

Jacob M. Graving

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Research Interests

Computational models of collective animal behavior, Bayesian statistical inference, deep learning, probabilistic programming, nonlinear dynamics

Positions

2020–present

Research Scientist

Max Planck Institute of Animal Behavior

Role: Head of central machine learning research group for developing advanced, general-purpose methods for the measurement and analysis of animal behavior in laboratory and field environments using computer vision, deep learning, and modern statistical methods, such as Bayesian causal inference.

Education

2021

Dr.rer.nat., Biology (0,0 “summa cum laude”)

“Deep Learning and Computer Vision Methods for Measuring and Modeling Animal Behavior”
Department of Collective Behaviour, Max Planck Institute of Animal Behavior
Department of Biology, University of Konstanz
Centre for the Advanced Study Collective Behaviour, University of Konstanz
International Max Planck Research School (IMPRS) for Organismal Biology

2015

M.Sc., Biology

Focus: Ethology, Neuroscience
Department of Biological Sciences, Bowling Green State University

2013

B.Sc., Biology

Department of Biological Sciences, Bowling Green State University

Relevant Publications

In Revision

Bath, D.E., **Graving, J.M.**, Walter, T., Sridhar, V.H., Vizcaíno, J.P., Couzin, I.D. Collective detection and processing of distributed information by fish schools. In revision.

- Collaborated with researchers from multiple disciplines to test the collective intelligence of large schools of fish using computer vision, deep learning, and Bayesian inference
- Developed and applied a generative Bayesian statistical model using JAX, Numpyro, and Tensorflow Probability to analyze an extremely large and complex time series data set (approx. 3 billion observations across and 400+ experimental conditions)

In Review

Graving, J.M., Couzin, I.D. (2020). VAE-SNE: a deep generative model for simultaneous dimensionality reduction and clustering. bioRxiv: <https://doi.org/10.1101/2020.07.17.207993>

- Developed a deep generative model using PyTorch to reveal the structure of biological data including the stereotyped dynamical motifs in high-dimensional body posture data measured from animals (<https://youtu.be/JlbSdKzvLfk>), as well as single cell transcriptomic data and natural images.)

2020

Li, L., Nagy, M., **Graving, J.M.**, Bak-Coleman, J., Guangming X., Couzin, I.D. (2020). Vortex phase matching as a strategy for schooling in robots and in fish. Nature Communications 11, 5408 <https://doi.org/10.1038/s41467-020-19086-0>

- Collaborated with researchers from multiple disciplines to test theoretical predictions developed using robots for how schooling fish might collectively optimize their swim pattern to maximize energy savings in flow environments

2019

- Measured and analyzed detailed body posture data of schooling fish using computer vision, deep learning, and mechanistic models of behavior to show that fish adopt optimal swimming patterns

Graving, J.M., Chae, D., Naik, H., Li, L., Koger, B., Costelloe, B.R., Couzin, I.D. (2019). DeepPoseKit, a software toolkit for fast and robust animal pose estimation using deep learning. eLife, 8. <https://doi.org/10.7554/elife.47994> bioRxiv: <https://doi.org/10.1101/620245> Code: <https://github.com/jgraving/deepposekit>
Press: Quanta Magazine, Nature Methods, Nature News & Views, eLife Science Digests

- Collaborated with researchers from multiple disciplines to develop a general purpose few-shot deep learning toolkit for measuring the body posture of animals using TensorFlow (<https://youtu.be/hCa2zaoUWbs>; <https://youtu.be/dSjaphoGHAY>).
- Supervised Daniel Chae, a visiting Bachelor's student from Princeton University, to develop a keypoint annotation GUI and custom data augmentation methods for the toolkit

Teaching

2019

ASAB 2019 Summer Conference, University of Konstanz

Workshop Organizer and Lecturer

- Seminar on "Machine Learning in the Behavioral Sciences"
- Practical Workshop on "Quantifying Behavior with Machine Learning"

2016–2020

University of Konstanz, Department of Biology

Lecturer and Project Advisor, Intensive Research Course for Master's Students

- Measuring Animal Behavior with Computer Vision
- Analyzing Behavioral Data
- Introduction to Programming in Python

Skills

Languages:

Python

Applications:

Bayesian inference, causal inference, statistical analysis, data visualization, machine learning, deep learning, computer vision, and image processing

Libraries:

JAX, Numpyro, Stan, TensorFlow, PyTorch, scikit-learn, OpenCV