Dissertation Defense

Large-Scale Parameter Estimation in Geophysics and Machine Learning

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Abstract: The ability to collect large amounts of data with relative ease has given rise to new opportunities for scientific discovery. It has led to a new class of large-scale parameter estimation problems in geophysics, machine learning, and numerous other applications. Traditionally, parameter estimation aims to infer parameters in a physical model from indirect measurements, where the model is often given by a partial differential equation (PDE). Here, we also associate parameter estimation with machine learning, where rather than having a PDE as the model, we have a hypothesis function, e.g., a neural network, and the parameters of interest correspond to the weights. A common thread in these problems is their massive computational expense. The underlying parameter space in both applications is typically very high-dimensional. This makes the optimization computationally demanding, sometimes intractable, when large amounts of data are available.

In this thesis, we address two general approaches to reduce the computational burdens of big-data parameter estimation in geophysics and machine learning. The first approach is an adaptive model reduction scheme that reduces the computational complexity of the model while achieving highly accurate solutions. This approach is tailored to problems in geophysics, where PDEs must be solved numerous times throughout the optimization. The second approach consists of novel parallel/distributed methods that lower the time-to-solution through avoided communication and latency, and can be used in both applications. We exemplarily show the potential of our methods on several geophysics and image classification problems.

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