Mini-Course Proposal: Computational Methods for Inverse Problems in PDE Applications

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Abstract

The following course proposal to IMPA will require four lectures over two weeks (two per week), each lecture lasting 90 to 120 minutes (with a break)

1 Description

Inverse problems involving partial differential equations (PDEs) in the forward model have long been the subject of intense theoretical investigation and practical implementation. And yet, our grasp of how to handle the computational solution of such problems is not even close to being as tight as that of designing efficient numerical methods for PDEs alone. This general observation is not about to change, because inverse problems that arise naturally in applications are typically ill-posed – often extremely so. Moreover, the computational issues that arise are often significantly more complicated, involving handling ill-conditioning, solution discontinuities, noise, global rather than local effects and very large scale computations.

Nonetheless, a careful infusion of any additional knowledge into the mathematical model, employment of appropriate statistical techniques, and increased level of expertise in computational methods often result in meaningful advances towards practical simulations.

Below is a tentative list of topics, with a few references that are either mine or textbooks. More general literature will be used during the course.

- Distributed parameter function estimation problems in 2D and 3D, and applications in computed myography, electromagnetic data inversion, DC resistivity, electric impedance tomography and seiemic problems; [6, 5].
- Surface reconstruction with discontinuities; [2, 7].
- Nonlinear optimization methods; [9].

- Preconditioned conjugate gradient and gradient descent methods; [10, 1].
- Dynamic regularization and level set methods for shape optimization; [8, 3, 4].
- Handling many experiments (many right hand sides) and stochastic optimization.

References

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