Statement of Purpose

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Ph.D. Application for Northeastern University

During the summer of 2019, as an Admissions intern at St. Lawrence University, I was tasked with manually (and rather monotonously) collecting data from a customer report management system and exporting it to Excel. This experience inspired me to pursue more efficient solutions to this problem. Hence, for my second introductory computer science course, I decided to work on a program to automate summarizing Admissions email data. The following summer, I was awarded a research fellowship to develop a data visualization web application for Admissions, expanding on my previous class project. While this was a fulfilling experience, I became motivated to more deeply explore the role of systemizing processes and how computing could work as a tool to approach problem-solving. This, alongside my background and interest in mathematics, fuels my aspirations to complete a doctoral degree in computer science at Northeastern University. I hope to research open questions in mathematics of computational interest, and the theoretical bases fundamental to the field. Ultimately, I aim to pursue an academic career after completing a Ph.D.

My research interests lie in the intersection of computer science and math, namely in expanding answers to questions in optimization problems in graph theory, algorithms, and complexity. For this reason, I am captivated by the opportunity to work with the Algorithms and Theory group at Northeastern. The current faculty research in optimization theory aligns with my curiosity in exploring the abstract models and algebraic methods used in algorithm design. I am also fascinated by questions in epistemology and believe that academia is crucial to how we acquire and consume knowledge as a society. This inspires me to promote conversations of representation, accessibility, and pedagogy while in academia.

My undergraduate coursework reflects this interest, with a range in mathematics and computer science electives such as Graph Theory, Programming Languages, Complex Analysis, and Ring Theory. To better prepare myself for graduate school, I have taken the initiative to complete independent studies for courses not offered in a given class cycle. In particular, I took Linear Algebra, Algorithm Analysis, Software Engineering, Artificial Intelligence, and Topology as independent studies to expand my arsenal of mathematical knowledge. This has allowed me to explore the material with more rigor and creativity, furthering my interest in exploring research projects such as the ones I pursued in my undergraduate degree. For Linear Algebra, I developed a program to display a 3-dimensional cube that can be rotated around various axes and translated across the 2-dimensional screen. I am currently completing an independent study in Artificial Intelligence, where I am combining the concepts I learned in this class with a Game Development course. After examining possible approaches to control enemy behavior, like Monte Carlo simulations, I decided to implement an environment to utilize reinforcement machine learning to train the enemy agents in a video game. Beyond independent work, I also enjoy collaborating with other students on research projects. In Graph Theory, I was part of a group that analyzed bipartite graphs and tournaments for character matchups in a video game. We created metrics to define what constitutes positive and negative matchups and compared our results to online rankings. Our professor encouraged us to present our project at the Hudson River Undergraduate Math Conference, but we could not attend due to COVID-19. My academic background demonstrates my interest in pursuing intellectually stimulating and academically rigorous environments, which I believe will help me successfully complete a Ph.D.

This year, I am engaging with graduate-level material in two honors theses, one for each of my majors. For mathematics, I am researching the relationships between planar graph representations of mathematical knots and their seemingly unrelated invariants. This semester, I am developing a literature review to identify

open questions that arise from previously explored connections in knot theory. For example, I am currently reading about possible generalizations to calculate the determinant of a link via the spanning trees of a planar graph for families of non-alternating knots. This problem is relevant to knot theory as it relates invariants such as p-colorability and knot polynomials with a graph data structure for that link projection. Next semester, I will also be completing an honors project in cybersecurity, where I intend to study the practical implementation of security systems and the underlying mathematical structures behind cryptography.

Aside from working in Admissions, I have had the privilege of being a mentor for the Peterson Quantitative Resource Center. My role spans helping tutor classes like Calculus, Introduction to Computer Science, Data Structures, and other quantitative courses. During tutoring sessions, I facilitate discussions about the motivation and abstract models behind a concept. I also help students through their code debugging process by simplifying problems and running through algorithms on a whiteboard. I also prepared a LaTeXworkshop and two mathematics refresher sessions. These experiences have helped me learn to effectively communicate mathematical concepts to students both inside and outside my field. In addition, I was recruited to work as a peer tutor, where I tutor a group of students in data structures and object-oriented programming. In this role, I design personalized sessions where I help my mentees better internalize the concepts they learn in class. I deeply value my mentoring experience, which influences my desire to pursue an academic career that includes teaching.

Collectively, my undergraduate experiences have allowed me to learn about the process of designing and conducting research projects. I have practiced identifying relevant problems (e.g., automating Admissions analyses, and formalizing connections between knot invariants), developing key insights to solve these problems through coursework, and prototyping solutions during summer fellowships, independent studies, and honors projects. While I have enjoyed projects that produce software deliverables, these experiences have driven my interest in researching abstract mathematical models and their relation to computing. I believe these experiences have helped prepare me for the rigorous academic challenges at Northeastern. Therefore, I am excited for the opportunity to build toward my career in research and academia through a graduate degree.