Wavelet-Based Computational Modeling and Operator Compression for 3D Elliptic Problems

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Abstract

Wavelet representations have previously been used with reasonable success in the computer simulation of physical processes. A common approach is to use a Galerkin formulation, which leads to multilevel schemes in which the rate of convergence improves proportionately with the number of zeros at π. One of the primary limitations of the classical wavelet representations, however, is that they are restricted to regular grids. This places wavelets at a serious disadvantage with respect to other computational methods such as the Finite Element Method and Boundary Element Method, which offer greater flexibility for modeling domains with complex geometry.

In this talk, we develop a wavelet approach for efficiently modeling problems with fairly complex 3D geometry. The approach is based on the use of second generation wavelets, in which the strict shift invariance and scale invariance laws usually associated with classical wavelets are relaxed. We are thus able to derive the benefits of multiresolution without losing flexibility in the description of the geometry. The wavelet approach opens the possibility for very significant compression of the operator matrix when modeling boundary integral equations in 3D. We demonstrate this by considering an example of a potential problem described by a surface mesh with over ten-thousand degrees of freedom. Compression factors of over 100 can easily be achieved with only a modest loss in computational accuracy. Consequently, the wavelet approach offers considerable savings in computer processing power and memory over the Boundary Element Method.

This talk should be accessible to graduate students.