Statement of Purpose

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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 and 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. Second, my withdrawal in graduate school was due to a death in my family. Neither pose risks to future academic endeavors.

Institution Selection

When I asked Dr. Lumsdaine his recommendation for programs that would meet my research and career goals, he stated without hesitation: "UT Austin." I trust his advice implicitly, but have additionally had the pleasure of meeting two other graduates of your undergrad program (one in my current program and another at a conference) who echoed his sentiment. All evidence suggests a highly collaborative environment, with options for both Electrical Engineering and Computational Engineering for coursework and advising. This is exactly where I hope to conduct research – rigorous mathematics and clever algorithms supporting meaningful and far-reaching engineering to support the next generation of power systems design.

Faculty Selection

It was requested to include which faculty I would be interested in working with. Without having had the opportunity to meet with any of them and assess fit, I cannot reliably make a determination on particular individuals. However, I do have confidence there will be someone with whom I can establish a mutually beneficial research relationship.

Other Institutions Applied To

As requested by the instructions, the following section details the other programs I have applied to and my rationale for such.

University of Texas, Austin: ECE

I have applied to the ECE program at UT Austin as well as CSEM. While I hope my reasoning has been explained so far, I want to straddle CSEM and ECE. Either department seems to represent the opportunity to do so, provided I'm able to find co-advisors or committee members amenable to this arrangement.

Georgia Institute of Technology: ECE and CSE

GA Tech represents one of the other major programs with an exceptionally strong computational science and mathematics program, as well as an excellent ECE program – I've applied to both. For this reason, it was the second suggestion of my advisor following UT Austin. Additionally, an information session I attended hosted by a professor in CSE confirmed the ability to collaborate with professors within either department, provided I'm admitted to at least one.

University of Washington: ECE and AMATH

I am currently a student at the UW, and have been highly impressed with the faculty and my peers within the AMATH program. It seems obvious to continue in this environment. Several professors, including Dr. Kutz, are the experts in sparse system identification techniques that I suspect will have powerful applications in power systems analysis. In addition, there are locale considerations, as well as the opportunity for a joint UW-PNNL fellowship opportunity.

Purdue: ECE

Purdue has one of the best power engineering programs in the country. My employer maintains strong relationships with this university, going so far as to have endowed a professorship and to construct new manufacturing and engineering facilities a stone's throw from campus. This presents an opportunity for continued collaboration with my employer, and a trustworthy endorsement of the merits of the program. Additionally, they offer a non-degree option for computational science and engineering that one can apply for after admission into a degree seeking program — I intend to pursue this, should I be admitted and elect to attend.

University of Illinois, Urbana-Champaign: ECE and CSE

It seems half the papers I've read related to high-performance computing have been authored, at least in part, by an affiliate of UIllinois. This was also a top recommendation from my advisor if I were interested in emphasizing more in HPC (a notion I'm amenable to). This is another school offering both ECE and CSE.

Oregon State University: EE

I've had the privilege to collaborate briefly with several students and faculty from OSU's EE program on a project sponsored by the Department of Energy. I was impressed with their contributions, and the atmosphere the advising professors fostered, and they seemed to be practiced at finding industry collaborators to ground their research. Similar to the UW, they also have a joint PNNL fellowship that is highly alluring.

Massachusetts Institute of Technology: EECS

At risk of sounding flippant, this program needs little explanation. I've now been able to work with several faculty who graduated from here (Dr. Andrew Lumsdaine, Dr. Tony Chiang) as well as being an avid subscriber of their open source courseware. In fact, I was a pilot student for the first iteration of what is now edX (originally MITx) in their 6.002x course during my senior year of high school — I even managed a B! Every time, I've been awed by the ability of their graduates to develop powerful abstractions for complex topics and disseminate them in a way that makes it obvious.

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.