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# ADJOINT BASED DATA ASSIMILATION FOR QUANTIFYING MECHANICAL PROPERTIES IN CLINICAL CARDIAC MECHANICS

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**Summary:** Computational mechanical analysis of the heart has received much attention in the last decades, as accurate biophysical models offer promise of allowing greater understanding of cardiac functionality. However, the myocardium is a complex material, and while detailed models and constitutive laws have been developed, properly fitting these models to obtained data is made difficult by the number of interacting parameters that are often needed. Although numerous techniques, from trial and error to advanced optimization, can be used to fit data, challenges still exist, often due to the computational requirements when many control parameters are needed.

This is particularly a challenge in the case of computational cardiology, where heterogeneous noisy data sets are used, and time constraints on analysis are present. Here we discuss the use of adjoint methods as an attractive, efficient means to rapidly assimilate large data sets into personalized models of cardiac mechanics derived from clinical data. These adjoint-based optimization techniques allow us to fit models at a cost that does not significantly depend upon the numbers of parameters to be fit, and thereby provide an excellent means to assimilate high dimensional parameter spaces at a relatively low computational cost. These methods are enabled by the new generation of software tools that automatically create physical models and derive adjoint equations for problems of interest.

We show the utility of this method in a range of clinical settings, from heart failure, to pulmonary hypertension, to myocardial infarction. In all these cases, we use an efficient pipeline to create cardiac models directly from medical imaging and assimilate detailed strain data and pressure measurements and estimates. Parameterized mechanical models are used to demonstrate differences in active and passive properties of the myocardium in disease states, which may have diagnostic use in clinical applications.

Reducing the computational cost of accurate computational models is a key step towards translating modelling into greater utility, both for basic science and for clinical adoption. Adjoint based PDE constrained optimization methods, with their applicability in data assimilation for cardiac mechanics, offer the means to accelerate the use of biophysical models in both experimental and clinical cardiac applications.