Scott R. Pope

Parameter Estimation with a Blood Flow, Blood Pressure Model

North Carolina State University
Dept of Mathematics
255 Harrelson Hall
Box 8205
Raleigh
NC 27695
srpope@ncsu.edu
C. T. Kelley
Mette Olufsen
Laura Ellwein, Cheryl Zapata

There are many aspects of the human circulatory system that affect blood flow and blood pressure, but which cannot be measured directly. For instance, vascular resistance and compliance affect blood flow and pressure, but neither can be accurately measured without full access to the veins and arteries. Further complications arise because these resistances and compliances vary throughout the body. To get estimates for these parameters, we have developed a lumped parameter model of the human circulatory system. Our model treats the circulatory system as a collection of interconnected compartments exchanging blood. For example, the entire collection of veins in the brain is treated as a single compartment. A compartment for the heart at the center of the system drives blood flow. Each compartment has an associated compliance parameter. Connections between compartments have an associated resistance parameter. Treating the system as analogous to an electric circuit, we derive a corresponding ordinary differential equation system dependent upon our set of unknown parameter values. Finding parameter values that cause the solution to the ODE system to best fit cerebral blood flow and arterial blood pressure data collected non-evasively is a nonlinear least squares problem. Various optimization techniques are used to find parameter values that minimize the least squares error. We handle several issues that make our problem difficult. These issues include finding which parameter values that can be reliably predicted, handling non-smooth aspects of the model, and various methods of obtaining a Jacobian.