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Topology optimization of unsteady fluid flow patterns using lattice the Boltzmann method

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Abstract

The focus of this work in on topology optimization of unsteady fluid flow problems using the lattice Boltzmann method (LBM). The fluid domain is modelled using the density approach and a partial bounceback formulation of the LBM to model the transition from fluid to solid. The aim of the work is to control the unsteady patterns produced by flow past obstacles at moderate Reynolds number, by altering their topology. The optimization problem is formulated as a time averaging of the desired objective over all time steps, and the sensitivities are obtained by solving the discrete adjoint problem. Well known pressure drop type problems are also considered, in order to validate the partial bounceback formulation and to demonstrate some of the limitations of currently utilized interpolation schemes. Preliminary findings show that many possible topologies can be used to recover a given spatial and temporal flow profile, suggesting a large amount of local minima in the problem. Topology optimization results in reproducible complex unsteady flow patterns which paves the way for investigating more complex flow control devices like mixers, control valves, embedded coolers and fluid distributors.