Statement of Purpose

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I am applying to the Master's program in Operations Research at MIT to translate my mathematical foundation, particularly in combinatorics, to abilities that can address real-world problems. My primary interests lie in combinatorial and network optimization, where the interplay between theory and application is most apparent to me, and I envision myself contributing to fields like transportation systems and resource allocation in the industry.

As a mathematics-computer science major at UC San Diego, I placed most of my attention to mathematics in my undergraduate studies, primarily through honors and graduate-level coursework. While I appreciate the beauty of pure mathematics, I wasn't satisfied pursuing abstract results for its own sake. I instead looked for a field in mathematics with a closer connection to the real world and turned to graph theory, the study of relationships that can model a wide range of practical problems effectively.

During my sophomore year, I began my research journey by directly reading under Professor Jacques Verstraete, exploring the vast literature on extremal graph theory. Through the readings, I was exposed to a variety of powerful techniques for tackling extremal graph problems, from probabilistic methods to algebraic constructions, which laid the groundwork for my honors thesis centered on the Double Turán problem. The problem asks for the maximum possible number of edges across n subgraphs of a complete graph K_n such that no pairwise intersection of these subgraphs contains a specified forbidden structure. After dedicating my summer to studying the case where the forbidden graph is non-bipartite, I established a tight upper bound on the number of edges under the stricter condition that each subgraph is induced. Specifically, I showed that the extremal condition is uniquely achieved when all subgraphs are extremal graphs for the forbidden graph, by recursively expanding the intersection of all subgraphs. This case serves as a stepping stone for the project, and I am currently working on the general case.

As I progressed in my research, I also developed an interest in the computational aspects of combinatorial problems. I had the opportunity to learn about computational complexity theory directly from Professor Russell Impagliazzo, studying Arora and Barak's text, Computational Complexity: A Modern Approach [1]. With this foundation, I then joined Professor Impagliazzo's research group, studying Multicalibration to mitigate unintended biases to certain subpopulations in learning models from the perspective of complexity theory. We are trying to connect notions in smooth boosting to multicalibration. By modeling the fairness of algorithms with random-like structures yielded by Szemeredi's Regularity Lemma, this research brought the application of extremal combinatorics and complexity theory to a new level and further strengthened my commitment to utilize my mathematical foundation to solve practical problems.

MIT Operations Research program's rigorous theoretical training and emphasis on practical, interdisciplinary applications perfectly aligns with my goal. I aim to contribute to fields where combinatorial tools are applied extensively, and taking courses like Combinatorial Optimization (18.433), Network Optimization (15.082J), Logistics Systems (15.770J), along with the extensive operations management courses would provide with the necessary background of combinatorial applications to real-world problems.

I am most drawn to the opportunities to conduct independent research with MIT's faulty members, particularly in network optimization. This field aligns best with my combinatorics background and offers versatile applications. I am especially keen to work with Professor James Orlin. He is the leading expert in network and combinatorial optimization, and I believe his guidance would be invaluable for me to convert my mathematical foundation into applicable skills. One research topic I am eager to explore is the optimization of medical evacuation (MEDEVAC) helicopter routing. This topic is crucially important on its own right, but I am particularly invested in it due to the increasing geopolitical tension surrounding my home country, Taiwan. More specifically, I am curious about how the routing of MEDEVAC helicopters can be optimized in extreme situations where the helicopters are in high demand and potentially face contested airspace, such as a military conflict. I believe this issue can be modeled as a network optimization problem and effectively analyzed. Furthermore, I would also like to seek advice from Professor Alexandre Jacquillat. His research on vertiport planning for urban aerial mobility [2] is highly relevant to optimizing MEDEVAC helicopter routing in urban environments during a conflict, and his expertise could provide crucial insights on how to adapt his methodologies to optimize MEDEVAC helicopter routing.

I have only begun to scratch the surface of operations research, and there are still a lot of topics to explore. I am excited about the prospect of joining MIT's Master's in Operations Research program to expose me to a broader range of topics in operations research through rigorous coursework and extensive research opportunities. With the mathematical foundation I built during my undergraduate studies, I am confident in my ability to excel in the program and evolve into a capable problem-solver. I look forward to contributing to the vibrant academic community at MIT and bridging the worlds of mathematics and real-world problems.

References

[1] Sanjeev Arora and Boaz Barak. *Computational complexity: a modern approach*. Cambridge University Press, 2009.

[2] Wang Kai, Alexandre Jacquillat, and Vikrant Vaze. Vertiport planning for urban aerial mobility: An adaptive discretization approach. *Manufacturing & Service Operations Management*, 24(6):3215–3235, November 2022.