UBC-Vancouver STAT 547L, 2014-15 Term 1

Dynamic Computer Experiments

Instructor: William J. Welch

Prerequisites

Familiarity, at a senior undergraduate level, with variance and covariance properties of linear combinations of random variables, statistical concepts such as estimation bias and variance, statistical regression modelling. Experience with Matlab or R.

Course contents

The rapid growth in computing power has made the computational simulation of complex systems feasible. Scientists are able to adjust inputs to computer simulators in order to help understand their impact on a system. That is, they perform a designed computer experiment (or simply a computer experiment). These are commonly used in science and engineering, and are making inroads in health sciences, etc.

The course will introduce students to the statistical design and analysis of computer experiments in general. Of particular interest are *dynamic* computer models, with output over time and/or space.

Specific topics to be covered are likely to include:

- What is a computer experiment?
  - Motivating examples selected from glaciology, atmospheric pollution, ocean science and other domains; the data and scientific objectives
- Analysis
  - Emulation of a computer code: Gaussian process (GP) statistical models to predict the output of a computer code from its inputs, along with a measure of uncertainty
  - Estimation of parameters of the GP model using likelihood and Bayesian methods
  - Assessment of prediction error; statistical model diagnostics
  - Building a GP model (choosing the components)
  - Other methods, e.g., MARS, polynomial chaos
  - Computation: avoiding ill-conditioning; faster computations for large sample sizes
- Design of computer experiments
  - Space-filling designs: Latin hypercubes and variants

  - Sequential design for optimization and quantile estimation

- Scientific and engineering objectives
  - Screening and sensitivity analysis, visualization
  - Propagation of variation

- Combining computer model runs and physical data
  - Calibration of unknown parameters in a computer model
  - Estimating the discrepancy between computer code output and physical reality

- Dynamic computer codes
  - Statistical approaches to handle computer-model output over time and/or space
  - Motivating applications revisited

Logistics

Classes at SFU and UBC will be held jointly by video link, with Professor Derek Bingham the instructor at SFU. A video link with researchers at Acadia University is also planned, and Professors Chipman and Ranjan at Acadia may give guest presentations (as may others).

Mode of instruction

An introduction to the above topics and their computer implementation will take about half the class time. Students will present reviews of key papers and projects in an informal discussion setting for the remaining classes.

Grading

Assignments 30%; presentation(s) of papers in the literature 30%; analysis / computing mini project(s) 40%

Professor Welch will be responsible for assessment of UBC students.

Further details

Instructor	Will Welch, ESB 3132, Ext 2-3339, email will [AT] stat [DOT] ubc [DOT] ca
Office hours	Tuesday, 2:00–3:00, Thursday, 3:00–4:00, or by appointment
Lecture time/place	Tuesday and Thursday, 9:30–11:30 am in ESB 4127
Course web page	`http://www.stat.ubc.ca/~will/cx/`
Course text	See the web page; a list of seminal papers will also be provided