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Optimization and surgical design for applications in pediatric cardiology[1] ALISON MARSDEN, University of California San Diego, ADAM BERNSTEIN, CHARLES TAYLOR, JEFFREY FEINSTEIN, Stanford University — The coupling of shape optimization to cardiovascular blood flow simulations has potential to improve the design of current surgeries and to eventually allow for optimization of surgical designs for individual patients. This is particularly true in pediatric cardiology, where geometries vary dramatically between patients, and unusual geometries can lead to unfavorable hemodynamic conditions. Interfacing shape optimization to three-dimensional, time-dependent fluid mechanics problems is particularly challenging because of the large computational cost and the difficulty in computing objective function gradients. In this work a derivative-free optimization algorithm is coupled to a three-dimensional Navier-Stokes solver that has been tailored for cardiovascular applications. The optimization code employs mesh adaptive direct search in conjunction with a Kriging surrogate. This framework is successfully demonstrated on several geometries representative of cardiovascular surgical applications. We will discuss issues of cost function choice for surgical applications, including energy loss and wall shear stress distribution. In particular, we will discuss the creation of new designs for the Fontan procedure, a surgery done in pediatric cardiology to treat single ventricle heart defects.

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