Session B Abstracts

Joint Optimization of Data Sampling and Reconstruction for Dynamic MRI Data
Andy Dimnaku
Mentors: Shreyas Vasanawala, Cagan Alkan, and Mikhail Shapiro

Magnetic resonance imaging (MRI) is a powerful diagnostic imaging technique, however it is limited by the long acquisition times. To shorten the acquisition times, MRI data is undersampled by reducing the number of spatial frequency (k-space) measurements. This requires using advanced reconstruction techniques, such as deep neural networks, that produce high fidelity images without artifacts. However, the sampling patterns used for undersampling MRI data are typically chosen heuristically. Recently developed techniques proposed joint optimization of data sampling and reconstruction for static MRI acquisitions, taking into account only the spatial redundancies. In this proposal, we extend the joint data sampling and optimization framework to dynamic MR imaging where the data is acquired in k-t space that includes an additional temporal dimension. Our aim is to find sampling patterns that explore spatiotemporal redundancies across a wide range of acceleration factors. The proposed process involves representing the data sampling with a non-uniform FFT and then using an unrolled neural network consisting of spatial and temporal convolutions to reconstruct the final dynamic MR images. On a dataset consisting of 2D+time abdominal scans, our optimized sampling patterns show improved image quality compared to the traditionally used variable density sampling patterns. Our findings highlight the importance of joint learning of data sampling and reconstruction for dynamic MRI and provide insights about designing k-t sampling patterns.

VorGLEAM: Enabling Large-Scale RobustAccelerated MRI Reconstruction With Greedy Consistency Learning
Soham Dasgupta
Mentors: Shreyas Vasanawala and Elena Mantovan

Magnetic Resonance Imaging (MRI) \cite{carmo2023automated} is a vital tool in medical diagnostics, yet accelerated image reconstruction remains a challenge. Recent advances in deep learning \cite{DBLP:journals/corr/HammernikKKRSPK17} \cite{DBLP:journals/corr/SchlemperCHPR17} have shown promise in addressing this challenge, but there is a need for methods that are robust, efficient, and can generalize across various perturbations. In this work, we introduce VorGLEAM, a novel approach that synergistically combines the strengths of Vortex \cite{desai2022vortex} and GLEAM\cite{ozturkler2022gleam} methodologies for optimized MRI reconstructions. By leveraging the consistency training from Vortex and the greedy optimization of unrolled networks in GLEAM, VorGLEAM delivers reconstructions that surpass the performance of its parent models. Experimental results confirm the superiority of VorGLEAM in terms of key metrics such as SSIM, nRMSE, and PSNR. Furthermore, our approach demonstrates robustness against common MRI perturbations and offers a new paradigm in MRI image reconstruction that has the potential to advance clinical diagnostics.

Robust Accelerated MRI Reconstruction Methods for Complex Motion Types in Clinical Pediatric Imaging
Deepro Pasha
Mentors: Shreyas Vasanawala, Mikhail Shapiro, and Arjun Desai

Advances in deep-learning (DL)-based magnetic resonance image (MRI) reconstruction have substantially improved reconstruction quality and reduced inference times. However, these DL methods are sensitive to acquisition-related distribution shifts, such as patient motion. While newer DL reconstruction methods have been designed for robustness to these acquisition-related distribution shifts, these approaches have not generalized to complex distribution shifts, such as multi-dimensional patient motion. In this work, we generalize VORTEX, a semi-supervised consistency-based training strategy for MRI reconstruction models, to complex motion types, including rotation and 2D translation, which are typically observed among pediatric scans. We demonstrate that VORTEX reconstruction performance increases with this new training. We also show that VORTEX performs better than other baseline models that are also trained with 2D roto-translationally motion corrupted MRI scans.

Effectiveness of Reward Systems in Preventing Toxic Disinhibition
Julia Kim
Mentors: Dean Mobbs and Swati Pandita

Online disinhibition is a common phenomenon in internet spaces, characterized by less restraint in a person’s words and actions when they are online compared to in-person. Toxic disinhibition is a type of online disinhibition in which a person displays more harmful behavior towards others (i.e. making discriminatory comments, using rude language) when they are online. Social media is the birthplace of a lot of toxic disinhibition. Users are being exposed to increasingly more toxic disinhibition, which is correlated to becoming perpetrators themselves. This project aims to mitigate toxic disinhibition online by developing an “honoring” system that uses positive reinforcement within a chat room app. The system introduces “honors”, which are awarded by a user to another

user that they feel made a positive influence on the chat. As a user earns more honors, they increase their honor level and their ranking on a public leaderboard that orders all registered users. We also implement avatar border customization, where users unlock more customization options as their honor level increases. We expect that we see less signs of toxic disinhibition in the chats when the honoring system is implemented compared to without the system.

Understanding the Role of Microglia in Neurodegenerative Diseases
Sophia Wu
Mentors: Thomas Südhof, Viviana Gradinaru, and Connie Wong

Neurodegenerative diseases, characterized by protein aggregation and synaptic dysfunction, pose significant challenges to the global health sector. My study explores two interlinked facets of these disorders: protein aggregation and synaptic content. With recent studies highlighting microglia activation in neurodegenerative diseases, the first objective of my study is to investigate the potential impact of microglia removal on protein aggregation. Therefore, I eliminated microglia in culture to assess the histological and biochemical aggregation properties of proteins (Aβ, α-Synuclein, TMEM106B), which aggregate in neurodegenerative diseases. Our preliminary findings from these explorations suggest that removing microglial cells in primary culture does not significantly alter protein aggregates or protein expression. Beyond protein aggregation, synaptic alterations is another common feature in neurodegeneration. Therefore, we pioneer a new method for visualizing and tracking synapses in real-time by adding fluorescently labeled nanobodies to an ALFA tag inserted to the presynaptic marker Neurexin3β in primary culture. This novel technique offers valuable capabilities for studying synaptic dynamics in neurodegenerative diseases. Overall, our integrated approach seeks to unravel the intricate interplay among protein aggregation, microglial function, and synaptic activity, potentially revealing novel therapeutic avenues for these debilitating diseases.

The Role of Kinetochores in Mammalian Neural Development
Aditee Prabhutendolkar
Mentors: Thomas Schwarz and Guoli Zhao

The kinetochore is a protein complex found at the centromere of chromosomes. It plays an essential role in mitosis, but our lab is investigating the role of the kinetochore in a surprising post-mitotic setting. Specifically, we are focusing on the presence of kinetochores in the synapses and axons of mammalian nerve cells, implying that kinetochores play a key role in neural development.

Here we have engineered strains of mouse embryonic hippocampal nerve cells with certain kinetochore-encoding genes knocked out, and then fluorescently imaged their axonal growth cones. To quantify the change in dynamicity of the growth cones after gene knockout, we used image classification and machine learning techniques and found statistically significant results between the knockout and wildtype strains of nerve cells, indicating that kinetochores are essential to functional axon growth.

Exploring Human Magnetoreception: Examining How Magnetosensory Information Influences Behavior and Modulates Multisensory Integration
Maxwell Montemayor
Mentors: Shinsuke Shimojo and Lara Krisst

Magnetoreception is a sensory modality whose existence is well established in animals, but is not well researched in humans. Our research builds upon a 2019 study that found that some people exhibited a neural response to a magnetic field that mimics the earth’s, although participants did not consciously perceive it. To further probe the existence of this sense, we carried out a series of tests to see how magnetosensory information may influence behavior and how it is integrated with other sensory modalities. In experiment 1, participants chose which of 4 dixie cups contained a magnetized disk underneath. In experiment 2, participants chose which of 4 buttons had a powered electromagnet underneath. In a third EEG experiment, subjects were exposed to a magnetic field sweep moving left or right horizontally, then were asked to report the direction of the sweep, while EEG data were collected. In an additional set of studies which examined the cross modal integration of implicit and explicit information, participants reported the direction of perceived visual motion of dots moving on a screen, while concurrently being exposed to a directional but implicit audio cues. We aimed to measure how implicit auditory, visual, and magnetosensory information integrate.

Integration of Human Stem-Derived Retinal Ganglion Cells Into Zebrafish
Simon Hu
Mentors: Jeff Mumm, Anneliese Ceisel, Gianna Graziano, and David Prober

Retinal ganglion cells (RGCs) are neurons that bridge the retinal input to the processing neurons in the central nervous system. The loss and/or faultiness of these cells characterize progressive blinding diseases like glaucoma, the leading cause of blindness worldwide. Cell replacement therapies may be the key to curing these diseases. However, the feasibility of incorporating human stem cell-derived RGCs as a therapeutic approach has yet to be

deeply explored. Since zebrafish have naturally regenerative properties, we used zebrafish as a model organism to study the potential of human RGC (hRGC) regeneration. In this study, we injected hRGCs transgenically labeled with a red fluorescent protein into zebrafish and visualized the presence of such cells using confocal imaging. Zebrafish were injected at various time points in development to determine which stage best promotes hRGC survival, integration, and function. By using transgenic zebrafish lines expressing bacterial nitroreductase (NTR) in RGCs, we also selectively ablated zebrafish RGCs by adding the prodrug prodrug Metronidazole (Mtz), which is converted into a cytotoxin in the presence of NTR. These assays provide insight as to how injections act in an environment similar to that of a neurodegenerative disorder.