Chaitanya Kapoor

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(Nationality: Citizen of the United States of America)

Research Interests

My research interests lie at the intersection of Deep Learning and Neuroscience, aiming to understand and reverse engineer neural computation. I aim to develop computational models of cognitive neural circuits, with an overarching goal of designing efficient, biologically-constrained learning algorithms.

Education

University of California, San Diego **Sep. 2024 – Present**
Incoming PhD Student (Cognitive Science) *La Jolla, CA*

University of California, San Diego **Aug. 2024 – Present**
Post-Baccalaureate Student (NeuroML Group) *La Jolla, CA*
Advisor: Meenakshi Khosla

Massachusetts Institute of Technology **Jan. 2024 – July 2024**
Visiting Student (Senseable Intelligence Group) *Cambridge, MA*

Thesis: LUMIN: Light-sheet Microscopy Analysis Unified with Distributed and Domain-Randomized Generative Models

Advisor: Satrajit Ghosh

Birla Institute of Technology and Science, Pilani **Nov. 2020 – July 2024**
B.E. (Hons.) in Electrical and Electronics engineering *Pilani, India*

Honors & Awards

04/24 **NeuroMatch Academy**: Computational Neuroscience Summer School
02/24 **COSYNE 2024:** Undergraduate Travel Grant Award
04/23 **OxML 2023:** ML × Health Summer School, Oxford Mathematical Institute

Publications

Bridging Critical Gaps in Convergent Learning: How Representational Alignment Evolves Across Layers, Training, and Distribution Shifts
C. Kapoor, *S. Srivastava, M. Khosla*
(Under review) - **preprint**, **CCN Extended Abstract**

Multiplexed Expansion Revealing for Imaging Multiprotein Nanostructures in Healthy and Diseased Brain
J. Kang, M. Schroeder, Y. Lee, ***C. Kapoor****, E. Yu, T. B. Tarr, K. Titterton, M. Zeng, D. Park, E. Niederst, D. Wei, E. S. Boyden*
Nature Communications, 2024 - **paper**, **code**, **news story**

RnR-ExM: Robust Non-Rigid Registration Challenge for Expansion Microscopy Volumes
E. Besier, R. Zhang, Y. Bando, Y. Quéméner, ***C. Kapoor****, M. Alawi, M. Hoffman, A. Dalca, A. Casamitjana, I. Arganda-Carreras, E. S. Boyden, H. Pfister, D. Wei*
IEEE International Symposium on Biomedical Imaging (IEEE ISBI), 2023 - **code**, **website**

Attention-enabled Deep Neural Network for Enhancing UAV-Captured Pavement Imagery in Poor Visibility
C. Kapoor*, A. Warrier, M. Singh, P. Narang, H. Puppala, R. Srinivas, A. P. Singh*
IEEE Multimedia Information Processing and Retrieval (IEEE MIPR), 2023 - **paper**

Fast and Lightweight UAV-based Road Image Enhancement Under Multiple Low-Visibility Conditions
C. Kapoor*, A. Warrier, M. Singh, P. Narang, H. Puppala, R. Srinivas, A. P. Singh*
PerCom Workshops (PerSASN 2023) - **paper**

Dense Residual Networks for Gaze Mapping on Indian Roads
C. Kapoor, *K. Kumar, S. Vishnoi, S. Ramanathan*
preprint

Research Experience

NeuroML Lab **Aug. 2024 – Present**
Supervisor: Prof. Meenakshi Khosla *La Jolla, CA*

- Leading the development and design of new optimal transport-based representational similarity metrics allowing for matching and detection of single-neuron tuning outliers across biological and artificial neural networks.
- Led and discovered via a large-scale audit (CNNs, ViTs, LLMs) that orthogonal mappings align networks nearly as well as full linear transforms.
- Challenged prevailing assumptions by showing simple geometric invariances drive convergence, rapid cross-network alignment occurs far earlier than thought, and alignment robustness degrades proportionally with OOD shift—insights not reported in prior CCA/regression-based studies. This work is currently under review.

Talmo Lab **May 2023 – Aug. 2024**
Supervisor: Dr. Talmo Pereira *Salk Institute, La Jolla, CA*

- Worked on the development of methods for pose estimation and tracking to quantify animal behavior through robust tracking of anatomical landmarks in 3D.
- Designed algorithms utilizing projective geometry to create inputs for a CNN that leverages geometric reasoning.

Senseable Intelligence Group **Jan. 2024 – July 2024**
Supervisor: Prof. Satrajit Ghosh *Massachusetts Institute of Technology, MA*

- Developed a distributed framework for large-scale ($\approx$ 1TiB) image segmentation for light-sheet microscopy images.
- Designed a domain-randomized generative model, using spherical harmonics to synthesize cortical sections of *ex-vivo* human brains to enable zero-shot segmentation.
- Worked on designing few-shot, *spatially* guided semantic segmentation algorithms for MRI segmentation.
- Proposed the use of a topologically aware Graph Neural Network which is capable of encoding spatial and anatomical constraints.

Synthetic Neurobiology Group **Feb. 2022 – Jan. 2024**
Supervisors: Prof. Ed Boyden, Prof. Donglai Wei *Massachusetts Institute of Technology, MA*

- Worked on the development of a *generalist* 3D segmentation model for Expansion Microscopy (ExM) volumes for various animal species.
- Proposed a human-in-the-loop feedback learning mechanism, built on top of an existing deep learning framework, NucMM.
- Worked on developing a new joint-intensity and point-based, high throughput image registration algorithms having nanoscale precision ($\mathbf{10-40}$ nm) for Multiplexed Expansion Revealing **(multiExR)**. This work has been published at Nature Communications.

Invited Talks and Tutorials

02/24 **Automating behavior quantification using deep learning**, *COSYNE 2024*
06/23 **SIS Symposium, Harvard SEAS,** *Seeing Beyond the Camera*

Teaching Experience

Department of Mathematics, BITS Pilani **August 2023 – Dec. 2023**
Teaching Assistant *Pilani, India*

- **Undergraduate TA**: assisted with the course Combinatorial Mathematics (MATH F421)

Students Mentored

- **Pratham Yashwante**: Masters Student at UC San Diego
- **Chanyoung Park**: Undergraduate Student at UC San Diego

Technical Skills

Languages: Python, C, MATLAB, Unix Shell Scripting , LaTeX
Technologies/Frameworks: Keras, Tensorflow, Numpy, PyTorch, Git, OpenCV