Akshay Rangamani

Postdoctoral Associate, McGovern Institute for Brain Research, MIT

Personal Information

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Academic Positions

Massachusetts Institute of Technology **Feb 2020 - Present**
Postdoctoral Associate at the Center for Brains, Minds and Machines
Host: Prof. Tomaso A. Poggio

Research Interests

Theory of Deep Learning, Representation Learning, Associative Memories, Neural Assemblies, Assembly Calculus, Working Memory, Compressed Sensing and Sparse Signal Processing,

Education

Johns Hopkins University **Sept 2013 - Dec 2019**
Ph.D. Candidate in Electrical and Computer Engineering GPA: **3.95/4**
Advisor: Prof. Trac D. Tran
Thesis: *Loss Landscapes and Generalization in Neural Networks: Theory and Applications*
MSE in Electrical and Computer Engineering **May 2015**

Indian Institute of Technology Madras, Chennai **August 2009 - May 2013**
B.Tech in Electrical Engineering, Minor: Biomedical Engineering GPA: **9.19/10**
Thesis: *Low Cost Autofocus System for Optical Microscopes* guided by Dr. S. Mohanasankar

Talks and Invited Presentations

- *To Interpolate or Not to Interpolate?* August 2022
  Theory Day – Brains, Minds and Machines Summer School
- *Tutorials on Deep Learning and Signal Processing* August 2022
  Brains, Minds and Machines Summer School
- *Supervised Learning with Assemblies of Neurons* Nov 2021
  Neural Systems Analysis Lab, Johns Hopkins University
- *Loss Landscapes of Neural Networks and Generalization* Apr 2021
  Microsoft Applied Sciences, Redmond
- *Stability of Kernel Ridgeless Regression* Apr 2021
  TOPML Workshop 2021
- *Towards Understanding Neural Networks* May 2019
  Microsoft Research India, Bangalore
- *Sparse Coding and Autoencoders* June 2018
  ISIT 2018, Vail, CO, USA
- *A Greedy Pursuit Algorithm for Separating Signals from Nonlinear Compressive Observations* Apr 2018
  ICASSP 2018, Calgary, Canada
- *Learning Maliciousness in Cybersecurity Graphs* Dec 2016
  NeurIPS Workshop on Tensor Learning, Barcelona

Selected Publications and Preprints

- *Feature Learning in Deep Classifiers through Intermediate Neural Collapse*, **Rangamani, A.**, Lindegaard, M., Galanti, T., & Poggio, T. (2022) *in preparation*
- *Associative Memory Structure and Capacity in Assembly Calculus*, **Rangamani, A.**, Xie, Y., Li, Y., & Poggio, T. (2022) *in preparation*
- *Dynamics in Deep Classifiers trained with the Square Loss: normalization, low rank, neural collapse and generalization bounds*, Xu, M., **Rangamani, A.**, Liao, Q., Galanti, T., & Poggio, T., (2022) Submitted to RESEARCH
- *Neural Collapse in Deep Homogeneous Classifiers and The Role of Weight Decay.* **Rangamani, A.**, & Banburski-Fahey, A. (2022) IEEE ICASSP.
- *For Interpolating Kernel Machines, Minimizing the Norm of the ERM Solution Maximizes Stability*, **Rangamani, A.**, Rosasco, L., & Poggio, T., (2022) Submitted to Analysis and Applications
- *A Scale Invariant Flatness Measure for Deep Network Minima*, **Rangamani, A.**, Nguyen, N.H., Kumar, A., Phan, D., Chin, S.H. & Tran, T.D., (2021) IEEE ICASSP

- *Deep learning-based target tracking and classification for low quality videos using coded aperture cameras.*, Kwan, C., Chou, B., Yang, J., **Rangamani, A.**, Tran, T.D., Zhang, J., & Etienne-Cummings, R. (2019) Sensors
- *Sparse Coding and Autoencoders*, **Rangamani, A.**, Mukherjee, A., Basu, A., Arora, A., Ganapathi, T., Chin, S.H. & Tran, T.D., (2018) IEEE ISIT, *Oral Presentation*
- *A Greedy Pursuit Algorithm for Separating Signals from Nonlinear Compressive Observations*, Tran, D. **Rangamani, A.**, Chin, S.H., Tran, T.D., (2018) IEEE ICASSP *Oral Presentation*
- *Reconstruction-free deep convolutional neural networks for partially observed images*, Nair, A., Liu, L., **Rangamani, A.**, Chin, S.H., Bell, M.A.L., & Tran, T.D., (2018) IEEE GlobalSIP
- *Chief: a change pattern based interpretable failure analyzer.* Patel, D., Nguyen, L.M., **Rangamani, A.**, Shrivastava, S., & Kalagnanam, J. IEEE Big Data 2018
- *Predicting local field potentials with recurrent neural networks.* Kim, L., Harer, J., **Rangamani, A.**, Moran, J., Parks, P.D., Widge, A., Eskander, E., Dougherty, D. & Chin, S.P., IEEE EMBC 2016
- *Targeted Dot Product Representation for Friend Recommendation in Online Social Networks*, Dao, M.D., **Rangamani, A.**, Chin, S.H., Nguyen, N.P., & Tran, T.D., ASONAM 2015, IEEE/ACM, *Oral Presentation*

Selected Workshop Presentations

- *Feature Learning in Deep Classifiers through Intermediate Neural Collapse*, DEEPMATH 2022
- *Neural Collapse in Deep Homogeneous Classifiers with the Square Loss*, DEEPMATH 2021
- *For Interpolating Kernel Machines, Minimizing the Norm of the ERM Solution Optimizes Stability*, Theory of Overparameterized Machine Learning (TOPML) Workshop 2021
- *Supervised Learning with Brain Assemblies*, NeurIPS 2020 Beyond Backpropagation Workshop
- *A Scale Invariant Flatness for Deep Network Minima*, Berlin Mathematical School, Summer School on Mathematics of Deep Learning, 2019
- *A Scale Invariant Flatness for Deep Network Minima*, MIT Institute for Foundations of Data Science, Workshop on Non-convex Optimization and Deep Learning 2019
- *Sparse Coding and Autoencoders*, NeurIPS 2017 Workshop on Bridging Theory and Practice of Deep Learning
- *Landmark Detection and Tracking in Ultrasound using a CNN-RNN Framework*, NeurIPS 2016 Workshop on 3D Deep Learning
- *Learning Maliciousness in Cybersecurity Graphs*, NeurIPS 2016 Workshop on Tensor Learning
- *Modeling local field potentials with recurrent neural networks*, NeurIPS 2015 Workshop on Statistical Methods for Understanding Neural Systems
- *Learning Program Attributes in Control Flow Graphs*, Duke Workshop on Sensing and Analysis of High Dimensional Data, 2015

Scholastic Achievements

- Johns Hopkins University Payback Fellowship, 2013
- IIT Madras Governor's Prize for the student with all round proficiency in Curricular and Extracurricular activities, 2013
- DAAD-WISE fellowship, 2012 for an internship at the University of Luebeck, Germany
- Finalist at the TI India Analog Design Contest 2011, among the top 25 projects out of 300
- IIT Madras Merit Certificate for placing **89th** nationwide in IITJEE-2009
- Ranked **43rd** in India in the 2009 All India Engineering Entrance Examination

Skills

Python, PyTorch, Tensorflow, MATLAB, LaTeX

Teaching, Mentoring, and Service

Courses:

- Co-instructor, Statistical Learning Theory, Fall 2020 - 22 (MIT)
- Teaching Assistant, Brains, Minds, and Machines Summer Course 2022
  Conducted tutorials on Deep Learning Theory and Signal Processing. Mentored a student on a project linking Assembly Calculus and Associative Memories
- Teaching Assistant, Machine Learning, Spring 2017, 2019 (JHU)
- Teaching Assistant, Compressed Sensing and Sparse Recovery, Spring 2015, 2017 (JHU)
- Teaching Assistant, Networked Dynamical Systems, Fall 2016 (JHU)
- Teaching Assistant, Medical Imaging Systems, Fall 2014 (JHU)
- Teaching Assistant, Introduction to Electrical and Computer Engineering, Fall 2015-2018 (JHU)

Direct Mentorship:

- Marius Lindegaard, CBMM Research Assistant — Jun 2022 - Present
- Yi (Eva) Xie, MIT UROP Student — Jan 2022 - Present
- Anshula Gandhi, CBMM Research Assistant — Feb 2020 - Apr 2021

Reviewer for NeurIPS (Outstanding Reviewer Top 8% 2021), ICML, ICLR, IEEE Transactions on Circuits and Systems for Video Technology, IEEE Transactions on Image Processing, IEEE Transactions on Pattern Analysis and Machine Intelligence

Internships and Visits

IBM T.J. Watson Research Center, Yorktown Heights, NY **Feb - Aug 2018**

- Worked on Deep Learning techniques for Time Series Analysis, and contributed to an IBM framework for applying machine learning to data from manufacturing and other heavy industries

Uplevel Security, New York, NY **June - Aug 2016**

- Uplevel Security is building an cybersecurity incident response platform to help automate investigation of suspicious events.
- In the duration of my internship we developed a new ontology for Uplevels cybersecurity graph and implemented an ingestor pipeline to process artifacts
- We also implemented a version of RESCAL, an algorithm to learn embeddings for nodes in relational graphs, and adapted it to handle missing data and attributes.

Draper Laboratories, Cambridge, MA **June - Jul 2015**

- We performed scalable analysis of software programs to discover Common Vulnerabilities and Exposures by extracting a number of structural features from code, like Control Flow Graphs, Use-Def graphs, etc.
- We achieved good performance on the SATE-IV database of programs for testing CVEs

Past Research Projects

Low Cost Autofocus System for Optical Microscopes **August 2012 - June 2013**

Work with: Dr. S. Mohanasankar, IIT Madras & Dr. Niranjan Joshi, Healthcare Technology Innovation Centre (HTIC)

- Designed and machined mechanical components for controlling coarse and fine adjustments
- Implemented an autofocus algorithm in MATLAB to focus on slides placed on the stage

Artifact Removal from EEG by Adaptive Information Filtering **May - July 2012**

Work with: Dr. Ulrich Hofmann & Mehrnaz Hazrati, University of Luebeck

- Implemented an Adaptive Information Filter which uses Entropy as a cost function to remove ocular artifacts from EEG. Performance was found to be better than a Mean-Squared Error adaptive filter

Low Cost Pulse Oximeter that measures Respiratory Rate **Sept 2011 - Feb 2012**

Work with: Dr. Nitin Chandrachoodan, IIT Madras

- Designed and constructed a pulse oximeter to measure respiratory rate for non-invasive screening of pneumonia
- Implemented time and frequency domain algorithms to measure respiratory rate in MATLAB
- Designed and constructed an embedded system to implement the algorithms on a TMS320 DSP

Screening Tool for Anterior Visual Pathway Diseases **Sept 2010 - July 2011**

Work with: Dr. S. Mohanasankar, IIT Madras & Dr. Rashmin Gandhi, Sankara Nethralaya

- Designed, built and evaluated a test for screening optic nerve diseases based on red desaturation
- More sensitive than current diagnostic tests

Volunteer Positions

- Founding Vice-President of the Electrical and Computer Engineering Graduate Students Association, 2015-17
- President of the Indian Graduate Students Association at Johns Hopkins University, 2015
- Volunteer for the Association for India's Development, JHU Chapter 2014-15

References

- Tomaso A. Poggio, Professor, Brain and Cognitive Sciences, Massachusetts Institute of Technology
- Lorenzo Rosasco, Professor, DIBRIS, Universita' degli Studi di Genova
- Trac D. Tran, Professor, Electrical and Computer Engineering, Johns Hopkins University
- Sang (Peter) Chin, Research Professor, Computer Science, Boston University
- Nam H. Nguyen, Research Staff Member, IBM T.J. Watson Research Center
- Abhishek Kumar, Research Scientist, Google Brain