UNIVERSITY of HOUSTON

Department of Mathematics

Scientific Computing Seminar

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Fast methods and software for singular and near-singular boundary and volume integral operator evaluation

Thursday, March 28, 2024
1 PM- 2 PM
Room 646 PGH

Abstract: This talk will (1) Introduce a regularization strategy for evaluating singular volume integral operators and (2) Present a new Julia project for working with boundary and volume integral equations. Volume integral operators are fundamental tools for solving volumetric problems with integral equation methods, in particular for challenging wave scattering problems in inhomogeneous media with discontinuous material properties as well as for nonlinear or time-dependent problems. Their evaluation presents a number of analytical and computational challenges including treatment of singular quadratures at every evaluation location in the domain, need for coupling to fast algorithms, etc. We will present a dimension-agnostic method that leverages Green's third identity and a local polynomial interpolant of the density function to recast the volume potential as a sum of single- and double-layer potentials and a volume integral with a regularized (bounded or smoother) integrand. The layer potentials can be accurately and efficiently evaluated everywhere in the plane by means of existing methods (e.g. the density interpolation method), while the regularized volume integral can be accurately evaluated by applying elementary quadrature rules. We present an error and stability analysis of the regularization performed by the method which provably enables high-order accurate operator evaluation with generic (e.g. Gauss) volumetric quadratures, demonstrate optimal complexity evaluation of the operators via fast algorithms like FMMs, H-matrices and the IFGF method (through integration with the recently-introduced `Inti.jl` Julia package), and show application to scattering problems and inhomogeneous PDEs.