

# LUCÍA PRIETO SANTAMARÍA

Assistant Professor, Universidad Politécnica de Madrid  
lucia.prieto.santamaria@upm.es  
Madrid, Spain  
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## EDUCATION

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| <b>PhD</b> | Software, Systems and Computing<br>(Industrial and international doctor distinction, <i>cum laude</i> )<br>Ezeris Networks Global Services S.L.<br>Universidad Politécnica de Madrid | July 2023 |
| <b>MSc</b> | Computational Biology<br>Data Science itinerary<br>Universidad Politécnica de Madrid                                                                                                 | July 2019 |
| <b>BSc</b> | Biotechnology<br>Computational biotechnology itinerary<br>Universidad Politécnica de Madrid                                                                                          | July 2018 |

## MAIN RESEARCH INTERESTS

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- Biomedical informatics and computational biology
- Artificial intelligence and machine learning applied to biomedical domains
- Network medicine, human disease networks and drug repurposing
- Knowledge representation and semantic web
- Health-related social media analysis

## ACADEMIC POSITIONS, RESEARCH AND PROFESSIONAL EXPERIENCE

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**Universidad Politécnica de Madrid** September 2024 – Present

**Assistant Professor** (Profesor/a Ayudante Doctor/a)

Departamento de Lenguajes y Sistemas Informáticos e Ingeniería del Software

**Researcher**

Medical Data Analytics Laboratory (MEDAL), Centre for Biomedical Technology (CTB)

**MEDAL** (<https://medal.ctb.upm.es/>)

July 2023 – September 2024

**Postdoctoral researcher**

Centro de Tecnología Biomédica (CTB)

Universidad Politécnica de Madrid (UPM)

**Universidad Internacional de La Rioja**

March 2024 – September 2024

**External professor**

Escuela Superior de Ingeniería y Tecnología

**Ezeris Networks Global Services S.L.**

February 2020 – February 2023

**Industrial doctorate** (industrial supervisor: Yuliana Pérez Gallardo)

Junior software developer

**MEDAL** (<https://medal.ctb.upm.es/>)

September 2019 – July 2023

**PhD candidate** (academic supervisor: Alejandro Rodríguez González)

Doctoral thesis. “Creation, integration and analysis of disease networks towards a better understanding in the context of drug repurposing”, July 2023.

**Barabasi’s Lab** (<https://www.barabasilab.com>)

January 2023 – June 2023

**Visiting PhD student**

Center for Complex Networks Research (CCNR)

Network Science Institute (NetSI)

Northeastern University (NEU)

5-month research stay funded by UPM (supervised by Albert-László Barabási).

Researched on network medicine to generate new drug repurposing hypotheses, focusing on different complex human diseases.

**MEDAL** (<https://medal.ctb.upm.es/>)

September 2017 – July 2019

**Research intern**

MSc and BSc theses and internships (under the supervision of Alejandro Rodríguez González)

- Master thesis and internship. “Biological and phenotypical data analysis to generate new nosological models of diseases”, July 2019.
- Bachelor thesis and internship. “Extraction, similarity computing and analysis of biological features towards the creation of complex human disease networks”, July 2018.

**RESEARCH PROJECTS**

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Active involvement in research **projects** and main responsibilities and contributions:

- **DISNET** (“Drug repositioning and disease understanding through complex networks creation and analysis”, <http://disnet.ctb.upm.es/>, RTI2018-094576-A-I00 from the Spanish Ministry of Science, Innovation and Universities).
  - Human disease complex networks to gain a better disease understanding and drug repurposing. Extraction and integration of biomedical data structured in 3 levels: the phenotypical, the biological and pharmacological.
  - Intensive analysis of the information and generation of drug repurposing hypotheses. Employment of machine learning techniques both supervised and unsupervised.
  - Management tasks. Scientific writing and communication, as well as dissemination to the general public.
- **CUREX** (“Secure and private health data exchange”, <https://curex-project.eu/>, European Commission, Programme Horizon 2020, G.A. n 826404).
  - Creation of a basic NLP module for texts related to computer network topologies.
  - Development of an ontology for the semantic representation of data regarding asset discovery in distributed networks for healthcare environments.
- **P4-LUCAT** (“Personalized medicine for lung cancer treatment”, <https://p4-lucat.eu/>, ERA PerMed of Joint Transnational Call 2019 No. 163).
  - Design and implementation of a relational database for the storage of lung cancer patient information.

- Drafting of deliverables and assistance in the project management tasks in its initial stages.
- **MAVIS** (“Study on sentiments expressed on social media during the period 2015-2018 in posts related to vaccines”, funded by MSD, Spain, VEAP ID: 7789).
  - Analysis, visualization and understanding of data collected from Twitter posts and their polarity.
  - Scientific writing and dissemination in the form of journal papers.
- **3DR-GNN** (“Data-driven drug repositioning applying graph neural networks”, PID2021-122659OB-I00 from the Spanish Ministry of Science and Innovation).
  - Writing of the project proposal. Project planification and management.
  - Implementation and supervision of the technical tasks to predict repurposing disease-drug links in a biomedical heterogeneous graph.
  - Scientific writing and dissemination in the form of journal and conference papers.
- **GRENADA** (“Drug repurposing hypotheses through a data-driven approach”, PDC2022-133173-I00 from the Spanish Ministry of Science and Innovation).
  - Writing of the project proposal. Project planification and management.
  - Implementation of a relational database to store drug repurposing predictions generated by different data-driven methodologies.
- **LUCIA** (“Understanding Lung Cancer related risk factors and their Impact”, European Commission - Horizon Europe, ref 101096473).
  - Technical tasks related to mapping lung cancer terminologies and creating a lung cancer risk factors ontology.
  - Assistance on the prediction of risk factors by means of Artificial Intelligence applied to knowledge graphs.

## PUBLICATIONS

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### *JCR-indexed journals (17)*

1. A. Collin, A. Ayuso-Muñoz, P. Tejera-Nevado, **L. Prieto-Santamaría**, A. Verdejo-García, C. Díaz-Batanero, F. Fernández-Calderón, N. Albein-Urios, O.M. Lozano, and Alejandro Rodríguez-González, «Analyzing Dropout in Alcohol Recovery Programs: A Machine Learning Approach», *Journal of Clinical Medicine*, vol. 13, no. 16, Art. no. 16, Aug. 2024, doi: 10.3390/jcm13164825.
2. N. García Sánchez, E. Ugarte Carro, **L. Prieto-Santamaría**, and A. Rodríguez-González, «Protein sequence analysis in the context of drug repurposing», *BMC Med Inform Decis Mak*, vol. 24, no. 1, p. 122, May 2024, doi: 10.1186/s12911-024-02531-1.
3. B. Otero-Carrasco, E. Ugarte Carro, **L. Prieto-Santamaría**, M. Diaz Uzquiano, J. P. Caraça-Valente Hernández, and A. Rodríguez-González, «Identifying patterns to uncover the importance of biological pathways on known drug repurposing scenarios», *BMC Genomics*, vol. 25, no. 1, p. 43, Jan. 2024, doi: 10.1186/s12864-023-09913-1.
4. A. Ayuso-Muñoz, **L. Prieto-Santamaría**, E. Ugarte Carro, E. Serrano, and A. Rodríguez-González, «Uncovering hidden therapeutic indications through drug repurposing with graph neural networks and heterogeneous data», *Artificial Intelligence in Medicine*, p. 102687, Oct. 2023, doi: 10.1016/j.artmed.2023.102687.
5. A.J. Diaz-Honrubia, A. Blázquez Herranz, **L. Prieto Santamaría**, E. Menasalvas Ruiz, A. Rodríguez-González, G. Gonzalez-Granadillo, R.Díaz, E. Panaousis, and C. Xenakis, «A Trusted Platform Module-based, Pre-emptive and Dynamic Asset Discovery Tool», *J. Inf. Secur. Appl.*, vol. 71, p. 103350, Dec. 2022, doi: 10.1016/j.jisa.2022.103350.

6. B. Otero-Carrasco, **L. Prieto Santamaría**, E. Ugarte Carro, J. P. Caraça-Valente Hernández, and A. Rodríguez-González, «Repositioning Drugs for Rare Diseases Based on Biological Features and Computational Approaches», *Healthcare*, vol. 10, no. 9, Art. no. 9, Sep. 2022, doi: 10.3390/healthcare10091784.
7. **L. Prieto Santamaría\***, M. Díaz Uzquiano\*, E. Ugarte Carro, N. Ortiz-Roldán, Y. Pérez Gallardo, and A. Rodríguez-González, «Integrating heterogeneous data to facilitate COVID-19 drug repurposing», *Drug Discov. Today*, vol. 27, no. 2, pp. 558–566, Feb. 2022, doi: 10.1016/j.drudis.2021.10.002.
8. **L. Prieto Santamaría\***, E. Ugarte Carro\*, M. Díaz Uzquiano, E. Menasalvas Ruiz, Y. Pérez Gallardo, and A. Rodríguez-González, «A data-driven methodology towards evaluating the potential of drug repurposing hypotheses», *Comput. Struct. Biotechnol. J.*, vol. 19, pp. 4559–4573, 2021, doi: 10.1016/j.csbj.2021.08.003.
9. **L. Prieto Santamaría**, E. P. García del Valle, M. Zanin, G. S. Hernández Chan, Y. Pérez Gallardo, and A. Rodríguez-González, «Classifying diseases by using biological features to identify potential nosological models», *Sci. Rep.*, vol. 11, no. 1, p. 21096, Oct. 2021, doi: 10.1038/s41598-021-00554-6.
10. **L. Prieto Santamaría**, J. M. Tuñas, D. Fernández Peces-Barba, A. Jaramillo, M. Cotarelo, E. Menasalvas Ruiz, A. J. Conejo Fernández, A. Arce, A. Gil de Miguel, and A. Rodríguez-González, «Influenza and Measles-MMR: two case study of the trend and impact of vaccine-related Twitter posts in Spanish during 2015-2018», *Hum. Vaccines Immunother.*, pp. 1-15, Mar. 2021, doi: 10.1080/21645515.2021.1877597.
11. **L. Prieto Santamaría**, D. Fernández Lobón, A. J. Díaz-Honrubia, E. Menasalvas Ruiz, S. Nifakos, and A. Rodríguez-González, «Towards the representation of network assets in health care environments using ontologies», *Methods Inf. Med.*, vol. 60, no. S 02, pp. e89–e102, Dec. 2021, doi: 10.1055/s-0041-1735621.
12. E. P. García del Valle, G. Lagunes García, **L. Prieto Santamaría**, M. Zanin, E. Menasalvas Ruiz, and A. Rodríguez-González, «DisMaNET: A network-based tool to cross map disease vocabularies», *Comput. Methods Programs Biomed.*, p. 106233, Jun. 2021, doi: 10.1016/j.cmpb.2021.106233.
13. E. P. García del Valle, G. Lagunes García, **L. Prieto Santamaría**, M. Zanin, E. Menasalvas Ruiz, and A. Rodríguez-González, «Leveraging network analysis to evaluate biomedical named entity recognition tools», *Sci. Rep.*, vol. 11, no. 1, Jun. 2021, doi: 10.1038/s41598-021-93018-w.
14. A. Rodríguez-González, J. M. Tuñas, **L. Prieto Santamaría**, D. Fernández Peces-Barba, E. Menasalvas Ruiz, A. Jaramillo, M. Cotarelo, A. J. Conejo Fernández, A. Arce, and A. Gil de Miguel, «Identifying Polarity in Tweets from an Imbalanced Dataset about Diseases and Vaccines Using a Meta-Model Based on Machine Learning Techniques», *Appl. Sci.*, vol. 10, no. 24, p. 9019, Dec. 2020, doi: 10.3390/app10249019.
15. G. Lagunes García, A. Rodríguez-González, **L. Prieto Santamaría**, E. P. García del Valle, M. Zanin, and E. Menasalvas Ruiz, «How does Wikipedia disease information evolve over time? An analysis of disease-based articles changes», *Inf. Process. Manag.*, vol. 57, no. 3, p. 102225, May 2020, doi: 10.1016/j.ipm.2020.102225.
16. G. Lagunes García, A. Rodríguez González, **L. Prieto Santamaría**, E. P. García del Valle, M. Zanin, and E. Menasalvas Ruiz, «DISNET: a framework for extracting phenotypic disease information from public sources», *PeerJ*, vol. 8, p. e8580, Feb. 2020, doi: 10.7717/peerj.8580.
17. E. P. García del Valle, G. Lagunes García, **L. Prieto Santamaría**, M. Zanin, E. Menasalvas Ruiz, and A. Rodríguez-González, «Disease networks and their contribution to disease understanding: A review of their evolution, techniques and data sources», *J. Biomed. Inform.*, vol. 94, p. 103206, Jun. 2019, doi: 10.1016/j.jbi.2019.103206.

**Other journals (1)**

1. E. Anokian, J. Bernett, A. Freeman, M. List, **L. Prieto-Santamaría**, Z. Tanoli, and S. Bonnin, «Machine Learning and Artificial Intelligence in Drug Repurposing – Challenges and Perspectives», *Drug Repurposing*, vol. 1, p. 20240004, Jul. 2024, doi: 10.58647/DRUGREPO.24.1.0004.

**Conference proceedings (27)**

1. A. Álvarez Pérez, **L. Prieto Santamaría**, and A. Rodríguez González, 'From Systems to Single Cells: Advancing Network Medicine in Neurological Disorders', in REXPO Conference Series, REPO4EU, Jun. 2025. doi: 10.58647/REXPO.25000083.v1.
2. M. L. Palacios-Jaén, **L. Prieto-Santamaría**, E. Menasalvas, and A. Rodríguez-González, 'Using ChatGPT to Structure Phenotypical Entities from Disease Texts', in MEDINFO 2025 — Healthcare Smart x Medicine Deep, IOS Press, 2025, pp. 1808–1809. doi: 10.3233/SHTI251225.
3. A. Gil Hoed, **L. Prieto-Santamaría**, and A. Rodríguez-González, 'Evaluating the Influence of Disease-Gene Associations in the Significance of Disease Modules Through the Lens of Network Medicine', in 2025 IEEE 38th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2025, pp. 357–362. doi: 10.1109/CBMS65348.2025.00080.
4. A. Álvarez-Pérez, **L. Prieto-Santamaría**, and A. Rodríguez-González, 'Decoding Cell-Type-Specific Alterations in Alzheimer's Disease Through scRNA-Seq and Network Analysis', in 2025 IEEE 38th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2025, pp. 240–245, doi: 10.1109/CBMS65348.2025.00056.
5. B. Otero-Carrasco, **L. Prieto-Santamaría**, and A. Rodríguez-González, 'Prioritization of Potential Drugs Through Pathway-Based Drug Repurposing and Network Proximity Analysis', in 2025 IEEE 38th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2025, pp. 246–251, doi: 10.1109/CBMS65348.2025.00057.
6. P. Tejera-Nevado, N. Junod, E. H. Kwon, **L. Prieto-Santamaría**, and A. Rodríguez-González, 'Benchmarking Docking Tools on Experimental and Artificial Intelligence-Predicted Protein Structures', in 2025 IEEE 38th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2025, pp. 252–257, doi: 10.1109/CBMS65348.2025.00058.
7. D. A. Moreno-Perdomo, P. Tejera-Nevado, **L. Prieto-Santamaría**, G. Viguera, A. J. Diaz-Honrubia, and A. Rodríguez-González, "Lung-CABO: Lung Cancer Concepts Association Biological Ontology," in 2025 IEEE 38th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2025, pp. 660–663. doi: 10.1109/CBMS65348.2025.00136.
8. A. Rodríguez-González, **L. Prieto-Santamaría**, B. Otero Carrasco, A. Alvarez Perez, and D. Juste Urraca, 'DRIVE: A Data-Driven Platform for Disease Visualization and Drug Repurposing', in 2025 IEEE 38th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2025, pp. 504–505, doi: 10.1109/CBMS65348.2025.00106.
9. B. Otero Carrasco, **L. Prieto-Santamaría**, and A. Rodríguez-González, 'Exploring Innovative Approaches to Drug Repurposing: Emphasizing the Relevance of Biological Pathways', in REXPO24 Conference, REPO4EU, Jul. 2024. doi: 10.58647/REXPO.24000039.v1.
10. M. Marín Tercero, **L. Prieto-Santamaría**, and A. Rodríguez-González, 'Exploring Drug Repurposing Opportunities for Schizophrenia: A Network Medicine Approach', in 2024 IEEE 37th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2024, pp. 106–111. doi: 10.1109/CBMS61543.2024.00026. [Best paper award]

11. R. Artiñano-Muñoz, **L. Prieto-Santamaría**, A. Pérez-Pérez, and A. Rodríguez-González, ‘DRAGON: Drug Repurposing via Graph Neural Networks with Drug and Protein Embeddings as Features’, in 2024 IEEE 37th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2024, pp. 170–175. doi: 10.1109/CBMS61543.2024.00036.
12. Á. García-Barragán, A. González Calatayud, **L. Prieto-Santamaría**, V. Robles, E. Menasalvas, and A. Rodríguez-González, “Step-forward structuring disease phenotypic entities with LLMs for disease understanding,” in 2024 IEEE 37th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2024, pp. 213–218. doi: 10.1109/CBMS61543.2024.00043.
13. **L. Prieto Santamaría**, A. Ayuso-Muñoz, and A. Rodríguez-González, ‘Enhancing drug repurposing through graph neural networks and link prediction’, in REXPO23 Conference, REPO4EU, Oct. 2023. doi: 10.58647/REXPO.23000022.v1.
14. A. Ayuso-Muñoz, **L. Prieto-Santamaría**, A. Álvarez-Pérez, B. Otero-Carrasco, E. Serrano, and A. Rodríguez-González, ‘Enhancing Drug Repurposing on Graphs by Integrating Drug Molecular Structure as Feature’, in 2023 IEEE 36th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2023, pp. 192–197. doi: 10.1109/CBMS58004.2023.00215.
15. B. Otero-Carrasco, S. Romero-Brufau, A. Álvarez-Pérez, A. Ayuso-Muñoz, **L. Prieto-Santamaría**, J. P. Caraça-Valente Hernández, A. Rodríguez-González, ‘Orphan Drugs and Rare Diseases: Unveiling Biological Patterns through Drug Repurposing’, in 2023 IEEE 36th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2023, pp. 185–191. doi: 10.1109/CBMS58004.2023.00214.
16. A. Álvarez-Pérez, **L. Prieto-Santamaría**, E. Ugarte-Carro, B. Otero-Carrasco, A. Ayuso-Muñoz, and A. Rodríguez-González, ‘Exploring disease-drug pairs in Clinical Trials information for personalized drug repurposing’, in 2023 IEEE 36th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2023, pp. 179–184. doi: 10.1109/CBMS58004.2023.00213.
17. A. J. Díaz-Honrubia, **L. Prieto-Santamaría**, A. Rodríguez-González, E. Menasalvas-Ruiz, L. Mengual-Galán, and C. Fernández-Baizán, ‘THE GREAT QUIZ OF DATABASES’, INTED2023 Proceedings, pp. 1395–1403, 2023, doi: 10.21125/inted.2023.0408.
18. **L. Prieto Santamaría** and A. Rodríguez-González, ‘DISNET: Drug repositioning and disease understanding through complex networks creation and analysis’, presented at the REXPO22 - 1st International Conference on Drug Repurposing, ScienceOpen, Sep. 2022. doi: 10.14293/S2199-1006.1.SOR-PPPGCKMC.v1.
19. A. Álvarez Pérez, A. Iglesias-Molina, **L. Prieto Santamaría**, M. Poveda-Villalón, C. Badenes-Olmedo, and A. Rodríguez-González, ‘EBOCA: Evidences for BiOmedical Concepts Association Ontology’, in Knowledge Engineering and Knowledge Management, Cham, 2022, pp. 152–166. doi: 10.1007/978-3-031-17105-5\_11.
20. A. Ayuso Muñoz, E. Ugarte Carro, **L. Prieto Santamaría**, B. Otero-Carrasco, E. Menasalvas Ruiz, Y. Pérez Gallardo, and A. Rodríguez-González, ‘REDIRECTION: Generating drug repurposing hypotheses using link prediction with DISNET data’, in 2022 IEEE 35th International Symposium on Computer-Based Medical Systems (CBMS), Jul. 2022, pp. 7–12, doi: 10.1109/CBMS55023.2022.00009.
21. B. Otero-Carrasco, A. Pérez Pérez, E. Mensalvas Ruiz, J. P. Caraça-Valente Hernández, **L. Prieto Santamaría**, and A. Rodríguez-González, ‘Drug repositioning with gender perspective focused on Adverse Drug Reactions’, in 2022 IEEE 35th International Symposium on Computer-Based Medical Systems (CBMS), Jul. 2022, pp. 435–440, doi: 10.1109/CBMS55023.2022.00084.
22. B. Otero-Carrasco, **L. Prieto Santamaría**, E. Ugarte Carro, J.P. Caraça-Valente Hernández, A. Rodríguez González, ‘A computational drug repositioning method for rare diseases’, in: Bio-inspired

Systems and Applications: from Robotics to Ambient Intelligence. IWINAC 2022. Lecture Notes in Computer Science, vol 13259, pp. 551–561. Springer, Cham. doi: 10.1007/978-3-031-06527-9\_55.

23. E. P. García Del Valle, **L. Prieto Santamaría**, G. Lagunes García, M. Zanin, E. Menasalvas Ruiz, and A. Rodríguez-Gonzalez, ‘A meta-path-based prediction method for disease comorbidities’, in 2021 IEEE 34th International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2021, pp. 219–224. doi: 10.1109/CBMS52027.2021.00022.
24. **L. Prieto Santamaría**, E. P. García Del Valle, G. Lagunes Garcia, M. Zanin, A. Rodríguez-Gonzalez, E. Menasalvas Ruiz, Y. Pérez Gallardo, G. S. Hernández Chan. ‘Analysis of new nosological models from disease similarities using clustering’, in 2020 IEEE 33rd International Symposium on Computer-Based Medical Systems (CBMS), Jul. 2020, pp. 183–188. doi: 10.1109/CBMS49503.2020.00042.
25. E. P. García del Valle, G. Lagunes García, E. Menasalvas Ruiz, **L. Prieto Santamaría**, M. Zanin, and A. Rodríguez-González, ‘Completing missing MeSH code mappings in UMLS through alternative expert-curated sources’, in 2019 IEEE 32nd International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2019, pp. 174–179. doi: 10.1109/CBMS.2019.00044. [Best student paper award]
26. G. Lagunes García, **L. Prieto Santamaría**, E. P. García del Valle, M. Zanin, E. Menasalvas Ruiz, and A. Rodríguez González, ‘Wikipedia disease articles: an analysis of their content and evolution’, in 2019 IEEE 32nd International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2019, pp. 664–671. doi: 10.1109/CBMS.2019.00136.
27. E. P. Garcia del Valle, G. Lagunes García, **L. Prieto Santamaría**, M. Zanin, E. Menasalvas Ruiz, and A. Rodríguez González, ‘Evaluating wikipedia as a source of information for disease understanding’, in 2018 IEEE 31st International Symposium on Computer-Based Medical Systems (CBMS), Jun. 2018, pp. 399–404. doi: 10.1109/CBMS.2018.00076.

## CONGRESSES AND CONFERENCES

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**CIABiomed** (I Congreso de la Sociedad Española en Biomedicina), Sevilla (Spain), October 2025.

**RExPO25** (4<sup>th</sup> International Conference on Systems Medicine, Artificial Intelligence and Drug Repurposing), Barcelona (Spain), September 2025.

**CIMI2025** (I Congreso Interdisciplinar de Medicina e Ingeniería), Burgos (Spain), September 2025.

**CBMS2025** (2025 IEEE 38th International Symposium on Computer-Based Medical Systems), Madrid (Spain), June 2025.

**AI in Drug Discovery and Biomedicine**, IRB Barcelona, BioMed Conferences, Barcelona (Spain), March 2025.

**ECMTB2024** (13<sup>th</sup> European Conference on Mathematical and Theoretical Biology), Toledo (Spain), July 2024.

**CBMS2024** (2024 IEEE 37th International Symposium on Computer-Based Medical Systems), Guadalajara (Mexico), June 2024.

**RExPO23** (2<sup>nd</sup> International Conference on Systems Medicine, Artificial Intelligence and Drug Repurposing), Stockholm (Sweden), October 2023.

**CBMS2023** (2023 IEEE 36th International Symposium on Computer-Based Medical Systems), L’Aquila (Italy), June 2023.

**EKA2022** (23rd International Conference on Knowledge Engineering and Knowledge Management), Bolzano (Italy), September 2022.

**CBMS2022** (2022 IEEE 35th International Symposium on Computer-Based Medical Systems), online, June 2022.

**CamAIDD** (1st Cambridge AI in Drug Discovery Conference), online, February 2022.

**CDW21** (Connected Data World 2021), Online, December 2021.

**CAEPIA20/21** (XIX Conference of the Spanish Association for Artificial Intelligence), Málaga (Spain), September 2021.

**CBMS2021** (2021 IEEE 34th International Symposium on Computer-Based Medical Systems), online, June 2021.

**CBMS2020** (2020 IEEE 33rd International Symposium on Computer-Based Medical Systems), online, July 2020.

**Drug repurposing meeting**, Biochemical Society Event, Birmingham (UK), November 2019.

**CBMS2019** (2019 IEEE 32nd International Symposium on Computer-Based Medical Systems), Córdoba (Spain), June 2019.

## TALKS

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**Conference talk**, “Disease Understanding and Visualization of Drug Repurposing Hypotheses”, CIABiomed 2025, Sevilla (Spain), October 2025.

**Conference talk**, “A Weak Supervision Approach for Monitoring Recreational Drug Use Effects in Social Media”, CIABiomed 2025, Sevilla (Spain), October 2025.

**Invited talk**, “Rediscovering treatments: Artificial Intelligence for Drug Repurposing”, CIMI2025, Burgos (Spain), September 2025.

**Invited talk**, “AI in Biomedicine: From Data to Drug Repurposing”, XVI Convegno Interregionale Congiunto SIBIOC Piemonte - Valle d’Aosta, Big Data e Intelligenza Artificiale in Medicina di Laboratorio, online, June 2025.

**Seminar talk**, “Turning Data into Treatments: AI and Network Medicine for Drug Repurposing”, MSc in Computational Biology (UPM), May 2025.

**Workshop talk**, “Possibilities of LLMs in the Healthcare Sector”, EIT Digital in Mobile Talent Arena, Barcelona (Spain), March 2025.

**Seminar talk**, “Disease understanding: Dealing with complex and unstructured big data in biomedical domain”, MSc in Data Science (UPM), February 2025.

**Invited round table discussion**, ‘The Scope of Artificial Intelligence in Biomedicine’, XIII Congreso de Investigación Biomédica (CIB 2025), Valencia (Spain), February 2025.

**Invited talk**, “Rediscovering treatments: Artificial Intelligence for Drug Repurposing”, I Jornada de la Sociedad Española de IA en Biomedicina, Madrid (Spain), November 2024.

**Outreach talk**, “Artificial Intelligence to understand and combat diseases”, Week of the Science and Innovation in Madrid 2024, November 2024.

**Invited talk**, “Bridging networks for drug repurposing: Insights from network medicine”, Mini-symposium on Complexity science for biological and medical problems, ECMTB2024, Toledo (Spain), July 2024.

**Conference talk**, “Exploring Drug Repurposing Opportunities for Schizophrenia A Network Medicine Approach”, CBMS2024, Guadalajara (Mexico), June 2024.

**Conference talk**, “DRAGON: Drug Repurposing via Graph Neural Networks with Drug and Protein Embeddings as Features”, CBMS2024, Guadalajara (Mexico), June 2024.

**Outreach talk**, “Innovating in feminine: Women in Montegancedo”, International Day of Women and Girls in Science 2024, February 2024.

**Outreach talk**, “¿How can we study and combat diseases with computers?”, Week of the Science and Innovation in Madrid 2023, November 2023.

**Conference talk**, “Enhancing drug repurposing through graph neural networks and link prediction”, RexPO23 Conference, Stockholm (Sweden), October 2023.

**Scientific talk**, “On giving drugs a new life with the help of data”, Made in UPM Seminars at Real Colegio Complutense in Harvard, Boston (USA), May 2023.

**Outreach talk**, “¿How can we study and combat diseases with computers?”, Week of the Science and Innovation in Madrid 2022, November 2022.

**Seminar talk**, “Disease understanding: Dealing with complex and unstructured big data in biomedical domain”, MSc in ICT Innovation: Data Science (EIT Digital – UPM), February 2022.

**Outreach talk**, “¿How can we study and combat diseases with computers?”, Week of the Science and Innovation in Madrid 2021, November 2021.

**Conference workshop talk**, “DISNET: extracting public phenotypical knowledge of diseases”, CAEPIA2021, II Workshop of Spanish Research Groups of AI in Biomedicine, September 2021.

**Doctoral symposium**, “My Thesis in a Nutshell: Disease networks towards drug repurposing”, UPM, June 2021. Finalist award.

**Seminar talk**, “From data to treatments: Can we use public data to have a better understanding of diseases and reuse treatments?”, MSc in Computational Biology (UPM), online, May 2021.

**Workshop talk**, “Healthcare security ontologies for semantic representation of data / CUREX Asset Discovery”, MSc in Data and Web Science (Aristotle University of Thessaloniki, Greece), online, March 2021.

**Seminar talk**, “Disease understanding: Dealing with complex and unstructured big data in biomedical domain”, MSc in Data Science (UPM), online, February 2021.

**Outreach talk**, “¿How can we study and combat diseases with computers?”, Week of the Science and Innovation in Madrid 2020, Online, November 2020. (<https://short.upm.es/vaxv3>)

**Conference talk**, “Analysis of new nosological models from disease similarities using clustering”, CBMS2020, online, July 2020.

**Conference oral communication**, “DISNET: Drug repurposing and disease understanding through complex networks creation”, Drug repurposing meeting, Biochemical Society Event, Birmingham (UK), November 2019.

**Seminar talk**, “Disease understanding: Dealing with complex and unstructured big data in biomedical domain”, MSc in Data Science (UPM), February 2019.

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## SERVICE

### *Peer reviewing for scientific journals*

- Frontiers in Medicine (2025)
- Translational Psychiatry (2025)
- BMC Digital Health (2025)

- Network and Systems Medicine (2025)
- PeerJ (2024)
- CIBM - Computers in Biology and Medicine (2024)
- BMC Methods (2024)
- Cell iScience (2024)
- PLOS ONE (2024)
- BMC Medical Informatics and Decision Making (2024, 2022)
- ESWA - Expert Systems with Applications (2023)
- IJMEDI - International Journal of Medical Informatics (2023)
- BMC Medical Genomics (2023)
- Frontiers in Digital Health (2022)
- KHVI - Human Vaccines and Immunotherapies (2022, 2021)
- JMIR - Journal of Medical Internet Research (2022, 2021)
- Frontiers in Medical Technology (2021)
- JBI - Journal for Biomedical Informatics (2020)
- IPM - Journal of Information Processing and Management (2019)

### ***Conference member committee/reviewer***

- Machine Learning for Health Symposium (ML4H2025)
- 1<sup>st</sup> Conference of the Spanish Society of Artificial Intelligence in Biomedicine (CIABiomed2025)
- 2<sup>nd</sup> International Conference on Artificial Intelligence: Theories and Applications (ICAITA25)
- Conference on Health, Inference, and Learning (CHIL2025)
- Machine Learning for Health Symposium (ML4H2024)
- XX Conference of the Spanish Association for Artificial Intelligence (CAEPIA2024)
- Conference on Health, Inference, and Learning (CHIL2024)
- 2023 IEEE 36<sup>th</sup> International Symposium on Computer-Based Medical Systems (CBMS2023)
- Conference on Health, Inference, and Learning (CHIL2023)
- EURECA-PRO Conference - 2022
- 2022 IEEE 35<sup>th</sup> International Symposium on Computer-Based Medical Systems (CBMS2022)
- 2021 IEEE 34<sup>th</sup> International Symposium on Computer-Based Medical Systems (CBMS2021)
- 2020 IEEE 33<sup>rd</sup> International Symposium on Computer-Based Medical Systems (CBMS2020)
- Knowledge Discovery in Databases 2020 (KDD2020)
- SIAM International Conference on Data Mining (SDM2020)
- 2019 12<sup>th</sup> International Conference on Health Informatics (HEALTHINF2019)
- 2019 IEEE 32<sup>nd</sup> International Symposium on Computer-Based Medical Systems (CBMS2019)

### ***Programme Committee Chair***

- 2025 IEEE 38<sup>th</sup> International Symposium on Computer-Based Medical Systems (CBMS2025)
- 2024 IEEE 37<sup>th</sup> International Symposium on Computer-Based Medical Systems (CBMS2024)

### ***Journal Editor***

- Associate Editor of Progress in Artificial Intelligence Journal (2024 – Present).
- Guest Editor of “Innovations in decision support systems for personalized medicine” in BMC Medical Informatics and Decision Making (2025 – Present).
- Guest Editor of “Innovations in Artificial Intelligence for Medicine and Healthcare” in Springer Health Information Science and Systems (2024 – 2025).
- Guest Editor of Collection “Computational techniques for drug repositioning” in BMC Medical Informatics and Decision Making (2023 – 2024).

**FELLOWSHIPS AND AWARDS**

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**Premio Extraordinario de Doctorado** Awards to the best doctoral theses defended at Universidad Politécnica de Madrid (academic year 2022-23).

**Premio Francisco del Pozo 2023** Award to the best doctoral thesis defended in the Center for Biomedical Technology (Centro de Tecnología Biomédica, CTB) in 2023.

Competitive call for mobility research fellowships in North America funded by Universidad Politécnica de Madrid (January – June 2023).

**IND2019/TIC-17159** “Support for research and innovation programme (Industrial doctorates)”, Community of Madrid, Spain (2020 – 2023).

“Academic excellence scholarship”, Community of Madrid, Spain (2014 – 2015).

**TEACHING EXPERIENCE**

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***Universidad Politécnica de Madrid***

Course 2024/25

**Assistant Professor**, Computer Languages and Systems and Software Engineering Department (“Escuela Técnica Superior de Ingenieros Informáticos”)

Subjects:

- Data Processes (EIT Digital MSc in Digital Innovation)
- Data Processes (MSc in Computer Engineering)
- Processes in Data Science (MSc in Data Science)
- Complex Data in Health (EIT Health MSc Health and Medical Data Analytics)
- Data Analytics (BSc in Mathematics and Computer Science)
- Databases (BSc in Biotechnology)
- Databases (BSc in Mathematics and Computer Science)
- Databases I (BSc in Data Science and Artificial Intelligence)

**Supervision of Master Theses**

- Marcel Luis Palacios Jaén, “Application of ChatGPT for the Extraction of Knowledge from Disease Texts”, MSc in Data Science (UPM), September 2024.
- Mikel De La Fuente Landa, “Obtaining an index for evaluating the efficacy of a drug-disease pair, based on a generated Database: Comprehensive Analysis from Clinical Trials (CACT)”, MSc in Data Science (UPM), July 2025.
- Mariajose Franco Orozco, “Disease module extraction with Graph Neural Networks”, MSc in Data Science (UPM), July 2025.
- Lucía Sánchez Bella, “Analyzing the Impact of COVID-19 on Cocaine Addiction Treatment Dropout: A Machine Learning Approach”, MSc in Data Science (UPM), July 2025.
- Alejandro De Santos Otero, “Predicting Readmissions with Graph Neural Networks in Alcohol Recovery Programs”, MSc in Data Science (UPM), July 2025.
- Virginia González Díez, “Updating a Spring Data Extraction and Analysis Pipeline”, European MSc in Software Development (UPM), July 2025.
- Sofía Ferrández Benito, “Machine Learning for Drug Combination Therapy in the context of Network Medicine and Omic Signatures”, EIT Health MSc in Digital Innovation, Health and Medical Data Analytics (UPM), July 2025.
- Nathan Junod, “In Silico Drug Repurposing for Dermatological Disorders”, MSc in Computational Biology (UPM), July 2025.
- Elizabeth Kwon, “In Silico Repurposing Approach to Elucidate Novel Drug Treatments for Multiple Sclerosis”, MSc in Computational Biology (UPM), July 2025.
- Adam Varadi, “AI-Driven Insights for Fertility: A Machine Learning Approach to Hormonal Data”, EIT Digital MSc in Data Science (joint between UPM and Eotvos Lorand University), July 2025.

**Supervision of Bachelor Theses**

- Alba Sanz Bustos, “Generación de un Metamodelo Basado en Machine Learning para Determinar Casos de Reposicionamiento de Fármacos”, BSc in Data Science and Artificial Intelligence (UPM), June 2025.
- Alba Cortés Iglesias, “Análisis de los Efectos del Consumo Recreativo de Drogas en Publicaciones de Twitter”, BSc in Mathematics and Computer Science (UPM), June 2025.
- Antonio Gil Hoed, “Network Medicine Strategies for Disease Module Characterization”, BSc in Biotechnology (UPM), July 2025.
- Sara Santamaría Varona, “Análisis sistemático de estrategias, metodologías y resultados de la medicina de redes hasta el año 2024”, BSc in Biotechnology (UPM), July 2025.

***Universidad Politécnica de Madrid***

Course 2023/24

**Teaching assistant**, Computer Languages and Systems and Software Engineering Department (“Escuela Técnica Superior de Ingenieros Informáticos”)

**Subjects:**

- Data Processes (EIT Digital MSc in Digital Innovation) (3h)
- Data Processes (MSc in Computer Engineering) (3h)
- Complex Data in Health (EIT Health MSc Health and Medical Data Analytics) (20h)
- Processes in Data Science (MSc in Data Science) (3h)
- Data Analysis (EIT Digital MSc in Digital Innovation) (6h)
- Databases (BSc in Biotechnology) (17h)
- Data Analytics (BSc in Mathematics and Computer Science) (2h)
- Databases (BSc in Mathematics and Computer Science) (3h)

**Co-supervision of Master Theses**

- Laura Masa Martínez, “Analyzing Gene Expression Datasets for Disease Annotation Modelling”, MSc in Computational Biology (UPM), July 2024.

**Co-supervision of Bachelor Theses**

- María Marín Tercero, “Análisis de redes y reposicionamiento de fármacos: potencial a través de la medicina de redes”, BSc in Biotechnology (UPM), February 2024.

**Universidad Internacional de La Rioja**

Course 2023/24

**External professor**, Escuela Superior de Ingeniería y Tecnología | Facultad de Ciencias de la Salud**Subjects:**

- Databases and Bioinformatic Resources (MSc in Bioinformatics) (60h)

**Supervision of Master Theses**

- David González López, “Uso de LLM para la extracción de conceptos SNOMED CT en anotaciones clínicas”, MSc in Artificial Intelligence (UNIR), July 2024.
- Celia Cabello Collado, “Imputación de Datos Genómicos Faltantes con técnicas de Aprendizaje Automático”, MSc in Artificial Intelligence (UNIR), September 2024.
- Carlos Fernández Herrero, “Análisis y comparación de algoritmos de clasificación en paciente de diabetes”, MSc in Artificial Intelligence (UNIR), September 2024.
- Anna Gracia Colmenarejo, “Predicción de la respuesta al tratamiento del cáncer de pulmón mediante redes neuronales artificiales”, MSc in Artificial Intelligence (UNIR), September 2024.
- Alejandra Saiz Jimenez, “Análisis de expresión de microARNs y abundancia microbiana mediante IA para la detección de cáncer de mama”, MSc in Artificial Intelligence (UNIR), September 2024.

**Universidad Politécnica de Madrid**

Course 2022/23

**Teaching assistant**, Computer Languages and Systems and Software Engineering Department (“Escuela Técnica Superior de Ingenieros Informáticos”)**Subjects:**

- Data Processes (EIT Digital MSc in Digital Innovation) (4h)
- Data Processing Engineering (MSc in Computer Engineering) (4h)
- Complex Data in Health (EIT Health MSc Health and Medical Data Analytics) (8h)
- Processes in Data Science (MSc in Data Science) (4h)
- Data Analysis (EIT Digital MSc in Digital Innovation) (10h)
- Databases (BSc in Biotechnology) (10h)

**Co-supervision of Bachelor Theses**

- Álvaro Gutiérrez Castanedo, “Entendimiento de casos exitosos de reposicionamiento de fármacos mediante análisis de secuencias de proteínas”, BSc in Biotechnology (UPM), July 2023.

**Universidad Politécnica de Madrid**

Course 2021/22

**Teaching assistant**, Computer Languages and Systems and Software Engineering Department (“Escuela Técnica Superior de Ingenieros Informáticos”)

Subjects:

- Data Processes (EIT Digital MSc in Digital Innovation) (1.32h)
- Data Processing Engineering (MSc in Computer Engineering) (1.32h)
- Complex Data in Health (EIT Health MSc Health and Medical Data Analytics) (8h)
- Data Analytics (BSc in Mathematics and Computer Science) (8h)
- Processes in Data Science (MSc in Data Science) (1.32h)
- Databases I (BSc in Data Science and Artificial Intelligence) (8h)
- Databases (BSc in Mathematics and Computer Science) (8h)
- Databases (BSc in Biotechnology) (9h)

**Co-supervision of Master Theses**

- Andrea Álvarez Pérez, “On giving disease networks data a semantic context: generating an ontology reusing existing ones”, MSc in Computational Biology (UPM), July 2022.

**Co-supervision of Bachelor Theses**

- Natalia García Sánchez, “Biological sequence analysis in the context of drug repurposing and human disease complex networks”, BSc in Biotechnology (UPM), July 2022.
- Adrián Ayuso Muñoz, “Análisis y desarrollo de modelos de predicción de ejes en redes mediante técnicas de Deep Learning”, BSc in Computer Engineering (UPM), June 2022. [With honours]

**Universidad Politécnica de Madrid**

Course 2020/21

**Teaching assistant**, Computer Languages and Systems and Software Engineering Department (“Escuela Técnica Superior de Ingenieros Informáticos”)

Subjects:

- Complex Data in Health (EIT Digital MSc in ICT Innovation: Data Science – Health Itinerary) (7.5h)
- Data Analytics (BSc in Mathematics and Computer Science) (9h)
- Databases (BSc in Biotechnology) (7h)

**Co-supervision of Master Theses**

- Pablo Soto García, “Study and integration of new biological features data from public sources in the context of human complex disease networks”, MSc in Computational Biology (UPM), July 2021.

**Co-supervision of Bachelor Theses**

- Ignacio Montero Callejas, “Desarrollo de procesos para el análisis y visualización de datos fenotípicos y biológicos en el contexto de las redes de enfermedades humanas”, BSc in Biomedical Engineering (UPM), July 2021.
- Esther Ugarte Carro, “Drug repurposing approaches and validation through DISNET data”, BSc in Biotechnology (UPM), July 2021. [With honours]

**Universidad Politécnica de Madrid**

Course 2019/20

**Co-supervision of Master Theses**

- Sara Jaramillo Cárdenas, “Analysis of public data sources and drugs information extraction towards the elaboration of human complex disease networks”, MSc in Computational Biology (UPM), September 2020.
- Rizwan Saleem, “Towards drug repositioning: analysis of relevant drug features and computational methods”, MSc in Computational Biology (UPM), September 2020.
- Youness Elkhailil, “Analysis of phenotypic data on diseases and their relationships for drug repositioning”, MSc in Computational Biology (UPM), July 2020.

## TAUGHT COURSES

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|                                                                                                                         |               |
|-------------------------------------------------------------------------------------------------------------------------|---------------|
| <b>Coding and Programming (16h)</b><br>Samsung Innovation Campus, Madrid, Spain                                         | October 2025  |
| <b>Data Analysis (4h)</b><br>UPM International Summer School, Madrid, Spain                                             | July 2025     |
| <b>Introduction to Databases (14h)</b><br>Cabify, Madrid, Spain                                                         | November 2024 |
| <b>Artificial Intelligence Course (30h)</b><br>Samsung Innovation Campus, online                                        | October 2024  |
| <b>Unsupervised machine learning (5h)</b><br>Banco Santander Internal Educational Programme, Madrid, Spain              | October 2020  |
| <b>Data mining, solutions and horizontal applications (4h)</b><br>University of Military Forces, Ecuador                | October 2020  |
| <b>Unsupervised machine learning (5h)</b><br>Banco Santander Internal Educational Programme, Madrid, Spain              | February 2020 |
| <b>Introduction to databases for Data Science (5h)</b><br>Banco Santander Internal Educational Programme, Madrid, Spain | January 2020  |
| <b>Unsupervised machine learning (5h)</b><br>Banco Santander Internal Educational Programme, Madrid, Spain              | December 2019 |

## TECHNICAL SKILLS

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### Information extraction and storage

- Programmatic access to data sources by means of APIs and web services.
- Strong knowledge of relational databases, with emphasis on MySQL database management system.
- Strong knowledge of Python scripting and basic knowledge of R.
- Familiar with NoSQL databases, in particular with graph databases. Notions on Neo4J.
- Familiar with semantic technologies, biomedical ontologies, RDF language and SPARQL queries.
- Familiar with NLP pipelines and tools.

### Data processing, manipulation and analysis

- Python (pandas, numpy, scipy, scikit-learn) and R.

### Data visualization

- Python (matplotlib, seaborn, plotly) and R (ggplot).
- Graph visualization (gephi, cytoscape).

### Machine learning

- Strong knowledge in unsupervised and supervised learning.
- Python (scikit-learn, PyTorch, DGL, pyclustering).
- Basic knowledge of Weka and Knime.

### Bioinformatic tools

- Sequence alignment (BLAST, ClustalW) and phylogenetic studies.
- Basic knowledge of genomic data analysis.

### Others

- Anaconda, JupyterLab, Visual Studio Code
- Unix/Linux systems
- Version control with Git
- Notions of Perl, Ruby and Matlab
- Docker, VMware, Oracle VMVirtualBox
- Microsoft Word, LaTeX

## LANGUAGES

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- Spanish: native
- English: C1 (Cambridge Assessment English – Certificate in Advanced English, March 2022)
- French: Basic

## COURSES

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- Researcher Connect training programme (British Council), online, January 2024.
- Data visualization courses (Domestika), online, ongoing.
  - “Introduction to data visualization”
  - “Data visualization and information design: creating a visual model”
  - “Data visualization for editorial projects”
- KNIME Analytics Platform for Data Scientist: Basics, online, October 2021.
- SNOMED-CT E-Learning, online, March 2021.

**PROFESSIONAL AFFILIATIONS**

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|                               |                                                                                                             |
|-------------------------------|-------------------------------------------------------------------------------------------------------------|
| Since September 2017          | ETS Ingenieros Informáticos, Universidad Politécnica de Madrid, 28660 Boadilla del Monte, Madrid, España    |
|                               | Centro de Tecnología Biomédica, Universidad Politécnica de Madrid, 28660 Boadilla del Monte, Madrid, España |
| February 2020 – February 2023 | Ezeris Networks Global Services S.L., 28028 Madrid, España                                                  |

**SPANISH ANECA ACCREDITATIONS**

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|                     |                                   |
|---------------------|-----------------------------------|
| Since December 2023 | Profesor/a Contratado/a Doctora/a |
| Since December 2023 | Profesor/a de Universidad Privada |

**SCIENTIFIC SOCIETIES AND ASSOCIATIONS**

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|                                                                                                                                                       |                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| Sociedad Española de Inteligencia Artificial en Biomedicina – <b>IABiomed</b><br>(Spanish Society of Artificial Intelligence in Biomedicine)          | Since 2024     |
| • <b>Board Member</b> , Director of Training and Professional Development Area                                                                        | 2025 – Present |
| Sociedad Española en Bioinformática y Biología Computacional – <b>SEBiBC</b><br>(Spanish Society of Bioinformatics and Computational Biology, Member) | Since 2024     |
| Sociedad Española en Ingeniería Biomédica – <b>SEIB</b><br>(Spanish Society in Biomedical Engineering, Member)                                        | Since 2023     |
| Asociación Española para la Inteligencia Artificial – <b>AEPIA</b><br>(Spanish Association for Artificial Intelligence, Member)                       | Since 2021     |

**OTHERS**

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- Title of Rhythmic Gymnastics Coach (1<sup>st</sup> Level), RFEG (Royal Spanish Gymnastics Federation), July 2014, coaching in several schools and clubs (Madrid, Spain), 2014 – 2020.
- Driving license (Madrid, Spain), May 2015.
- Private tutor for high school students in subjects such as mathematics, physics and chemistry (Madrid, Spain), 2012 – 2014.
- YMCA Camp Weona counselor volunteer (Buffalo, USA), July 2012 and July – August 2013.