.14557. *Accepted*, Neurocomputing.
2. **G. A. D’Inverno**, M. Bianchini, F. Scarselli. “VC dimension of Graph Neural Networks with Pfaffian activation functions” (2023). arXiv:2401.12362. *Under review*, Neural Networks.
3. **G. A. D’Inverno**, S. Brugiapaglia, M. Ravanelli. “Generalization Limits of Graph Neural Networks in Identity Effects Learning” (2023). arXiv:2307.00134. *Under review*, Neural Networks, Special Issue: Graph Representation Learning

## Teaching and supervision

### Teaching: Bachelor and master level

- 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

- 2021 **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

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## Research Stays

- 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

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## Conferences, workshops and seminars

### Invited talks

- 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

- 16–20/09/2024 **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
- 24–28/06/2024 **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 **Third Young Applied Mathematicians Conference**, *University of Siena*, Italy, with G. Auricchio, C. Graziani, V. Lachi, F. Locatelli, G. Loli, L. Zambon

### Conferences and workshops: attendance

1. Attended WCCI2022, Pavia (PV), July 18–22, 2022
2. Attended 21th AlxIA Conference, Udine (UD), November 28–30, 2022

### Journal activities

#### Referee work

IEEE Transaction on Neural Network and Learning Systems, Neural Networks, Neurocomputing, Applied Numerical Mathematics, Soft Computing, Opuscula Mathematica, International Journal of Knowledge-Based and Intelligent Engineering Systems

### Research projects

- 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

- 10/2021 **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 Category (2009–2011), Individual Category (2011)**, Cesenatico (RI), Italy

### Computer skills and competencies

- R, HTML, Javascript, C, C++ : basic knowledge
- 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)

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## References

Prof. Dr. **Maria Lucia Sampoli**

Associate Professor in Numerical Analysis

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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

SISSA, Mathematics Area, mathLab

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