M Ganesh Kumar

Webpage: https://mgkumar138.github.io/ GitHub: https://github.com/mgkumar138
LinkedIn: www.linkedin.com/in/m-ganesh-kumar E-mail: m_ganeshkumar@u.nus.edu

Summary

I am broadly interested in understanding how the brain learns world models to solve new problems quickly, and implement these principles as algorithms to improve artificial systems. My postdoctoral training is to develop a normative models that can explain the representations we observe in animals, and investigate if these principles can improve sample and compute efficiency in deep reinforcement learning algorithms. In my interim research stint, I developed Vision-Language models to achieve zero-shot inference on out-of-distribution datasets. For my PhD, I developed biologically plausible spatial navigation reinforcement learning models to replicate one-shot learning behavior seen in animals. Prior, I worked with human EEG and macaque neural spike data to develop Brain-Computer Interfaces.

Education

Harvard University **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)
- Collaborators: Boaz Barak (Computer Science), Venkatesh Murthy (Experimental Neuroscience)

National University of Singapore (NUS) **January 2023**
- Ph.D. 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)
- Collaborators: Cheston Tan (Computer vision), Camilo Libedinsky (Psychology)

National Institute of Education, Nanyang Technological University (NTU) **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) **July 2017**
- B.Sc. with Honors (Distinction) Life Sciences (Biomedical Sciences)
- 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
Summer 2016	**Intern**, Institute for Infocomm Research, A*STAR
Summer 2015	**Intern**, Molecular and Cellular Biology, A*STAR
Summer 2013	**Intern**, Environmental Health Institute, National Environmental Agency (NEA)
Spring 2013	**Intern**, Ministry of Education, Singapore (MOE)

Awards

- Postdoctoral Fellowship in Computer Science 2023, Harvard University
- Annual Symposium Neuroscience Singapore 2022 – Best flash talk
- AI Singapore Summer school 2020 – Best Poster
- 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 (Top 10%)
- A*STAR Undergraduate Scholarship (AUS) 2013 for B.Sc.
- SINDA Excellence Awards (JC) 2013 – Top 10% Singapore Indian tertiary student

Selected Publications

- Blake Bordelon, M Ganesh Kumar, Cengiz Pehlevan. Dynamics of policy learning as learning an attractor manifold. ***In prep***.

- M Ganesh Kumar, Cengiz Pehlevan. Normative navigation agent for representation learning in the hippocampus. ***In prep.***

- Zijun Lim, M Ganesh Kumar, Cheston Tan. Multi-modal embodied agents learn Determiners and Prepositions concepts using synthetic environments. ***In prep.***

- Leon Guertler, M Ganesh Kumar, Cheston Tan. TellMe What You See: Using LLMs to Explain Neurons in Vision Models. ***In prep***.

- 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.

- 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]

- 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]

- M Ganesh Kumar, Cheston Tan, Camilo Libedinsky, Shih-Cheng Yen, Andrew Tan Yong-Yi (2023). One-shot learning of paired association navigation using biologically plausible schemas. ***Under review at Neural Networks.*** https://arxiv.org/abs/2106.03580 [GitHub]

- 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]

- 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

Invited talks

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, 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*.

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.

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.

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.

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.

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.

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.

Ad hoc Reviewer

Journals	IEEE Transactions on Cognitive and Developmental Systems
Conferences	Neural Information Processing Systems (NeurIPS), International Conference on Learning Representations (ICLR), International Conference on Machine Learning (ICML)

Programming

Python - Tensorflow, PyTorch, JAX, OpenCV; Matlab

Teaching

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

Mentoring

Aug 2023 – Aug 2024	Capstone student project, Singapore University of Technology and Design
Jul 2023 – Apr 2024	Leon Guertler, NTU Honors Project – ongoing
May 2023 – Apr 2024	Zijun Lin, NTU Honors Project – ongoing
Mar 2023 – Aug 2023	Haidi Azaman, NUS Honors Project – pursuing M.Comp. at NUS
Sep 2022 – Mar 2023	Clarence Sheng, A*STAR Internship – on exchange at University of Bristol
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, Education Tech
Feb 2011 – Present	Appointment: **Operations officer**, Rank: **Major**	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).
- **Motorcycle touring.** I love to ride, and occasionally tour parts of South East Asia.
- **Theatre productions.** I have produced, directed, and acted in student theatre productions.
- **Crossfit.** My wife convinced me that crossfit is fun.