Department of Mathematics

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Scientific Computing Seminar

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Deterministic and Stochastic Inverse Scattering Problems Using Fast Direct Solvers

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1:30 PM- 2:30 PM
Room 646 PGH

Abstract: Inverse scattering problems arise in many areas of science and engineering, including medical imaging, remote sensing, ocean acoustics, nondestructive testing, geophysics and radar. This talk focuses on two dimensional deterministic and stochastic inverse acoustic scattering medium problems. Chief among the many challenges associated with these problems are the fact that they are nonlinear, ill-posed and computationally expensive.

Techniques for dealing with the nonlinearity and the ill-posedness of these inverse problems have existed in the literature. Unfortunately, these methods were computationally prohibitive due to the large number of forward scattering solves needed until recently. The last decade has seen a lot of progress in the development of fast direct solvers. These techniques build/approximate the inverse of the system for the forward scattering operator, allowing for the solution of each partial differential equation to be obtained by performing an extremely inexpensive collection of small matrix vector multiplies. Thus being ideal for accelerating the inversion techniques.

In this talk, I will describe a fast, stable algorithm that can be applied as a framework for the solution of both the discrete and the stochastic inverse scattering problems. Given scattering data from multiple incident waves and frequencies, the Gauss-Newton method is coupled to the recursive linearization algorithm to reconstruct an approximation of the media by solving many least squares problems at successively higher frequencies using fast direct solvers.

Using this framework, we obtained the solution of the deterministic inverse scattering problem with high resolution. In this case, we solve approximately one million partial differential equations(where the largest problems considered, involved 19,600 unknowns), requiring approximately two days to compute using a parallel MATLAB implementation on a multi-core workstation. We applied the same code to solve in a similar amount of time the stochastic inverse scattering problem for a very large number of samples(up to 4000).