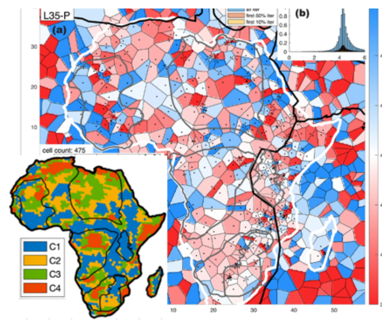
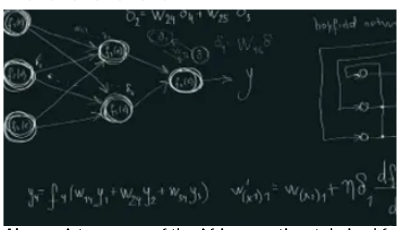
Open Position

RA, Spring ‘24

Earth Imaging Lab

Keywords:
Deep learning, neural networks, Bayesian probability, Markov chains,





Above: A taxonomy of the African continent derived from probabilistic imaging with long-running McMC simulations. The goal of this project is to use generative AI (below) to compress this computation in time and memory requirements (upscaling, downscaling and speed-up_.

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Put Continents Together Again...

UPDATED: 7, FEB `24

Earth Imaging with Generative AI

Summary

Are you looking for a research project with ‘non-traditional’ applications of machine learning in the natural sciences? Do you have a strong background in data science, deep learning, math, physics, and signal processing? Are you a highly talented master’s student in data sciences interested in exploring a year-long project investigation of our planet through applied mathematics, data science and geophysical techniques? If your answer is yes to all these questions, then we encourage you to apply to work as a year-long research assistant on a project that bridges earth science and data science! The student will apply deep learning architectures to: (1) speed up and improve the imaging process, (2) quantify all forms of uncertainties (measurement and modeling) efficiently, and (3) compactly represent the results of large simulations for efficient dissemination. Plate tectonics puts South America and Africa together. We want to test how close this fit is beneath the subsurface. This is the goal of Earth imaging with Generative AI.

Research Objective

The student will work closely with research data scientists to implement and train neural networks on images constructed from probabilistic imaging of real and toy data. The student will train a **deep convolutional generative adversarial networks (DC-GAN)** using images generated concurrently from a reversible jump **Markov chain Monte Carlo** algorithm (rj-McMC). The student with gain experience with pytorch (or keras) and MATLAB. The student will extend the algorithm for propagating waves through a velocity image. This involves transforming a fast-marching algorithm from cartesian to spherical coordinates. Interest or experience in the following is beneficial: (1) Bayesian Neural Networks for Image Reconstructions, (2) Generative Models for Describing Probability Distributions,(3) Training with Physics-informed Neural Network Architectures

Review Eligibility & Other Conditions

1. Although **master’s students are preferred, highly talented juniors and seniors** are welcome to apply.
2. You must be ready to commit to working for at least **one (1) full year in the lab** (Spring, ‘24 - Fall, ‘25).
3. Demonstrate domain knowledge (imaging algorithms, computational methods, deep learning, or data structures)
4. We will provide **full summer (2024)** pay, following a successful evaluation based on criteria no. 3 above and progress with the research project (offer letter confirmed in late **spring, 2024**)
5. Interested students should contact the PI or Sayan Swar (sswar@ur.rochester.edu)

Make the Invisible Visible…

UPDATED: 9, FEB `24

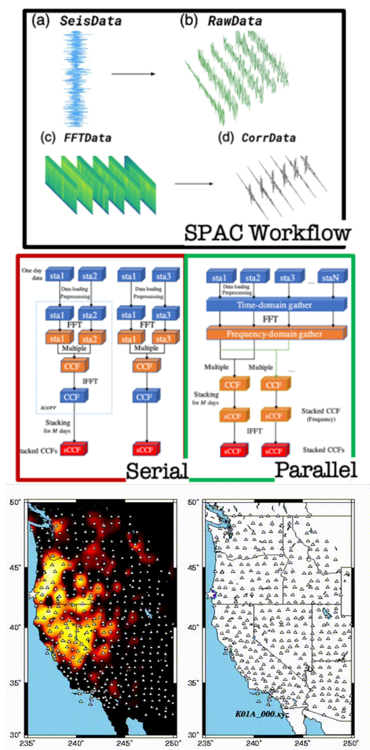
Waves in Noise using Graphs &GPUs

UNIVERSITY of ROCHESTER

Open Position RA, Spring '24

Earth Imaging Lab

Keywords:
Surface Waves, Spectral Analysis, Parameter Estimation, Seismic Interferometry, Comp. Graphs



Above: A top-level overview of two realizations of the SPAC workflow. The Algorithm that extracts wave from noise. For a large array, an emergent surface wave derived from SPAC between a single station virtual source (star) and all the other stations in the west coast of the USA (triangle). Courtesy *Fan-chin Lin.*

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Summary

Traditional methods for illuminating our planet's interior require extracting and modeling waves propagating through rocks and metals and are generated from controlled explosions or earthquakes. The observational goal being the identification of the source 'signal' over and above the ever-present nuisance of contaminating 'noise'. More recently, however, solid earth scientists have succeeded in turning this convention on its head[1–3]. The nuisance is now the signal. This background noise - continuous recordings of ground vibration - is now faithfully used to extract our planet's elastic properties[4]. The technique is ambient noise interferometry[5]. However, the most popular implementations are time-consuming and not amenable to automation[6-7]. In this project **the student will revisit the imaging challenge by exploring ideas in network analysis and parallel computation using GPUs (graphical processing units)**. The goal is to design algorithms that ensure the pair-wise connections (edges in a graph) optimally cover a spherical surface and are efficiently scheduled for rapid computation of cross-correlations (nodes between the edges). The goal is to transform algorithms that take a decade to ones that finish in months. Are you up for the challenge?

Research Objective

The student will extract dispersion measurements with (1) spatial auto-correlation (SPAC[8,9]) (2) create network algorithms to identify optimal scheduling of nodes for spectral analysis and pair-wise convolutions (3) design metrics for estimating the quality of SPAC results useful for early algorithm termination (4) evaluate existing GPU algorithms[10-12] and design/implement new algorithms for speeding up the SPAC calculations.

Selected References

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