Dominik Dold, Dr. rer. nat.

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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.
2014 – 2015 **Research Assistant.** Evers group for theoretical quantum dynamics, MPIK Heidelberg.

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

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 under ESA's OSIP program.

2022 – · · · · A. Thomas. I am project and research mentor for her time as a **Young Graduate Trainee (YGT)** at ESA (1 year position). Currently working on totimorphic lattice materials.

Supervision of graduate students

2023 – · · · · I. Walford. *Olfactory system as a blueprint for novel neural architectures for spacecraft autonomy.* **Internship**, ESA ESTEC.

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.

Teaching

- 2019 Teaching position, *Physics Laboratory Course for Beginners*, Heidelberg University, Germany.
- 2018 Teaching assistant for the lecture *Brain-Inspired Computing*, Heidelberg University, Germany.
- 2017 Teaching position, *Laboratory Courses for Medical Students*, Heidelberg University, Germany.
- 2016 Teaching position, *Physics Laboratory Course for Beginners*, Heidelberg University, Germany.
- 2015 Teaching position, *Medicine Beginner's Introduction Courses in Physics and Mathematics*, Heidelberg University, Germany.
- 2014 Teaching position, *Physics Laboratory Course for Beginners*, Heidelberg University, Germany.
- 2013 Teaching position, *Physics Laboratory Course for Beginners*, Heidelberg University, Germany.

Engagement beyond research activities

Institutional responsibilities

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

Community service

- 2023 Co-organiser of the *Artificial Intelligence Application* session of the Italian Association of Aeronautics and Astronautics (AIDAA) XXVII International Congress.
- 2023 Session chair at the first workshop on Linguistics and Graphs for Space (LING4S), hosted at ESTEC, ESA.
- 2023 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).
- 2021 Reviewer for the International Conference on Artificial Neural Networks (ICANN).

Memberships of scientific societies

- 2022 – .... Member of the *International Neural Network Society (INNS)*.
- 2017 – .... Member of the *Bernstein Network Computational Neuroscience*.

Participation in scientific collaborations

- 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 **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.**†
- June 2019 **DS^3 data science summer school.**
  Five-day school co-organized by the École polytechnique & the DATAIA Institute.
- February 2019 **Business management course "Grundlagenwissen BWL".**†
- October 2018 **Computational physics with GPUs.**†

Additional training and experience (continued)

April 2017 — **Machine learning in science and industry.**†
† Courses offered by the Heidelberg graduate academy and graduate school for physics.

Science communication

Invited talks (7)

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 (6)

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 (9)

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.*

Science communication (continued)

- **Intel Neuromorphic Research Community (INRC) Workshop**, Reykjavik, Iceland.
  Title: *Real-time error backpropagation for deep cortical networks.*
- **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 (9)

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 (5 in Germany, 3 in the US)

2022
- *Method and system for anomaly detection in a network.*
  Dold, D., Liu, Y., Joblin, M. and Hildebrandt, M.
  DE: first published in 07/2022.
- *Method and Device for Providing a Recommender System.*
  Dold, D., Hildebrandt, M. and Mogoreanu, S.
  DE: first published in 03/2022.

2021
- *Industrial device and method for building and/or processing a knowledge graph.*
  Dold, D. and Soler Garrido, J.
  DE: File No.: 21152148.9 (18/01/2021).
  US: Document ID "US 20220229400 A1" (21/07/2022)

Publications (continued)

- *Neuromorphic hardware for processing a knowledge graph represented by observed triple statements and method for training a learning component.*
  Dold, D. and Soler Garrido, J.
  DE: File No. 21152139.8 (18/01/2021).
  US: Document ID "US 20220230056 A1" (21/07/2022).
- *Neuromorphic hardware and method for storing and/or processing a knowledge graph.*
  Dold, D. and Soler Garrido, J.
  DE: File No. "21152142.2" (18/01/2021).
  US: Document ID "US 20220237441 A1" (28/07/2022).

Peer-reviewed (co-)first author publications (9)

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).
- *SpikE: 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 (3)

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.

Publications (continued)

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 (2)

2023 *AI4Space: Neuromorphic Computing and Sensing in Space.*
Izzo*, D., Hadjiivanov*, A., **Dold*, D.**, Meoni* and G. and Blazquez*, E., CRC Press (in print).

AI4Space: Selected Trends in Artificial Intelligence for Space Applications.
Izzo, D., Meoni, G., Gomez, P., **Dold, D.** and Zoechbauer, A., CRC Press (in print).

Publications in preparation (2)

Differentiable graph-structured models for inverse design of lattice materials.
Dold*, D. and Aranguren van Egmond*, D.

A neural least action principle for real-time dendritic error backpropagation across cortical circuits.
Senn*, W., **Dold*, D.**, Kungl, A.F., Ellenberger, B., Bengio, Y., Sacramento, J., Jordan, J. and Petrovici*, M.A.

* marks equal contributions