**M Ganesh Kumar**

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Summary

I am interested in understanding how the brain learns abstract concepts to solve new problems quickly and implement these principles into algorithms to improve artificial systems. My postdoctoral training is to develop a framework that improves 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.

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Education

**Harvard University Present**

* Postdoctoral Fellow, Machine Learning Foundations, School of Engineering and Applied Sciences (SEAS)
* Advisors: [Demba Ba (Signal processing)](https://seas.harvard.edu/person/demba-ba), [Cengiz Pehlevan (Theoretical Neuroscience)](https://seas.harvard.edu/person/cengiz-pehlevan), [Lucas Janson (Statistics)](https://seas.harvard.edu/person/lucas-janson)
* Collaborators: [Boaz Barak (Computer Science)](https://seas.harvard.edu/person/boaz-barak), [Venkatesh Murthy (Experimental Neuroscience)](https://www.mcb.harvard.edu/directory/venkatesh-murthy/)

**National University of Singapore (NUS)**  **January 2023**

* Ph.D. Computational Neuroscience
* Doctoral thesis: Biologically plausible computations underlying one-shot learning of paired associations
* Advisors: [Andrew Tan](https://nus.edu.sg/lsi/principal-investigators-3/dr-andrew-tan-yong-yi/) (Physiolgy), [Shih-Cheng](https://cde.nus.edu.sg/idp/staff/yen-shih-cheng/) Yen (Engineering)
* Collaborators: [Cheston Tan (Computer vision)](https://www.a-star.edu.sg/cfar/about-cfar/our-team/dr-cheston-tan), [Camilo Libedinsky (Psychology)](http://www.libedinskylab.com/)
* Integrative Science and Engineering Programme (ISEP), NUS Graduate School (NGS)

**National Institute of Education,** **Nanyang Technological University (NTU) April 2021**

* Student 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)

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Research Experience

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| 2023 – Present | **Postdoctoral Fellow**, Machine Learning Foundation, 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) |

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Awards

* Postdoctoral Fellowship in Computer Science 2023, Harvard University
* Annual Symposium Neuroscience Singapore 2022 – Best flash talk
* [AI Singapore Summer school 2020 – Best Poster](https://aisummerschool2020.aisingapore.org/)
* [MIT’s Center for Brains, Minds, Machines 2019 – Fujitsu Laboratories Fellow](https://cbmm.mit.edu/summer-school/fellows)
* NUS Graduate School Scholarship (NGSS) 2018 for Ph.D.
* [NUSS Gold Medal for Outstanding Achievement 2017 (Best overall student in cohort for B.Sc.)](https://www.usp.nus.edu.sg/curriculum/awards-and-recognition/award-winners-of-class-2017/)
* 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

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Publications

* Zijun Lim, M Ganesh Kumar, Cheston Tan. Learning Determiners and Prepositions foundational word groups through deep reinforcement. ***In prep.***
* Leon Guertler, M Ganesh Kumar, Cheston Tan. TellMe What You See: Using LLMs to Explain Neurons in Vision Models. ***Under review***.
* Leon Guertler, M Ganesh Kumar, Cheston Tan. Adding 32 parameters to a LLM can improve fine-tuned classification performance by 1.5-6 percentage points. ***Under review***.
* Leon Guertler, M Ganesh Kumar, Cheston Tan. NoiseOut: Learning to gate improves robustness in deep neural networks. ***Under review***.
* Hui Min Tan, M Ganesh Kumar, Andrew Tan Yong-Yi, Shih-Cheng Yen. Spatial Representations “Right Here” and “Out There” in the Hippocampus. ***Under review***.
* M Ganesh Kumar, Cheston Tan, Camilo Libedinsky, Shih-Cheng Yen, Andrew Tan Yong-Yi. One-shot learning of paired association navigation using biologically plausible schemas. ***Under review.*** <https://arxiv.org/abs/2106.03580> [[GitHub](https://github.com/mgkumar138/schema4one)]
* M Ganesh Kumar, Shamini Ayyadhury, Elavazhagan Murugan (2023). Trends, Innovations and Challenges in employing Interdisciplinary Approaches to Biomedical sciences. Book Chapter, Springer. ***In press***.
* Zijun Lim\*, Haidi Azaman\*, M Ganesh Kumar, Cheston Tan (2023). Compositional learning of word groups through embodied reinforcement learning. ***arXiv preprint arXiv:2309.04504***. <https://arxiv.org/abs/2309.04504> [[GitHub](https://github.com/haidiazaman/RL-concept-learning-project)]
* 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](https://github.com/clarence-lee-sheng/DetermiNet)]
* 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)***. <https://doi.org/10.1093/cercor/bhab456> [[GitHub](https://github.com/mgkumar138/TDHL_6PA)]
* 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>

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Invited talks

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| 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 |

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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.

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Ad hoc Reviewer

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

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Programming

Python - Tensorflow, PyTorch, OpenCV; Git; Matlab

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Teaching

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| 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 |

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Mentoring

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| May 2023 – Aug 2023 | 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 |

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Besides research

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| May 2019 – Present | **Co-founder, Principal Consultant, ML Scientist** | [Nugen.ai](https://nugen.ai/) |
| Feb 2011 – Present | **Operations officer (S3),** Company Commander (OC) | Singapore Armed Forces |
| Aug 2014 – Present | **Advisory Panel**, President | NUS Tamil Language Society |
| Jan 2019 – Dec 2019 | Chairman | Tamil+AI 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.

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