Thesis Title

Institution Name

Author Name

Day Month Year

Innhold

1 Implementation of Fluid Structure Interaction **5**
1.1 FEniCS . . . 5
1.1.1 DOLFIN . . . 5
1.2 Implementation . . . 6
1.2.1 Variational Form . . . 6
1.3 Optimization of Newtonsolver . . . 7
1.4 Consistent methods . . . 8
1.4.1 Jacobi buffering . . . 8
1.5 Non-consisten methods . . . 8
1.5.1 Reuse of Jacobian . . . 8
1.5.2 Quadrature reduce . . . 8

Kapittel 1

Numerical Results

In this chapter the main calculations of the proposed theories and will be presented.

1.1 Verification

1.2 Validation

For verification purposes the numerical benchmark presented in .. has been chosen for this thesis. This benchmark as been widely accepted throughout the fluid-structure interaction community as a rigidly validation benchmark. This is mainly due to its diversity of tests included, challenging all the main components of a FSI solver.
The benchmark is divided into three main testenvironments, subdivided into an additional three test with increasing difficulty.

- **CFD**
  In the first environment the purely fluid solver is tested for a range of different inflow parameters.
- **CSM**
  test
- **FSI**

1.3 Mesh movement

Bibliografi

[1] Robert T Biedron and Elizabeth M Lee-Rausch. Rotor Airloads Prediction Using Unstructured Meshes and Loose CFD/CSD Coupling.

[2] J Donea, A Huerta, J.-Ph Ponthot, and A Rodríguez-Ferran. Arbitrary Lagrangian-Eulerian methods. (1969):1–38, 2004.

[3] Th Dunne. An Eulerian approach to uid – structure interaction and goal-oriented mesh adaptation. *International Journal for Numerical Methods in Fluids*, (December 2005):1017–1039, 2006.

[4] Thomas Dunne and Rolf Rannacher. Adaptive Finite Element Approximation of Fluid-Structure Interaction Based on an Eulerian Variational Formulation. *Fluid-Structure Interaction*, 53:110–145, 2006.

[5] Richard P Dwight. Robust Mesh Deformation using the Linear Elasticity Equations.

[6] Miguel A Fernández and Jean-Frédéric Gerbeau. Algorithms for fluid-structure interaction problems. 2009.

[7] Brian T. Helenbrook. Mesh deformation using the biharmonic operator. *International Journal for Numerical Methods in Engineering*, 2003.

[8] Su-Yuen Hsu, Chau-Lyan Chang, and Jamshid Samareh. A Simplified Mesh Deformation Method Using Commercial Structural Analysis Software.

[9] Hrvoje Jasak and Željko Tuković. Automatic mesh motion for the unstructured Finite Volume Method. *Transactions of Famena*, 30(2):1–20, 2006.

[10] V V Meleshko. Bending of an Elastic Rectangular Clamped Plate: Exact Versus 'Engineering' Solutions. *Journal of Elasticity*, 48(1):1–50, 1997.

[11] Selim MM and Koomullil RP. Mesh Deformation Approaches – A Survey. *Journal of Physical Mathematics*, 7(2), 2016.

[12] Thomas Richter. Fluid Structure Interactions. 2016.

[13] K Stein, T Tezduyar, and R Benney. Mesh Moving Techniques for Fluid-Structure Interactions With Large Displacements.

[14] T E Tezduyar, M Behr, S Mittal, and A A Johnson. COMPUTATION OF UNSTEADY INCOMPRESSIBLE FLOWS WITH THE STABILIZED FINITE ELEMENT METHODS: SPACE-TIME FORMULATIONS, ITERATIVE STRATEGIES AND MASSIVELY PARALLEL IMPLEMENTATIONSt. *New Methods in Transient Analysis ASME*, 246(143), 1992.

[15] Wolfgang A. Wall, Axel , Gerstenberger, Peter , Gamnitzer, Christiane , Förster, and Ekkehard , Ramm. Large Deformation Fluid-Structure Interaction – Advances in ALE Methods and New Fixed Grid Approaches. In *Fluid-Structure Interaction: Modelling, Simulation, Optimisation*, pages 195—-232. Springer Berlin Heidelberg, 2006.

[16] Thomas Wick. *Adaptive Finite Element Simulation of Fluid-Structure Interaction with Application to Heart-Valve*. PhD thesis, Heidelberg.

[17] Thomas Wick. Solving Monolithic Fluid-Structure Interaction Problems in Arbitrary Lagrangian Eulerian Coordinates with the deal.II Library.

[18] Thomas Wick. Fully Eulerian fluid-structure interaction for time-dependent problems. *Computer Methods in Applied Mechanics and Engineering*, 255:14–26, 2013.