A Nonlocal Vector Calculus and Finite Element Methods for Nonlocal Diffusion and Mechanics

Distinguished Research Seminar Series

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103 Engineering Management

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Abstract: We develop a vector calculus for nonlocal operators that mimics the classical differential vector calculus. Included are the definition of nonlocal divergence, gradient, and curl operators and derivations of nonlocal Gauss and Stokes theorems and Green's identities. Through appropriate limiting processes, relations between the nonlocal operators and their differential counterparts are established. The nonlocal calculus is applied to nonlocal diffusion and mechanics problems; in particular, strong and weak formulations of these problems are considered and analyzed, showing, for example, that unlike elliptic partial differential equations, these problems do not necessarily result in the smoothing of data. Finally, we briefly consider finite element methods for nonlocal problems, in particular focusing on solutions containing jump discontinuities; in this setting, nonlocal problems can lead to optimally accurate approximations.

Biographical Sketch: Max Gunzburger is the Frances Eppes Eminent Professor and Chair of the Department of Scientific Computing at Florida State University. He has held several other academic and laboratory positions, has served as a consultant for several national laboratories and in an advisory capacity for SAMSI as well as several other domestic and international departments, programs, and institutes, and serves as a distinguished visiting professor at Yonsei University in Korea and has previously served in that capacity at Peking University. Max Gunzburger has been awarded several honors, including the W.T. and Idelia Reid Prize in Mathematics from the Society of Industrial and Applied Mathematics; that society also named him to its charter class of fellows. His current research interests focus on climate modeling, nonlocal problems in diffusion and mechanics, numerical methods for uncertainty quantification of systems governed by partial differential equations having random inputs, control and optimization problems for such equations, and superconductivity.

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