Individual Capstone Assessment

For my capstone project, I will be applying data analysis and machine learning to conduct research in FC fingerprinting under the guidance of Professor Gowtham Atluri. More specifically, I will be applying Graph Neural Networks (GNN) to the task of identifying subjects based on their functional connectome (FC). The FC is a description of subject brain connectivity, and it is equivalent to the correlation matrix of brain node activity obtained through fMRI scans. I will be utilizing several areas of my academic experience, including linear algebra, algorithms, data analysis, and machine learning. While it builds upon my coursework, it will challenge me to use my knowledge in new ways to expand my experience and understanding of these subjects. This research project will both demonstrate and further develop the skills I have learned while enrolled in the Computer Science program.

The core foundation for my understanding and application of this topic is linear algebra, which I learned through the course Linear Algebra (MATH 2076). This is vital to conducting the research for this project, as nearly every step of the data pipelines I build will involve operations on data represented through matrices and vectors. Building on this, Intelligent Data Analysis (CS 5132), in which I am currently enrolled, is where I am learning much of the methodology for analyzing datasets like the fMRI data in this research. I have already used concepts I have or will learn in this course, such as principal component analysis and clustering, in to understand an essential FC fingerprinting paper. This knowledge is much more targeted to the research I will be involved in. Finally, I hope to involve deep learning approaches to FC fingerprinting for this research, and Machine Learning (CS 5137) provides another basis for this. This class covers the foundational machine learning concepts and algorithms. Finally, I plan on taking a deep learning course next semester, but I will be working with the GNN models well before then.

My co-op experiences provide a different, yet still impactful, role in my preparedness for this project. My first two co-op experiences were in web app development at two different companies, Siemens PLM and Edaptive Computing Inc. While these first two co-ops were in a practically unrelated field of computer science, I gained useful experience in time management and digital communication. At Siemens I worked with a team based in Italy, so I communicated primarily through instant messaging and video calls. The coronavirus pandemic was in full swing while I worked at ECI, so the entirety of my communication was digital. This experience in communicating technical ideas through messaging and video calls gives me a basis for remotely communicating with Professor Gowtham about the research when we do not meet in person. My most recent co-op at Refract Labs is closer in subject to the research. At Refract, I worked on training machine learning models for sentiment analysis, which involved some research into the workings of models for natural language processing such as BERT. This provides some cursory foundation for understanding models that are applicable to the problem of FC fingerprinting.

I am motivated to carry out this project for several reasons. First, I am excited to use the education from my classes in linear algebra, data analysis, and machine learning to solve an involved problem. Investigating the issues in deep learning for FC fingerprinting will challenge me and provide an opportunity to hone my analytical skills. Second, I will be making a contribution to brain connectivity research. Understanding brain connectivity has very promising uses in precision psychiatry, in which

diagnoses and treatments are applied to more specific sub-groups of patients, thereby increasing their accuracy and effectiveness. Finally, I am excited to do research for the first time, and through this research gain skills that will enable me to both conduct and analyze research in the future.

My first step in researching the issues in FC fingerprinting is to fundamentally understand the topic under the direction of Professor Atluri. I am starting by reading relevant papers on the topic that he is providing. Following this, I will focus on a specific problem that I will address through my research. I will then conduct the research to address the problem, and then take the final step of writing the paper. This project has a specific ending point, when the paper is finished. My expected results are to have provided some additional insight into the issues in identifying functional connectivity among subjects. I look forward to the work ahead of me.