Online Proceedings

POSTER SESSION 2

MGH 241, Easel 126

1:00 PM to 2:30 PM

Deep Learning-Based Image Analysis to Extract Brain Region Features

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Mentor: Elizabeth Nance, Chemical Engineering
Mentor: Sarah Stansfield, Anthropology, Epidemiology
Mentor: Mike McKenna, Chemical Engineering

Computer vision models are used to help analyze biomedical images for diagnosis and treatment through looking for differences between images by a comparison to a template image. For instance, optical coherence tomography (OCT) is used to diagnose and treat retinal issues. When looking at the brain, injury, cellular uptake and characteristic features vary across regions, therefore images are often segmented into established brain regions to determine how the brain is impacted in a particular study. Current models fail to work in segmenting brain regions because each brain has variation in local microstructure, making it difficult to compare one brain to another. Furthermore, when brains are sliced, the exact location within the brain can be difficult to pinpoint, particularly in regard to depth, because the regions vary slice to slice. Therefore, my research addresses the increasing need for a method of analysis to align and compare images from brain regions across slices from a single brain, and from brain to brain. Using scikit-image analysis tools, I extracted information from cell images and videos of nanoparticles obtained in brain slices and determined trends within various regions. My program extracted cell density, shape, and death, then analyzed the uptake of nanoparticles to determine where a small segment of an image is most likely located within the brain. Iterating over the entire image generated a rough map of the regions within the brain which is refined using mapping descriptions detailed in literature. This research resulted in a systematic program that uses image analysis tools to extract features of defined brain regions. This program allows for quick, accurate and consistent analysis of regional differences of cellular features, nanoparticle distribution, toxicity, and other important measures.

POSTER SESSION 2

MGH 241, Easel 124

1:00 PM to 2:30 PM

Characterizing Microstructural Changes in Perineuronal Nets in the Presence of Neuroinflammation and Oxidative Stress

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Mentor: Elizabeth Nance, Chemical Engineering
Mentor: Mike McKenna, Chemical Engineering
Mentor: Chad Curtis

As the global burden of neurological diseases continues to grow each year, there exists a need for drug delivery vehicles that can overcome barriers specific to the brain. The heterogeneous brain extracellular matrix (ECM) is an understudied barrier to effective therapeutic delivery, particularly in the presence of disease states. We utilize a novel multiple particle tracking (MPT) approach to characterize microstructural changes in perineuronal nets (PNNs), a key structural mediator of plasticity, in the developing brain. Our overarching goal is to develop a combined approach of MPT, statistical analysis using Python-based software packages, immunohistochemistry (IHC), and mRNA expression profiles to monitor changes in PNN structure and function through development and in the presence of neuroinflammation and oxidative stress processes. For this, we cultured 300 μm-thick organotypic whole hemisphere (OWH) brain slices prepared from postnatal day 35 (P35) rats. We treated slices with 100 ng/mL lipopolysaccharide (LPS, induced-inflammation model) or 100mM glutamate (MSG, induced-excitotoxicity model) for 3 h, removed the toxin and fixed slices at 1 h, 6 h, and 24 h after toxin removal. Fixed slices were stained using Wisteria floribunda agglutinin (WFA) and PNN counts were quantified using the ImageJ software package. In LPS and MSG-treated slices, 100-nm particles were added to live slices stained with WFA and MPT was performed in WFA+ regions, followed by statistical analysis of individual nanoparticle trajectories. From the IHC imaging and PNN count quantification, we observed differences in the number and morphology of PNNs present in the MSG and LPS models when compared to healthy controls. Characterizing structural changes in PNNs in living tissue furthers our understanding of the impact of neuroinflammation and oxidative stress on neuronal

plasticity, and the subsequent impact on progression of neuropsychiatric diseases.

POSTER SESSION 3

MGH 241, Easel 138

2:30 PM to 4:00 PM

Engineering Iron-oxide Nanoparticle-Based T1 Contrast Agent for Magnetic Resonance Imaging

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Mentor: Mike Jeon, Materials Science and Engineering

Magnetic Resonance Imaging (MRI) is an invaluable imagining modality that allows physicians to quickly analyze the anatomical and physiological processes of the body. To improve contrast efficiency, MRI contrast agents are frequently administered to patients. However, the most commonly used T1 contrast agent – gadolinium-based contrast agent (GBCA) – has been associated with many adverse health effects, such as reduced white blood cell count, increased serum levels of inflammatory cytokines, and vacuolar degeneration. As such, there is an urgent need to design a T1 contrast agent that has a short half-life and that does not produce toxic endpoints in patients. To address this need, the present study developed an iron-oxide nanoparticle (IONP)-based T1 contrast agent by synthesizing 4 nm oleic acid-coated IONP and reacting them with phosphine oxide-PEG. Next, this study characterized the biological and the magnetic properties of the generated IONP system in vitro in order to determine its suitability as a T1 contrast agent. Finally, this study also analyzed the synthesized contrast agent's use in other biomedical applications, specifically targeted drug delivery. Previous research has shown that cells can undergo ferroptosis – a regulated form of cell death – upon loss of activity of the lipid repair enzyme glutathione peroxidase 4 (GPX4). As such, a silencing RNA (siRNA) that can mark GPX4 mRNA for degradation was conjugated to these IONPs in order to downregulate GPX4 expression in mesenchymal stem cell – a type of stem cell that are particularly involved in cancer progression and that are especially resistant to radiotherapy – and sensitize them to radiotherapy. Ultimately, the findings of this study not only offer a safer alternative to GBCAs but also provide a foundation for a versatile, tunable IONP system that can be used in a variety of biomedical settings.