Research Statement

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Love is a language that is not recursively enumerable, because no finite description exists for it. Thus begins one of my poems [1], inspired by a classmate asking, "What is a real-life example of non-recursively enumerable languages?" While initially meant in jest, these words aptly encapsulate what drives my research interests and aspiration to earn a PhD in Computer Science: not the finicky emotion sometimes understood as love, but a concrete passion for problem-solving and service that actively seeks the benefit of others. This passion is demonstrated both in my chosen specialties - health, education, and enabling technology - and in my work to equitably build bridges from technology to other domains.

Health

Comparing Natural Substances to Combat Catheter-Associated Urinary Tract Infections (12.2019 - 2.2020). My initial foray into research was as a dual-enrolled community college and high school pre-medical student without access to a formal research lab and funding. As a person with significant lower-body paralysis due to spina bifida, I chose to examine the related issue of catheter-associated urinary tract infections (CAUTIs) under the mentorship of Dr. Shuangying Yu (Department of Biology, Central Piedmont Community College). Over the course of several months, I designed and carried out an independent study to test the efficacy of common nutrient supplements *in vitro* in preventing bacterial growth associated with CAUTIs. To overcome the hurdles of operating without a formal laboratory, I conducted analyses of bacterial growth in a chemistry prep closet (equipped with a biosafety level II hood) using spare materials gifted by the department, and I relied on my mobile phone camera and open-source R software for data analysis. Data analysis using Welch's ANOVA and White-adjusted ANOVA showed no significant differences between bacterial colony counts for tested substances and the control, although negative binomial regression for count data showed that the honey solution resulted in more bacterial growth than the control ($p = 0.0434$, <0.05).

Besides teaching me resourcefulness and adaptability and introducing me to STEM research, the experience motivated me to expand access to similar opportunities by co-founding an organization (Student Researchers in Science) to connect students to STEM research opportunities and mentoring. While I no longer lead the organization, since its inception, six other students have conducted research under three faculty members at CPCC and presented at statewide conferences.

Education

In Fall of 2020, I took an introductory computer science course that led to me declaring the computer science major and serving as an undergraduate teaching assistant for the course. I subsequently interned at SAS Institute for 1.5 years (full-time summers, part-time fall/spring semesters), working on independent research projects that aided their Education Division. During this time, I developed a passion for both educating others in diverse domains of computer science and utilizing automation to enhance education.

Leveraging Predicted Dataset Relationships to Automate Documentation Generation (5.2021 - 5.2022). During my first year at SAS, I was tasked with identifying and documenting over 500 SAS-hosted datasets used in data science course creation. As information on datasets was sparse and dispersed over a multitude of files (upload request tickets, course documents, and webpages), I used Python to run

unsupervised clustering of the unstructured text data. This exposed a variety of dataset relationships (such as replication, time series, similarity in usage, and similarity in topics) that were used to fill gaps in documentation and identify places where cloud resource usage could be minimized. The site [2] made with the resulting documentation received 1.5K visitors from 64 countries within the first few months of usage, and the Python library created remains as a resource for the department.

Automating Script Generation (5.2022 - 1.2023). After deployment of the dataset documentation site, I was moved to a software team responsible for creating webpages that surface key insights on standardized assessment data for K-12 classrooms nationwide. As part of an initiative to reduce the time developers take making manual code adjustments to satisfy client requirements, I prototyped a SQLite/GraphQL/Spring Boot/React application for automatically generating custom scripts. While my internship ended before the prototype reached its final stages, the project laid a foundation for language-agnostic code templating that fills a gap made by existing code-generating tools (which focus on producing HTML/CSS/JS and require knowledge of specialized syntax).

Enabling Technology

Concurrent to my time spent on automation in education, I have conducted research to aid those with disabilities under the mentorship of Dr. Gary Bishop (Department of Computer Science, University of North Carolina at Chapel Hill) and Dr. Karen Erickson (Director, Center for Literacy and Disability Studies, University of North Carolina at Chapel Hill). Such research has reinforced my passion and given me tools for using technology to empower those with disabilities and bridge gaps in accessibility, education, and health.

Teacher Report Automation (3.2021 - 1.2022). The Early Literacy Alternate Assessment System developed by the Center for Literacy and Disability Studies [3] is used by teachers of K-6 students with developmental and intellectual disabilities in the State of Iowa to benchmark student progress. However, the existing system for entering such information requires manual input and sorting and lacks tools for data analysis. To remedy this problem, I prototyped an open-source Google Drive extension written in JavaScript and Google Apps Script to automate the creation of progress reports and provide tools for data analysis easily accessible via the Google Workspace interfaces. This extension was used as inspiration for the development of an official product.

Augmentative and Alternative Communication (8.2022 - 12.2022). People with difficulties in natural speech or typing rely on alternate technologies, known as *augmentative and alternative communication* (AAC) interfaces, to communicate. As development of such interfaces can be difficult and time-consuming for speech-language researchers, the Open-Source Design and Programmer Interface (OS-DPI) [4] is being developed by Dr. Bishop in collaboration with AAC researchers as an experimental system to allow for non-programmers to develop new AAC interfaces. Under Dr. Bishop's direction, I helped streamline the OS-DPI website via implementation of an accessible context-specific menu bar for adding, deleting, and editing components. I also wrote an initial developer's documentation [5] and aided in OS-DPI testing and bug fixes. Besides integrating me with more experienced developers/researchers and teaching me the principles of accessible web development, the experience inspired me to see accessibility as an inherent dimension of every interface (physical, digital, conceptual) and approach interface development as one would approach developing a structured language, with meaning communicated via each component of the interface.

The Polaris Project for Accessible Campus Directions (12.2021 - Present). People with disabilities face numerous obstacles to accessing activities in the form of physical barriers (ex. stairs, broken elevators, steep inclines, sidewalk blockages) and knowledge barriers (ex. lack of information on accessibility equipment status, confusing signage for accessible routes), but existing widespread navigation applications lack detailed real-time reporting and adaptive routing for such obstacles. Where smaller-scale solutions exist, they are often designed without feedback and evaluation by diverse sets of users or without the principles of universal design [6]. As someone with intimate knowledge of both living with a disability and application

development, I am currently spearheading the creation of Polaris Maps [7], a collaborative, user-centered, student-volunteer-staffed, open-source initiative started in 2021 that aims to address the knowledge barriers around campus route-finding by crowdsourcing information on obstacles to suggest routes to rooms customized to the needs of the specific user. Leading the project has both immersed me in literature regarding accessible campus routing and optimization of such systems and allowed me to facilitate cross-team collaborations among users with and without disabilities, disability advocates, software developers, user interface designers, and university administration.

Future Directions

In the immediate future, I am excited to continue the collaborative research and development involved in Polaris Maps. I envision three primary areas of research being explored in greater depth as the project continues, if granted approval and funding:

- **Physical accessibility.** College campuses have a variety of physical accessibility issues, but to my knowledge, large-scale user studies among campus affiliates with and without disabilities have not been conducted to identify obstacles most relevant to campus way-finding. In keeping with the principles of user-centered design, we hope to garner survey data on these topics from college campuses nationwide to guide development of the application. Similarly, after piloting the application among current and new students/staff at UNC Chapel Hill to evaluate its efficacy in easing the mental and physical burden of route-finding, we hope to expand usage of the application to campuses nationwide and test both the scalability of the open-source initiative and its effectiveness on United States college campuses.
- **User interface (digital) accessibility.** Of equal importance to obtaining information on physical obstacles is ensuring user access to said information. While applying the principles of universal design to the development of the application, we hope to solicit user feedback on the ease and ability of access to necessary information and actions.
- **Distributed systems.** As with any routing system, this project presents many opportunities for distributed system research. One open question (extending Gharebaghi et al.'s fuzzy approach to route planning for people with motor disabilities [8]) is if quality of suggested routes will improve using an algorithm that defines route optimality based on environmental features, users' confidence in navigating said features, and route history of users with similar confidence profiles. With enough users, projected/actual traffic could also be incorporated into preferences and optimality metrics, and efficient methods of client-to-client sharing of obstacle data and routes could enhance system performance and scalability.

Outside of Polaris Maps, I hope to bring my interests full circle by applying my study of distributed systems and automata to unexplored areas of computational biology. As someone majoring in nutrition in addition to computer science, one topic of interest to me is mathematical models of metabolism. Specifically, as the prevailing model fails to capture the dynamic and distributive nature of the system, and alternative models (stochastic Petri nets and cellular automata) lack the notion of spatial dependencies and dynamics of individual reactions, respectively [9–12], I hope to explore a potential alternate model (cellular automata in which cells are Petri nets) and its ability to model self-stabilization properties of cyclic and acyclic metabolic pathways. I could then study the potential for generated Petri nets to evolve and the potential implications of similar models in diverse areas of networking.

Through it all, I am drawn to computer science partially because I love to be challenged, to knit patterns into programs and poetry. I want to reach in and tear apart computational principles and weave them back together to discover something new that ultimately benefits others. But what anchors my passion for the field is not just the joy of learning and creating, but the ability to give back to the community through teaching and through collaborative research that address real-world problems, to the glory of God. For, returning to the poem from the beginning:

There is so much infinity
in what appears to be finite,
galaxies within molecules
and subdivisions within space. [1]

And the beauty of computer science lies in its ability to touch the intangible, opening up galaxies of thought and creation for us to step through, together.

References

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