Dylan Paiton

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Research Focus

How does our brain convert noisy signals from the world into what we perceive? How does it represent the world in a way that is both efficient and useful? These questions motivate my research, which lies at the intersection of artificial intelligence (AI) and visual neuroscience. While AI may not ultimately turn out to be a veridical clone of its biological counterpart, animal brains have and will continue to provide a wealth of inspiration for developing robust and efficient thinking machines. We must couple AI development with neuroscience study as much as possible, and in a way that exploits the strengths of each to overcome challenges. I propose a research agenda that treats artificial and biological neural networks as alternative solutions for similar objectives. I have previously demonstrated that such a perspective can allow us to overcome known shortcomings of modern Deep Neural Networks (DNNs) by integrating computational elements found in biology. I am currently extending an experimental method from vision science research to provide causal explanations for DNN function that are complementary to the gradient-based optimal stimuli used by the "circuits" team at Open AI. The method characterizes individual network neurons in terms of the geometry of their stimulus-response surfaces and will increase our understanding of both biological and artificial neural networks. My work has led to several published novel neural network architectures that have been applied to visual scene analysis, image storage, improving adversarial robustness, and clinical patient prognosis.

Academic Affiliations

The University of Tübingen • Tübingen, Baden-Württemberg, Germany — 2019 – present
Postdoctoral Researcher • *Computational Neuroscience* • Lab: Prof. Dr. Matthias Bethge

The University of California, Berkeley • Berkeley, California, USA — 2013 – 2019
Doctor of Philosophy • *Vision Science* • Advisor: Prof. Dr. Bruno Olshausen

Los Alamos National Laboratory • Los Alamos, New Mexico, USA — 2011 – 2013
Postbaccalaureate Researcher • *Computational Neuroscience* • Advisors: Dr. Steven Brumby, Dr. Garrett Kenyon

New Mexico Institute of Mining and Technology • Socorro, New Mexico, USA — 2007 – 2011
Bachelor of Science • *Electrical Engineering w/ minor in Optical Sciences and Engineering*

Publications — Google Scholar Profile: goo.gl/mkF1jU

Papers

- D Klindt*, L Schott*, Y Sharma*, I Ustyuzhaninov, W Brendel, M Bethge*, **DM Paiton***. "Towards Nonlinear Disentanglement in Natural Data with Temporal Sparse Coding." *International Conference on Learning Representations (ICLR)*, 2021. – third highest average reviewer score out of all submissions and accepted for an oral presentation; * Indicates shared authorship position

- **DM Paiton**, CG Frye, SY Lundquist, JD Bowen, R Zarcone, BA Olshausen. "Selectivity and robustness of sparse coding networks." *Journal of Vision (JoV)*, 2020.

- **DM Paiton**, S Shepard, KHR Chan, BA Olshausen. "Subspace locally competitive algorithms." *Neurally Inspired Computational Elements (NICE)*, 2020. – invited for a spotlight talk

- Y Chen, **DM Paiton**, BA Olshausen. "The sparse manifold transform." *Neural Information Processing Systems (NeurIPS)*, 2018.

- X Zheng, R Zarcone, **DM Paiton**, A Anderson, J Engel, W Wan, BA Olshausen, HSP Wong. "Error-Resilient analog image storage and compression with analog-valued RRAM arrays: An adaptive joint source-channel coding approach." *International Electron Devices Meeting (IEDM)*, 2018.

- R Zarcone, **DM Paiton**, A Anderson, J Engel, HSP Wong, BA Olshausen. "Joint source-channel coding with neural networks for analog data compression and storage." *Data Compression Conference (DCC)*, 2018.

- **DM Paiton**, SY Lundquist, WB Shainin, X Zhang, PF Shultz, GT Kenyon. "A deconvolutional competitive algorithm for building sparse hierarchical representations." *Conference on Computational Models of the Visual Cortex (CMVC)*, 2016.

- SY Lundquist, **DM Paiton**, PF Shultz, GT Kenyon. "Sparse Encoding of Binocular Images for Depth Inference." *IEEE Southwest Symposium on Image Analysis and Interpretation (SSIAI)*, 2016.

- PF Schultz, **DM Paiton**, W Lu, GT Kenyon. "Replicating Kernels with a short stride allows for sparse reconstructions with fewer independent kernels." *arXiv preprint. arXiv:1406.4205*, 2014.

- **DM Paiton***, SY Lundquist*, BM Nowers, PF Schultz, SP Brumby, AM Jorgensen, GT Kenyon. "Biologically-inspired distributed sensor networks: Collective signal amplification with ultra-low bandwidth spike-based communication." *IEEE International Joint Conference on Neural Networks (IJCNN)*, 2013.

- **DM Paiton**, SP Brumby, GT Kenyon, GJ Kunde, KD Peterson, MI Ham, PF Schultz, JS George. "Combining multiple visual processing streams for locating and classifying objects in video." *IEEE SSIAI*, 2012.

Posters

- **DM Paiton**, SA Cadena, Z Razzaghpanah, AS Ecker, M Bethge. "Response surfaces reveal invariance and selectivity in V1 neurons." *From Neuroscience to Artificially Intelligent Systems (NAISYS)*, 2020.

- **DM Paiton**, J Bowen, J Collins, C Frye, A Terekhov, BA Olshausen. "Sparse coding protects against adversarial attacks." *Computational and Systems Neuroscience (COSYNE)* – travel grant awarded, 2019.

- S Sanborn, **DM Paiton**, BA Olshausen. "Efficient coding in V1: Oriented filters vs. orientation selectivity." *COSYNE*, 2018.

- WB Shainin, **DM Paiton**, GT Kenyon, BA Olshausen. "Sampling l_0 sparse codes for task-optimal representations." *NICE*, 2016.

- **DM Paiton**, GT Kenyon, SP Brumby. "Ultra-light weight, low-power, neurally-inspired object detection and tracking systems for autonomous remote operation." *Technology Ventures Deal Stream Summit*, 2013.

- PF Schultz, SY Lundquist, **DM Paiton**, SP Brumby, GT Kenyon. "Neuro-inspired dynamics for sparse approximation in video." *Workshop on Statistical Image Analysis*, 2013.

- **DM Paiton**, SP Brumby, GT Kenyon, KD Peterson, MI Ham, PF Schultz, JS George. "Neuromorphic algorithms for classifying and locating objects in a fixed camera video feed." *Conference on Data Analysis (CODA)*, 2012.

- **DM Paiton**, SP Brumby. "Scaling of Object Detection Algorithms with Training Set Size." *Los Alamos National Laboratory Annual Student Symposium*, 2011.

Invited Talks

- "Towards nonlinear disentanglement in natural data with temporal sparse coding" *University of Bristol Mind and Machine Seminar Series*, March, 2021.

- "Subspace locally competitive algorithms" *Neurally Inspired Computational Elements*, March, 2021.

- "Selectivity and robustness of sparse coding networks" *Serre lab, Brown University*, December, 2020.

- "Selectivity and robustness of sparse coding networks" *Tolias & Pitkow labs, Baylor College of Medicine*, September, 2020.

- "Iso-response surface geometry of artificial and biological neurons" *Tübingen Robust Learning Symposium Workshop on Neuroscience and Machine Learning*, February, 2020.

- "Locally competitive, neurally inspired algorithms for generating sparse representations from video" *Mitchell lab, University of Portland*, February, 2013.

- "Flow – A visual programming environment for developing hierarchical temporal memory models" *Numenta, Inc*, February, 2010.

USA Patents

- S129,622 "Object detection approach using generative sparse, hierarchical networks with top-down and lateral connections for combining texture/color detection and shape/contour detection", Filed 13 Sept. 2012.

- S129,623: "System and Method for Automatic Object Detection in an Image", Filed 13 Sept. 2012.

FUNDING

I was the primary or co-primary applicant for the following funding awards:

- $204,000 (2019) Intelligence Community ORISE postdoctoral research fellowship

- $1,000 (2019) COSYNE travel grant

- $1,000 (2018) NeurIPS travel grant

- $70,000 (2012) DARPA Innovation House research award

Teaching

Graduate Student Instructor – The University of California, Berkeley   2013 – 2018
Berkeley, CA, USA

Neural Computation, 1 semester
- I rewrote several lab assignments in Jupyter Notebooks to improve the overall quality of the course, wrote new handouts for clarifying course material, gave full course lectures on theory and applications of sparse coding, held office hours, and graded coursework.

Optical Systems and Physical Optics, 2 semesters
- I ran weekly lab sections with around 20 students, gave lectures on lab material as well as lectures on course material in recitation (review) sessions, held office hours, and graded coursework.

Teaching Assistant – New Mexico Institute of Mining and Technology   2008
Socorro, NM, USA

Introduction to Electrical Engineering lab, 1 semester
- I aided students with completing weekly labs and gave several lectures on lab material.

Lab attendant and tutor; volunteer tutor, 4 years
- Under both a volunteer and paid capacity I advised students at weekly tutoring sessions and held regular office hours for the Electrical Engineering department.

Industry Experience

Co-founder – Glia Consulting, LLC   2018 – 2019
Berkeley, CA, USA

- I co-founded a machine-learning consultancy that focused on developing ML applications for biotech startups.

Vision and machine learning intern – Flickr   Summers 2015, 2016
San Francisco, CA, USA

- I developed semi-supervised recurrent models with directed feedback signals to improve object classification when trained with restricted label sets

Technical Skills

- I have contributed research on unsupervised representation learning, sparse coding and related probabilistic models, neural system identification and classification, recurrent neural networks, natural video statistics, distributed ensemble remote sensing, natural image compression and storage on analog memory devices.
- Mathematics – Deep learning, linear & nonlinear transforms, probability theory, information theory & compression, vector symbolic computing, differential equations, biophysical neuroscience models, natural scene statistics
- Machine learning – PyTorch, TensorFlow (contributor), PetaVision (contributor), Caffe, Scikit-learn, libSVM
- Multi-level programmer – Python, C++, parallel MATLAB/Octave, Latex, IDL, Perl, Java, MPI, Open MP, CUDA, BLAS, GIT

Outreach

- I am a lead organizer for the 2021 Neuromatch Academy Deep Learning summer school ethics team. I am responsible for ensuring that each course day includes an ethics component, and I work with lecturers to develop material for discussions, demonstrations, tutorials, etc.
- As a graduate student, I volunteered for the Bay Area Scientists in Schools program, where we met regularly with children to teach vision science and talk about life as a scientist. I presented my research to a broad audience at a public outreach seminar series called Grounds for Science in Oakland, California, USA. I also participated in the Berkeley AI Research mentorship program for introducing underrepresented individuals to research in AI.
- As an undergraduate, I actively participated in several organizations around campus that focused on community service, diversity, and career building projects. These clubs included IEEE, ASME, SHPE, and EWB.
- In 2016 I co-founded the UC Berkeley Neuroscience intramural ultimate frisbee team and in 2009 I co-founded the New Mexico Tech university ultimate frisbee team, which both continue to compete regularly.