## Foundation Models of Brain Computations During Cognitive Tasks


## PIs: SP Arun (CNS) & Sriram Ganapathy (EE)



**Abstract:** Understanding how neural populations represent sensory information and guide behavior is a central challenge in systems neuroscience. Recent advances in large-scale neural recordings from non-human primates, combined with progress in self-supervised and foundation models, create an unprecedented opportunity to learn general-purpose representations of brain activity. This project aims to develop foundation models for neural population activity using recordings from the visual and motor cortices of macaque monkeys performing visually guided tasks.

The project will leverage multi-electrode recordings from visual areas (e.g., V1/V4/IT) and motor-related regions (e.g., PFC/PMv) collected while animals perform visual discrimination, categorization, and visuo-motor decision-making tasks. The central hypothesis is that large, task-agnostic models trained across brain areas, tasks, and animals can discover latent neural representations that generalize across recording conditions and support multiple downstream analyses.

Methodologically, the project will develop scalable neural foundation models using self-supervised and weakly supervised objectives, such as masked neural prediction, contrastive learning across time and modalities, and alignment with task variables. Architectures may include transformer-based sequence models, graph neural networks, and hybrid state-space models adapted to neural data. The learned representations will be evaluated on their ability to (i) predict held-out neural activity, (ii) decode visual stimuli and motor outputs with minimal fine-tuning, and (iii) transfer across tasks, brain areas, and individuals.

Scientifically, this work will provide a unified modeling framework linking sensory and motor representations and offer insights into shared computational principles across cortical systems. More broadly, the project will contribute foundational tools for analyzing large-scale brain recordings, with implications for neuroscience, brain–machine interfaces, and biologically grounded artificial intelligence.


**Preferred background:**

Relevant project work on computer vision/speech models