New submission from ARC Award Final Report

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To: Scholarly Activity <scholarlyactivity@langara.ca>

Name of Researcher

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Department/Faculty

Mathematics and Statistics

Position in Department/Faculty

Instructor

Project Title

Phase Identification of Smart Meters through a Fourier Series Compression

Term of Project

Summer 2022 - Fall 2022

Please introduce yourself – include pertinent background information relating to the topic of your research project.

I am a math instructor at Langara College since 2016. I did my MSc in SFU's Applied and Computational Mathematics program, where we learned how to use analytical and numerical methods to compress large data sets.

Please discuss your educational background and your work experience that led you to taking on this research project. If possible, include a quote that helps define your interest in this project.

I attended Langara's Data Analytics capstone project presentations. Students were solving a problem initially posed by Harris SmartWorks, a smart meter data management and analytics company. The students were trying to use statistical methods to estimate information (that wasn't properly bookkept) about the power grid system, but ultimately encountered challenges that gave unsatisfactory results. I got involved when I thought that techniques learned in my MSc program (which involved data compression) could be used to address some of the challenges.

Please summarize your project in plain language that others not in your field could understand.

Accurate labeling of phase connectivity in electrical distribution systems is important for maintenance and operations but is often erroneous or missing. In my project, we presented a process to identify which smart meters must be in the same phase using a statistical clustering method on voltage time series data. The data set was the hourly voltage of ~2000 smart meters across California over a 3-month period. To improve accuracy, we compress the data and reduce the size by using Fourier series – ultimately, we used an approximation that was 2% in size but still retained 80% of the original features.

Identify the project goals and objectives. Explain how the results may be used to solve a problem or inform further research in the field.

The project goal (accurately identify smart meter phases using voltage time series) was set by the capstone's industry partner, Harris SmartWorks. They wanted methods to statistically infer missing phase information, which is quite costly to physically measure.

Briefly explain the steps taken (methods used) to conduct the research, and describe the key findings.

We started by examining the work of the capstone project, where they explored various statistical techniques. We ended up using the statistical techniques they found were the best. Our goal was to improve the accuracy of their estimates by using a “Fourier compression”. We measured the accuracy of the Fourier compression by using error-validation techniques from applied mathematics. We then attempted the phase identification problem using the Fourier compression.
Recall that the actual phases are unknown, and so had to develop methods to validate (or invalidate) our findings. Our error validation methods were to see if our results were consistent across different months; comparing our results to known phase-connectivity diagrams; and other statistics error validation techniques. Using these tests, for certain data sets, our solutions went from <50% accuracy (without compression) to >95% accuracy (with compression).

Who was involved in this project (eg. faculty, students, community partners)? How did their involvement contribute to the project’s success? Were there any challenges to overcome?

James Park, a student from my calculus course. James did most of the grunt work, including writing code, simulating experiments, documenting results, and generating figures. The ARC Fund was entirely spent on James’ wage.

Albert Wong, a statistics instructor. Albert served as a senior member and guided the research process. He also had expertise in the statistics side of the project, and so I could focus on the applied mathematics compression.
Engineers from Harris SmartWorks (Michael Ferri, Tim Berson, and Vice President of Research & Development Joe Mahony) met with us to give counsel and to examine our results. In addition to asking

Please share any personal stories that made this research experience memorable/valuable.

This project culminated in my first peer-reviewed publication (https://ieeexplore.ieee.org/document/10000137) . We published and presented in the IEEE Electrical Power and Energy Conference (presentation: https://mediaspace.langara.ca/my-media?controller=user&action=user-media&keyword=fouri&sortBy=relevance&do-table=1). I was also happy to present at Langara’s Applied Research Day.

What are the next steps for this project and for you as a researcher?

We would like to apply our methods to data sets with more meters, where our results are currently inaccurate. Finding another student to take over is key – most first- or second- year students don’t have the necessary computing / math background to solve the project. It would be nice if ARC funding could go towards a student who isn’t currently enrolled at Langara college but has the necessary experience.

Please upload any images that will help to showcase your project.

- Fourier-Clustering-Dec22-v2.pdf
- Fourier_Paper_Publication-nov3.pdf

Langara Institutional Repository Consent

By submitting, I consent to uploading my ARC Fund final report to the Langara Institutional Repository (The LaIR).