

Personal, Background, and Future Goals Statement: **Kavin M. Govindarajan**

For many, patience is a virtue; however, in my life, there have been many personal and professional instances where *impatience* has been a virtue. In particular, my impatience has driven me to **proactively seek out and explore opportunities** that will expand my understanding of the physical world, even when they were not directly made accessible to me at the time. For instance, as a high school student, I enrolled in higher-level math courses at North Carolina State University (NCSU). This enabled me to better understand the mathematics that governed the physics I was learning in my courses in high school.

Just as my past experiences have been guided by a proactive desire to expand my understanding of the physical world, my personal goals for the future, both as a researcher and a member of my community, will be guided by the same principles. In this personal statement, I will elaborate on some of my most formative experiences to date and explain how those will shape my future as a researcher and scholar.

Competitive Robotics While I learned physics and mathematics in my coursework, I **sought out more opportunities to expand my knowledge** by joining a robotics team. This team is where I first found my passion for **controls and optimization**. The competitive nature of high school robotics required me to work with my team to develop creative solutions under the constraints of both the competition's rules and the capabilities of our team. To be successful, we identified a metric of "cycle times" to optimize. This metric represents the amount of time it takes for the robot to pick up an object, travel to a desired location, and score the object for points. By minimizing the time it takes for the robot to accomplish those tasks, we were able to maximize the scoring output of the robot in a match. As a member of the controls team, I further identified that we could minimize cycle times by minimizing the necessary inputs from the drivers, reducing decision-making time, and increasing response times. Implementing autonomous control onboard the robot enabled us to successfully accomplish those goals and optimize our cycle times. Overall, it was through this experience that I learned to **identify problems and derive optimal solutions** to those problems.

To solve these problems and deliver a successful product, I learned skills such as hardware design, sensor integration, and implementing control algorithms in software. However, in addition to the technical skills, I learned some valuable soft skills. At one of our competitions, our robot had been damaged in a match and we had to diagnose and repair the issue in the 15 minutes before the next match. As captain of our team, I had to identify the right personnel for the task and coordinate their efforts under the stressful environment while also maintaining team morale. We were able to successfully repair the robot and compete, and instances like these served as valuable experiences and learning opportunities in **leadership, teamwork, and communication**.

Academic Experience Following high school, I was offered the Park scholarship at NCSU; a full-ride merit-based scholarship awarded in recognition of my scholarship, leadership, service, and character. Accepting the scholarship, I sought to expand my knowledge by pursuing my interest in airplanes and rockets and enrolling in the aerospace engineering program. To further supplement my knowledge, I also enrolled in the applied mathematics program. In both programs, I have **proactively sought out opportunities to expand my knowledge** by enrolling in graduate-level courses such as multivariable controls (typically offered to 2nd year graduate students in the math department) as a junior. Enrolling in controls courses in both the mathematics and engineering departments enabled me to learn from both contexts, allowing me to solve controls problems with different approaches and mindsets. In sum, I will finish my undergraduate career this year having been able to vastly expand my knowledge in optimization and controls through undergraduate and graduate courses in both mathematics and engineering. Overall, from my academic career, I've been able to strengthen my **mathematical background, particularly in controls and optimization**.

Research Experience Perhaps the defining experience of my undergraduate career has been my experience in Dr. Vermillion's Control and Optimization for Renewables and Energy Efficiency (CORE) Lab. As a high school student, I **proactively sought out the opportunity to expand my knowledge** by reaching out

to Dr. Vermillion with the goal of gaining experience in a research lab. As a high schooler among graduate students, I was exposed to concepts such as model predictive control and dynamic programming, which most high school and even undergraduate students would not learn. Further, participating in lab meetings, I learned how to present scientific information from the graduate students.

In my time in the lab, I have contributed to research on energy-aware robotics and cyber-physical systems for persistent ocean monitoring. In particular, I have worked with solar-powered autonomous surface vessels (ASVs) to supplement existing persistent observation infrastructure in ocean environments. In my role, I have developed persistent path and velocity planning algorithms for the vehicle. As a result, I have published and presented two first-authored papers at the American Controls Conference. As part of my ongoing work, I am applying the knowledge I learned in my coursework to set up and solve optimal control problems, with the goal of maximizing the information an ASV can gain for the energy it expends. I aim to publish my ongoing work in another conference paper and a journal paper before I finish my undergraduate career. Overall, my work on this project has enabled me to gain **valuable research experience and publications**.

To design these control algorithms, I have had to work with oceanographers who provide me with knowledge from their discipline. This interdisciplinary knowledge has enabled us to more effectively develop controllers to solve the research problems of interest. I've also learned how **interdisciplinary thinking** and incorporating concepts from other fields can help solve problems in innovative ways.

DARPA Manta Ray During the third year of my undergraduate career, I had the unique opportunity of working on the DARPA Manta Ray project. I contributed to the development and field testing of an underwater energy-harvesting kite. This was my first experience having to deliver a product under customer constraints, which was a significant change from my research where I derived and defined my own constraints. Further, this project was my first large-scale software project, which enabled me to expand on my skill set.

In addition to my technical contributions and lessons from this project, I learned about effective technical communication. Having to communicate with a large team of contributors, I quickly learned the value of conveying information in a concise manner. I also had the opportunity to challenge my time management skills, balancing a full-time course schedule while conducting field testing for the project on the other side of the country. While challenging, I was able to experience a full engineering cycle of design, development, and testing in a new context, providing valuable lessons. Overall, this project served as valuable experience working on a large team, improving my **teamwork and effective communication skills**.

Liquid Rocketry Lab Outside of my professional and academic career, I spend my time contributing to Liquid Rocketry Lab (LRL). LRL is a student-run organization at NCSU with the goal of being the first student organization to launch a liquid bi-propellant rocket to the Karman line. In this organization, I have contributed to the mathematical modeling of the rocket, applying the skills I learned in my academic courses. Further, I have been involved with the design and development of the control system and its hardware for the rocket. Here, I have gained hands-on skills in design and manufacturing, as we work to build and test our vehicle. In developing a control system for the rocket under physical and financial constraints, I have been able to grow my skills in **controls and optimization**.

In addition to my technical role, I also serve as the chief financial officer for this organization. In this role, I am responsible for raising the funds necessary to accomplish our goals. In this leadership role, I have had to once again manage a team of people towards a common goal. Fundraising for our team can be quite difficult, which requires creative problem-solving. I worked to introduce a "consulting" program on our team, where our members provide their engineering expertise to research labs to help raise money for our team. Overall, I've been able to expand upon my **leadership, teamwork, and communication skills**.

Intellectual Merit As I move into my graduate career, I seek to study persistent optimal control of a fleet of renewably powered vehicles (as outlined in my research statement). My prior research experience and

coursework in controls and optimization provide the necessary foundation for this work. However, to aid in developing solutions, I will need to incorporate knowledge from other fields. As such, I will proactively seek out and enroll in courses such as environmental modeling (generally offered in the earth sciences department). The knowledge from such a course, even if it is not engineering related, will enable me to develop the statistical models for my optimal control formulation.

Further, to successfully conduct experimental testing and apply my proposed research into real-world missions, I will need to collaborate with members from industry. My leadership and teamwork skills, which I gained from my aforementioned experiences, will enable me to identify relevant stakeholders, manage their expectations, and deliver a successful product. This will both serve to validate my work and also advance the renewably powered robotics field.

Broader Impacts

Community Impact Throughout my time as a high school student and as an undergraduate student, a large portion of my time has been dedicated to the InspireNC non-profit organization. InspireNC is a non-profit started by me and my peers in high school with the goal of reducing barriers to entry and improving access to STEM education in my area. I recognized a need for this program when many of my peers in school expressed their interest in STEM programs such as robotics; however, they were unable to participate due to economic and social barriers present in their lives. In the time since the nonprofit was established, we have grown to impact nearly 1,000 students in our area.

Throughout my undergraduate career, I have served the community by mentoring students involved in the programs. I have had the opportunity to share the skills I learned in my academic and research experiences to teach younger students. I also worked to establish the only marine robotics team open to middle and high school students in our area. Through these efforts, I have grown my leadership and teaching skills while deriving satisfaction from the knowledge that I have inspired and enabled other students to pursue their interests. The passion I have for community service and outreach, coupled with the great satisfaction it provides me, is something I desire to expand upon as I move into my graduate education.

Research Impact Through my research, I aim to expand the utility of renewably powered robotic systems in all aspects of life. Combining my innate desire for efficiency and optimization with my passion for robotics, this research area is particularly exciting. As renewable technology improves, so will the demand for renewably powered systems, and I aim to satisfy and expand this demand by developing and optimizing the performance of renewably powered robotic systems.

Future Goals In pursuing further graduate education, I seek to leverage my comprehensive foundation. My goal: propel the field of renewably powered robotics. The NSF GRFP offers the platform to realize this ambition, enabling me to pursue a doctorate focused on robotics, controls, and optimization. As renewable technology improves and as the scope for robotics grows, my doctorate education and research experience will enable me to be best prepared to continue to identify problems and derive optimal solutions for them. I hope to apply my skills to set up my own research lab at an university, where I aim to build my own team of researchers to tackle interesting problems in the field of robotics. I aim to leverage my connections that I will form conducting research, collaborating with peers, and presenting work at conferences to establish my research lab. Working with researchers from other disciplines, I seek to find applications for renewably powered robotics in a wide variety of domains, whether it be marine, agriculture, or space.

In addition to my career aspirations, I am determined to dismantle barriers to STEM education and continue to inspire the next generation of students to pursue their interests. I aim to do this by expanding InspireNC through existing partnerships with organization such as Lenovo and new partnerships with other STEM-oriented organizations. I seek to introduce more high schoolers to marine robotics by establishing teams at local high schools. Through those teams, as a mentor, I will also be able to share my research and encourage students to explore the field of renewably powered robotics as well.