Course info PDE Project course 2016/2017 (TMA632/MMA500)

Lecturer:

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Assistant lecturer:

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Office hours: To be announced.

About the course: The topic of the course this year is the numerical solution of fractional order in time partial differential equations. Depending on the order of the time derivative they can be used to model diffusion in porous media or propagation of stress waves in viscoelastic solids. These equations are special cases of integro-differential equations of Volterra type. We will look at two research papers in this course:

(1) William Mclean and Vidar Thomée, Numerical solution via Laplace transforms of a fractional order evolution equation, J. Integral Equations Appl. 22 (2010), no. 1, 57–94.
(2) William McLean and Vidar Thomée, Time discretization of an evolution equation via Laplace transforms, IMA J. Numer. Anal. 24 (2004), no. 3, 439–463.

Both of these papers describe space-time discretization of fractional order in time partial differential equations. In both papers the spatial discretization is achieved via a standard continuous finite element method. The time discretization of these equations is based on the complex inversion formula for Laplace transforms where the path of integration is first deformed from a vertical line to a more suitable curve on the complex plane. Then various quadrature methods are used to discretize the line integrals. For the implementation though, one has to solve several elliptic problems with complex parameters using finite elements and then sum their solutions up with well-chosen weights. The first paper describes 3 different methods (covering both models of diffusion in porous media and propagation of stress waves in viscoelastic solids) while the second one discusses 2 different methods for waves in viscoelastic solids.

The first time we meet the students will form groups of 2-3 people. Each group is then assigned a time discretization method from the above 5 which they have to implement in FEniCS.

Lectures and tutorials: There will be lectures in the first two weeks to give an introduction to the topic and to describe the numerical methods to implement. We will discuss suitable lecture times the first time we meet. Magne and I will have office hours every week for several hours where you can discuss various problems arising during your work.

Assessment: Each group has to write a report on the implementation they have done. In each case the corresponding numerical example in the above papers have to be reproduced. The groups working on the second paper should extend the numerical example in the paper to 2 spatial dimensions by considering a square instead of an interval. The report has to be written in LaTeX in a research paper format containing: title, abstract, introduction, description of the method, numerical experiments, conclusions, references. At the end of the course each group has to present a 15 minutes talk on their project with the time approximately equally distributed between the group members.

In order to pass the course each group have to book two *consultations* with me where they report on their progress. The first one preferably in week 2 and the second one towards the end of the study period. These are compulsory.

The final mark in the course will be based on the written report (70%) and the presentation (30%) with both of them compulsory. The specific criteria in evaluating the final report:

- Format and organization (20%)
- Mathematical correctness (40%)
- Clarity of writing (40%)

The specific criteria in evaluating the presentation:

- Organization (40%)
- Clarity (40%)
- Mechanics (20%)

The mark for the final report and the presentation will be the same for each group member.

Deadlines:

- The final report has to be submitted in pdf format to me by 23:59, January 13, 2017.
- The presentation has to be scheduled January 9, 2017 – January 13, 2017.

Grading scale. In both the final report and the presentation you have to achieve 41% or more to pass the course. The final grading scale is as follows:

- Chalmers: 0 – 40% (U), 41 – 60% (3), 61 – 84% (4), 85 – 100% (5)
- GU: 0 – 40% (U), 41 – 80% (G), 81 – 100% (VG)

Text: I uploaded the two papers into the course resource bank together with some other papers describing the modeling aspects of fractional order in time differential equations for the interested student. I also uploaded a FEniCS tutorial written by Hans Petter Langtangen and Anders Logg.