

# Dominik Dold, Dr. rer. nat.

🎓 AI, neuromorphic computing, machine learning, neuroscience, physics, space

✉ dodo.science@web.de

🌐 <https://dodo47.github.io/>

🌐 <https://www.linkedin.com/in/dominik-dold/>

🌐 <https://scholar.google.de/citations?user=RNLSvncAAAAJ>



## Work experience

- 2021 – . . . . . 📌 **Internal Research Fellow in AI.** ESA ESTEC, Advanced Concepts Team, Noordwijk.
- 2020 – 2021 📌 **AI Residency Researcher.** Siemens AI Lab Residency, Siemens AG, Munich.
- 2017 – 2018 📌 **Visiting Researcher.** Senn group for computational neuroscience, University of Bern.
- 2016 – 2020 📌 **Doctoral Researcher.** Petrovici group for neuro-inspired AI, Heidelberg University.

## Education

- 2016 – 2020 📌 **Dr. rer. nat.,** Heidelberg University, Germany.  
Thesis title: *Harnessing function from form: towards bio-inspired AI in neuronal substrates.*
- 2014 – 2016 📌 **M.Sc. in Physics,** Heidelberg University, Germany.  
Thesis title: *Stochastic Computation in Spiking Neural Networks Without Noise.*
- 2010 – 2014 📌 **B.Sc. in Physics,** Heidelberg University, Germany.  
Thesis title: *Energy Conservation in Fano Spectral Line Shape Control.*

## Awards and fellowships

- 2023 📌 **Marie Skłodowska-Curie Action Fellowship** by the European Commission.
- 2021 📌 **Research Fellowship** by the European Space Agency (ESA).
- 2019 📌 **First prize** in the finals of the 2019 **International Collegiate Competition for Brain-Inspired Computing (ICCBC)** at Tsinghua University in Beijing, China.  
📌 **Selected and invited** to participate in the **first Neuro-inspired Computation Course** by the International Research Center for Neurointelligence (IRCN), the University of Tokyo.

## Mentoring

### Supervision of postgraduate researchers

- 2023 – . . . . . 📌 Z. Rudge. *Novel Memristor-based Neural Network Accelerators for Space Applications.* PhD thesis, co-funded via ESA's Open Space Innovation Platform.
- 2022 – 2023 📌 A. Thomas. I was her project and research mentor during her time as a **Young Graduate Trainee (YGT)** at ESA (1 year position).

### Supervision of graduate students

- 2023 📌 I. Walford. *Novel Neural Network Architectures for Spacecraft Autonomy.* **Internship & Master's thesis,** ESA ESTEC & University College London.
- 2021 📌 V. Caceres Chian. *Towards the integration of graph neural networks into neuromorphic architectures.* **Master's thesis,** Technical University Munich.
- 2018 📌 M. Zenk. *Spatio-temporal predictions with spiking neural networks.* **Master's thesis,** Heidelberg University.

## Engagement beyond research activities

### Institutional responsibilities

- 2021 – 2023    ■ Organiser of ESA's Advanced Concepts Team Science Coffee.
- 2018 – 2020    ■ Organiser of the Journal Club in my PhD research group.

### Community service

- 2023 – 2024    ■ Co-chair of the scientific committee of ESA's SPAICE conference on AI and Space, organised by ECSAT, ESA.
- 2023    ■ Co-organiser of the *Artificial Intelligence Application* session of the Italian Association of Aeronautics and Astronautics (AIDAA) XXVII International Congress.
- Session moderator at the first workshop on Linguistics and Graphs for Space (LING4S), hosted at ESTEC, ESA.
- Member of the Technical Program Committee of the International Joint Conference on Neural Networks (IJCNN)
- 2022 – . . . .    ■ Reviewer for the Journal *Physical Review Research* (PRR, APS physics).
- 2021    ■ Chair of the session *Graph Based Methods* at the International Conference for Machine Learning and Applications (ICMLA).
- Reviewer for the International Conference on Artificial Neural Networks (ICANN).

### Memberships of scientific societies

- 2023 – . . . .    ■ Member of the AIDAA *Scientific Committee*.
- 2022 – . . . .    ■ Member of the *International Neural Network Society (INNS)*.
- 2017 – . . . .    ■ Member of the *Bernstein Network Computational Neuroscience*.

### Participation in scientific collaborations

- 2023 – 2024    ■ Co-organizer of the *GECCO 2024 Space Optimisation Competition (SPOC)*.
- 2022 – 2023    ■ Co-organizer of the *GECCO 2023 Space Optimisation Competition (SPOC)*.
- 2016 – 2020    ■ My PhD research was part of subproject (SP) 4, SP9 and co-design project (CDP) 5 of the European Commission Future and Emerging Technologies Flagship *Human Brain Project*.

## Additional training and experience

- October 2022    ■ **Luiss Business School Workshop on Negotiation** organized by ESA.
- **ESA Academy's Ladybird Guide to Spacecraft Operations Training Course**
- June 2020    ■ **AI@Sustainability 72h Hackathon** organized by the Siemens AI Lab.
- August 2019    ■ **Team communication – key roles and intercultural contexts workshop.**<sup>†</sup>
- June 2019    ■ **DS<sup>3</sup> data science summer school.**  
Five-day school co-organized by the École polytechnique & the DATAIA Institute.
- February 2019    ■ **Business management course "Grundlagenwissen BWL".**<sup>†</sup>

## Science communication

### Invited talks

- 2023 ■ **Guest speaker at the UCL AI Society**, University College London, UK.  
Title: *Gazing into the future – From graphs, gradients and spiking neurons to space.*  
Invited by Miriam Jansen (events officer of the UCL AI Society).
- 2022 ■ **Talk at the MAFEX Gründungscamp AI-Day**, Philipps-Universität Marburg, Germany.  
Title: *Getting from there to here – Wie durch KI die Raumschiffe von morgen aussehen könnten.*  
Invited by Dipl.-Geogr. Astrid Bendix.
- **PhD seminar at the Observatory of the University of Vienna**, Vienna, Austria.  
Title: *Two Ways to ESA Fellowships.* Invited by Prof. G. van de Ven.
- **Galaxy Coffee seminar at the MPIA**, Heidelberg, Germany.  
Title: *New ways of finding old globular clusters.* Invited by Dr. N. Neumayer.
- 2019 ■ **Invited talk at Huawei research center**, Hangzhou, China.  
Title: *Deep learning and probabilistic computing in biological neural networks.* Invited by Dr. Y. Chua.
- **ICCBC 2019 at Tsinghua University**, Beijing, China.  
Title: *Why spikes? Exploring spike-based Bayesian inference for accelerated neuronal substrates.*
- 2018 ■ **ETH Institute of Neuroinformatics**, Zurich, Switzerland.  
Title: *From Euler-Lagrange to error backpropagation in cortical circuits.* Invited by Prof. B. Grewe.

### Conference talks

- 2023 ■ **German Aerospace Congress (DLRK)**, Stuttgart, Germany.  
Title: *Modelling the European Space Sector with Knowledge Graphs.*
- **AIDAA XXVII International Congress**, Padua, Italy.  
Title: *Totimorphic structures for space application.*
- 2022 ■ **International Conference on Neuromorphic Systems (ICONS)**, hybrid.  
Title: *Neuro-symbolic computing with spiking neural networks.*
- **IEEE World Congress on Computational Intelligence (WCCI, IJCNN)**, Padua, Italy.  
Title: *Relational representation learning with spike trains.*
- 2021 ■ **IEEE International Conference on Machine Learning and Applications (ICMLA)**, virtual.  
Title: *An energy-based model for neuro-symbolic reasoning on knowledge graphs.*
- **International Conference on Neuromorphic Computing (ICNC)**, virtual.  
Title: *Learning through structure: towards deep neuromorphic knowledge graph embeddings.*
- **International Joint Conference on Neural Networks (IJCNN)**, virtual.  
Title: *SpikE: spike-based embeddings for multi-relational graph data.*
- 2019 ■ **Computational and Systems Neuroscience (COSYNE) Conference**, Lisbon, Portugal.  
Title: *Lagrangian dynamics of dendritic microcircuits enables real-time backpropagation of errors.*

### Workshop talks

- 2021 ■ **Spiking neural networks as universal function approximators (SNUFA)**, virtual.  
Title: *Spike-based embeddings for multi-relational graph data.*
- 2019 ■ **Perception and attention mechanisms in the primate brain: An integrated, multi component perspective**, European Institute for Theoretical Neuroscience, Paris, France.  
Title: *Physics of perception: models of inference and learning in neuronal substrates.*
- **Human Brain Project Co-Design Project 5 Meeting**, Heidelberg, Germany.  
Title: *Predictive or prospective? Real-time backprop in cortical circuits.*
- 2018 ■ **Human Brain Project Subproject 9 Meeting**, Bern, Switzerland.  
Title: *Dendritic error backpropagation and reinforcement learning in deep cortical microcircuits.*
- **Intel Neuromorphic Research Community (INRC) Workshop**, Reykjavik, Iceland.  
Title: *Real-time error backpropagation for deep cortical networks.*

## Science communication (continued)

- **From Bench to Machine Learning Workshop**, Institute of Advanced Studies, University of Surrey, England.  
Title: *From Euler-Lagrange to time-continuous error backpropagation in cortical microcircuits.*
- **Human Brain Project Subproject 9 Fürberg Workshop**, Fürberg, Austria.  
Title: *Continuous error backpropagation in cortical microcircuits from Euler- Lagrange equations.*
- **From Neuroscience to Machine Learning Workshop**, European Institute for Theoretical Neuroscience, Paris, France.  
Title: *Real-time error backpropagation for deep cortical networks.*
- 2016 ■ **Human Brain Project Subproject 9 Fürberg Workshop**, Fürberg, Austria.  
Title: *Self-sustained sampling – using networks of LIF Boltzmann machines as intrinsic noise sources.*

## Poster presentations

- 2022 ■ **Neuromorphic Algorithms Workshop (NEAL)**, Volpriehausen, Germany.  
Title: *Relational representation learning with spiking neural networks.*
- 2019 ■ **Bernstein Conference**, Berlin, Germany.  
Title: *An energy-based model of folded autoencoders for unsupervised learning in cortical hierarchies.*
- **Annual Computational Neuroscience Meeting**, Barcelona, Spain.  
Title: *Lagrangian dynamics for real-time error backpropagation across cortical areas.*
- **DS3 Data Science Summer School**, Paris, France.  
Title: *Physical models of the brain – from theory to neural substrates.*
- **IRCN Course in Neuro-Inspired Computation**, Tokyo, Japan.  
Title: *Function from form – two models of coding and learning in cortical circuits.*
- 2018 ■ **Bernstein Conference**, Berlin, Germany.  
Title: *Continuous learning in dendritic cortical microcircuits using Lagrangian mechanics.*
- **EMBO Dendrites Workshop**, Heraklion, Greece.  
Title: *Continuous learning in dendritic cortical microcircuits using Lagrangian mechanics.*
- 2017 ■ **Bernstein Conference**, Göttingen, Germany.  
Title: *Stochastic computation on spiking neuromorphic hardware.*
- **Annual Computational Neuroscience Meeting**, Antwerp, Belgium.  
Title: *Spike-based inference with correlated noise.*

## Publications

### Patent applications

- 2022 ■ *Method and system for anomaly detection in a network.*  
Europe: EP4270227A1 (28/04/2022).  
USA: US20230353584A1 (24/04/2023).  
China: CN116980321A (28/04/2023).
- *Method and Device for Providing a Recommender System.*  
Europe: EP4231199A1 (22/02/2022).  
WIPO: WO2023160947A1 (30/01/2023).
- 2021 ■ *Industrial device and method for building and/or processing a knowledge graph.*  
Europe: EP4030351A1 (18/01/2021).  
USA: US20220229400A1 (28/12/2021).  
China: CN114819049A (18/01/2022).
- *Neuromorphic hardware for processing a knowledge graph represented by observed triple statements and method for training a learning component.*  
Europe: EP4030349A1 (18/01/2021).  
USA: US20220230056A1 (20/12/2021).  
China: CN114819048A (18/01/2022).

## Publications (continued)

- *Neuromorphic hardware and method for storing and/or processing a knowledge graph.*  
Europe: EP4030350A1 (18/01/2021).  
USA: US20220237441A1 (6/01/2022).  
China: CN114819047A (18/01/2022).

### Peer-reviewed (co-)first author publications

- 2023 ■ *Differentiable graph-structured models for inverse design of lattice materials.*  
Dold\*, D. and Aranguren van Egmond\*, D. (2023) Cell Reports Physical Science.
- *A Neuronal Least-Action Principle for Real-Time Learning in Cortical Circuits.*  
Senn\*, W., Dold\*, D., Kungl, A.F., Ellenberger, B., Bengio, Y., Sacramento, J., Jordan, J. and Petrovici\*, M.A. (2023). eLife.
- 2022 ■ *Neuro-symbolic computing with spiking neural networks.*  
Dold, D., Soler Garrido, J., Caceres Chian, V., Hildebrandt, M. and Runkler, T. (2022). 2022 International Conference on Neuromorphic Systems (ICONS).
- *Relational representation learning with spike trains.*  
Dold, D. (2022). IEEE World Congress on Computational Intelligence (WCCI) & International Joint Conference on Neural Networks (IJCNN).
- *Evaluating the feasibility of interpretable machine learning for globular cluster detection.*  
Dold\*, D. and Fahrion\*, K. (2022). Astronomy & Astrophysics (A&A), 663, 81.
- 2021 ■ *An energy-based model for neuro-symbolic reasoning on knowledge graphs.*  
Dold, D. and Soler Garrido, J. (2021). 20th IEEE International Conference on Machine Learning and Applications (IEEE ICMLA).
- *Learning through structure: towards deep neuromorphic knowledge graph embeddings.*  
Caceres Chian\*, V., Hildebrandt\*, M., Runkler, T. and Dold\*, D. (2021). 2021 International Conference on Neuromorphic Computing (ICNC).
- *Machine learning on knowledge graphs for context-aware security monitoring.*  
Soler Garrido\*, J., Dold\*, D. and Frank, J. (2021). 2021 IEEE International Conference on Cyber Security and Resilience (IEEE CSR).
- *SpikeE: spike-based embeddings for multi-relational graph data.*  
Dold, D. and Soler Garrido, J. (2021). 2021 International Joint Conference on Neural Networks (IJCNN)
- 2020 ■ *Versatile emulation of spiking neural networks on an accelerated neuromorphic substrate.*  
Billaudelle\*, S., Stradmann\*, Y., Schreiber\*, K., Cramer\*, B., Baumbach\*, A., Dold\*, D., Göltz\*, J., Kungl\*, A. F., Wunderlich\*, T. C. et al. (2020). 2020 IEEE International Symposium on Circuits and Systems (ISCAS), Sevilla, 2020, pp. 1-5.
- 2019 ■ *Stochasticity from function - why the Bayesian brain may need no noise.*  
Dold\*, D., I., Bytschok\*, Kungl, A. F., Baumbach, A., Breitwieser, O., Schemmel, J., Meier, K. and Petrovici\*, M. A. (2019). Neural Networks, 119, 200-213.

### Peer-reviewed co-author publications

- 2023 ■ *Modelling the European Space Sector with Knowledge Graphs*  
Berquand\*, A. & Dold\*, D., German Aerospace Congress (DLRK 2023).
- *Totimorphic structures for space application*  
Thomas, A., Grover, J., Izzo, D., & Dold, D., XXVII Italian Association of Aeronautics and Astronautics Congress (AIDAA 2023).

## Publications (continued)

- 2022    ■ *Detection, Explanation and Filtering of Cyber Attacks Combining Symbolic and Sub-Symbolic methods.*  
Himmelhuber, A., **Dold, D.**, Grimm, S., Zillner, S. and Runkler, T. (2022). Computational Intelligence In Cyber Security (IEEE CICS), IEEE Symposium Series on Computational Intelligence (IEEE SSCI 2022).
- 2021    ■ *Fast and energy-efficient neuromorphic deep learning with first-spike times.*  
Göltz, J., Kriener, L., Baumbach, A., Billaudelle, S., Breitwieser, O., Cramer, B., **Dold, D.**, ... Petrovici, M. A. (2021). Nature Machine Intelligence, Volume 3.
- 2019    ■ *Accelerated physical emulation of Bayesian inference in spiking neural networks.*  
Kungl, A. F., Schmitt, S., Klähn, J., Müller, P., Baumbach, A., **Dold, D.**, ... Kleider, M. et al. (2019). Frontiers in Neuroscience, 13, 1201.

## Book chapters

- 2023    ■ *Artificial Intelligence for Space: AI4SPACE – Trends, Applications, and Perspectives.*  
*Chapter: Neuromorphic Computing and Sensing in Space.*  
Izzo\*, D., Hadjiivanov\*, A., **Dold\***, D., Meoni\* and G. and Blazquez\*, E., CRC Press, ISBN 9781032432441.
- *Artificial Intelligence for Space: AI4SPACE – Trends, Applications, and Perspectives.*  
*Chapter: Selected Trends in Artificial Intelligence for Space Applications.*  
Izzo, D., Meoni, G., Gomez, P., **Dold, D.** and Zoechbauer, A., CRC Press, ISBN 9781032432441.

\* marks equal contributions