An introductory course on automation of finite element method

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Course Description

Numerical simulations are essential for solving complex scientific questions and industrial problems. With the advent of new computational formulations and nonlinear material models, the challenge lies in treating the associated severe nonlinearities and complexities. In this context, the finite-element method proves to be a powerful computational tool. However, the derivation of finite-element matrices and vectors in code development is a time-consuming and error-prone process. Thanks to advancements in symbolic computation and automatic differentiation, there is now a more efficient solution: Automated Computational Modeling. This approach generates accurate and fast codes for linear and nonlinear problems, streamlining the development of new finite element technologies and material models.

This course focuses on Automated Computational Modeling in Solid Mechanics by using the symbolic code generation tool AceGen and solving the associated boundary-value problems by using AceFEM. Both AceGen and AceFEM are add-on packages of Wolfram Mathematica. While our primary objective is on the use of Ace tools in Computational Solid Mechanics, a portion of the course is also devoted to a brief introduction of the Finite-Element Method itself, which serves as an essential prerequisite for the course. This course is mainly based on the book "Automation of Finite-Element Methods", by Joze Korelc and Peter Wriggers.

Contents

1. Introduction to the finite-element method
2. Symbolic-numeric programming: introduction to AceGen
3. Automation of the finite-element models in AceGen
    - Formulation of standard material (linear and nonlinear elasticity) models
    - Solving boundary-value problems: introduction to AceFEM
    - Efficient coding and debugging
    - Formulation of multi-physics problems in AceGen
    - Computational plasticity: global-local problems
    - More complex boundary conditions: contact problems
    - Finite-element technology: more advanced elements
    - The use of Ace tools in solving complex research problems

The total number of lectures: 36 hours (18 sessions), self-teaching: 30 hours, direct tutoring and consultations: 20 hours

ECTS Points: 3