Recent Development in Meshless PDE Approximations

Edward J Kansa
Mechanical and Aeronautical Engineering Department
University of California, Davis

Many areas of applied sciences such as the solution of Boltzmann's equations and molecular dynamics are multi-dimensional problems. For even 3D problems over irregular domains, mesh generation may require months of tedious trial and error intensive work. Meshfree solutions with radial basis functions (RBFs) was first published in 1990.

Certain C^∞ RBFs possess exponential convergence and are prewavelets. The prewavelet properties are constructed with variable RBF shape parameters. It is possible to obtain accuracies of 1e-10 to 1e-15 of PDEs with a relatively few data centers O(100) for 2D problems and O(1000) for 3D problems with combinations of domain decomposition, new greedy algorithms, and extended precision. Comparable calculations with traditional finite difference, element, or volume techniques require huge amount of CPU time and memory, whereas RBF methods can solve problems requiring only minutes of CPU time on PCs.

Examples will be provided to show the efficacy of this method. Turbulent flame combustion within an infinitely periodic domain will illustrate this method in which the hyperbolic PDEs are solved exactly by employing simple rotations and translational transformations to obtain a set of ordinary differential equations that is solved analytically.