The Hong Kong University of Science and Technology

Department of Mathematics

PhD THESIS EXAMINATION

Adaptive Moving Mesh Methods for Solving Partial Differential Equations and Applications

By

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ABSTRACT

The solutions to certain partial differential equations may exhibit large variations in small regions in the physical domain. When numerical methods are applied to solve these equations, overly fine meshes are often necessary to accurately resolve the solution behaviors, resulting in significant increases in computational expenses. In such cases, mesh refinement methods can be employed to generate nonuniform meshes, where the mesh resolutions are higher only in the areas with significant solution variations. This can help reduce computational costs while maintaining the accuracy of numerical solutions. The adaptive moving mesh method (also called r-refinement) is a mesh refinement method that seeks to find a coordinate transformation between the computational and the physical domain based on specific criteria. In this thesis, we explore the theories and techniques of the adaptive moving mesh method and propose two applications. First, we develop a moving mesh finite element method for the minimum compliance problem in topology optimization. Our numerical experiments demonstrate that using a coarser mesh alongside the moving mesh technique can yield desirable output configurations while also enhancing computational efficiency. Second, we propose a moving mesh method for the simulation of the finite-time blowup solution of the Landau-Lifshitz-Gilbert equation. With iterative remeshing, we are able to simulate the blowup solution with the magnitude of the maximum gradient up to 10^4, and that of the minimum mesh size being 10^-5. We study the self-similar patterns and the blowup rates of the solutions and also verify the numerical results by comparing them to established analytical results in a recent study.

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The student's thesis is now being displayed on the reception counter in the General Administration Office (Room 3461).