Stanford

Surya Ganguli

Associate Professor of Applied Physics and , by courtesy, of Neurobiology and of Electrical Engineering

Curriculum Vitae available Online

Bio

ACADEMIC APPOINTMENTS

- Associate Professor, Applied Physics
- Associate Professor (By courtesy), Neurobiology
- Associate Professor (By courtesy), Electrical Engineering
- Member, Bio-X
- Associate Director, Institute for Human-Centered Artificial Intelligence (HAI)
- Member, Wu Tsai Neurosciences Institute

HONORS AND AWARDS

- NSF Career Award, National Science Foundation (2019)
- Investigator Award in Mathematical Modeling of Living Systems, Simons Foundation (2016)
- McKnight Scholar Award, McKnight Endowment Fund for Neuroscience (2015)
- Scholar Award in Human Cognition, James S. McDonnell Foundation (2014)
- Outstanding Paper Award, Neural Information Processing Systems Foundation (2014)
- Sloan Research Fellowship, Alfred P. Sloan Foundation (2013)
- Terman Award, Stanford University (2012)
- Career Award at the Scientific Interface, Burroughs Wellcome Foundation (2009)
- Swartz Fellow in Computational Neuroscience, Swartz Foundation (2004)

PROFESSIONAL EDUCATION

- Ph.D., UC Berkeley , Theoretical Physics (2004)
- M.A., UC Berkeley , Physics (2000)
- M.A., UC Berkeley , Mathematics (2004)
- M.Eng., MIT , Electrical Engineering and Computer Science (1998)
- B.S., MIT , Physics (1998)
- B.S., MIT , Mathematics (1998)
- B.S., MIT , Electrical Engineering and Computer Science (1998)

LINKS

- Lab Website: http://ganguli-gang.stanford.edu/index.html

- Personal Website: http://ganguli-gang.stanford.edu/surya.html
- Applied Physics Website: https://web.stanford.edu/dept/app-physics/cgi-bin/person/surya-gangulijanuary-2012/

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

Theoretical / computational neuroscience

Teaching

COURSES

2019-20

- Artificial Intelligence, Entrepreneurship and Society in the 21st Century and Beyond: CS 28 (Aut)
- Introduction to Biophysics: APPPHYS 205, BIO 126, BIO 226 (Win)
- NeuroTech Training Seminar: NSUR 239, STATS 242 (Spr)
- Theoretical Neuroscience: APPPHYS 293, PSYCH 242 (Spr)

2018-19

- Introduction to Biophysics: APPPHYS 205, BIO 126, BIO 226 (Win)
- Theoretical Neuroscience: APPPHYS 293, PSYCH 242 (Spr)

STANFORD ADVISEES

Doctoral Dissertation Reader (AC)

Max Kanwal, Vasily Kruzhilin, Mark Plitt, Daniel Wennberg

Postdoctoral Faculty Sponsor

Sam Ocko, James Whittington

Doctoral Dissertation Advisor (AC)

Brandon Benson, Sarah Harvey, Daniel Paul Kunin, Gabriel Mel, Aran Nayebi, Tamra Nebabu, Mansheej Paul, Atsushi Yamamura

Doctoral Dissertation Co-Advisor (AC)

Feng Chen, Linnie Jiang, YoungJu Jo, Brett Larsen, Aiden Wang, Grace Woods

Doctoral (Program)

Tingting Gong, Zhaoheng Guo, Rochelle Radzyminski, Lauren Riddiford, Eun Sun Song, Aiden Wang

Postdoctoral Research Mentor

Sam Ocko

GRADUATE AND FELLOWSHIP PROGRAM AFFILIATIONS

- Neurosciences (Phd Program)

Publications

PUBLICATIONS

- **Distinct invivo dynamics of excitatory synapses onto cortical pyramidal neurons and parvalbumin-positive interneurons.** *Cell reports*
  Melander, J. B., Nayebi, A., Jongbloets, B. C., Fortin, D. A., Qin, M., Ganguli, S., Mao, T., Zhong, H.
  2021; 37 (6): 109972

- **Embodied intelligence via learning and evolution.** *Nature communications*
  Gupta, A., Savarese, S., Ganguli, S., Fei-Fei, L.
  2021; 12 (1): 5721

- **A neural circuit state change underlying skilled movements.** *Cell*
  Wagner, M. J., Savall, J., Hernandez, O., Mel, G., Inan, H., Rumyantsev, O., Lecoq, J., Kim, T. H., Li, J. Z., Ramakrishnan, C., Deisseroth, K., Luo, L., Ganguli, et al
  2021

- **Enhancing Associative Memory Recall and Storage Capacity Using Confocal Cavity QED** *PHYSICAL REVIEW X*
  Marsh, B. P., Guo, Y., Kroeze, R. M., Gopalakrishnan, S., Ganguli, S., Keeling, J., Lev, B. L.
  2021; 11 (2)

- **Coupling of activity, metabolism and behaviour across the Drosophila brain.** *Nature*
  Mann, K., Deny, S., Ganguli, S., Clandinin, T. R.
  2021

- **Distance-tuned neurons drive specialized path integration calculations in medial entorhinal cortex.** *Cell reports*
  Campbell, M. G., Attinger, A., Ocko, S. A., Ganguli, S., Giocomo, L. M.
  2021; 36 (10): 109669

- **Fundamental bounds on the fidelity of sensory cortical coding.** *Nature*
  Rumyantsev, O. I., Lecoq, J. A., Hernandez, O., Zhang, Y., Savall, J., Chrapkiewicz, R., Li, J., Zeng, H., Ganguli, S., Schnitzer, M. J.
  2020; 580 (7801): 100-105

- **Discovering Precise Temporal Patterns in Large-Scale Neural Recordings through Robust and Interpretable Time Warping** *NEURON*
  Williams, A. H., Poole, B., Maheswaranathan, N., Dhawale, A. K., Fisher, T., Wilson, C. D., Brann, D. H., Trautmann, E. M., Ryu, S., Shusterman, R., Rinberg, D., Olveczky, B. P., Shenoy, et al
  2020; 105 (2): 246-+

- **Statistical Mechanics of Deep Learning** *ANNUAL REVIEW OF CONDENSED MATTER PHYSICS, VOL 11, 2020*
  Bahri, Y., Kadmon, J., Pennington, J., Schoenholz, S. S., Sohl-Dickstein, J., Ganguli, S., Marchetti, M. C., Mackenzie, A. P.
  2020; 11: 501–28

- **GluD2- and Cbln1-mediated competitive interactions shape the dendritic arbors of cerebellar Purkinje cells.** *Neuron*
  Takeo, Y. H., Shuster, S. A., Jiang, L. n., Hu, M. C., Luginbuhl, D. J., Rülicke, T. n., Contreras, X. n., Hippenmeyer, S. n., Wagner, M. J., Ganguli, S. n., Luo, L. n.
  2020

- **Statistical mechanics of low-rank tensor decomposition** *JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT*
  Kadmon, J., Ganguli, S.
  2019; 2019 (12)

- **A deep learning framework for neuroscience.** *Nature neuroscience*
  Richards, B. A., Lillicrap, T. P., Beaudoin, P., Bengio, Y., Bogacz, R., Christensen, A., Clopath, C., Costa, R. P., de Berker, A., Ganguli, S., Gillon, C. J., Hafner, D., Kepecs, et al
  2019; 22 (11): 1761–70

- **A mathematical theory of semantic development in deep neural networks.** *Proceedings of the National Academy of Sciences of the United States of America*
  Saxe, A. M., McClelland, J. L., Ganguli, S.
  2019

- **Shared Cortex-Cerebellum Dynamics in the Execution and Learning of a Motor Task** *CELL*
  Wagner, M. J., Kim, T., Kadmon, J., Nguyen, N. D., Ganguli, S., Schnitzer, M. J., Luo, L.
  2019; 177 (3): 669-+

- **Cortical layer-specific critical dynamics triggering perception.** *Science (New York, N.Y.)*
  Marshel, J. H., Kim, Y. S., Machado, T. A., Quirin, S. n., Benson, B. n., Kadmon, J. n., Raja, C. n., Chibukhchyan, A. n., Ramakrishnan, C. n., Inoue, M. n., Shane, J. C., McKnight, D. J., Yoshizawa, et al
  2019

- **A unified theory for the origin of grid cells through the lens of pattern formation**
  Sorscher, B., Mel, G. C., Ganguli, S., Ocko, S. A., Wallach, H., Larochelle, H., Beygelzimer, A., d'Alche-Buc, F., Fox, E., Garnett, R.
  NEURAL INFORMATION PROCESSING SYSTEMS (NIPS).2019

- **Universality and individuality in neural dynamics across large populations of recurrent networks**
  Maheswaranathan, N., Williams, A. H., Golub, M. D., Ganguli, S., Sussillo, D., Wallach, H., Larochelle, H., Beygelzimer, A., d'Alche-Buc, F., Fox, E., Garnett, R.
  NEURAL INFORMATION PROCESSING SYSTEMS (NIPS).2019

- **Reverse engineering recurrent networks for sentiment classification reveals line attractor dynamics**
  Maheswaranathan, N., Williams, A. H., Golub, M. D., Ganguli, S., Sussillo, D., Wallach, H., Larochelle, H., Beygelzimer, A., d'Alche-Buc, F., Fox, E., Garnett, R.
  NEURAL INFORMATION PROCESSING SYSTEMS (NIPS).2019

- **From deep learning to mechanistic understanding in neuroscience: the structure of retinal prediction**
  Tanaka, H., Nayebi, A., Maheswaranathan, N., McIntosh, L., Baccus, S. A., Ganguli, S., Wallach, H., Larochelle, H., Beygelzimer, A., d'Alche-Buc, F., Fox, E., Garnett, R.
  NEURAL INFORMATION PROCESSING SYSTEMS (NIPS).2019

- **A Unified Theory of Early Visual Representations from Retina to Cortex through Anatomically Constrained Deep CNNs** *International Conference on Learning Representations (ICLR)*
  Lindsay, J., Ocko, S., Ganguli, S., Deny, S.
  2019

- **An analytic theory of generalization dynamics and transfer learning in deep linear networks** *International Conference on Learning Representations (ICLR)*
  Lampinen, A., Ganguli, S.
  2019

- **Accurate estimation of neural population dynamics without spike sorting** *Neuron*
  Trautmann, E. M., Stavisky, S. D., Lahiri, S., Ames, K. C., Kauffman, M. T., O'Shea, D. J., Vyas, S., Sun, X., Ryu, S. I., Ganguli, S., Shenoy, K. V.
  2019; 103: 1-17

- **Emergent elasticity in the neural code for space.** *Proceedings of the National Academy of Sciences of the United States of America*
  Ocko, S. A., Hardcastle, K., Giocomo, L. M., Ganguli, S.
  2018

- **Inferring hidden structure in multilayered neural circuits.** *PLoS computational biology*
  Maheswaranathan, N., Kastner, D. B., Baccus, S. A., Ganguli, S.
  2018; 14 (8): e1006291

- **Principles governing the integration of landmark and self-motion cues in entorhinal cortical codes for navigation.** *Nature neuroscience*
  Campbell, M. G., Ocko, S. A., Mallory, C. S., Low, I. I., Ganguli, S., Giocomo, L. M.
  2018

- **SuperSpike: Supervised Learning in Multilayer Spiking Neural Networks.** *Neural computation*
  Zenke, F. n., Ganguli, S. n.
  2018: 1–28

- **Task-Driven Convolutional Recurrent Models of the Visual System**
  Nayebi, A., Bear, D., Kubilius, J., Kar, K., Ganguli, S., Sussillo, D., DiCarlo, J. J., Yamins, D. K., Bengio, S., Wallach, H., Larochelle, H., Grauman, K., CesaBianchi, et al
  NEURAL INFORMATION PROCESSING SYSTEMS (NIPS).2018

- **The emergence of multiple retinal cell types through efficient coding of natural movies**
  Ocko, S. A., Lindsey, J., Ganguli, S., Deny, S., Bengio, S., Wallach, H., Larochelle, H., Grauman, K., CesaBianchi, N., Garnett, R.
  NEURAL INFORMATION PROCESSING SYSTEMS (NIPS).2018

- **Statistical mechanics of low-rank tensor decomposition**
  Kadmon, J., Ganguli, S., Bengio, S., Wallach, H., Larochelle, H., Grauman, K., CesaBianchi, N., Garnett, R.
  NEURAL INFORMATION PROCESSING SYSTEMS (NIPS).2018

- **The emergence of multiple retinal cell types through efficient coding of natural movies** *Neural Information Processing Systems (NIPS)*

Deny, S., Lindsey, J., Ganguli, S., Ocko, S.
2018

- **Task-Driven Convolutional Recurrent Models of the Visual System** *Neural Information Processing Systems (NIPS)*
  Nayebi, A., Bear, D., Kubulius, J., Kar, K., Ganguli, S., Di Carlo, J., Sussillo, D., Yamins, D.
  2018

- **Statistical mechanics of low-rank tensor decomposition** *Neural Information Processing Systems (NIPS)*
  Kadmon, J., Ganguli, S.
  2018

- **Unsupervised Discovery of Demixed, Low-Dimensional Neural Dynamics across Multiple Timescales through Tensor Component Analysis.** *Neuron*
  Williams, A. H., Kim, T. H., Wang, F. n., Vyas, S. n., Ryu, S. I., Shenoy, K. V., Schnitzer, M. n., Kolda, T. G., Ganguli, S. n.
  2018

- **The emergence of spectral universality in deep networks** *Artificial Intelligence and Statistics (AISTATS)*
  Pennington, J., Schoenholz, S., Ganguli, S.
  2018

- **An International Laboratory for Systems and Computational Neuroscience** *NEURON*
  Abbott, L. F., Angelaki, D. E., Carandini, M., Churchland, A. K., Dan, Y., Dayan, P., Deneve, S., Fiete, I., Ganguli, S., Harris, K. D., Hausser, M., Hofer, S., Latham, et al
  2017; 96 (6): 1213–18

- **Cell types for our sense of location: where we are and where we are going** *NATURE NEUROSCIENCE*
  Hardcastle, K., Ganguli, S., Giocomo, L. M.
  2017; 20 (11): 1474–82

- **A Multiplexed, Heterogeneous, and Adaptive Code for Navigation in Medial Entorhinal Cortex** *NEURON*
  Hardcastle, K., Maheswaranathan, N., Ganguli, S., Giocomo, L. M.
  2017; 94 (2): 375-?

- **The temporal paradox of Hebbian learning and homeostatic plasticity.** *Current opinion in neurobiology*
  Zenke, F., Gerstner, W., Ganguli, S.
  2017; 43: 166-176

- **A saturation hypothesis to explain both enhanced and impaired learning with enhanced plasticity.** *eLife*
  Nguyen-Vu, T. B., Zhao, G. Q., Lahiri, S., Kimpo, R. R., Lee, H., Ganguli, S., Shatz, C. J., Raymond, J. L.
  2017; 6

- **Social Control of Hypothalamus-Mediated Male Aggression.** *Neuron*
  Yang, T. n., Yang, C. F., Chizari, M. D., Maheswaranathan, N. n., Burke, K. J., Borius, M. n., Inoue, S. n., Chiang, M. C., Bender, K. J., Ganguli, S. n., Shah, N. M.
  2017; 95 (4): 955–70.e4

- **On the expressive power of deep neural networks** *International Conference on Machine Learning (ICML)*
  Raghu, M., Poole, B., Kleinberg, J., Ganguli, S., Sohl-Dickstein, J.
  2017

- **Resurrecting the sigmoid in deep learning through dynamical isometry: theory and practice** *Neural Information Processing Systems (NIPS)*
  Pennington, J., Schoenholz, S., Ganguli, S.
  2017

- **Variational Walkback: Learning a Transition Operator as a Stochastic Recurrent Net** *Neural Information Processing Systems (NIPS)*
  Ke, R., Goyal, A., Ganguli, S., Bengio, Y.
  2017

- **Continual Learning with Intelligent Synapses** *International Conference on Machine Learning (ICML)*
  Zenke, F., Poole, B., Ganguli, S.
  2017

- **Deep information propagation** *International Conference on Learning Representations (ICLR)*
  Schoenholz, S., Gilmer, J., Ganguli, S., Sohl-Dickstein, J.
  2017
- **Statistical Mechanics of Optimal Convex Inference in High Dimensions** *PHYSICAL REVIEW X*
  Advani, M., Ganguli, S.
  2016; 6 (3)
- **Direction Selectivity in Drosophila Emerges from Preferred-Direction Enhancement and Null-Direction Suppression.** *journal of neuroscience*
  Leong, J. C., Esch, J. J., Poole, B., Ganguli, S., Clandinin, T. R.
  2016; 36 (31): 8078-8092
- **An equivalence between high dimensional Bayes optimal inference and M-estimation** *Neural Information Processing Systems (NIPS)*
  Advani, M., Ganguli, S.
  2016
- **Deep Learning Models of the Retinal Response to Natural Scenes.** *Advances in neural information processing systems*
  McIntosh, L. T., Maheswaranathan, N. n., Nayebi, A. n., Ganguli, S. n., Baccus, S. A.
  2016; 29: 1369–77
- **Exponential expressivity in deep neural networks through transient chaos** *Neural Information Processing Systems (NIPS)*
  Poole, B., Subhaneil, L., Raghu, M., Sohl-Dickstein, J., Ganguli, S.
  2016: 3360–3368
- **Role of the site of synaptic competition and the balance of learning forces for Hebbian encoding of probabilistic Markov sequences** *FRONTIERS IN COMPUTATIONAL NEUROSCIENCE*
  Bouchard, K. E., Ganguli, S., Brainard, M. S.
  2015; 9
- **On simplicity and complexity in the brave new world of large-scale neuroscience** *CURRENT OPINION IN NEUROBIOLOGY*
  Gao, P., Ganguli, S.
  2015; 32: 148-155
- **Environmental Boundaries as an Error Correction Mechanism for Grid Cells** *NEURON*
  Hardcastle, K., Ganguli, S., Giocomo, L. M.
  2015; 86 (3): 827-839
- **Evidence for a causal inverse model in an avian cortico-basal ganglia circuit** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
  Giret, N., Kornfeld, J., Ganguli, S., Hahnloser, R. H.
  2014; 111 (16): 6063-6068
- **Fast large scale optimization by unifying stochastic gradient and quasi-Newton methods** *International Conference on Machine Learning (ICML)*
  Dickstein, J. S., Poole, B., Ganguli, S.
  2014
- **Exact solutions to the nonlinear dynamics of learning in deep neural networks** *International Conference on Learning Representations (ICLR)*
  Saxe, A., McClelland, J., Ganguli, S.
  2014
- **Identifying and attacking the saddle point problem in high-dimensional non-convex optimization** *Neural Information Processing Systems (NIPS)*
  Dauphin, Y., Pascanu, R., Gulchere, C., Cho, K., Ganguli, S., Bengio, Y.
  2014
- **Investigating the role of firing-rate normalization and dimensionality reduction in brain-machine interface robustness.** *Conference proceedings : ... Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Conference*
  Kao, J. C., Nuyujukian, P., Stavisky, S., Ryu, S. I., Ganguli, S., Shenoy, K. V.
  2013; 2013: 293-298
- **A Hebbian learning rule gives rise to mirror neurons and links them to control theoretic inverse models** *FRONTIERS IN NEURAL CIRCUITS*

Hanuschkin, A., Ganguli, S., Hahnloser, R. H.
2013; 7

- **Statistical mechanics of complex neural systems and high dimensional data** *JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT*
  Advani, M., Lahiri, S., Ganguli, S.
  2013
- **A memory frontier for complex synapses** *Neural Information Processing Systems (NIPS)*
  Lahiri, S., Ganguli, S.
  2013
- **Learning hierarchical category structure in deep neural networks** *Proceedings of the Cognitive Science Society*
  Saxe, A., McClelland, J., Ganguli, S.
  2013: 1271–1276
- **Vocal learning with inverse models** *Principles of Neural Coding*
  Hahnloser, R., Ganguli, S.
  CRC Press.2013
- **Spatial Information Outflow from the Hippocampal Circuit: Distributed Spatial Coding and Phase Precession in the Subiculum** *JOURNAL OF NEUROSCIENCE*
  Kim, S. M., Ganguli, S., Frank, L. M.
  2012; 32 (34): 11539-11558
- **Compressed Sensing, Sparsity, and Dimensionality in Neuronal Information Processing and Data Analysis** *ANNUAL REVIEW OF NEUROSCIENCE, VOL 35*
  Ganguli, S., Sompolinsky, H.
  2012; 35: 485-508
- **Short-term memory in neuronal networks through dynamical compressed sensing** *Neural Information Processing Systems (NIPS)*
  Gangui, S., Sompolinsky, H.
  2010
- **Feedforward to the Past: The Relation between Neuronal Connectivity, Amplification, and Short-Term Memory** *NEURON*
  Ganguli, S., Latham, P.
  2009; 61 (4): 499-501
- **Memory traces in dynamical systems** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
  Ganguli, S., Huh, D., Sompolinsky, H.
  2008; 105 (48): 18970-18975
- **One-dimensional dynamics of attention and decision making in LIP** *NEURON*
  Ganguli, S., Bisley, J. W., Roitman, J. D., Shadlen, M. N., Goldberg, M. E., Miller, K. D.
  2008; 58 (1): 15-25
- **Function constrains network architecture and dynamics: A case study on the yeast cell cycle Boolean network** *PHYSICAL REVIEW E*
  Lau, K., Ganguli, S., Tang, C.
  2007; 75 (5)
- **E10 Orbifolds** *Journal of High Energy Physics*
  Brown, J., Ganguli, S., Ganor, O., Helfgott, C.
  2005; 06 (057)
- **Twisted six dimensional gauge theories on tori, matrix models, and integrable systems** *JOURNAL OF HIGH ENERGY PHYSICS*
  Ganguli, S., Ganor, O. J., Gill, J.
  2004
- **Holographic protection of chronology in universes of the Godel type** *PHYSICAL REVIEW D*
  Boyda, E. K., Ganguli, S., Horava, P., Varadarajan, U.
  2003; 67 (10)