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Topology optimisation of fluid flow in MATLAB: a detailed introduction

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This work presents a full MATLAB framework for the topology optimisation of fluid flow in two dimensions governed by the Navier-Stokes equations. The framework utilises a density-based formulation with a frictional resistance term [1]. The goal is to introduce newcomers to the field, students and researchers alike, with an easy to use and extendable MATLAB code (also compatible with Octave).

The Symbolic Toolbox is used to derive the finite element formulation and the corresponding exact derivatives for use in both the Newton solver for the state problem and the formulation of the adjoint problem. Secondly, a MATLAB code based on the popular "88-line" code for solid mechanics [2] is used to drive the topology optimisation of fluid flow problems. The code has been extended to handle the non-linear state problem and solve an adjoint problem, since all functionals are non-self-adjoint for Navier-Stokes flow.

It is shown that an optimality criteria solver performs very well for minimum dissipation/pressure-drop problems, despite being driven only by negative gradients (more fluid is better). Several extensions are made possible by switching to a more general optimisation solver, namely the Method of Moving Asymptotes (MMA) [3]. These include flow focusing/reversal and drag/lift optimisation.

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