Adjoint-Based Optimisation of Flow Control for Unsteady Transport Problems in Microfluidic Applications

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ABSTRACT

Defining optimal control strategies for unsteady transport problems requires simulations with sufficient time resolution, which results in a huge number of control variables. Finding optimal solutions to such systems can be efficiently done using unsteady adjoint-operator methodology (see [1,2]).

In the present research, we find optimal solution to the fluid flow control problem coupled with passive scalar transport problem. The continuous adjoint methodology is presented and applied to a microfluidic device with two inlets and two outlets (Figure 1). Controlling the outflow pressure at one outlet allows to manipulate convective flux of the substrate (passive scalar in terms of governing equations) on the other outlet. The control task considered in this study is defined as follows: Find optimal pressure control strategy so that the time variations of the outflow flux of the transported substance follow prescribed temporal profile.

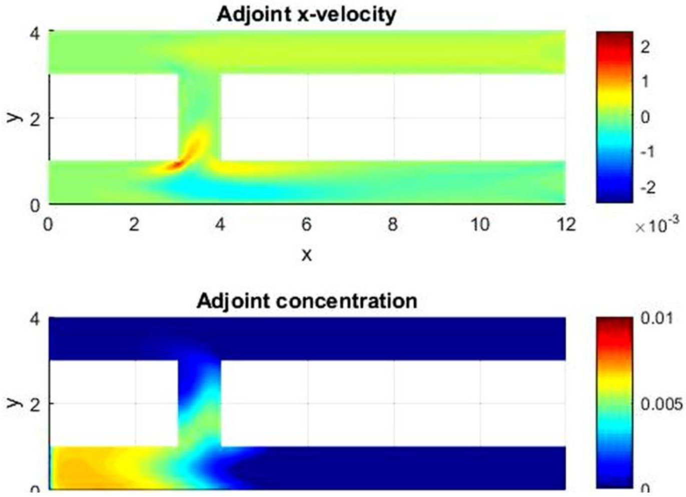

Figure 1 - Snapshot of the adjoint solution for velocity and concetration in benchmark geometry.

Application of the continuous adjoint methodology allows to compute gradient of the objective function with respect to given control parameters. The finite element flow and passive scalar transport solver is coupled with the MMA optimisation algorithm of the NLopt library [3]. It converges to the optimal solution within moderately small number of iterations (around 50 for 500 design parameters).

The methodology proves robust and omitting one of the troublesome terms in adjoint formulation seems not to affect the end result of the optimisation. Furthermore, the research showed that the flux behaviour is not very sensitive to small changes in control strategy. Hence, methodology is promising for successful implementations in practical control applications.

REFERENCES

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