

Partial differential equations with deal.II. A short course

Guido Kanschat, IWR, Heidelberg University

Pacific Institute for Mathematical Sciences (PIMS)
August 2016

Abstract

In this class, we introduce into using the finite element library deal.II in order to solve partial differential equations. The class covers basic topics from installing the library and adding support for auxiliary software to setting up a mesh. It advances to defining various finite element spaces on such a mesh and the implementation of bilinear forms. We will cover the implementation of discontinuous Galerkin methods as well as multigrid solvers and preconditioners. The capabilities of deal.II for multithreading and message passing parallelization will be introduced. The course discusses applications like potential problems, linear and nonlinear elasticity, incompressible flow, porous media flow, Maxwell eigenvalue problems, and possibly applications contributed by the audience.

Course outline

The course will be given in 10 lectures with time for programming after each lecture. Participants should have deal.II and amandus installed

1. Grand overview of deal.II and details of the installation process.
2. Creating and refining meshes. Setting up finite element spaces.
3. A first Poisson solver
4. A state-of-the-art multilevel Poisson solver with discontinuous Galerkin methods
5. I have an equation and want to solve it. No more. Amandus.
6. Mixed finite elements
7. Eigenvalue problems
8. Exploring error estimation and adaptive refinement
9. Multigrid preconditioning
10. Parallelization

Deviations from this schedule can be agreed on with the participants.

Prerequisites

Participants should have a basic general knowledge of the finite element method as well as of C++.

Software should be downloaded (see below) and tested on participants' computers.

Downloading and installation

We will use the program package deal.II and the application framework amandus which is built on top of it. It will simplify and speed up the progress of participants considerably, if both are already preinstalled on the participants' computers.

The widely used (more than 500 downloads per month) finite element library deal.II can be downloaded from

`www.dealii.org`.

For this class, we recommend following the instructions for the developer version, which involves cloning from github. For beginners, it is recommended to install deal.II as standard installation without support for MPI, Petsc and Trilinos. If parallelization is an immediate objective, MPI and Trilinos support should be activated. Petsc is only recommended if it is preinstalled on your computer.

Amandus is a small package simplifying the implementation of a lot of applications. It can be cloned from bitbucket at

`https://bitbucket.org/guidokanschat/amandus`.

Instructions for installation AFTER deal.II can be found under the link above.