Optimal Control for Fluid-Structure Interaction with Application to Heart Valve Settings

T. Wick[1]

Abstract: In this talk, we are concerned with optimal control problems where the state is given by means of fluid-structure interaction equations. We consider a heart valve configuration, where the cost functional is used for the minimization of wall stresses measured on the interface between the blood (fluid) and the arterial wall (structure). The corresponding control is either prescribed on outer boundaries as some Neumann condition. In a second setting, the stiffness of the valve material is used as control. To be able to employ a gradient-based optimization approach, we couple the state equations in a monolithic fashion. That is derived by re-formulating the fluid equations in a fixed reference domain via the arbitrary Lagrangian-Eulerian (ALE) method. The non-linear problem is solved by a Newton-like method, where the Jacobian is derived in an exact manner. The optimal control problem is solved by a reduced approach, where the state is computed in terms of the control. We discuss numerical examples for prototypical two-dimensional heart valve simulations that show the performance of our proposed technique. Specifically, we first consider a bypass setting (Neumann boundary control that is prescribed as an additional inflow). In a second example, we allow to influence the material stiffness of the valves (e.g., for the modeling of artificial heart valves), i.e., we take the structural parameter as control

[1] Institute of Applied Mathematics
University of Heidelberg
Im Neuenheimer Feld 293/294, 69120 Heidelberg, Germany
thomas.wick@iwr.uni-heidelberg.de