Parameter Estimation of Multi-Fiber Family Models for Biaxial Mechanical Behavior of Arteries in the Presence of the Measurement Errors

S. Baek, S. Zeinali-Davarani, J. Choi

Department of Mechanical Engineering, Michigan State University, East Lansing, MI48864 USA
sbaek@egr.msu.edu

It appears that multi-fiber family constitutive models with exponential functions can capture well the progressive arterial stiffening with the increasing stretch. However, previous studies with the models did not account for measurement errors in independent variables for parameter estimation. In this work, we develop a parameter estimation technique for the multi-fiber family constitutive model accounting for the measurement errors. We first characterize the uncertainty propagation due to the errors in variable using the constitutive model. Then, a nonlinear least squares (NLS) optimization for the artery model is formulated with proper weight factors from the uncertainty model, and the proposed techniques is evaluated using multiple sets of synthesized data with fictitious measurement noises. The results of the estimation are compared with the results from the conventional method without weight factors (Fig. 1). The proposed method significantly improves the quality of parameter estimation than the NLS without weight factors, and the advantage of using the weighted NLS method is more pronounced at higher noise level. We also investigate model selection criteria to decide the optimal number of fiber families with respect to the experimental data balancing between variance and bias errors. We used three criteria, Akaike information criterion (AIC), a modified form of AIC, and the root mean square error measure, to evaluate optimal number of parameters (or fiber families) for the multi-fiber constitutive model of arteries. Experimental data from two rabbit basilar arteries and three mouse carotid arteries are used to investigate the optimal number of fiber families. Interestingly, these three different criteria result in an identical optimal number, 11 parameters (six fiber families), for mouse and rabbit data.

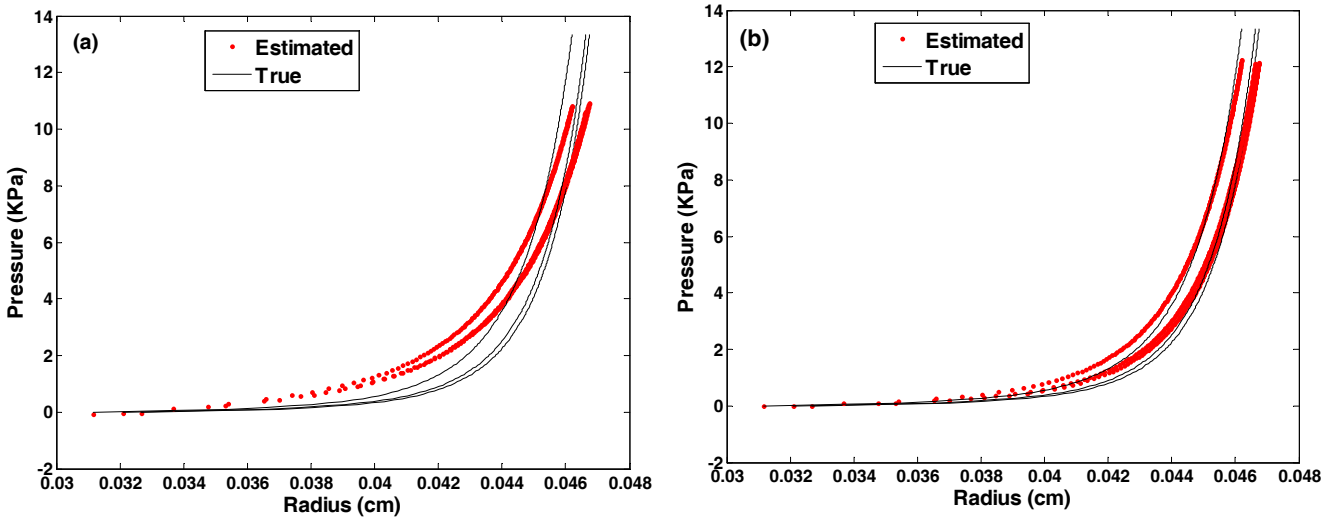

Figure 1. Comparison between the NLS (a) and WNLS (b) optimizations. Pressure versus radius is plotted using true parameters (solid) and estimated parameters (dotted) at different axial stretches