Springer Series in Computational Mathematics 53

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Numerical Verification Methods and Computer-Assisted Proofs for Partial Differential Equations

Springer

1st ed. 2019, XIII, 467 p. 233 illus., 11 illus. in color.

Printed book

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Numerical Verification Methods and Computer-Assisted Proofs for Partial Differential Equations

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In the last decades, various mathematical problems have been solved by computer-assisted proofs, among them the Kepler conjecture, the existence of chaos, the existence of the Lorenz attractor, the famous four-color problem, and more. In many cases, computer-assisted proofs have the remarkable advantage (compared with a "theoretical" proof) of additionally providing accurate quantitative information. The authors have been working more than a quarter century to establish methods for the verified computation of solutions for partial differential equations, mainly for nonlinear elliptic problems of the form -u=f(x,u,u) with Dirichlet boundary conditions. Here, by "verified computation" is meant a computer-assisted numerical approach for proving the existence of a solution in a close and explicit neighborhood of an approximate solution. The quantitative information provided by these techniques is also significant from the viewpoint of a posteriori error estimates for approximate solutions of the concerned partial differential equations in a mathematically rigorous sense.

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