Dakota Bryan – Statement of Purpose

Motivation & Professional Experience:
I aspire to pursue a PhD at the University of Colorado Boulder with a focus in programming languages and verification or theoretical computer science. Through classes and projects involving discrete mathematics and proofs, I have developed a passion for using mathematical logic to formulate, prove, and solve computational problems. The concepts I love often require a variety of frameworks to solve or even understand. Beyond theory, my previous research in programming languages has shown me the power of using theoretical underpinnings in software systems to tackle applied problems. More generally, I strive to learn new concepts, toil for results, and experience the moments when it all comes together. A PhD in computer science will allow me to immerse myself in these moments for the rest of my career, while utilizing my passion for research in contributions to intricate problems.

My current role as a software engineer for IBM has strengthened my skills in many areas that complement my academic interests. In this job, I lead the development of a new web-based access management application, improving my ability to understand complex requirements, gather necessary information, and implement solutions. Although this role excites me, my undergraduate research experiences have motivated me to pursue a career where I can devote more time proposing new problems and creating novel solutions, piquing my love for knowledge.

Research Experience – Sudoku Graph Theory:
Throughout my undergraduate education, I excelled in computer science and mathematics courses (4.0 in CS and 3.98 in Math), gaining experience crafting and solving complex problems through large projects. One such project that solidified my interest in academics and research was a paper and web application exploring the graph representation of the sudoku puzzle. While many reports and images demonstrate the sudoku graph, the application I created is the first to allow users to solve a sudoku as a graph, with a side-by-side comparison to the grid. It features animated graph layout changes, visualizations of backtracking coloring algorithms that auto-solve the sudoku, and edge colorings to aid users in understanding the structure of the sudoku graph. Additionally, I implemented a backtracking algorithm to generate valid puzzles and many human-solving strategies for an advanced “help” feature. In this project, I found a niche where I could demonstrate to others how multiple frames can be useful in understanding a single problem, which drove me to enthusiastically spend substantial time and energy on it.

Research Experience – Honors Thesis:
Beyond class projects, I engaged in an in-depth, year-long research experience during my senior year. Under the advisement of Dr. Kevin Angstadt and with influence from mathematics professor Dr. Daniel Look, I researched and implemented a web-based, complex dynamics scripting language and fractal-generating application. The project involved substantial work in translating intricate mathematical concepts to software, designing a simple scripting language, and an innovative application of the web assembly language, WebAssembly. The web app, Fractal Voyager, allows users to generate and explore fractals based on inputted custom scripts representing iterative functions and conditions. It supports parameter and dynamical plane fractals, point orbit visualizations and calculations, and a scripting language. These features are

necessary for mathematicians studying complex dynamics, but the only other application supporting them is no longer maintained and runs on 2008 macOS.

At the beginning of the project, I had no understanding of complex dynamics, but quickly learned the basics. Eventually, I leveraged incomplete documentation from the 2008 macOS fractal generator and created a new grammar using ANTLR4, for a language that would be brought to the web. At this point in the research process, a pivotal question arose: how could fractals be generated in a timely manner on the web, given their computationally intense nature? WebAssembly, or wasm, was the best answer. But then, how could the scripting language be compiled in the browser to wasm and run? To achieve this, I crafted a source-to-source compiler to translate the scripting language to C++. Then, to execute this on the web, the core functionality of an in-browser C++ code editor was used to compile the C++ to wasm. Finally, the wasm is run to generate fractals. This compiled code is parameterized, which allows users to explore the fractal, change parameters, and generate Julia set fractals without needing to recompile.

The application was launched and can be used to conduct research in complex dynamics and as an educational tool. I prepared an in-depth research report on the project and presented the findings. Furthermore, Dr. Angstadt, Dr. Look, and I plan to prepare the work for publication in a mathematics journal.

Faculty Alignment & Research Goals:
The University of Colorado Boulder is a great fit for my research interests that have been shaped by the experiences above. Generally, I aspire to conduct research in the realm of programming languages or theoretical computer science that works towards solutions to critical issues such as truthfulness, system verification, and developer assistance. Dr. Sankaranarayanan and Dr. Trivedi's work aligns well with this interest and integrates my passions for both theory and implementation. I find Dr. Sankaranarayanan's approach of using reachability analysis and Lyapunov theory to model and analyze critical hybrid systems compelling. I would be excited to dive into this work, researching questions such as: could we use real-time analysis to improve the verifiable model checking of dynamical hybrid systems? While my previous work provides a solid foundation for such research, I look forward to learning techniques such as formal methods, static analysis, proof assistants, and program synthesis to help solve these questions.

Beyond such specific applications, I am interested in the wide array of work done by professors in the CUPLV lab. Crafting a domain-specific language for Fractal Voyager illustrated to me that programming language development often involves employing logic and other theoretical foundations in software to create eloquent abstractions. I am interested in utilizing this experience, along with my time in industry, to create complex software projects that aid the developer, improve system performance, or solve intricate computational problems with Dr. Kaki or Dr. Chang.

Outside of programming languages, my strong foundation in discrete mathematics and proofs, along with previous coursework in economics, give me confidence that game theory is a field in which I can thrive. Specifically, Dr. Frongillo and Dr. Waggoner's work in information elicitation and dynamical systems excites me. Designing mechanisms in which agents are

incentivized to tell the truth, then creating accurate loss functions for such mechanisms, is compelling and widely applicable research I would be interested in.

Work in any of the fields outlined above represents a path towards my research goal of using theory or programming languages to solve critical issues, and my previous experiences have prepared me for further study in them. I am eager to embrace the challenge of a PhD at the University of Colorado Boulder, where my desire to learn and innovate will propel me to contribute to complex problems.

Dakota Bryan – Diversity Statement

I will bring my unique worldview to the University of Colorado Boulder; shaped by not only empathy-building personal challenges, but also experiences of societal issues that have demonstrated the need for diverse and equitable communities, especially in the realm of education. Some of these experiences include coaching for a Special Olympics swim team, coming from a low-income family, and many encounters while studying abroad in Kenya. They have made me passionate about doing my small part in the large effort of forging a world that is inclusive and accessible to underrepresented communities. Along with this, they have pushed me to put myself in spaces where I can learn from diverse backgrounds, creating a holistic worldview.

One such experience that shaped the way I see the world was my time as a coach for a Special Olympics swim team throughout high school. It introduced me to the myriad of challenges people with developmental disabilities face, most of them having nothing to do with the disability. Instead, they are dependent on other people's perceptions of them when finding jobs or even just interacting. Beyond being a formative experience for me, this work was a way for me to give back and see how my actions can have a clear, positive impact on others. It was also one of many influences that cultivated a desire to continue to be exposed to, and improve my understanding of, systemic disadvantages. Due to this, I chose to receive a liberal arts undergraduate education and spent a semester studying abroad in Kenya during it.

During college, as the treasurer for my school's outing club, one systemic issue that became clear to me was the lack of access to outdoor spaces for the BIPOC community. To combat this, I helped lead initiatives to allocate our budget in ways which create a more welcoming and diverse outdoor space at my small university. These initiatives included the creation of a "BIPOC gear grant," allowing BIPOC-identifying students to purchase or subsidize outdoor gear. In conjunction with the grant, we donated to local BIPOC outdoor organizations through fundraising, hosted workshops, and proactively collaborated with various diverse organizations on campus. These efforts made a small dent towards creating a more inclusive outdoor space, but also led to many positive changes to the way our club operates.

The above experience illustrated that diversity in spaces is important not just for the sake of equity, but also because it is the best way to solve problems and innovate. This is especially true in the realm of education, which is why I have made efforts to fight societal challenges in accessing education. One such endeavor was interning at a non-profit, Swahilipot Hub. This organization provides an educational space for the youth of the Kenyan coast to learn technical skills and hosts events to foster community-driven development. Through this organization's work and my integration into its community, I saw the clear struggles for women and people coming from extreme poverty to enter the technology industry. Hopefully, I made some small contributions to this issue by improving the organization's website and collaborating with other developers to learn from each other. Primarily, embracing this experience broadened my view of the world, and demonstrated that putting yourself in situations where you can learn from a diverse group of people is the best way to learn and change negative worldviews.

One of the best ways to cultivate a society in which people are most likely to learn from a diverse group of people is by equitably promoting anyone to go far in their classes and fields. I have tried to chip away at this task through years of mentorship at my university's quantitative resource center. In this role, I helped many students gain better understand course material and cultivated an open, collaborative learning environment. My time as a peer mentor, along with influence from great professors at my school, has shown me the dual-sided power of mentorship. Due to this, one advantage of enrolling in a PhD program is the possibility of entering academia, allowing myself the opportunity to encourage students to succeed in anything they set their minds to. This could be my small way of helping students from marginalized groups have better opportunities in the field of Computer Science.

I look forward to bringing my holistic perspectives to the University of Colorado Boulder, while maintaining my commitment to gain insights from diverse backgrounds which will allow me to succeed there.