Howard C. Elman

Fast Solvers for Models of ICEO Microfluidic Flows

Department of Computer Science
University of Maryland
College Park
MD 20817
USA
elman@cs.umd.edu
Robert R. Shuttleworth
Kevin R. Long
Templeton, Jeremy A.

We demonstrate the performance of a fast computational algorithm for modeling the design of a microfluidic mixing device. The mixing device uses an electrokinetic process, induced charge electroosmosis, by which a flow through the device is driven by a set of charged obstacles in it. The device's design is realized by manipulating the shape and orientation of the obstacles in order to maximize the amount of fluid mixing within the device. The computations required in the modeling of the electrokinetic process entails the solution of a constrained optimization problem in which function evaluations require the numerical solution of a set of partial differential equations: a potential equation, the incompressible Navier-Stokes equations, and a mass transport equation. The most expensive component of the function evaluation (which must be performed at every step of an iteration for the optimization) is the solution of the Navier-Stokes equations. We show that by using some new robust algorithms for this task, based on certain preconditioners that take advantage of the structure of the linearized problem and approximate the Schur complement, this computation can be done efficiently. Using this computational strategy, in conjunction with a derivative-free pattern search algorithm for the optimization, applied to a finite element discretization of the problem, we are able to determine optimal configurations of microfluidic devices.