Topology optimization of flow problems - DTU Orbit (21/07/2019)

Topology optimization of flow problems
This thesis investigates how to apply topology optimization using the material distribution technique to steady-state viscous incompressible flow problems. The target design applications are fluid devices that are optimized with respect to minimizing the energy loss, characteristic properties of the velocity field or mixing properties. To reduce the computational complexity of the topology optimization problems the primary focus is put on the Stokes equation in 2D and in 3D. However, the thesis also contains examples with the 2D Navier-Stokes equation as well as an example with convection dominated transport in 2D Stokes flow. Using Stokes flow limits the range of applications; nonetheless, the thesis gives a proof-of-concept for the application of the method within fluid dynamic problems and it remains of interest for the design of microfluidic devices. Furthermore, the thesis contributes to the development of the topology optimization method by studying different problem formulations related to topology optimization of fluid problems. In addition, the COMSOL software has been used as a post processing tool. Prior to design manufacturing this allows the engineer to quantify the performance of the computed topology design using standard, credible analysis tools with a body-fitted mesh. Also, the thesis encompasses work on how to utilize the finite volume method (FVM) in the topology optimization context. This is motivated by the momentous position the FVM has in the fluid dynamics community. Although the study of the FVM is carried out using a simple heat conduction problem, the work illuminates and discusses the technicalities of employing the FVM in connection with topology optimization. Finally, parallelized solution methods are investigated using the high performance computing facility at the Technical University of Denmark. Large topology optimization problems with 2D and 3D Stokes flow modeling are solved with direct and iterative strategies employing the parallelized Sun Performance Library and the OpenMP parallelization technique, respectively.

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