Boeing Project Description

Statistical data fitting for simulation and optimization

Working with engineers and scientists, mathematicians at Boeing are confronted by a wide range of multivariate data fitting problems. We analyze data from physical experiments and computer simulations. For example, data from wind tunnel and flight tests are used in computer simulations to predict behavior of the vehicle and to program flight simulators for pilot training. In addition, our most powerful and widely used method for vehicle design is based on response surface models, where engineering software output is treated as experimental data. We deal with finite element analysis, computational fluid dynamics, trajectory simulation and many other engineering codes. Typical methods include kriging models, tensor product polynomial splines, procedural approaches such as projection pursuit regression, and others. This broad field offers a number of challenging questions of interest to Boeing. Of particular and immediate concern is creating models accounting for uncertainty in the data, an area rich in open issues.

A fit to multivariate test data can include estimation of an error model, an underlying statistical model of sources of uncertainty. The error model can be used, for example, to assess quality of information from a test, for calibrating engineering simulations, for designing future tests, or for uncertainty analysis in engineering design. Statistical fitting for simple error structures is well understood, and can be computationally fast even for moderately large data sets. The theory for complicated error structures and large data sets is a subject of research, and there are significant computational challenges to be resolved. Two areas of research are of particular potential value to Boeing: constrained multivariate data fitting with an error model, simple or not, and high-dimensional de Boor-Ron least polynomial fitting, where a long-sought rapid model update procedure is needed.

Another general application area is design optimization with complex computer simulations. These simulations may involve iterative solutions of ODEs and PDEs or other complex physical phenomena. The responses from these simulations may be noisy but in a different way than the physical experiments. When using these simulations with optimization it is common to form surrogate models of the simulation via some data fitting method, optimize the model, and then get more data to update the model. Understanding the interaction between the optimization method and the uncertainty in the data and the data models is in its infancy.