deal.II crash course

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Overview

1. Session 1: Poisson's Problem
2. Session 2: Heat Equation
3. The End

General information on this class

Institut für Angewandte Mathematik · Leibniz Universität Hannover

1. Crash course part of the 2023 deal.II Workshop
   `https://www.dealii.org/workshop-2023/` [1]
2. Two sessions each 90 minutes
3. Overview, 'theory', practice (code snippets to be completed)
4. (Short) Overview on deal.II via `https://www.dealii.org` [2]
5. Self-learning via Wolfgang's video tutorials
   `https://www.math.colostate.edu/~bangerth/videos.html`
6. Self-learning via tutorial steps `https://www.dealii.org/current/doxygen/deal.II/Tutorial.html`
7. Readme via `https://www.dealii.org/current/readme.html`
8. Download via `https://www.dealii.org/download.html`
9. Expert discussions, further information in the Coding Jam from Wed-Fri

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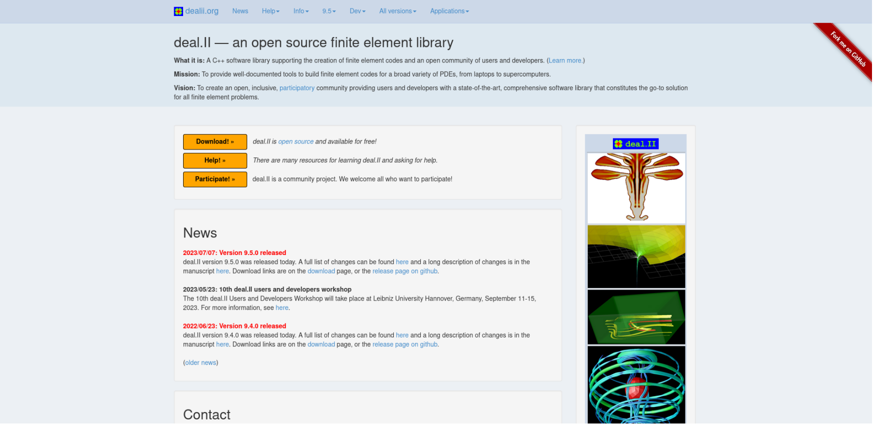
[1] Links are active and can be accessed

[2] Arndt et al.; 2023, `https://dealii.org/deal95-preprint.pdf`

deal.II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deal.II — an open source finite element library
What it is: A C++ software library supporting the creation of finite element codes and an open community of users and developers. (Learn more.)
Mission: To provide well-documented tools to build finite element codes for a broad variety of PDEs, from laptops to supercomputers.
Vision: To create an open, inclusive, participatory community providing users and developers with a state-of-the-art, comprehensive software library that constitutes the go-to solution for all finite element problems.
Download! »
deal.II is open source and available for free!
Help! »
There are many resources for learning deal.II and asking for help.
Participate! »
deal.II is a community project. We welcome all who want to participate!
deal.II
News
2023/07/07: Version 9.5.0 released
deal.II version 9.5.0 was released today. A full list of changes can be found here and a long description of changes is in the manuscript here. Download links are on the download page, or the release page on github.
2023/05/23: 10th deal.II users and developers workshop
The 10th deal.II Users and Developers Workshop will take place at Leibniz University Hannover, Germany, September 11-15, 2023. For more information, see here.
2022/06/23: Version 9.4.0 released
deal.II version 9.4.0 was released today. A full list of changes can be found here and a long description of changes is in the manuscript here. Download links are on the download page, or the release page on github.
(older news)
Contact

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1. Basically, we go through the famous step-3 `https://www.dealii.org/current/doxygen/deal.II/step_3.html`
2. Fantastic documentation
3. Only prerequisites of four classes: knowledge of C++ [3], introduction to numerical analysis[4], (theory of) PDEs/FA[5] and finite elements[6]

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[3] `https://cplusplus.com/`

[4] Richter, Wick; 2017, `https://link.springer.com/book/10.1007/978-3-662-54178-4`

[5] Ciarlet; 2013, `https://my.siam.org/Store/Product/viewproduct/?ProductId=24997945`

[6] Brenner, Scott; 2008, `https://link.springer.com/book/10.1007/978-0-387-75934-0`

Poisson's problem / step-3

Let $\Omega \subset \mathbb{R}^d$ and dimension $d = 1, 2, 3$. Find $u : \bar{\Omega} \to \mathbb{R}$ such that

$$
\begin{aligned}
-\Delta u &= f \quad \text{in } \Omega \\
u &= g \quad \text{on } \partial\Omega
\end{aligned}
$$

with $f \in L^2(\Omega)$ and $g \in L^2(\partial\Omega)$.

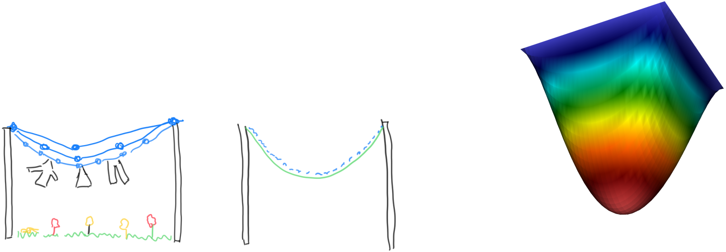

Figure: Poisson problem in 1D (left and middle). Poisson problem in 2D (right).

Poisson's problem / step-3

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deal.II_Crash_Course_2023

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Heat equation

1. Relation to step-26 `https://www.dealii.org/current/doxygen/deal.II/step_26.html`
2. Modified for our purposes in this class
3. `https://github.com/Hendrik240298/deal.II_Crash_Course_2023`

Heat equation

Find $u := u(x,t) : \bar{\Omega} \times \bar{I} \to \mathbb{R}$ such that

$$
\begin{aligned}
\rho \partial_t u - \nabla \cdot (\alpha \nabla u) = f \quad &\text{in } \Omega \times I, \\
u = u_D \quad &\text{on } \partial\Omega \times (0, T), \\
u(0) = u_0 \quad &\text{in } \Omega \times \{t = 0\},
\end{aligned}
$$

where $f : \Omega \times I \to \mathbb{R}$ and $u_0 : \Omega \to \mathbb{R}$ and $\alpha > 0$ and $\rho > 0$ are material parameters, and $u_D \geq 0$ is a Dirichlet boundary condition. As an example, u_0 is the initial temperature and u_D is the wall temperature, and f is some heat source.

Some numerical simulations[7]

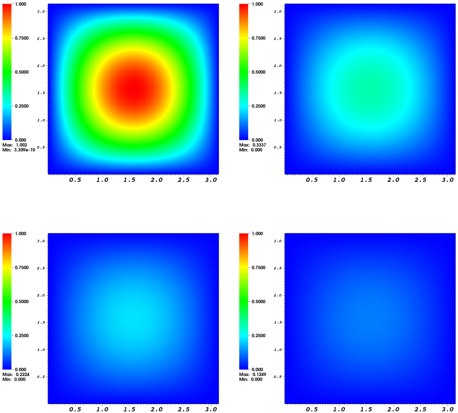

Figure: Heat equation with $\theta = 1$ (backward Euler) at $T = 0, 1, 2, 5$. The solution is stable and satisfies the parabolic maximum principle. The color scale is fixed between 0 and 1.

[7] Wick; 2022, `https://doi.org/10.15488/11709`

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The End

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Thanks a lot for participating,
enjoy the further conference, and Coding Jam!
Don't hesitate to ask questions now or later!