CURRICULUM VITAE

Name	Danillo Barros de Souza
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Research IDs	ORCID 0000-0002-7762-8862
Current position	Postdoctoral Research Fellow at Basque Center for Applied Mathematics (BCAM), Mathematical, Computational and Experimental Neuroscience (MCEN) Group, Universidad del País Vasco (UPV), Basque Country, Spain
Research line	My research lies in data analysis and applications of Artificial Intelligence approaches. In particular, focusing on network Topological and Geometrical data analysis, specifically in designing optimal techniques to analyze big data. In particular, I explore the use of such techniques in the context of time-series, protein data and neuronal data (e.g., functional Magnetic Resonance Imaging (fMRI) time series and Magnetoencephalography (MEG) data), image processing, clustering and machine learning algorithms.

EDUCATION

- 03/2025 – 09/2025: **Certificated Degree on Applied Artificial Intelligence and Its Mathematical Foundations** at Universidad del País Vasco (UPV/EHU), Basque Country, Spain
  - Supervisor: Javier del Ser
  - Research topic: Machine learning methods for Depression detection from social media posts.
- 2017–2021: **PhD Degree** in Mathematics at Universidade Federal de Pernambuco, Recife, Brazil.
  - Supervisor : Prof. Fernando A. N. Santos
  - Reseach topic: Topological and Geometric approaches in Epidemiology, PhD Thesis repository.
- 2015–2017: **Master's Degree** in Mathematics at Universidade Federal de Pernambuco, Recife, Brazil.
  - Supervisor : Prof. Fernando A. N. Santos
  - Reseach topic: Fock space approach to stochastic epidemic models, MSc Thesis repository.
- 2009–2014: **Undergraduate Degree** in Mathematics at Universidade Federal de Pernambuco, Recife, Brazil.
  - Supervisor 1: Prof. Marcos Rabelo
  - Reseach topic: Study of asymptotic behavior of two-dimensional systems
  - Supervisor 2: Prof. Solange Rutz
  - Reseach topic: Finsler geometry for modelling the coral bleaching problem

PROFESSIONAL EXPERIENCE

- 03/2021 – present: **Postdoctoral Research Fellow** at Basque Center for Applied Mathematics (BCAM), Mathematical, Computational and Experimental Neuroscience (MCEN) Group, Universidad del País Vasco (UPV), Basque Country, Spain
  - Supervisor: Prof. Serafim Rodrigues
  - Research topic: Topological and Geometrical approached to analyse fMRI Data.

TEACHING EXPERIENCE

- 03/2019 – 07/2019: Teaching assistant for the course "Mathematical problem-solving techniques".

EXPERTISE AND INTERESTS

- Big Data
- Data Analysis
- Topological & Geometrical Data Analysis
- Machine Learning
- Deep Learning
- Artificial Intelligence

CODING SKILLS

- Python
- Lua
- R
- Wolfram Mathematica
- Matlab
- Maple
- Shell

SOFTWARE DEVELOPMENTS

- 09/05/2024: "FastForman - An efficient Forman-Ricci Curvature computation for higher-order faces in Simplicial Complexes". Python code developed under the supervision of Serafim Rodrigues at MCEN Group, BCAM, Bilbao, Spain, DOI: 11396603, weblink.
- 18/08/2024: "Emergence of High-Order Functional Hubs in the Human Brain". Python Code-block development in collaboration with Fernando A. N. Santos for the Human Connectome Project (HCP), weblink.
- 03/04/2025: "FastKnill - An alternative fast computation of Euler characteristics and Knill curvature from networks, weblink, DOI:10.5281/zenodo.15476107.

CODE AND DATA REPOSITORIES

- Kaggle repository: weblink.
- Github repository: weblink.

LANGUAGES

- Portuguese (Native)
- English (IELTS certified)
- Spanish (Cervantes certified)

SUPERVISING AND MENTORING ACTIVITIES

2020 – 2022 Lead Scientist in Secretary of Health of the State of Pernambuco, Brazil. This data science project consists of real-time COVID-19 data processing, as well as estimates and forecasting of cases by using topological data analysis and classical epidemiology models. The data is still being updated on a weekly basis, weblink.

ACADEMIC AND NON-ACADEMIC COLLABORATIONS

- Collaborating with Prof. Javier del Ser at UPV.
  One manuscript in preparation : *Introducing a geometry-based clustering detection algorithm with data applications*.

- Collaborating with Dr. Fatemeh (Hannaneh) Fahimi at the Max Planck Institute for Mathematics in the Sciences (MPI-MIS). One manuscript in preparation: *Geometrical classification of high-order network dynamics via clustering and dimension reduction methods.*
- Collaborating with Dr. Parvaneh Joharinad at MPI-MIS.
  One manuscript in preparation: *Theoretical insights of curvature and applications to protein databases.*
- Collaborating with Dr. Alvaro Díaz-Ruelas at MPI-MIS.
  One manuscript in preparation: *A clustering collaboration network model in a geometric perspective.*
- Collaborated with the Secretary of Health of Malawi on *Predictions of COVID-19 new cases and deaths, as well as decision-making protocols for sanitary measures*.
- Collaborated with the Secretary of Health of Pernambuco, Brazil on *Predictions of COVID-19 new cases and deaths*.

EDUCATION

- 03/2017 – 02/2021: **PhD in Mathematics** at the Federal University of Pernambuco (UFPE), Recife, Brazil
  - Thesis Title: Topological and Geometric approaches in Epidemiology
  - Advisor: Professor Fernando A. N. Santos (f.a.nobregasantos@uva.nl)
  - Defense committee: Cesar Castilho (UFPE, Brazil), Manoel Lemos (UFPE, Brazil), Jones Albuquerque (UFRPE, Brazil), Fernando Moraes (UFRPE, Brazil)
  - Defense: 26/01/2022 at UFPE (Recife, Brazil)
- 03/2015 – 02/2017: **MSc. Degree in Mathematics** at Federal University of Pernambuco, Recife, Brazil
  - MSc. thesis title: Analytic Solutions to Stochastic Epidemic Models
- 03/2009 – 02/2014: **BSc. Degree in Mathematics** at Federal University of Pernambuco (Recife, Brazil)

PARTICIPATION IN FUNDED PROJECTS

- 03/2021-02/2023: Postdoctoral Research Fellow on the project **"Mathematical, Computational and Experimental Neuroscience"**, funded by the Juan de La Cierva.
- 03/2021–present: Postdoctoral Research Fellow on the project **"Topological, Geometrical and AI methods in Neuroscience"**, funded by the IKUR Initiative.

SCIENTIFIC OUTPUT

Indicators of quality of scientific production (25/09/2025):

- 8 publications, 48 citations (source: Google Scholar).

PUBLICATIONS [*: Corresponding author]

- D. B. de Souza, J. T. Da Cunha, E. F. dos Santos, J. B. Correia, H. P. da Silva, J. L. de Lima Filho, F. A. Santos. "Using discrete Ricci curvatures to infer COVID-19 epidemic network fragility and systemic risk", *Journal of Statistical Mechanics: Theory and Experiment.*, **5**: 053501, 2021. DOI: 10.1088/1742-5468/abed4e. **[22 citations]**
- D. B. de Souza, E. F. dos Santos, F. A. Santos. "The Euler characteristic as a topological marker for outbreaks in vector-borne disease". *Journal of Statistical Mechanics: Theory and Experiment.* **12**: 123501, 2022. DOI: 10.1088/1742-5468/aca0e5. **[2 citations]**
- D. B. de Souza*, H. A. Araújo, G. C. Duarte-Filho, E. A. Gaffney, F. A. Santos, E. P. Rapos. "Fock-space approach to stochastic susceptible-infected-recovered models". *Physical Review E*. **106**(01): 014136, 2022. DOI: 10.1103/PhysRevE.106.014136. **[10 citations]**
- D. B. de Souza*, J. T. da Cunha, F. N. Santos, J. Jost, S. Rodrigues. "Efficient set-theoretic algorithms for computing high-order Forman-Ricci curvature on abstract simplicial complexes".*Proceeding of the Royal Society A*, 2024, DOI: 2308.11763.

- F. N. Santos, P. B. Tewarie, P. Baudot, A. Luchicchi, D. B. de Souza, G. Girier, A. P. Milan, T. Broeders, E. Z. Centeno, R. Cofre, F. E. Rosas, D. Carone, J. Kennedy, C. J. Stam, A. Hillebrand, M. Desroches, S. Rodrigues, M. Schoonheim, L. Douw, R. Quax. "Emergence of High-Order Functional Hubs in the Human Brain". In revision in *Nature Communications*, 2024, bioRxiv: 10.1101/2023.02.10.528083v1. **[12 citations]**
- D. B. de Souza*, J. Teodomiro, F.A. Santos, M. Desroches, S. Rodrigues, "Alternative set-theoretical algorithms for efficient computations of cliques in Vietoris-Rips complexes". Arxiv: 2502.14593.
- R. Cavalcanti, N. Leal, D. B. de Souza, M. Desroches, S. Rodrigues, "Topological Data Analysis in Finsler Spaces". Arxiv: 2509.12660v2.
- D. B. de Souza*, J. Teodomiro, F.A. Santos, M. Ding, W. Sun, M. Desroches, J Jost, S. Rodrigues, "Efficient Decomposition of Forman-Ricci Curvature on Vietoris-Rips Complexes and Data Applications". Arxiv: 2504.21601.

CITED WORKS

- D.B. de Souza, "Analytic solutions to stochastic epidemic models", 2017, Master's Thesis, Federal University of Pernambuco, repository link. **[2 citations]**

INVITED TALKS

- "Introducing Efficient Algorithms for Computing Higher-Order Forman-Ricci Curvature from Complex Networks", invited seminar, niversity of Colorado Boulder, weblink.
- 15/01/2024 – 19/01/024: "Efficient Algorithms for Extracting Higher-Order Geometric Information from Complex Networks", invited talk at the *Max Planck Institute for Mathematics in the Sciences*, Leipzig, Germany, weblink.

SCIENTIFIC OUTREACH

- 31/05/2020: "Ricci Curvatures on Pandemics - Mathematical Analysis and Projections". Live presentation of Pandemic analysis using Ricci Curvatures. SEMSIS, Recife, Brazil, weblink.
- 04/05/2020 – 31/12/2020: "COVID-19 e matemática das epidemias: fazendo a ponte entre a ciência e a sociedade". Social project to outreach COVID-19 information from a mathematical point of view. CECINE/PROExC/UFPE, Recife, Brazil, weblink, project report link.
- 03/07/2020: "A matemática da pandemia". Radio interview regarding the applications of mathematics in the COVID-19 pandemic. Conexão UFPE, Recife, Brazil. Radio Podcast, weblink.

POSTER PRESENTATIONS

- 20–24/07/2024: "Efficient Algorithms for Extracting Higher-Order Geometric Information from Complex Networks and its Applications to Neuroscience" presented at *The 33rd Annual Computational Neuroscience Meeting (CNS 2024)*, Natal, Brazil, weblink.
- 25–27/04/2024: "Traumatic brain injury enhances the intrinsic excitation and excitatory transmission of granule cells" presented at the Neuronus 2024 Neuroscience Forum, Krakov, Polland, weblink.
- 22–26/07/2019: "Topological Data Analysis applied to Dengue Disease" presented at *Young Topologists Meeting*, EPFL, Louzane, Switzerland, weblink.
- 08–12/09/2014: "O problems de branqueamento dos corais". Presented at *XXXV Congresso Nacional de Matematica Aplicada e Computacional*, a pure and applied Mathematical congress at the national level in Natal, Brazil, weblink, website.
- 04 – 10/11/2012: "O problems de branqueamento dos corais". Presented at *VI Simpósio Nacional de Iniciação Científica*, at *IMPA*, a congress in a national level in Rio de Janeiro, Brazil, weblink, link.

EVENT ATTENDANCE

- 25–28/06/2024: "ScaDs.AI Summer School 2024". The conference promoted by the Max Plack Institute for Mathematics in the Sciences, Leipzig, Germany, weblink.
- 19–21/09/2022: "High-order interactions in the Human Connectome". BrainHack at Institute of Advanced Study (IAS), Amsterdam, the Netherlands, weblink.
- 19–22/05/2025: "BCAM Severo Ochoa Course: Machine Learning - The Mathematical Perspective", UPNA, Pamplona, Spain, weblink.

EVENT ORGANIZATION

- 03/06/2024 – 07/06/2024: "EBRAINS Brain Simulation Workshop 2024". Member of the organizing committee of the event in Bilbao, Spain, weblink.

COMPLEMENTARY TRAINING

- 13/06/2017: "Introduction to Python". A Python introductory course certification by *DataCamp*, weblink.
- 14/06/2017: "Intermediate Python". A Python intermediate course certification by *DataCamp*, weblink.
- 24/09/2018: "Python Toolbox". A course certification by *DataCamp*, weblink.
- 12/1/2018: "Introduction to R". An introductory course certification by *Datacamp*, weblink.
- 12/10/2018: "Introduction to Functions in Python". A Python course certification by *DataCamp*, weblink.
- 30/11/2018: "Introduction to Shell". A Shell introductory course certification by *DataCamp*, weblink.
- 02/03/2019: "Intermediate Network Analysis in Python". A course certification by *DataCamp*, weblink.
- 04/09/2020: "Time Series Analysis in Python". A course certification by *DataCamp*, weblink.
- 10/07/2023: "GitHub Concepts". A course certification by *DataCamp*, weblink.
- 11/07/2023: "Introduction to Network Analysis in Python". A network course certification by *DataCamp*, weblink.
- 13/07/2023: "Data Science for Business". A course certification by *DataCamp*, weblink.
- 01/08/2024: "Introduction to ChatGPT". A course certification by *DataCamp*, weblink.
- 20/12/2024: "Supervised Learning with scikit-learn". A course certification by *DataCamp*, weblink.
- 26/12/2024: "Unsupervised Learning in Python". A course certification by *DataCamp*, weblink.
- 02/01/2025: "Linear Classifiers in Python". A course certification by *DataCamp*, weblink.
- 16/01/2025: "Introduction to Deep Learning in Python". A course certification by *DataCamp*, weblink.
- 26/02/2025: "Data Manipulation with pandas". A course certification bt *DataCamp*, weblink.

REVIEWING ACTIVITY

- Regular reviewer for the journal *Chaos: An Interdisciplinary Journal of Nonlinear Science*.
- Regular reviewer for the journal *Scientific Reports*.