Statement of Purpose

Eric Silk
esilk16@uw.edu

Motivation and Background

I am a Research Engineer at Schweitzer Engineering Laboratories, Inc., and graduating masters student of Applied Mathematics at the University of Washington with a Bachelors of Science 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.

Upon transferring to SEL's Government Services division from R&D, it became apparent there is a need for people who are capable of bridging the gap between the abstract and esoteric world of mathematics and real-world applications in engineering. For this reason, I elected to pursue graduate education. Even with the huge strides I have made, my work has just started. Earning a PhD will allow me to transition into an independent, productive researcher and to speak with authority on topics related to electric power.

Relevant Experience

Career Research Due to the nature of my work for my employer, I am not allowed to discuss many specifics and definitely not allowed to publish. We are recognized as experts on power systems by various federal agencies and regularly provide research, analysis, and product in this space. In particular, the Data Analytics group marries this expertise with high performance computing, machine learning, and traditional applied mathematics to achieve novel and challenging goals. Of what I can discuss, the following stand out.

In February, I submitted a patent application for a compression method 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. We have a vested interest in long-term data captures at this fidelity, but the existing implementation had excessive storage requirements, (four terabytes for three weeks). During Dr. Kutz's class (AMATH 582), I applied his theme of assuming structure to solve $Ax = b$ given only b and assume an autoregressive model to produce lossy compression. Then, the errors are stored in Golomb-Rice codes, producing a reduction of 5.7 to 7.4 times less than prior art. This was a major achievement — it enabled storing one year of data on a single 3.5" drive, or streaming using less bandwidth than Netflix.

My first assignment in Government Services was developing sensor system to measure and subsequently 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 restarts, and code for Amazon Web Services' Internet of Things, Lambda, and S3 services – all while ensuring the devices were secure. We successfully deployed several devices that have now performed uninterrupted for several years.

A recent achievement was the synthesis of a massive schematic dataset for bootstrapping a machine learning model. Over ten-thousand Eagle schematics were generated, including components such as passives (resistors, etc.), active components (diodes, BJT's), integrated circuits, and more. This included bounding boxes and component identifiers — all without human intervention. I am actively expanding this capability to include more CAD programs.

Finally, I have applied optimization in several influential ways. The first was generating nonlinear transmission lines via genetic algorithms to achieve particular performance characteristics that would be intractable with traditional engineering techniques. From this, two lessons were gleaned: have frank discussions about requirements minimize iterations; and, while open-source software is a boon, niche projects can suffer from instability, end-of-life components, or even incorrect behaviors. Another project involved fitting high-order, nonlinear transformer parameters through genetic algorithms. This was quite successful, taught me that judicious use of penalties prevents computationally correct but physically nonsensical models, and is still in use by our power engineering team. Finally, I implemented a crest-factor minimization problem in PyTorch that will serve as a testbed for different optimizers, and introduced autodifferentiation and quasi-newton methods into our repertoire.

Independent Study and Scalable Second Order Optimizers As an online Masters student, I was unable to write a thesis. To ameliorate this, I arranged an independent study course with Dr. Andrew Lumsdaine. Topics ranged from power system simulations using PETSc, matrix decompositions in CUDA, and the intersection of graphs and linear algebra. I learned an incredible amount and made enough of an impression to help with his Second Order Methods for Scalable Optimization project. This project hinges around the use of finite-difference Hessian approximations, along with limited-memory techniques to accelerate machine learning training. Our git repository can be found here: https://github.com/lums658/ml20

Career Goals

I foresee three career trajectories: professorship, industry, and civil service. All share a common goal: perform at the intersection of applied math and engineering and provide relevant, timely, and digestible research and education to students, peers, or customers.

As an educator, I would provide power engineers with the tools to step beyond traditional power engineering analyses and engage with cutting-edge applied mathematics techniques, while providing context and constraints to keep these techniques grounded in industrial realities. In industry or civil service, I would continue in much my same role: exemplary work for government customers making the grid safer, cheaper, and more reliable. This would take the form of consulting and providing tools for use by the federal government, and sound advice for shaping policy.

Challenges

I want to address two points. First, I had a medical withdrawal in undergrad with lingering effects in subsequent semesters. This issue has since been fully resolved, as evidenced by my final semesters and my graduate performance. Secondly, my withdrawal in graduate school was due to a death in my family. Neither pose risks to future academic endeavors.

Institution Selection

Dr. Herb Hess, a professor at the University of Idaho and Alumni of your program, once described UW Madison as "the only school better than MIT when it comes to power systems." While I hadn't the foresight to see where my career would take me and thus never took additional classes from him, that comment stuck with me. Viewing your faculty research interests, I had difficulty winnowing my options as so many appear to mirror my own interests. Few other programs offer the potent combination of rigorous power systems knowledge with machine learning applications that go beyond the trendy "we threw a neural network at some power systems data." The gravity of the challenges presented by power systems design deserves better, and the US (and the world) need individuals able to meet these challenges to produce solutions that are reliable, explainable, equitable, and economical – I believe your program is the best suited for me, and that I'll be an asset to you.

In addition, the mathematics department at UW-Madison is highly regarded. Given my pending Masters in Applied Math, this provides opportunities for cross-department collaboration to apply novel mathematical techniques with rigorous backing to the aforementioned problems in mathematics.

Concluding Remarks

I hope I've demonstrated a clear upward trajectory in my career and research. I'm on the cusp of being a strong and independent researcher; a PhD from your program would be the keystone in my ability to contribute to electrical engineering and applied mathematics.