Experimental Design

4-15-2011

Opening Discussion

- Minute Essay comments
  - Supercomputers in the cloud.
  - Petroleum companies and supercomputers.
- Simulation at my conference.

Factors and Responses

- Factors are things we can control when we set up a simulation.
  - Quantitative
  - Qualitative
- Responses are values we get out of the simulation.
  - Sensitivity analysis
  - Metamodels/prediction surfaces
    - Predict behavior
    - Find optimum value

Differences from Normal Experiments

- Can control a lot more.
- Can apply variance reduction.
- Don't have to randomize to treat against systematic errors.
- Ability to run a system repeatedly for statistical purposes.

2^k Factorial Designs

- Imagine a system with k factors. We want to vary each one to see how much the system depends on it.
- We can vary them each independently for sensitivity analysis. This gives 2^k simulations. Requires lots of simulations and doesn't explore interactions.
- Look at average difference between all runs where a value is low vs. high.

Interactions

- We can also look at two factor differences. We want the average for one factor at plus and minus only in cases where another factor was at plus or minus.

Covering Parameter Space

- Sometimes you want more than just the + and – options for a value.
- In physical simulation there are often ranges of values that are physically significant and you want to check a range of those.
- This can only be done nicely for small dimensional parameter spaces.

2^{k-p} Fractional Factorial

- The “standard” 2^k factorial design method can often require far too many simulations.
- There are approaches where you don't cover the space quite as completely for large k situations yet still get most of the benefit.
- This section of the text has a lot of details in it on how you would design a test suite that doesn't fully investigate certain parameters. It does leave you with some ambiguity though.

Metamodels

- The earlier experimental design plans mainly aimed to allow you to see how a system responds relative to changes in certain variables. They also allowed exploration of mutual changes.
- Often you would like to be able to predict the response of a system based on a few of the factors.
- This basically uses linear regression to fit responses.

Building Models

- The type of model that you can build will depend a lot on the number of different values you try for each factor.
- With only two values, the model has to have no more than two parameters and will likely be linear. Larger numbers of data points can give you higher order fits.
- You want fits, not just interpolating of data.

Response Surfaces

- Another way to model data is to build a response surface.
- This is basically like what I showed you for my ring simulations.
- You vary 2 factors through a few values to form a surface of responses.
- If you had the right visualization software/hardware you might try to build a response space, but it can be harder to interpret.

Simulation Based Optimization

- Optimization is a field unto itself.
- The challenge with simulation is that evaluating new points in the parameter space can be costly.
- Unconstrained optimization basically uses Newton's method in a higher dimensional space. Derivatives typically taken numerically.
- Constrained optimization places bounds on where the solution can be. Linear programming.

Minute Essay

- Any questions?
- The second test will be next Wednesday. It will cover material we have done since the midterm.