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Optimal pressure boundary control of steady Fluid Structure Interaction systems

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In the last years adjoint optimal control has been increasingly used for design and simulations in several research fields such as shape optimization problems, fluid-solid conjugate heat transfer and turbulent flows. Recently the study of Fluid-Structure Interaction problems and its control have gained popularity because of many interesting applications in engineering and biomedical fields. Fluid-structure interaction systems consist of one or more solid structures that deform by interacting with a surrounding fluid flow. FSI simulations evaluate the tensional state of the mechanical component and take into account the effects of the solid deformations on the motion of the interior fluids. In many engineering applications it is interesting to study the inverse FSI problem which aims to achieve a certain objective by changing some design parameters such as forces, boundary conditions or geometrical domain shapes. In this paper we would like to study these inverse FSI problems by using an optimal control approach based on Lagrangian multipliers and adjoint variables. In particular we propose a pressure boundary optimal control method with the purpose to control the solid behavior by changing the fluid pressure on a domain boundary. The optimality system is derived from the first order optimality condition by taking the Fréchet derivatives of the Lagrangian with respect to all the variables involved. The optimality system is solved iteratively using and comparing different line search methods with a finite element code with mesh-moving capabilities for the study of large solid displacements. In order to support the proposed approach we perform numerical tests where the fluid domain boundary pressure controls the displacement that occurs in a well defined region of the solid domain. The approach presented in this work is general and can be used to assess different objectives and complex geometries.