PDE Project Course 07/08

Suggestions for projects

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General guidelines

This document contains instructions for the course and a list of projects. Since these are only suggestions, you are welcome with your own ideas. Regard the list as an inspiration, and perhaps a hint on the expected level of your projects. The projects can be done in groups of two persons.

Project plan

In the beginning of the course, each group have to hand in a project plan. It shall contain a description of the project, what differential equations it concerns and a description of an application of a relevant physical problem that the group want to solve, some theoretical background and the intended level of the project (which grade the group aims for). You have to do some own research in litterature and journals and you should have at least one reference from a journal concerning something in your project. On the course homepage there is a link to a template which you are supposed to use to your project plans.

Progress reports

During the course you have to do two progress reports. The progress reports are oral and you book time and come to Nils's office and tell what progress you have done since last time.

Presentation

Everybody have to make an oral presentation and attend the presentations of the other groups. The time set for the presentations is 15 minutes and the time should be equally divided between the members of the group. On the homepage there is a template for the presentation slides and there will be a computer and a projector available.

Report

All groups have to hand in a written report. There is a template on the homepage.

Grades

Concerning grades, the projects are divided into two parts: basic level and advanced level. Basic level means grade 3 and advanced level means grade 4 or 5. However, advanced level is no guarantee for grade 4 or 5. It is also required that your report and your presentation match the level of your project. It is also possible to receive a higher grade even if you only complete the basic level, if you deliver an excellent report and an excellent presentation.

Good luck!
Nils

1 Convection-Diffusion

Implement your own solver for the convection-diffusion equation in 2 dimensions in Matlab. Implement streamline diffusion stabilisation and verify that it performs as expected.

Advanced

Prove error estimates and implement adaptivity.

References

1. *Applied Mathematics: Body and Soul*, by Eriksson, Estep, and Johnson, Springer Verlag 2003.

2. *Computational Differential Equations*, by Eriksson, Estep, Hansbo, and Johnson. Studentlitteratur 1996.

2 Chemical reactions

Simulate the following system of chemical reactions, where the substances A and B react to form C: $A + B \to C$.

Consider a beaker containing a solution of A with given concentration. To this beaker, we add a drop of B every second until finally A has "completely" reacted with B. Try to find a suitable reaction to simulate in a chemistry book. Maybe the reaction you want to simulate is instead given by $2A+3B \to 4C$, or perhaps $5A + 2B + C \to 2C$?

Model this as a system of reaction–diffusion equations, where $u_1(x, t)$ and $u_2(x, t)$ are the two concentrations to be determined.

Implement your 2D solver in Matlab.

Advanced

Implement adaptivity.

References

1. *Applied Mathematics: Body and Soul*, by Eriksson, Estep, and Johnson, Springer Verlag 2003.

2. *Computational Differential Equations*, by Eriksson, Estep, Hansbo, and Johnson. Studentlitteratur 1996.

3. Some suitable book on chemistry.

3 The Navier-Stokes equations

Implement a solver for the Navier-Stokes equations in 2D in Matlab.

Advanced

Nothing extra is needed for advanced level

References

1. *Applied Mathematics: Body and Soul*, by Eriksson, Estep, and Johnson, Springer Verlag 2003.

2. *Computational Differential Equations* by Eriksson, Estep, Hansbo, and Johnson. Studentlitteratur 1996.

3. *Computability and adaptivity in CFD* by Claes Johnson and Johan Hoffman.¡p¿ Downloadable from the course web page.

4 Elasticity

Implement a solver for linear elasticity in 2D in Matlab. Assume that your materials are isotropic (same stiffness in all directions).

Advanced

Nothing extra is needed for advanced level

References

1. *Beyond the Elements of Finite Elements: General Principles for Solid and Fluid Mechanics Applications* by Hansbo. Department of Solid Mechanics, Chalmers University of Technology, 2002

5 The Wave equation

Advanced

Implement adaptivity.

References

1. *Applied Mathematics: Body and Soul*, by Eriksson, Estep, and Johnson, Springer Verlag 2003.

2. *Computational Differential Equations* by Eriksson, Estep, Hansbo and Johnson. Studentlitteratur 1996.

6 Eigenvalue computation

Write a solver in Matlab for computing eigenvalues for the Schrdinger operator in 2D.

Advanced

Implement adaptivity.

References

1. *Computational Differential Equations* by Eriksson, Estep, Hansbo and Johnson. Studentlitteratur 1996.

7 Parallel computation

Write a solver in Matlab for solving the Poisson equation using parallel computations in Matlab.

Advanced

No extra is needed

References

1. *One afternnon course* November 16, 2007, to be announced.