

Future CSE: Research Directions and Enabling Technology

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- 1 Problems in Multiresolution Methods
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Problems in Adaptive Methods and Multiscale Modeling

Multiresolution (or adaptive) methods for capturing all relevant scales within one continuum mechanics model have been studied intensively over the last twenty years, but there remains a number of open problems.

One of the main challenges now in CSE is to combine multiresolution methods for particular models with new methodologies for coupling different models together to allow for accurate modeling of phenomena in which widely varying length and time scales are important.

Some open problems requiring more efforts/resources:

- 1 Convergence of adaptive methods for particular models
- 2 Low-complexity algorithms/datastructures for adaptive methods
- 3 Multiscale modeling frameworks for coupling models of varying scales
- 4 Error propagation in multiscale methods
- 5 Convergence/reliability of multiscale methods
- 6 Interaction between multiscale methods and adaptive methods
- 7 “Geometric” numerical methods: preservation of key physical properties in the numerical solution

Problems in Scalable Algs and Multiphysics Modeling

Advances in multiresolution (adaptive) methods have been intimately connected to advances in multilevel (scalable) solvers for elliptic problems; their remains problems in scalable adaptive solvers.

It has become increasingly common that computational scientists are faced with with large complex mathematical models of multi-physics systems involving distinct physical subsystems with their own models.

Challenges that remain in both scalable algorithm development and multiphysics modeling include:

Some open problems requiring more efforts/resources:

- ① Combined theoretical framework for adaptivity/multilevel/multiscale
- ② Scalable/parallel algorithms that allow for use of adaptive methods
- ③ Convergence/complexity results for parallel adaptive methods
- ④ Analysis techniques/frameworks for multiphysics models
- ⑤ Propagation of error between subsystems in multiphysics models
- ⑥ Convergence/complexity of practical multiphysics iterations