Statement of Purpose

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Motivation and Background

I am a Research Engineer at Schweitzer Engineering Laboratories (SEL), and graduating masters student of Applied Mathematics at the University of Washington with an undergraduate education in Electrical Engineering from the University of Idaho. My employer's mission is one I believe in: to make electric power safer, more reliable, and more economical. On a daily basis I perform at the intersection of applied math, electrical engineering, and software engineering to further this goal.

When I transferred to Government Services from R&D, it became readily apparent there was an immense need for people who were capable of bridging the gap between the abstract and sometimes esoteric world of mathematics, and the real-world application of these ideas. To address my deficincies in the prior, I elected to pursue graduate education. Three years later, even with the huge strides I have made, it is obvious my work has just started.

Relevant Experience

Career Research I must preface this section: due to its nature, I'm not able to discuss specifics of much of the work I do for my employer, and we are definitely not allowed to publish. However, I can say we are recognized as experts on power systems by various federal agencies and regularly provide research, analysis, and product to this end. In particular, we in the Data Analytics group marry this expertise with high performance computing, machine learning, statistics, and traditional applied mathematics to achieve novel and challenging goals.

Of those I can discuss, several stand out. My first assignment was developing an Internet of Things (IoT) based sensor system to measure and store Synchrophasor data (GPS timestamped frequency, voltage, and phase) on the cloud. This involved selecting a computing platform, developing code to interact with a phasor measurement unit (PMU), robust logging and system restart behavior, and code for Amazon Web Services' IoT, Lambda, and S3 services. Then, these devices were hardened to prevent tampering through careful device configuration (SSH keys and passwords, disabling of WiFi, disabling of default accounts, etc.) We succesfully deployed several devices that showed greater resiliency than SEL's existing solution. These devices have performed uninterrupted for several years now, and we are currently investigating expansion of this sensor network.

Earlier this year I submitted a patent application for a compression method intended to help streamline the massive data output of SEL's flagship relay, the T400L/T401L – an 18 bit, megahertz sampling relay for the detection of traveling wave events on transmission lines. We have a vested interested in long-term data captures at this fidelity, but the existing implentation was naive and had excessive storage requirements, (three weeks on a four terabyte drive). As a project during Dr. Kutz's class at the UW (AMATH 582), I took his theme of assuming structure to solve $Ax = b$ given only b and assumed an autoregressive model to more compactly represent these time series, producing lossy compression. Then, the errors are stored in Golomb-Rice codes, producing a reduction of 5.7 to 7.4 times less than the existing implementation. This was a major achievement – it allows for one year of data to be stored on a single 3.5" drive, or streaming to offsite storage using less bandwidth than a 1080p Netflix stream.

A more recent achievement was the synthesis of a massive schematic dataset intended to bootstrap a related machine learning model we are working on. Over ten-thousand Eagle schematics were generated, including user specified components such as passives (resistors, etc.), active components (diodes, BJT's, etc.), transformers, integrated circuits, and more. This also included bounding boxes, component identifiers and values, rotations – all without human intervention. I am currently in progress of expanding this capability to include more CAD programs.

Finally, I have applied optimization in several impactful ways. The first was generating nonlinear transmission line designs to achieve particular performance characteristics (impulse response rise time, peak value, etc.) that would be intractable with traditional engineering techniques. While this was not a particulary succesful project, it taught me two valuable lessons: have frank discussions with customers about requirements and ensure both parties have clear objectives to minimize iterations; and, while open-source software is a boon, niche projects can suffer from poor stability, reliance on end-of-lifed components, or even just incorrect behaviors. Similarly, another project involved fitting high-order, nonlinear transformer parameters through genetic algorithms. This was quite sucessful, and allowed me to learn that judicious use of penalties prevents compuationally correct but physically nonsensical models. This tool is still in use by our power engineering team. Finally, a recent achievement was the implementation of a crest-factor minimization problem in PyTorch that meets current state of the art, but will serve as a testbed for different optimizers (the paper in question uses Levenberg-Marquardt) and hyperparameter searches for these alternate optimizers. Furthermore, it will be an excellent framework for other optimization problems we regularly encounter without having to determine gradients and Hessians by hand.

Independent Study and Scalable Second Order Optimizers As an online Masters student, I did not have the opportunity to write a traditional thesis. Instead, I approached Dr. Andrew Lumsdaine about doing an independent study course over the summer of 2020. Topics ranged from power system load flow simulations (using PETSc), CUDA/Thrust implementations of several matrix decompositions, and the intersection of graphs and linear algebra. Although there was no research output for this period of performance, I learned an incredible amount and made enough of an impression to be brought on helping with his Second Order Methods for Scalable Optimization project. This project involved using a trick (detailed in our preprint here: **TODO**) to reduce the memory and compuational requirements of Newton, Quasi-Newton, and other second order methods for applications in machine learning.

Career Goals

I see three non-orthogonal avenues in my future: professorship, industry, and civil service. All three share a common goal: perform at the intersection of applied math and engineering while providing relevant, timely, and understandable analysis and education to students, peers, or customers.

The first appeals strongly – the ability to conduct independent research while managing and enriching students is (as the audience is likely well aware) a rich and rewarding path in life. I've been priveleged to have had excellent professors, and have seen who I would want to be in engaging with students. I want to provide power engineers with the tools to step beyond traditional power engineering analyses and to engage with cutting-edge applied mathematics techniques. I regularly see brilliant power engineers failing to articulate problem statements or using heavy-handed approches out of ignorance – much of my optimization work has grown out of statements such as "I don't think this equation is solvable, so I'm not sure we can use this" or "Well, this system is highly nonlinear...". Being a educator and researcher could do much to alleviate this as our power system continues to grow in complexity. Failing the arduous task of a full time, tenured faculty position, I would seek out options for adjunct positions just so I can continue to engage with students.

In industry or civil service (working for an agency or a national lab), I would continue much in my same role if at all possible: providing exemplary work for government customers with the intent of making the grid safer, cheaper, and more reliable. This would take the form of consulting and providing tools and techniques for use by the federal government, and sound advice for shaping policy.

Institution Selection

Concluding Remarks