M Ganesh Kumar

Webpage: https://mgkumar138.github.io/ E-mail: m_ganeshkumar@u.nus.edu Citizenship: Singapore

Summary

I am interested to understand what are the neural mechanisms supporting complex behavior and generalization in biological systems. To do this, I develop mathematical models and evaluate their learning efficiency in artificial systems. I am also curious to characterize the mechanisms contributing to disorders, and develop tools to alleviate them e.g. Human-Computer Interfaces.

Keywords: Computational Neuroscience, Machine Learning, Human-Computer Interface.

Education

Harvard University **September 2023 – Present**
Postdoctoral Fellow
- Machine Learning Foundations, School of Engineering and Applied Sciences (SEAS)
- Advisors: Cengiz Pehlevan (Theoretical Neuroscience), Demba Ba (Signal processing), Lucas Janson (Statistics)

Simons Foundation **August 2024**
- Summer school 2024: Analytical Connectionism
- Project: Inducing psychiatric disorders in neural network-based reinforcement learning agents

National University of Singapore (NUS) **August 2018 – January 2023**
- Ph.D. in Computational Neuroscience
- Integrative Science and Engineering Programme (ISEP), NUS Graduate School (NGS)
- Doctoral thesis: Biologically plausible computations underlying one-shot learning of paired associations
- Advisors: Andrew Tan (Physiolgy), Shih-Cheng Yen (Engineering)

National Institute of Education, Nanyang Technological University (NTU) **January 2021 – April 2021**
- Graduate Exchange Programme: Early Childhood Education & Assessment

Massachusetts Institute of Technology (MIT) **August 2019**
- Summer school 2019: Center for Brains, Minds & Machines (CBMM)
- Project: Compositional Models for Adaptive Learning in Vision

National University of Singapore (NUS) **August 2013 – July 2017**
- B.Sc. with Honors (Distinction) in Life Sciences (Biomedical Sciences)
- Double Minors: University Scholars Programme (USP) and Special Programme in Science (SPS)
- Honors thesis: Wheelchair control using motor-imagery based Electroencephalogram (EEG)

Research Experience

2023 – Present	**Postdoctoral Fellow**, SEAS, Harvard University
2022 – 2023	**Research Scientist I**, Center for Frontier AI Research (CFAR), A*STAR
2017 – 2018	**Research Engineer**, A*STAR Artificial Intelligence Initiative (A*AI), A*STAR

Awards

- Postdoctoral Fellowship in Computer Science 2023, Harvard University
- MIT's Center for Brains, Minds, Machines 2019 – Fujitsu Laboratories Fellow
- NUS Graduate School Scholarship (NGSS) 2018 for Ph.D.
- NUSS Gold Medal for Outstanding Achievement 2017 (Best overall student in cohort for B.Sc.)
- University Scholars Programme (USP) Senior Honor Roll 2017
- A*STAR Undergraduate Scholarship (AUS) 2013 for B.Sc.

Publications

Understand Biological Intelligence, Improve Artificial Intelligence, Alleviate Neurological Disorders

Preprints

- U A: M Ganesh Kumar, Adam Manoogian, Nathan Cloos, Shawn Roads. Neurocomputational Underpinnings of Suboptimal Beliefs in Reinforcement Learning Agents.

- U I: M Ganesh Kumar, Blake Bordelon, Jacob Zavatone-Veth, Cengiz Pehlevan. A Model of Place Field Reorganization during Reward Maximization***. bioRxiv 2024.12.12.627755***. https://doi.org/10.1101/2024.12.12.627755 [GitHub]

- UA: M Ganesh Kumar, Cheston Tan, Camilo Libedinsky, Shih-Cheng Yen, Andrew Tan Yong-Yi (2024). One-shot learning of paired association navigation using biologically plausible schemas. ***arXiv 2106.03580.*** https://arxiv.org/abs/2106.03580[GitHub]

Full papers

- UA: M Ganesh Kumar, Cheston Tan, Camilo Libedinsky, Shih-Cheng Yen, Andrew Tan Yong-Yi (2022). A nonlinear hidden layer enables actor-critic agents to learn multiple paired association navigation. ***Cerebral Cortex 32 (18),* 3917-3936**. https://doi.org/10.1093/cercor/bhab456 [GitHub]

Peer Reviewed Conference Proceedings

- B I: Zijun Lim, M Ganesh Kumar, Cheston Tan. Multi-modal embodied agents learn Determiners and Prepositions concepts using synthetic environments for zero-shot navigation. ***Proceedings of the International Conference on Learning Representations (ICLR) Workshops, Singapore 2025.***

- U I: Zijun Lim*, Haidi Azaman*, M Ganesh Kumar, Cheston Tan (2024). Compositional visual grounding of word concepts through embodied reinforcement learning. ***Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) Workshops, Seattle 2024.*** https://arxiv.org/abs/2309.04504 [GitHub]

- U I: Clarence Lee*, M Ganesh Kumar*, Cheston Tan (2023). DetermiNet: A Large-Scale Diagnostic Dataset for Complex Visually-Grounded Referencing using Determiners. ***Proceedings of the IEEE/CVF International Conference on Computer Vision (ICCV), Paris 2023***. https://arxiv.org/abs/2309.03483 [GitHub]

- IA: Nathan Cloos, M Ganesh Kumar, Adam Manoogian, Christopher Cueva, Shawn Roads (2024). Generating and Validating Agent and Environment Code for Simulating Realistic Personality Profiles with Large Language Models. ***NeurIPS 2024 Workshop Foundation Models For Science, Vancouver 2024.*** [Short Paper].

- IA: M Ganesh Kumar, Kai Keng Ang, Rosa Q. So. (2017). Reject Option to reduce False Detection Rates for EEG-Motor Imagery based BCI. In *Engineering in Medicine and Biology Society, EMBC 2017.* ***39th Annual International Conference of the IEEE***. https://doi.org/10.1109/EMBC.2017.8037479

Book Chapters

- U I A: M Ganesh Kumar, Shamini Ayyadhury, Elavazhagan Murugan (2024). Trends, Innovations and Challenges in employing Interdisciplinary Approaches to Biomedical sciences. In ***Translational Research in Biomedical Sciences: Recent Progress and Future Prospects, Chapter 20***. Springer Nature. https://doi.org/10.1007/978-981-97-1777-4_20

Ongoing Projects

- BA: Vachan Shetru Jagadeesh*, Jiachuan Wang*, M Ganesh Kumar, Camilo Libedinsky, Shih-Cheng Yen, Andrew YY Tan & Jai S Polepalli. Cerebellin-4 signalling in the dentate gyrus inhibits activity-dependent neurogenesis.

- B I A: Praveena Satkunarajah, M Ganesh Kumar, Sarah Power, Ben Zendel. Online EEG-based classification using reservoir computing during timbre perception.
- B I: M Ganesh Kumar*, Sumedh Hindupur*, Demba Ba. Noisy prototype consolidation improves continual learning.
- B I: Jorin Overwiening, M Ganesh Kumar, Haim Sompolinsky. Motor control with deep spiking neural agents.
- U A: Niels Pacheco, Valerie Costa, M Ganesh Kumar, Demba Ba. Temporal kernels underlying seizure incidence.
- B I: Blake Bordelon*, M Ganesh Kumar*, Cengiz Pehlevan. Dynamics of Policy Learning resembles learning an Attractor Manifold.
- I: Leon Guertler, M Ganesh Kumar, Anh Tuan Luu, Cheston Tan. TellMe What You See: Using LLMs to Explain Neurons in Vision Models.
- B I: Leon Guertler, M Ganesh Kumar, Cheston Tan. NoiseOut: Learning to gate improves Robustness in Deep Neural Networks.

Invited talks

Mar 2025	Department of Computational Neuroscience, Max Planck Institute for Biological Cybernetics
Nov 2024	Annual Neuroscience Conference, Society for Neuroscience Singapore Chapter
Jun 2024	Neural Coding and Cognition group, National University of Singapore
Apr 2023	Foundations in Machine Learning group, Harvard University
Dec 2022	Neuroscience Singapore 2022, Society for Neuroscience Singapore Chapter
Nov 2022	Senseable Intelligence group, McGovern Institute for Brain Research, MIT
Oct 2022	Metaconscious group, Brain and Cognitive Science department, MIT
Sep 2022	Department of Computational Neuroscience, Max Planck Institute for Biological Cybernetics
Jun 2022	Three-minute thesis, Department of Physiology, NUS
Feb 2022	Biolins group, Brain and Cognitive Science department, MIT
Sep 2021	Neurobiology seminar, Life Science Institute, NUS

Conference posters

M Ganesh Kumar, Blake Bordelon, Jacob Zavatone-Veth, Cengiz Pehlevan. A Model of Place Field Reorganization during Reward Maximization***. Computational and Systems Neuroscience (COSYNE) Abstracts 2025****, Montreal, Canada.*

M Ganesh Kumar, Cengiz Pehlevan. Place fields organize along goal trajectory with reinforcement learning. ***Cognitive Computational Neuroscience (CCN) 2024***, Massachusetts, US. [Short Paper]

Clarence Lee*, Zijun Lin*, M Ganesh Kumar, Cheston Tan. Leveraging on synthetic datasets to advance visual grounding on natural language concept comprehension. **16th *Asia Pacific Computer Vision Conference (APCV) 2024***, Singapore. Talk.

M Ganesh Kumar, Cheston Tan, Camilo Libedinsky, Shih-Cheng Yen, Andrew Tan Yong Yi. One-shot learning of paired associations using biologically plausible schemas. ***RL@Harvard 2023***, Massachusetts, United States. Poster.

M Ganesh Kumar, Cheston Tan, Camilo Libedinsky, Shih-Cheng Yen, Andrew Tan Yong Yi. One-shot learning of paired associations by a reservoir computing model with Hebbian plasticity. ***Computational and Systems Neuroscience (COSYNE) Abstracts 2022***, Lisbon, Portugal. Poster. [Short Paper]

M Ganesh Kumar, Cheston Tan, Camilo Libedinsky, Shih-Cheng Yen, Andrew Tan Yong Yi. Learning working memory using a reservoir computing model trained by Hebbian plasticity for one-shot navigation to single displaced targets. ***Neuroscience to Artificially intelligent systems (NAISys) 2022***, Virtual. Talk.

M Ganesh Kumar, Cheston Tan, Camilo Libedinsky, Shih-Cheng Yen, Andrew Tan Yong Yi. One-shot learning of paired associations by a reservoir computing model with Hebbian plasticity. ***Neuroscience 2021, Society for Neuroscience (SfN)***, Virtual. Talk.

M Ganesh Kumar, Cheston Tan, Camilo Libedinsky, Shih-Cheng Yen, Andrew Tan Yong Yi. Learning multiple paired associations with temporal difference error modulated Hebbian plasticity. ***Neuroscience to Artificially intelligent systems (NAISys) 2020***, Virtual. Talk.

M Ganesh Kumar, Cheston Tan, Camilo Libedinsky, Shih-Cheng Yen, Andrew Tan Yong Yi. Learning multiple cue-reward location associations using reservoir computing model & temporal difference error modulated Hebbian plasticity. ***Neuromatch 2020***, Virtual. Talk.

M Ganesh Kumar, Cheston Tan, Camilo Libedinsky, Shih-Cheng Yen, Andrew Tan Yong Yi. Liquid State Machine acquisition of paired associations with reward modulated Hebbian learning. ***Bernstein Conference 2019***, Berlin, Germany. Poster.

Service

Journals	IEEE Transactions on Cognitive and Developmental Systems, PLOS Computational Biology
Conferences	Neural Information Processing Systems (NeurIPS), International Conference on Learning Representations (ICLR), International Conference on Machine Learning (ICML) Computational Cognitive Neuroscience (CCN)
Organizing Committee	Society for Neuroscience, Singapore Chapter

Programming

Python: JAX, Tensorflow, PyTorch; Matlab

Teaching

Jan 2025 – May 2025	APMTH 50: Introduction to Applied Mathematics (TF)
Jun 2022	STEP NUS Braincamp 2022
Oct 2021	NUS CET Beginning Artificial intelligence through Neuroscience
Jun 2021	Neuroscience, AI & Medicine workshop
Jun 2019	NUS Braincamp 2019
Jan 2019 – Dec 2019	LSM4213: Systems Neurobiology (TF)

Mentoring

Aug 2024	Jiachuan Wang, Ph.D. candidate, NUS
Aug 2023 – Apr 2024	Capstone student project, SUTD
Jul 2023 – Jul 2024	Leon Guertler, NTU Honors Project – Research Engineer at A*STAR
May 2023 – Jul 2024	Zijun Lin, NTU Honors Project – pursuing Ph.D. at NTU
Mar 2023 – Aug 2023	Haidi Azaman, NUS Honors Project – pursuing M.Comp. at NUS
Sep 2022 – Mar 2023	Clarence Sheng, A*STAR Internship – pursuing Ph.D. at SUTD
Aug 2021 – Apr 2022	Xi Zhi Low, NUS Honors Project – pursuing M.D. at Duke-NUS
May 2020 – Apr 2021	Hema Prashaad, NUS Honors Project – pursuing M.D. at Duke-NUS

May 2020 – Apr 2021	Franklin Leong, NUS Honors Project – pursuing Ph.D. at ETH Zurich	
Jan 2019 – Apr 2020	Graduate research mentor, Special Programme in Science	

Besides research

May 2019 – Present	Co-founder, Principal Consultant, ML Scientist	Nugen.ai, EduTech
Feb 2011 – Present	S3 Operations officer, Rank: Major (ROVERS)	Singapore Armed Forces
Aug 2014 – Present	Advisory Panel, President	NUS Tamil Language Society
Jan 2019 – Dec 2019	Chairman	1st Tamil+AI SG Symposium

- **Entrepreneurship.** I enjoy chatting with people to understand problem statements and figuring out solutions to improve outcomes. I am a Certified Scrum Product Owner (CSPO) and Scrum Master (CSM).
- **Travel.** I love to explore new places, especially by riding a motorcycle.
- **Theatre productions.** I have produced, directed, and acted in student theatre productions.
- **Crossfit.** My wife convinced me that crossfit is fun.