DD2365/FDD3371 Research Questions

20210414

Project assignment 1 (deadline Wed 21/4)

- The purpose of this assignment is to formulate your research question, which will guide the method you choose in your project, the analysis and discussion of your results.
- Together with your research question you should draft an introduction section for your project report, including:
  - (i) your research question,
  - (ii) background to your research question (why it is important),
  - (iii) state of the art in the field (including references).
- You submit (i)-(iii) as one pdf-document, maximum 2 pages.

Project assignment 1 (deadline Wed 21/4)

Some questions to guide your choice of research question:

1. In what area of fluid dynamics would I like to do my project?
2. What are the main challenges of that area?
3. Is there a research question related to these challenges that I can investigate with the methods and software tools used in the lab assignments 1-4? If not, would I be able to extend the methods and software to address the research question?

Final project report (deadline Sun 30/5)

Length: 10 pages (including title page and references)

Format: pdf

Layout:

- Title page (including abstract)
- Introduction (research question, background and state of the art)
- Method (methods to be used, and experiments to be performed)
- Results (present the results of the experiments)
- Discussion (discuss the results in relation to the research question)
- Conclusion (summarise your conclusion, and propose future work)
- References (list the literature you cite in the report)

Appendix

- Software implementation (source code)
- Literature review (extended state of the art section): 2 pages (only for FDD3371)

Style:

- Assume the reader to have taken the course
- Include images to support the text (reference all images in the text)

Final project presentation (Tue 8/6)

Length: 20 minutes

Layout:

- Title page
- Introduction
- Method
- Results
- Discussion
- Conclusion

Style:

- Assume the audience to have taken the course
- Use media (images, movies,...) to support your presentation

Nasa CFD Vision 2030

CFD TECHNOLOGY GAPS AND IMPEDIMENTS

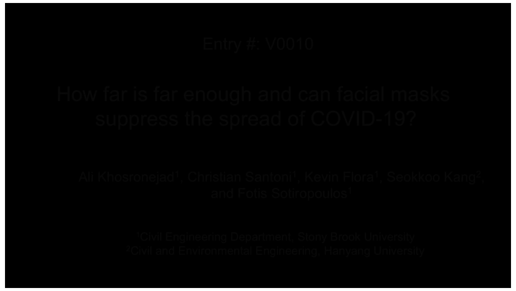
- Effective Utilization of High-Performance Computing (HPC)
- Unsteady Turbulent Flow Simulations Including Transition to Turbulence and Separation
- Autonomous and Reliable CFD Simulation
- Knowledge Extraction and Visualization
- Multidisciplinary/Multiphysics Simulations and Frameworks

Clay $1 million Prize problem

- Existence and smoothness of Navier–Stokes solutions on R^3. Take ν > 0 and n = 3. Let $u_\circ(x)$ be any smooth, divergence-free vector field satisfying (4). Take f(x,t) to be identically zero. Then there exist smooth functions p(x,t), u(x,t) on $R^3 \times [0, \infty)$.
- Breakdown of Navier–Stokes solutions on R^3. Take ν > 0 and n = 3. Then there exist a smooth, divergence-free vector field $u_\circ(x)$ on R3 and a smooth f (x, t) on $R^3 \times [0, \infty)$, for which there exist no solutions (p, u) of the Navier-Stokes equations.

Gallery of fluid motion

Ex. COVID spread with and without mask: differential equations vs deep learning



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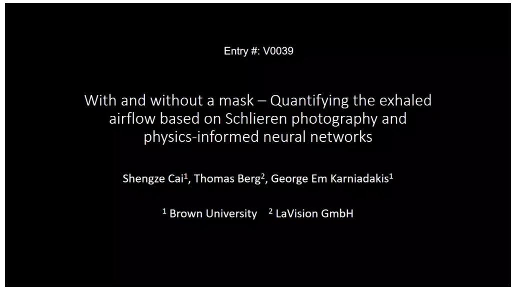

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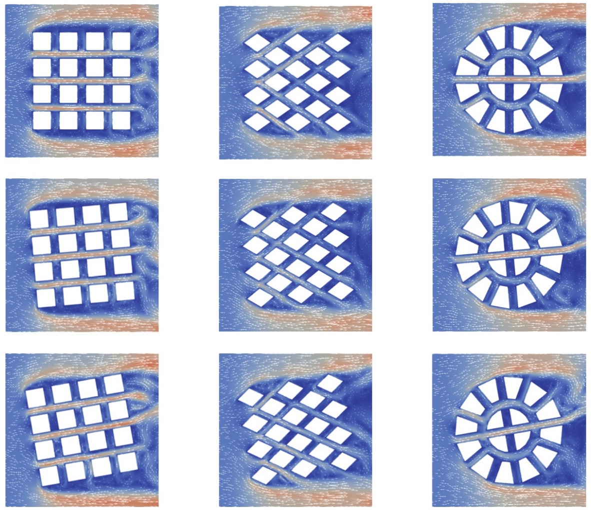
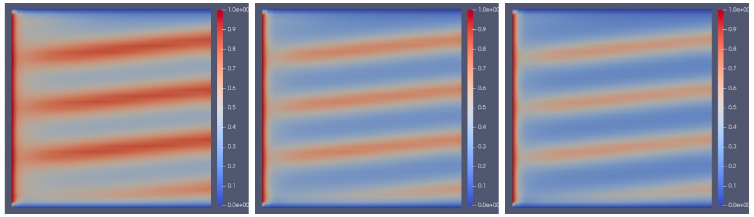
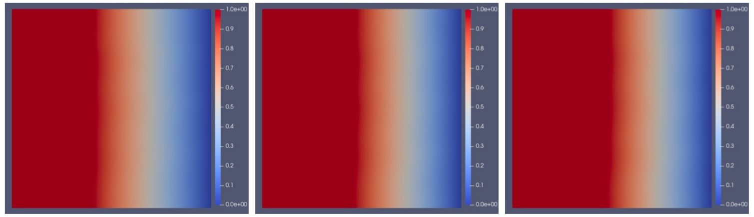
UN Sustainable Development Goals

Example projects (2020)

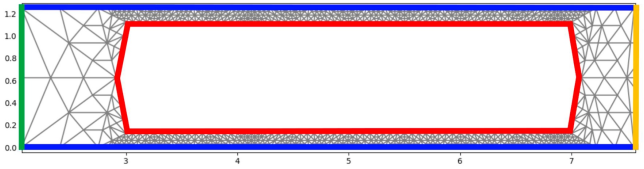


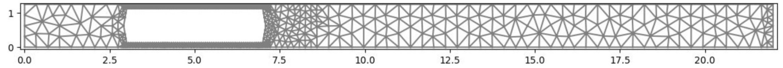


(a) $t = 5$ (b) $t = 7.5$ (c) $t = 9.5$



(d) $t = 5$ (e) $t = 7.5$ (f) $t = 9.5$





Drag force on a train in a long tunnel

Jonas Nylund

A Comparative Study of Pollution Dispersion in Basic City Morphologies

Linde van Beers

May 25, 2020

Fluid flow problems in printing applications Project report in FDD3371 Advanced Computation in Fluid Mechanics

Cecilia Rydefalk

May 25, 2020

'ig. 1: Underground train exiting a tunnel on ,ondons northern line. Note how the train is shaped o fit as tightly as possible in the tunnel. Image ource: SPSmiler - Own work, Public Domain, ıttps://commons.wikimedia.org/w/index.php?curid=400148

n open domains, high speed trains have long, sleek fronts to educe aerodynamic drag. However, this depends on the air ɪeing able to flow around the train. In a tunnel however the

On stabilization for Navier-Stokes equations

- Stabilization is used for two reasons:
  1. To be able to use equal order interpolation while respecting the inf-sup condition.
  2. To avoid spurious oscillations when the mesh is too coarse to resolve fine scale features in the solution.
- Least squares stabilization is based on a quadratic penalty term for the residual.
- Linear approximation in time: test functions are piecewise constant in time, so that the time derivative of the test function is zero. Hence, the residual of the test functions has zero time derivate.

On stabilization for Navier-Stokes equations

Least squares stabilization of the residual

The Galerkin Least Squares (GLS) method is based on a combination of Galerkin's method with a least squares minimization of the residual of the Navier-Stokes equations. GLS is a *consistent* method in the sense that all terms in the method are based on the residual of the equations, no artificial stabilization terms are added.

For each $t > 0$, find $(U(t), P(t)) \in V_h \times Q_h$, such that

$$(\dot{U}, v) + \bar{c}(U; U, v) + a(U, v) + b(v, P) - b(U, q) + s_1(U; U, v) + s_2(U, v) = (f, v),$$

for all $(v, q) \in V_h \times Q_h$, with the stabilization terms

$$\begin{aligned} s_1(w; U, v) &= (\delta_1(\dot{U} + (w \cdot \nabla)U + \nabla P), \dot{v} + (w \cdot \nabla)v + \nabla q) \\ s_2(U, v) &= (\delta_2 \nabla \cdot U, \nabla \cdot v), \end{aligned}$$

with stabilization parameters $\delta_1 \sim h/U_{n-1}$ and $\delta_2 \sim hU_{n-1}$.

On stabilization for Navier-Stokes equations

Example 13.4. Consider the approximation space V_N of continuous piecewise linear functions that satisfy the initial condition $U(0) = u_0$. A function $U \in V_N$ has one degree of freedom for each time step $I_n = [t_{n-1}, t_n]$, which is the value $U(t_n)$, since $U(t_{n-1})$ is determined at the previous time step I_{n-1}. The test space $\hat{V}_N$ of piecewise constant functions also has one degree of freedom per time step, with the global basis being the indicator functions for each time step I_n. Hence, the orthogonality of the residual to the test space $\hat{V}_N$ is expressed as

$$\int_{I_n} R(U(t))\, dt = 0, \quad n = 1, ..., N,$$

or equivalently,

$$U_n = U_{n-1} + \int_{I_n} f(U(t), t)\, dt, \quad n = 1, ..., N,$$

On stabilization for Navier-Stokes equations

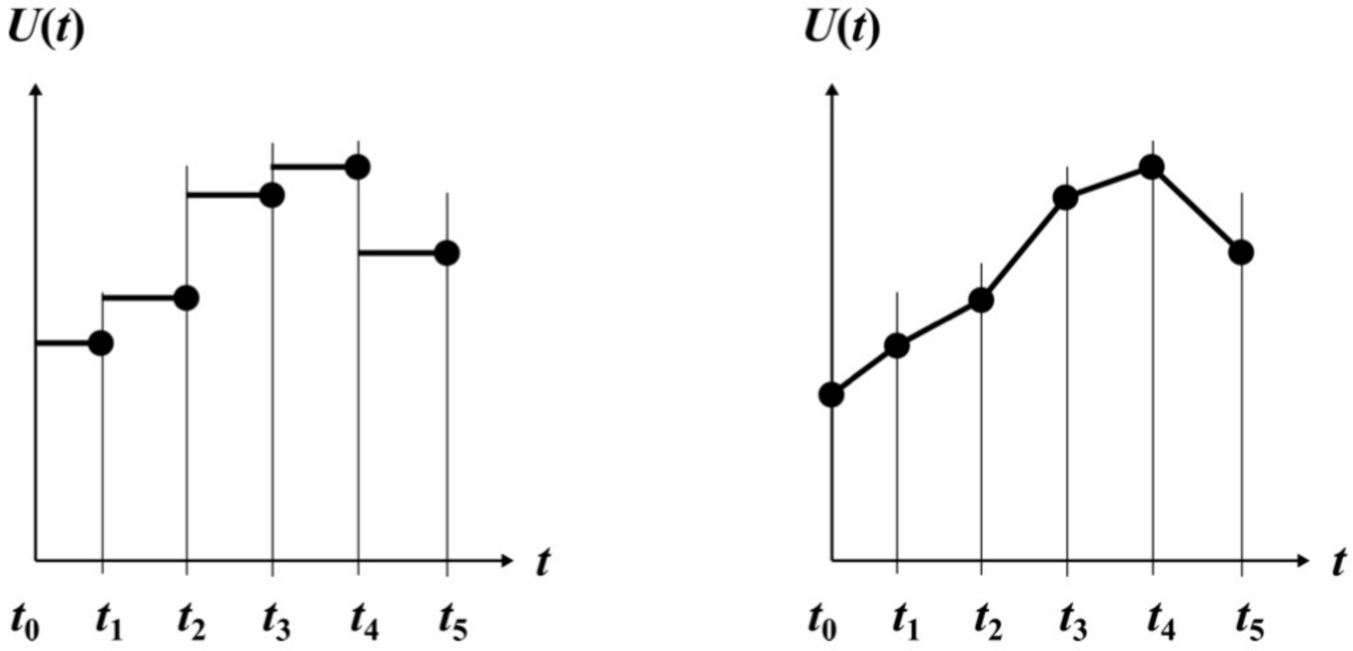


Figure 13.3. *Examples of a discontinuous piecewise constant polynomial determined by its value at the right endpoint of each subinterval (left), and a continuous piecewise linear polynomial determined by its value at the nodes of the partition (right).*