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Ludovic Chamoin · Pedro Díez
Editors

Verifying Calculations – Forty Years On

An Overview of Classical Verification Techniques for FEM Simulations

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Editors
Ludovic Chamoin
ENS Cachan
Cachan Cedex
France

Pedro Díez
UPC Barcelona Tech
Barcelona
Spain

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Preface

Numerical modeling and simulation is increasingly used as a complement to experimental modeling and analysis and as a design tool in engineering applications. Each of these numerical solutions is intrinsically carrying an error associated with the discretization (mesh) the modeler has decided to use. This decision is based on finding a tradeoff between the computational cost and the numerical quality. However, after almost forty years of worldwide and active research efforts, the problem of properly assessing and controlling the quality of the numerical simulations is still relevant and an issue of major interest. Currently, certain maturity has been reached and calculations for industrial applications can be verified and error bounds can be provided for many cases (even though they are rarely computed in practice). However, the design of sophisticated engineering systems requires increasingly complex and coupled modeling for which verification tools are missing. Furthermore, new issues are appearing as industry needs faster calculations for real-time decision making, design optimization, inverse analysis, or simulation-based control purposes, which urgently requires new strategies for mastering and certifying calculations, bounding errors, in particular in presence of uncertainties.

The present textbook is edited as a companion support of a pre-conference course given on the occasion of the ADMOS 2015 conference, held in Nantes (France) during June 7–10, 2015. It aims at providing the bases to error assessment tools, including state-of-the-art achievements on a posteriori verification in scientific computing. These topics pertain to the field of estimation of discretization errors associated with Finite Element simulations, with a focus on Computational Mechanics applications. This research discipline effectively enables to control the accuracy of numerical simulations and to drive adaptive algorithms. The document also aims at presenting recent advances and forthcoming research challenges on the subject. The content is made of four chapters written by expert researchers on the field, which present fundamental principles on classical a posteriori verification methods: explicit residuals methods, implicit residual methods, smoothing (recovery) methods, and duality-based methods.

We expect this book will help the reader to acquire an overview and insights into classical and state-of-the art techniques and tools for numerical verification.

Ludovic Chamoin
Pedro Díez

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